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R V R R COLLEGE OF EDUCATION, GUNTUR

PREPARED BY

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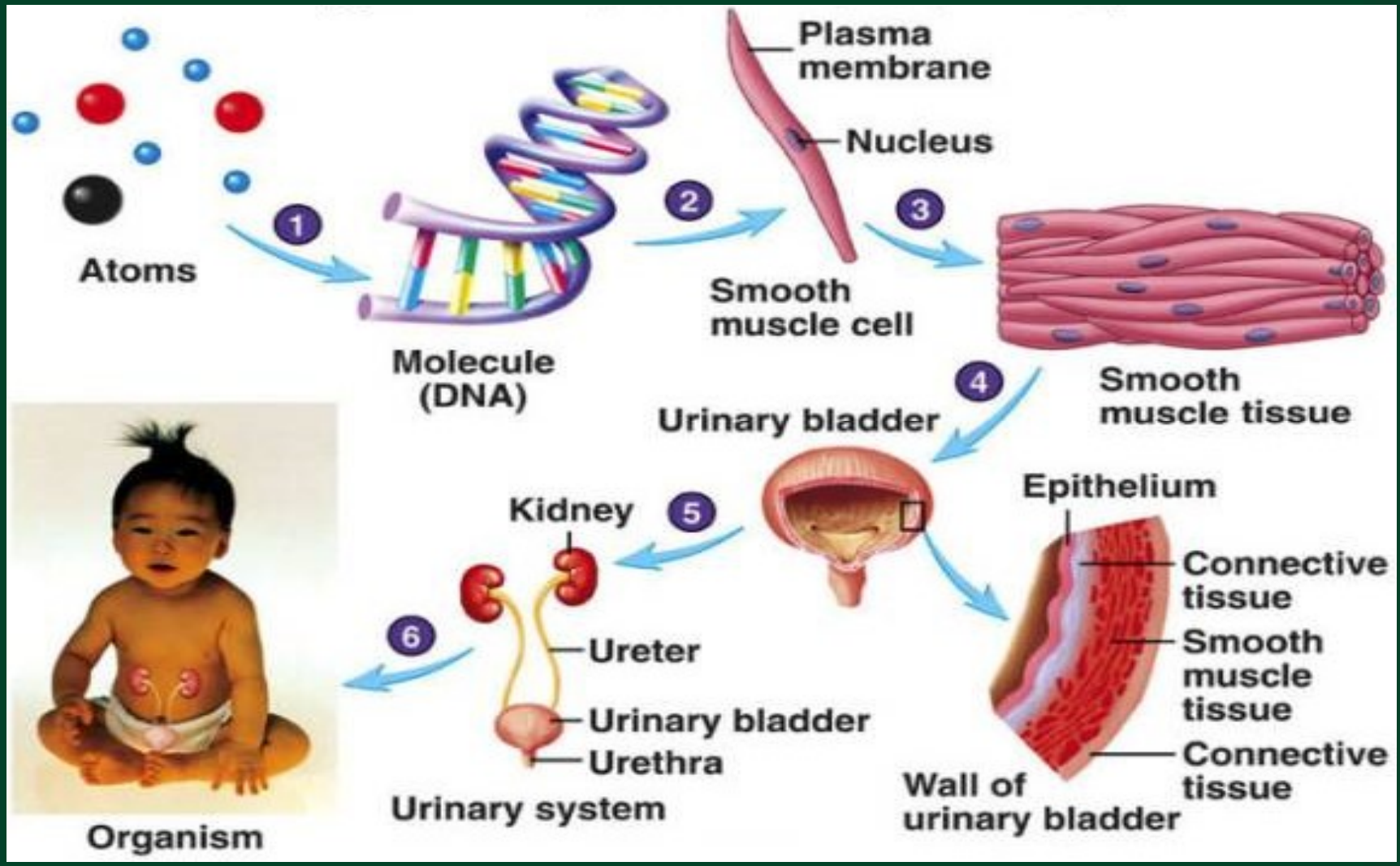
Study of Animal Tissues

Organization of an Organism



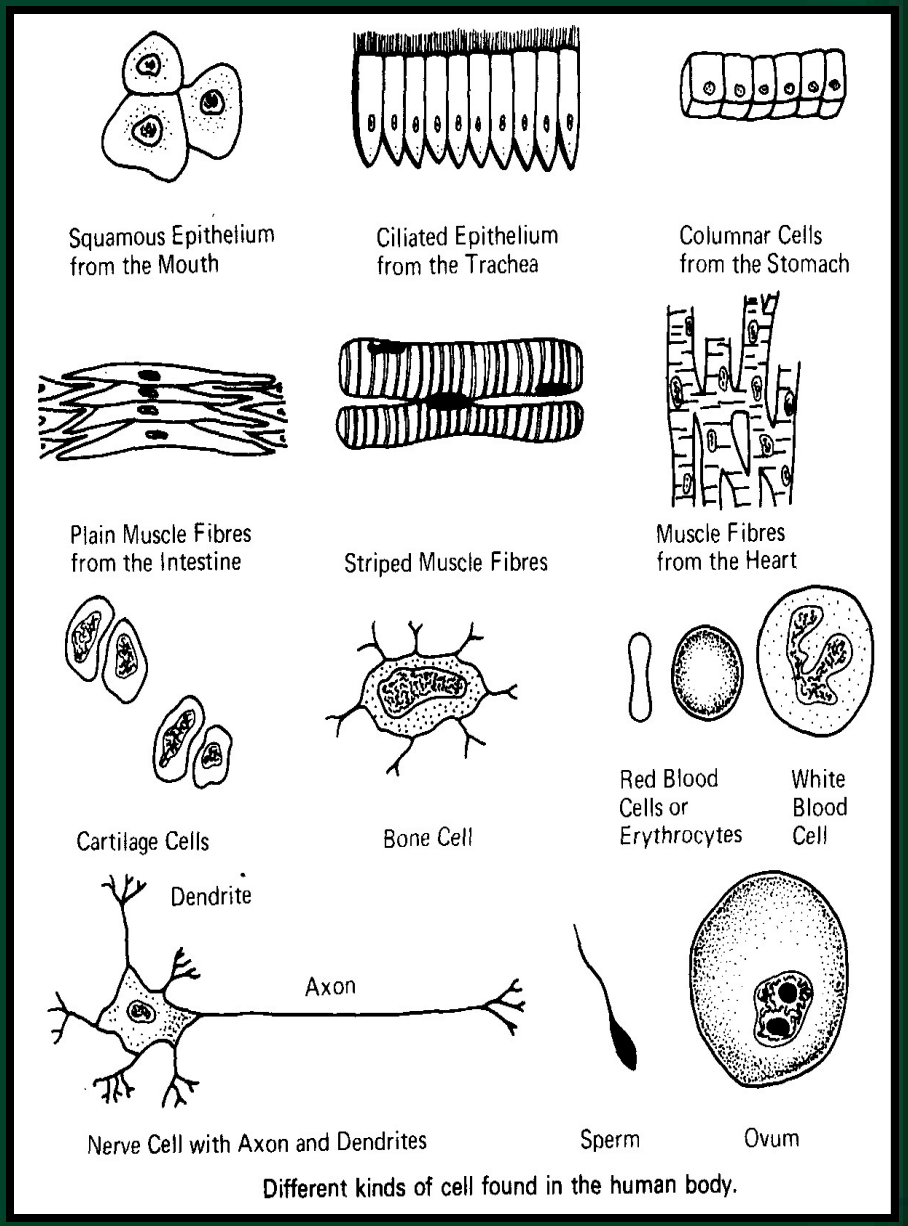
- A cell is the **structural and functional unit of life.**
- A cell is a mass of protoplasm surrounded by a plasma membrane.
- The protoplasm of cell is generally with a spherical **nucleus** and a variety of cytoplasmic living **cell-organelles** like the endoplasmic reticulum, mitochondria, Golgi bodies, centrioles, ribosomes, lysosomes, etc.
- Each cell organelle performs a specific function.

Somatic cells:

- These are general body cells present all over the body except reproductive organs. These cells are responsible for all the bodily activities.

Germ cells:

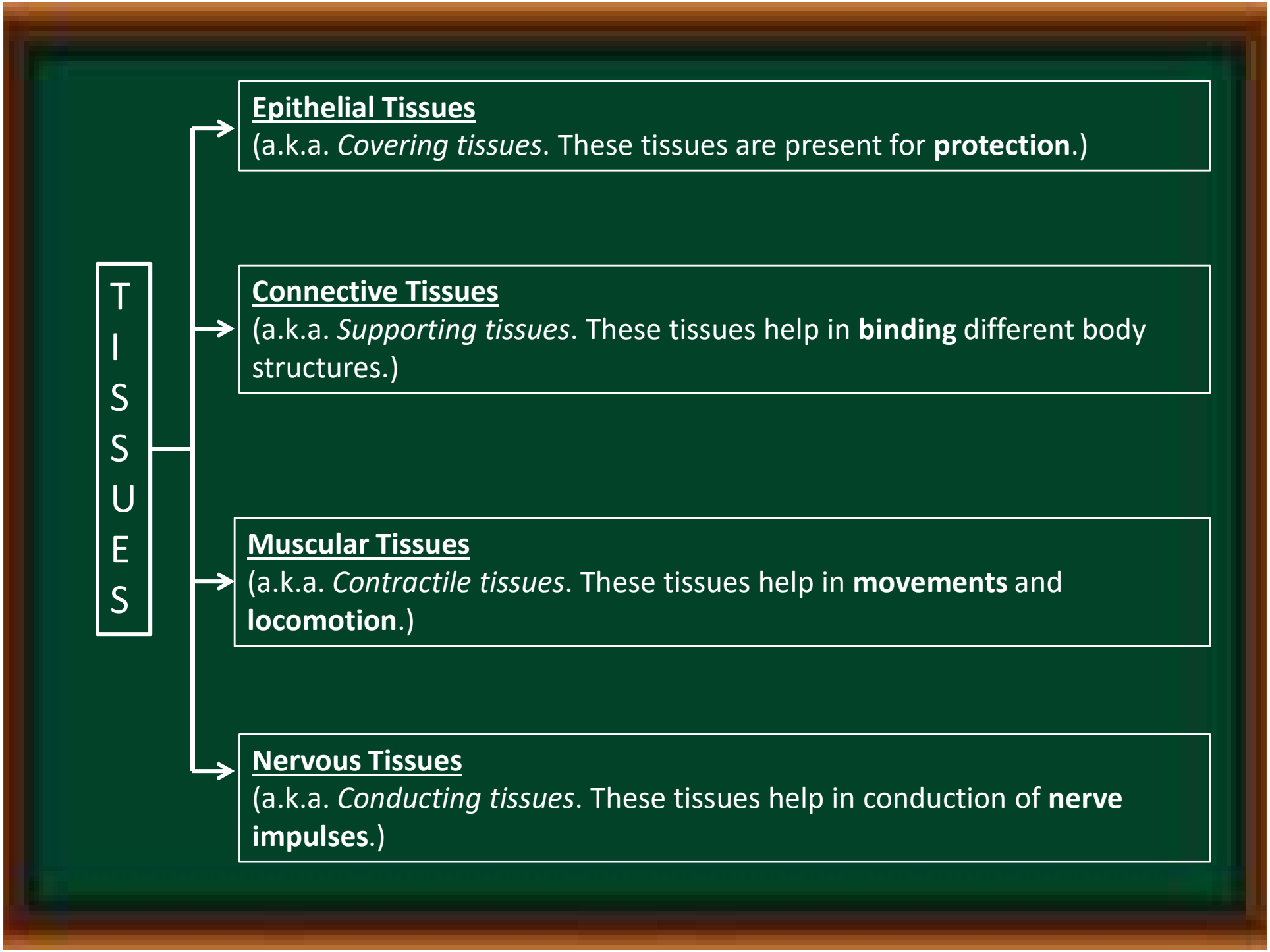
- These are also called 'sex cells'. These cells are concerned with the reproduction and are present in the reproductive system/organ.



Different kinds of cell found in the human body.

Tissue :

- A group of cells similar in **form, structure and embryonic origin** which coordinate to perform a specific function is called a **simple tissue,**
- while a group of cells, **different in their structure and function** but coordinating to perform a specific function, is called a **compound tissue.**
- Various tissues combine together in an orderly manner to form large functional units called **organs.** Number of organs work in coordination and give rise to **organ-system.**
- The branch of science that deals with the microscopic study of tissues is called **histology.**


TISSUES
Epithelial Tissues
(a.k.a. Covering tissues. These tissues are present for protection.)
Connective Tissues
(a.k.a. Supporting tissues. These tissues help in binding different body structures.)
Muscular Tissues
(a.k.a. Contractile tissues. These tissues help in movements and locomotion.)
Nervous Tissues
(a.k.a. Conducting tissues. These tissues help in conduction of nerve impulses.)

EPITHELIAL TISSUE

General position:

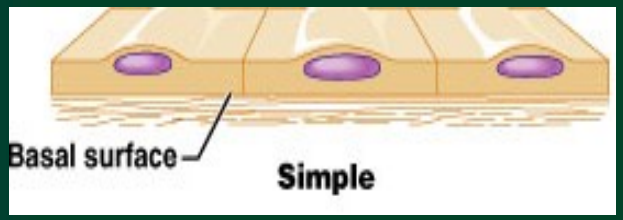
- It covers the outer surface of all the organs of the body and also lines the cavities of all the hollow organs of the body.

Structure:

- Cells are arranged in one or more **layers**.
- Cells are **compactly arranged** and there is **no or very little intercellular material (matrix)** between them.
- Cells of the lowermost layer rest on thin, double layered, non-cellular, non-living **basement membrane** (or **basal lamina**)
- Cells may originate from any primary germ layer i.e. **ectoderm** (e.g. epidermis of skin), **mesoderm** (e.g. coelomic i.e body cavity epithelium), **endoderm** (e.g. mid gut epithelium).
- Cells are **non-vascular** or **avascular**, i.e. they lack their own blood supply. These cells get their nutrition from the blood capillaries present in the underlying connective tissue.
- Cells have the power of **division and regeneration** throughout life. The old injured dead cells are **sloughed** off (removed) regularly.
- **Free surface** of the cells may be smooth, or may have fine hair-like cilia or microvilli.

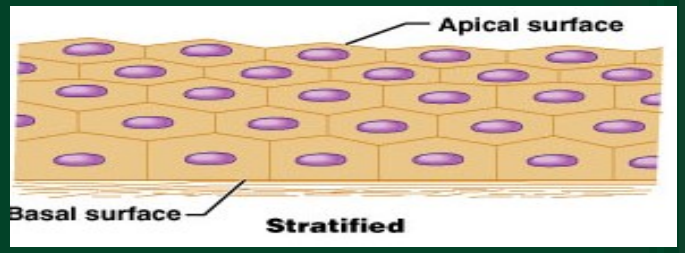
EPITHELIAL TISSUE

Simple



1. Simple Squamous
2. Simple Cuboidal
3. Simple Columnar
   a. Ciliated
   b. Non- ciliated
4. Simple Gandular
5. Simple sensory
6. Simple Germinal

Compound



1. Stratified
2. Transitional

SIMPLE SQUAMOUS EPITHELIUM

Origin:
- It is found in the peritoneum of coelom and endothelium (i.e. lining of the blood vessels).
- It is also found on the surface of the skin.

Structure:
- The cells are polygonal in shape, thin, delicate and flat.
- The nucleus is centrally placed. They appear like flat tiles when viewed from the top and so they are also called *pavement epithelium*.

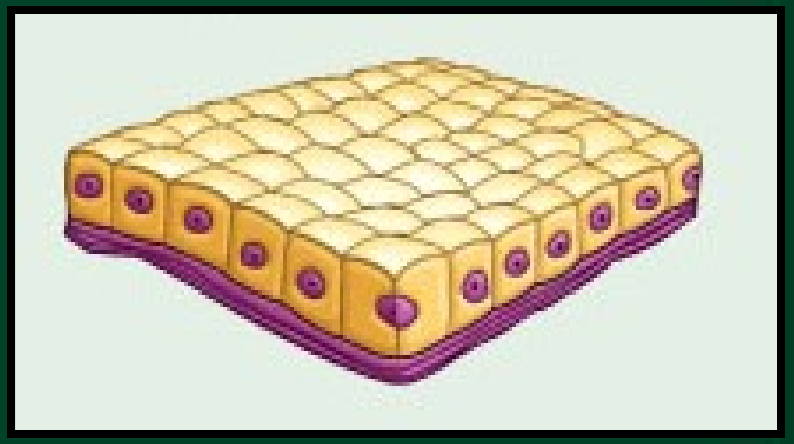
Functions:
- *Filtration* and *diffusion* of material.
- *Protection* of skin from micro-organisms and foreign particles.

SIMPLE CUBOIDAL EPITHELIUM

Origin:
- It is generally found in the thyroid gland and kidney.

Structure:
- The cells are cube shaped, with centrally placed round or spherical nucleus.

Functions:
- They play an important role in *absorption* and *secretion*.



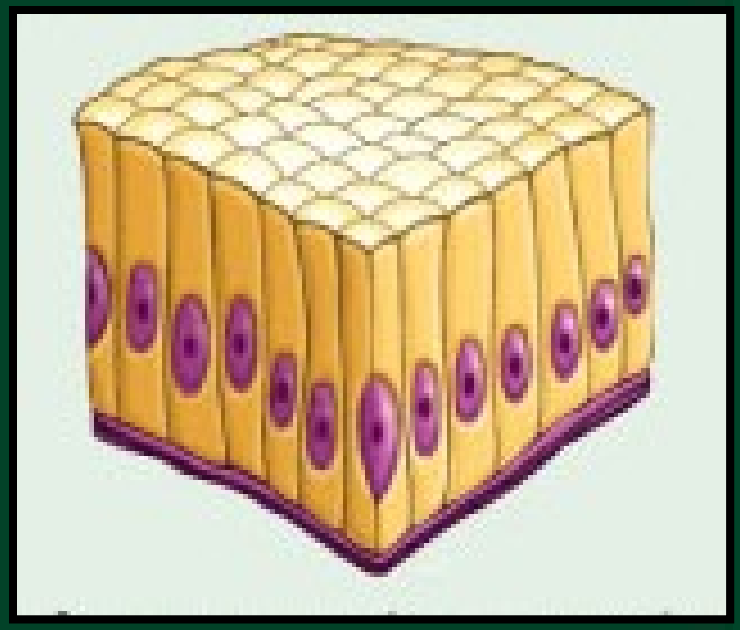
SIMPLE COLUMNAR EPITHELIUM

Origin:

- It makes the inner lining of stomach, intestine and other internal organs.

Structure:

- The cells are tall, pillar-like with anterior free end that is broader than the posterior narrow end resting on the basement membrane.
- Nucleus is oval or elliptical and is placed near the basal end



CILIATED COLUMNAR EPITHELIUM

Origin:

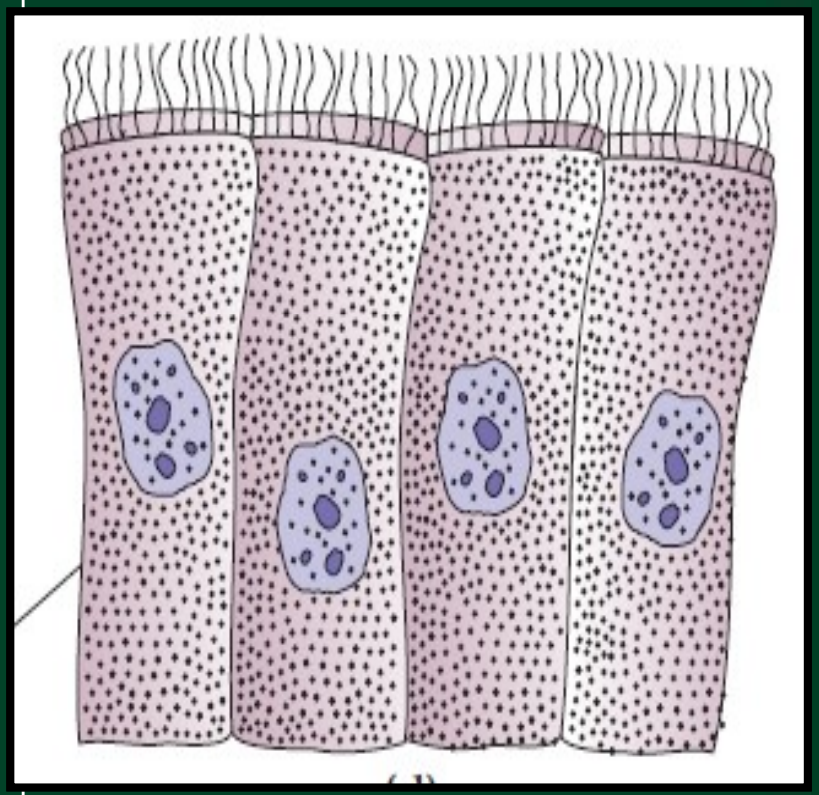
- It is found in the upper respiratory tract, fallopian tube of vertebrates.

Structure:

- The cells are tall, pillar-like with anterior free end that is broader than the posterior narrow end resting on the basement membrane.
- The anterior free end shows presence of large number of thin **protoplasmic extension** called **cilia**, which are seen rising from the basal granules.
- Nucleus is oval and placed at the basal end.

Functions:

- Since cilia are capable of **vibratory movement**, they are able to remove foreign particles from the surface. Cilia help in the movement of non-motile ovum.



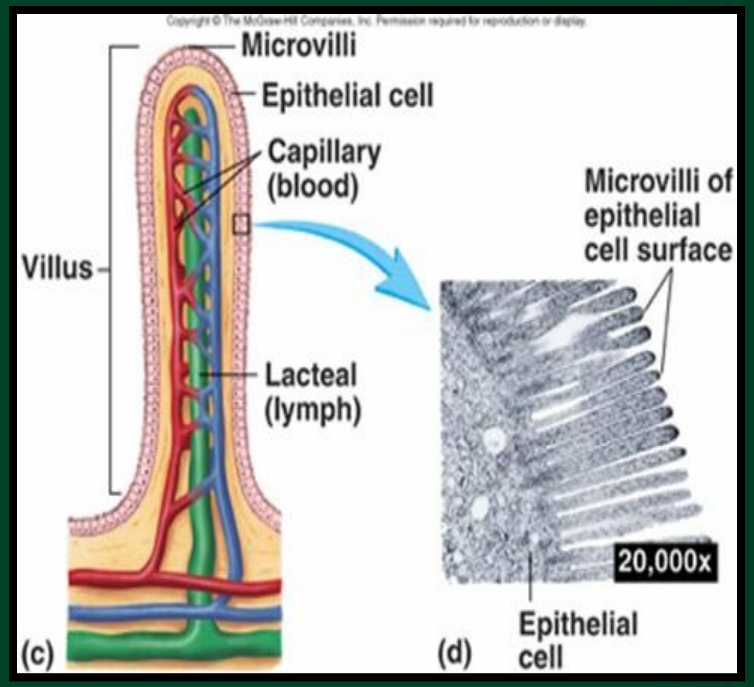
NON- CILIATED COLUMNAR EPITHELIUM

Structure:

- These are without cilia at their anterior free end and hence called non-ciliated columnar epithelium.
- Columnar cells at their apical region show presence of finger like protoplasmic projections called **microvilli.**

Functions:

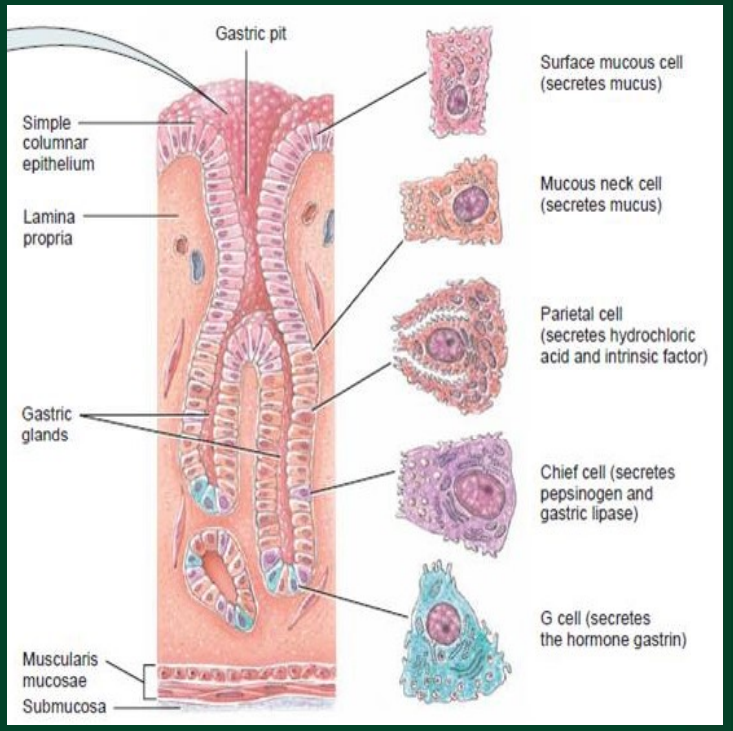
- Microvilli help in increasing the surface area of **absorption** which is the main function of non-ciliated columnar epithelium.



SIMPLE GLANDULAR EPITHELIUM

- These are specialized epithelial cells capable of synthesizing substances like enzymes, hormones, sweat, oil, etc.
- These secretions are carried into ducts (tubes) on the surface or into blood.
- The structure formed by these specialized epithelial cells is commonly called a ***GLAND***

- Glands are further classified as:
  a) Endocrine glands
  b) Exocrine glands



SIMPLE GLANDULAR EPITHELIUM

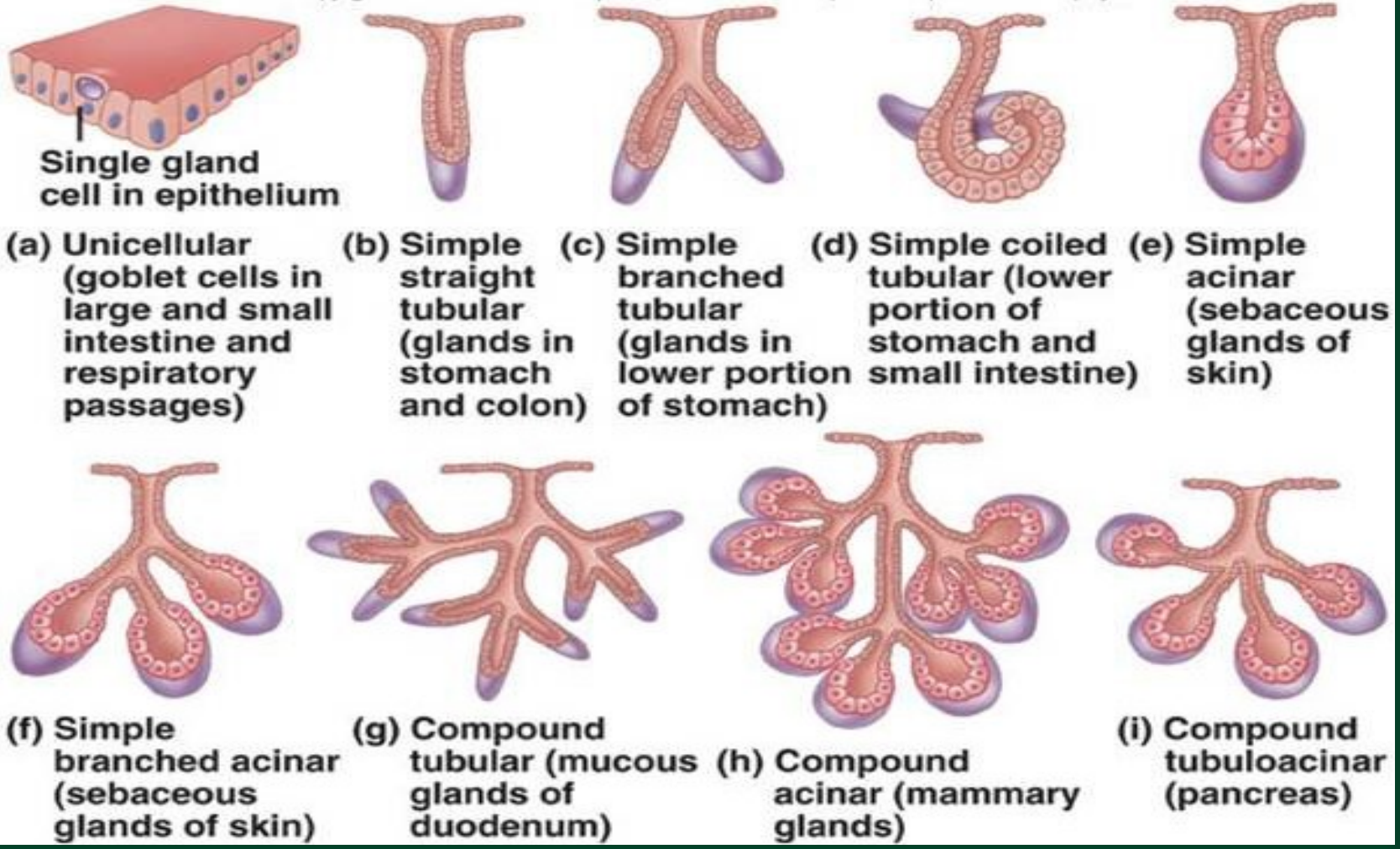
Endocrine Glands:

- These glands pour their secretion directly into the blood stream. Such glands lack ducts and are thus called **ductless glands**.
- e.g.: pituitary, thyroid, parathyroid, ovary, testis, adrenal, islets of Langerhans.

Exocrine Glands:

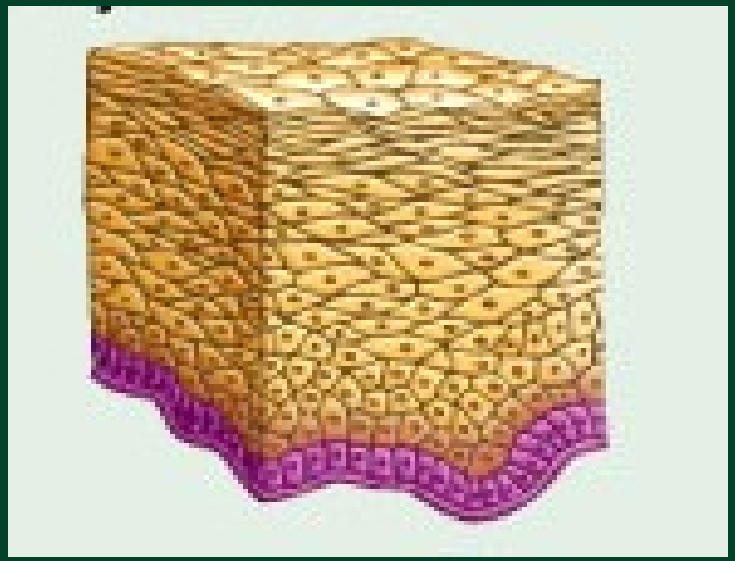
- These glands are **with ducts**. Their secretion is carried by means of a duct or tube to the site of action. They are responsible for body secretions.
- e.g.: tear glands, salivary glands, gastric and intestinal glands.

Exocrine Glands

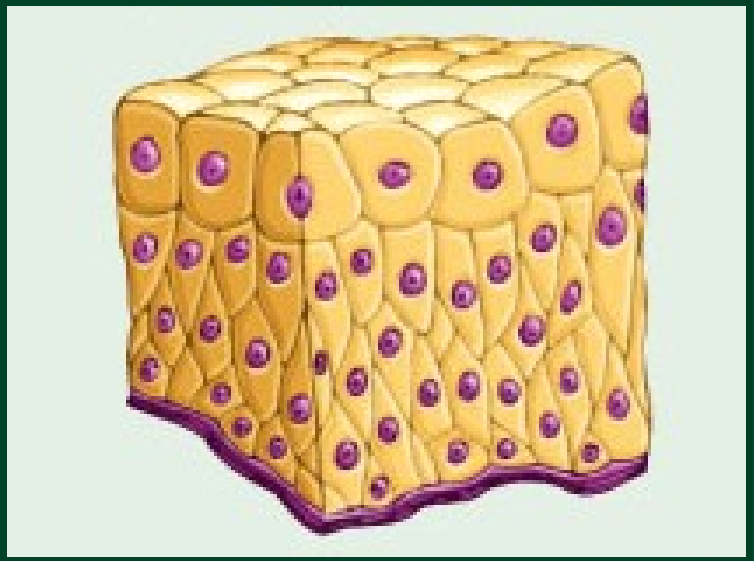


COMPOUND EPITHELIUM

1. STRATIFIED EPITHELIUM



2. TRANSITIONAL EPITHELIUM

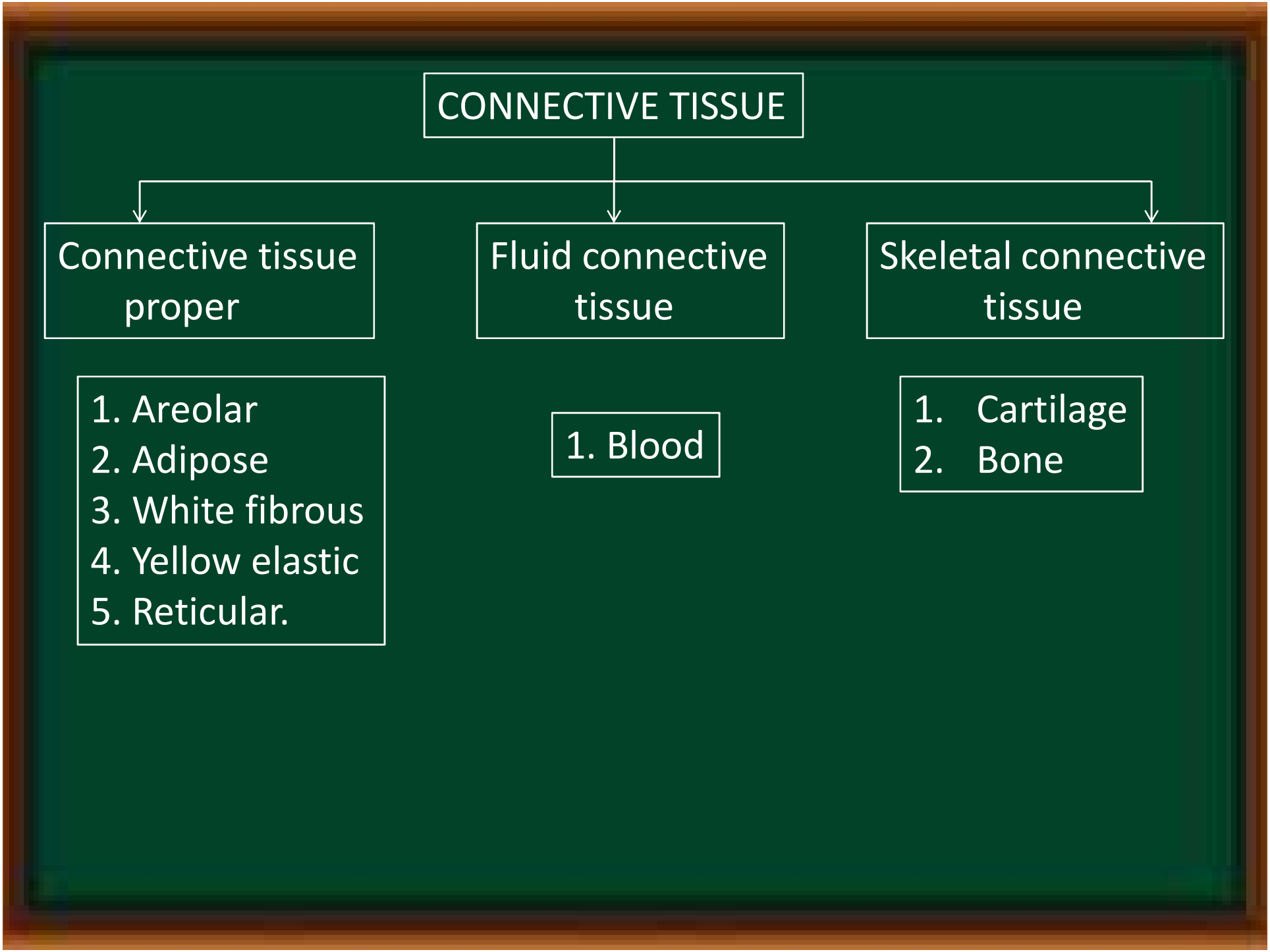


CONNECTIVE TISSUE

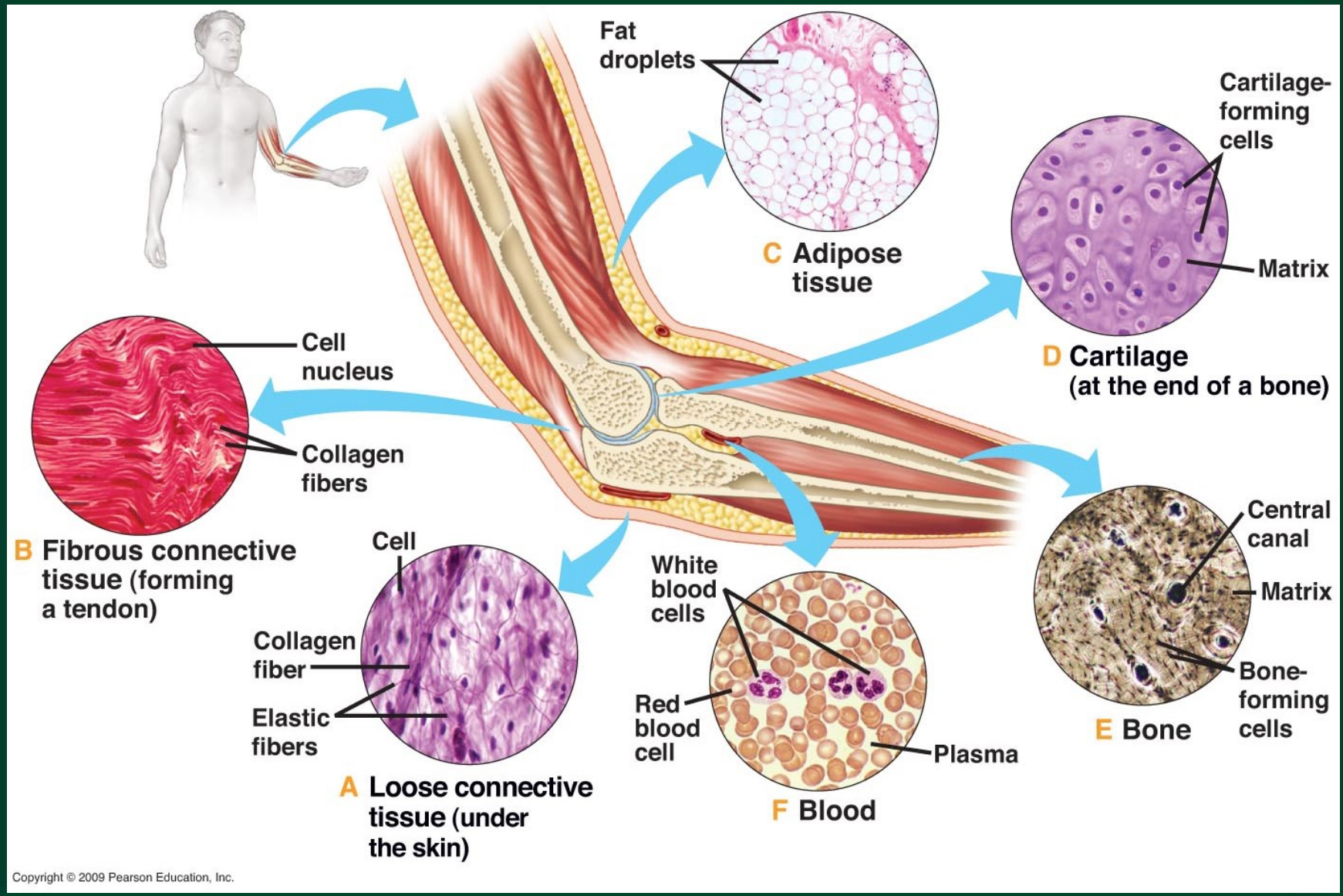
Origin: - Arise from the **mesoderm** of the embryo.
Most abundant type of animal tissue

Structure:

- The connective tissues consist of variously shaped cells lying wide apart in a large, amount of non-living intercellular or extracellular material called the **matrix.**
- The matrix is also called ground substance. It is usually secreted by the connective tissue cells themselves.
- This ground substance permits diffusion of food materials, water, gases and wastes to and from the cells.
- Thus, connective tissue usually comprises of two components: **matrix and cells**.
- The nature and proportion of these two components vary in different kinds of connective tissues.
- Almost all connective tissues are highly vascular in nature
- In all connective tissues, except blood, the cells secrete fibres of structural proteins called **collagen** or **elastin**.


CONNECTIVE TISSUE
Connective tissue proper
Fluid connective tissue
Skeletal connective tissue
1. Areolar
2. Adipose
3. White fibrous
4. Yellow elastic
5. Reticular.
1. Blood
1. Cartilage
2. Bone

CONNECTIVE TISSUE



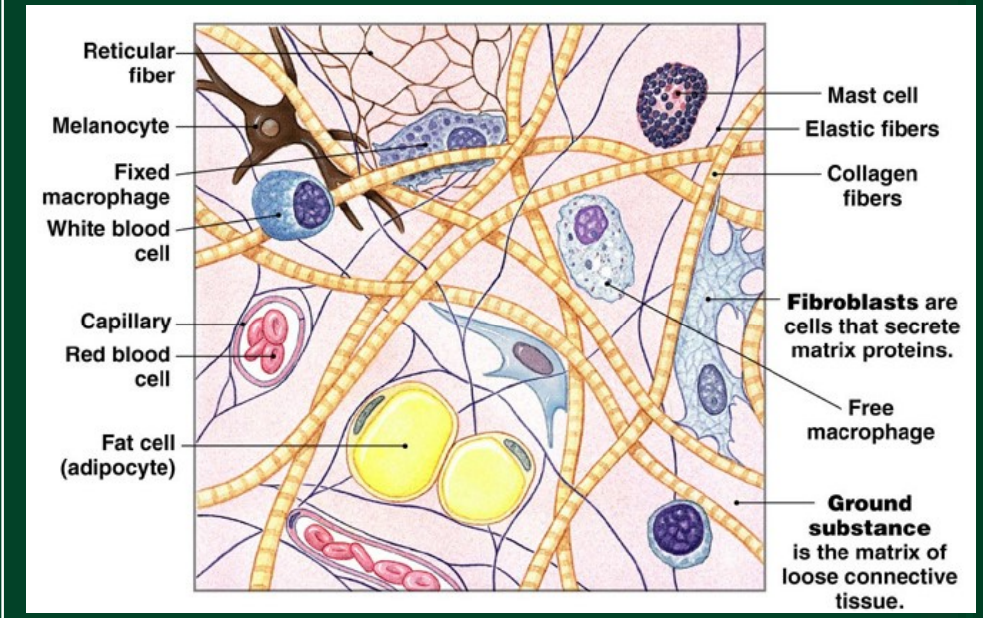
Connective tissue proper → Areolar connective tissue

Origin:

- It is found below the skin, muscles and bones.

Functions:

- The areolar tissue, also called loose connective tissue, is essentially connective in function.
- It fixes the skin with the muscles, attaches the blood vessels and nerves with the surrounding tissues, fastens the peritoneum to the body wall and viscera and keeps the muscle fibres together.



Connective tissue proper → Areolar connective tissue

Structure: The transparent jelly-like, sticky matrix contains numerous **fibres** and **cells** and abundant mucin.

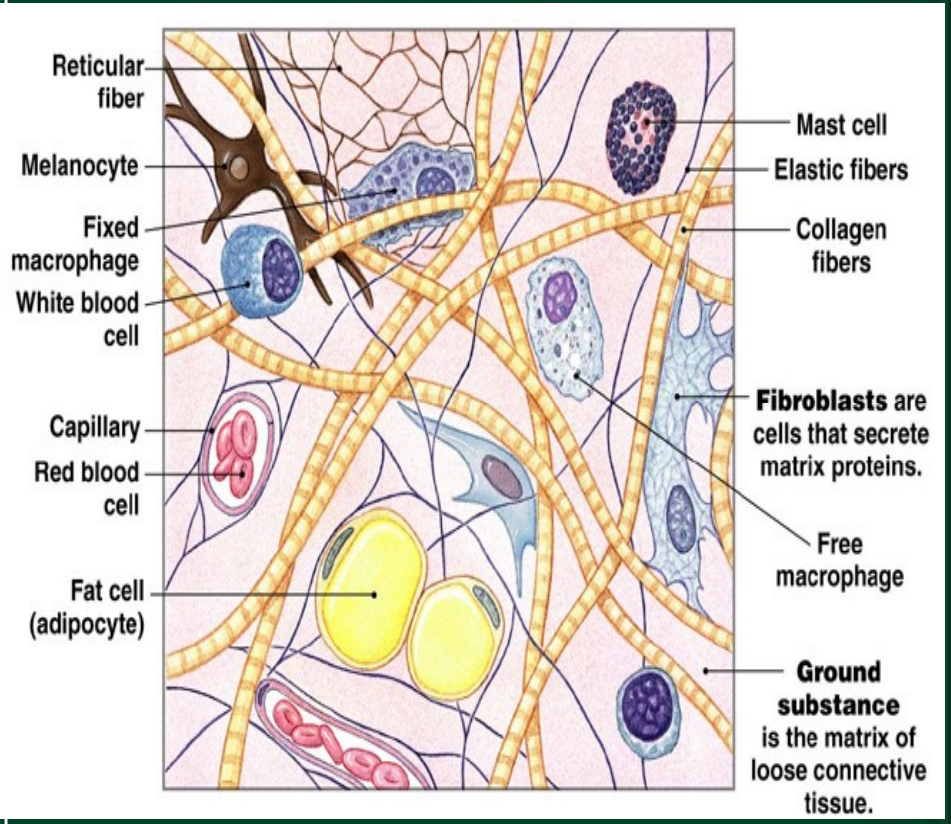
Fibres**:** The fibres are white and yellow.

White fibres:

- unbranched, wavy and arranged in bundles.
- also called **collagen fibres** as they contain proteinous substance called **collagen**
- These collagen fibres give ***tensile strength*** to the tissue. Collagen fibres are formed at the site of injury for tissue repair (healing).

Yellow fibres:

- **T**hin, slender and singly arranged.
- These are flexible, elastic and branched, the branches joining with one another to form an irregular but large network.
- They possess ***elastic property*** due to the presence of a protein called elastin.



Connective tissue proper → Areolar connective tissue

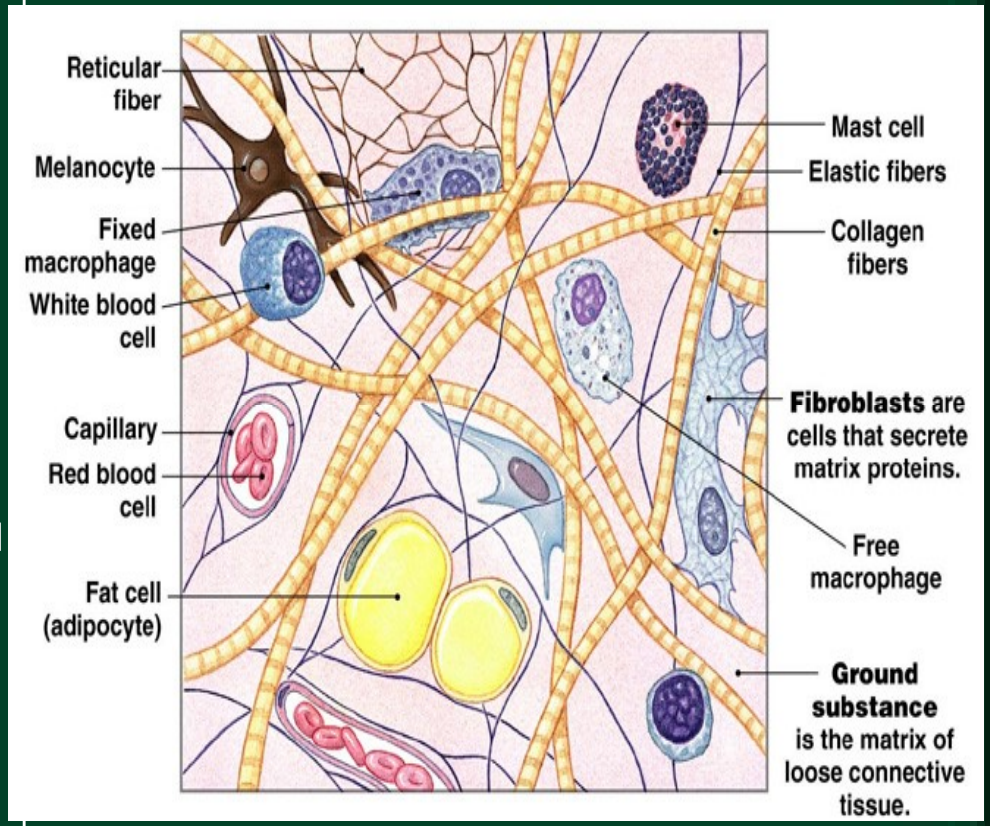
Cells: The cells in the matrix are of 4 main kinds: Fibroblasts, macrophages, mast cells and adipocytes

Fibroblasts:

- Main cells of the areolar tissue. They are large, flat and star-shaped cells with long and branched processes.
- They ***secrete the matrix*** and the material of which the fibres are formed (both white and yellow fibres).
- Fibroblasts migrate to the site of injury and **secrete more fibres to seal off the wound.**

Macrophages or Histiocytes:

- The macrophages are almost as numerous as the fibroblasts.
- They are large, long-lived and irregular cells.
- They engulf the microbes, foreign particles and damaged cells.
- Hence, they are **phagocytic in action**.



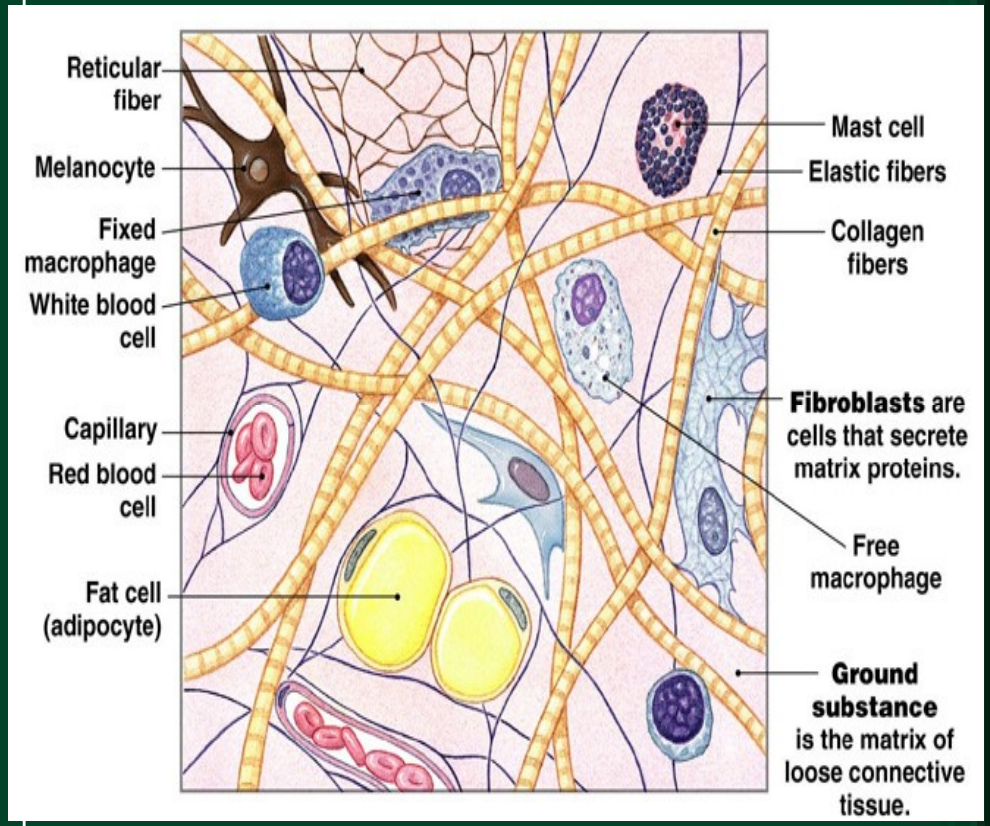
Connective tissue proper → Areolar connective tissue

Mast Cells:

- The mast cells are also called **mastocytes** and they are small oval cells in mammals.
- They produce **heparin and histamine**.
- Heparin ***prevents blood clotting*** in the uninjured vessels.
- Histamine is useful in ***dilating blood vessels***, an inflammatory response to injury or infection. Histamine is also involved in allergic reactions. Its release from the mast cells helps in body defence by attracting the phagocytes to the site of injury.

Adipocytes:

- These are useful in ***storage of fats***.



Connective tissue proper → Adipose connective tissue

Origin:

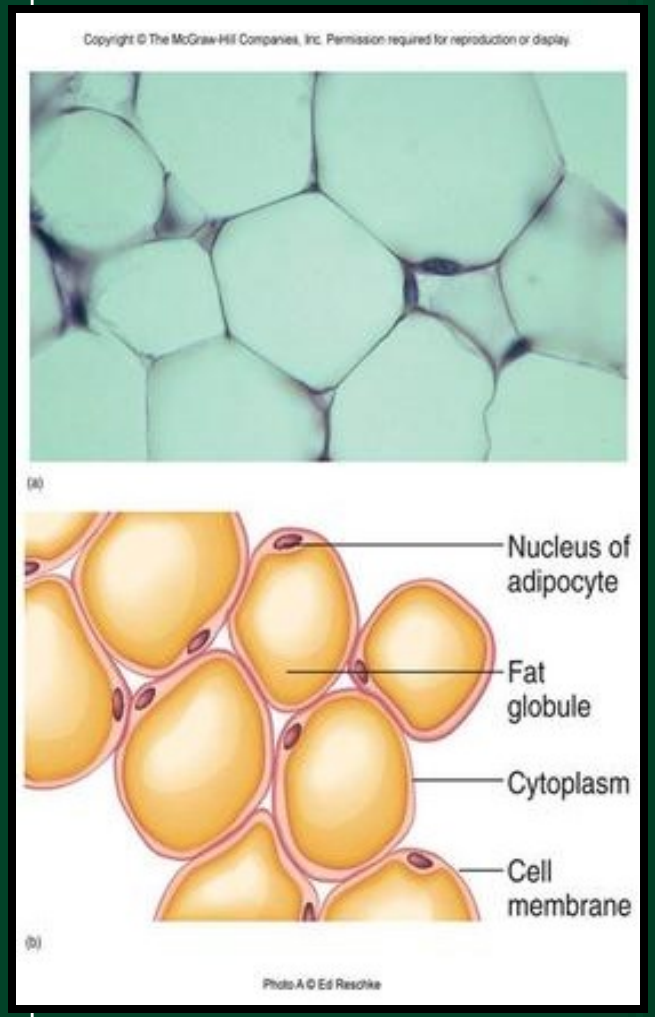
- The adipose tissue is found in the **subcutaneous** tissue (under the skin), in the covering of the heart and around the blood vessels and kidneys.
- It also forms the **yellow bone marrow**.

Functions:

- Adipose tissue is primarily a **food reserve**.
- The subcutaneous fat prevents heat loss from the body, particularly in polar animals and also rounds off the body contour (shape).
- It forms a shock absorbing cushion around the kidneys and the eyeballs.
- It also produces the blood corpuscles.

Structure:

- Adipose tissue is found in association with the areolar connective tissue.
- It is modified areolar tissue consisting of a large number of **adipocytes** i.e. cells specialised for fat storage. A fat cell first develops in it small fat droplets, which later fuse to form a large fat globule. These globules push the cytoplasm with its organelles to the periphery and the nucleus to one side.



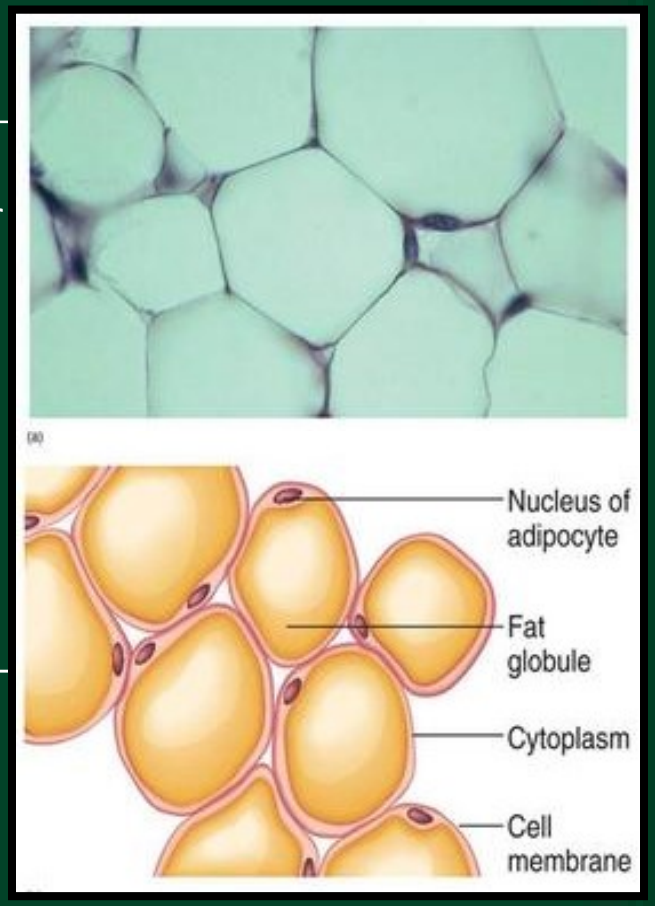
Connective tissue proper → Adipose connective tissue

White Adipose Tissue:

- These appear opaque due to the presence of a large number of adipocytes.
- It is commonly seen in adults.

Brown Adipose Tissue:

- These are reddish brown in colour due to the large number of blood vessels.
- It is mostly found in developing foetus and infants.



Connective tissue proper → White fibrous tissue

White Fibrous Tissue:

- The white fibrous tissue is especially rich in white collagen fibres.
- These are similar to but thicker than those found in the areolar tissue.
- This tissue is very tough and ***inelastic***. It appears as cords or sheets.
- As **cords**, the white fibres run parallel to form cords called **tendons.**

Tendons connect the skeletal muscles with the bones.

Tendons:

- They are specialized extensions or prolongations of muscles.
- They are formed of bundles of collagen fibres (white fibres).
- At one end, they are formed from the core of the muscles and the other end is attached to a bone.
- Some of the tendons are – **Achilles tendon, hamstring tendon.**
- They play an important role in various movements.

As **sheets,** it occurs in the pericardium of the heart, dura mater of the brain and spinal cord, capsule of the kidney, etc.

Connective tissue proper → Yellow elastic tissue

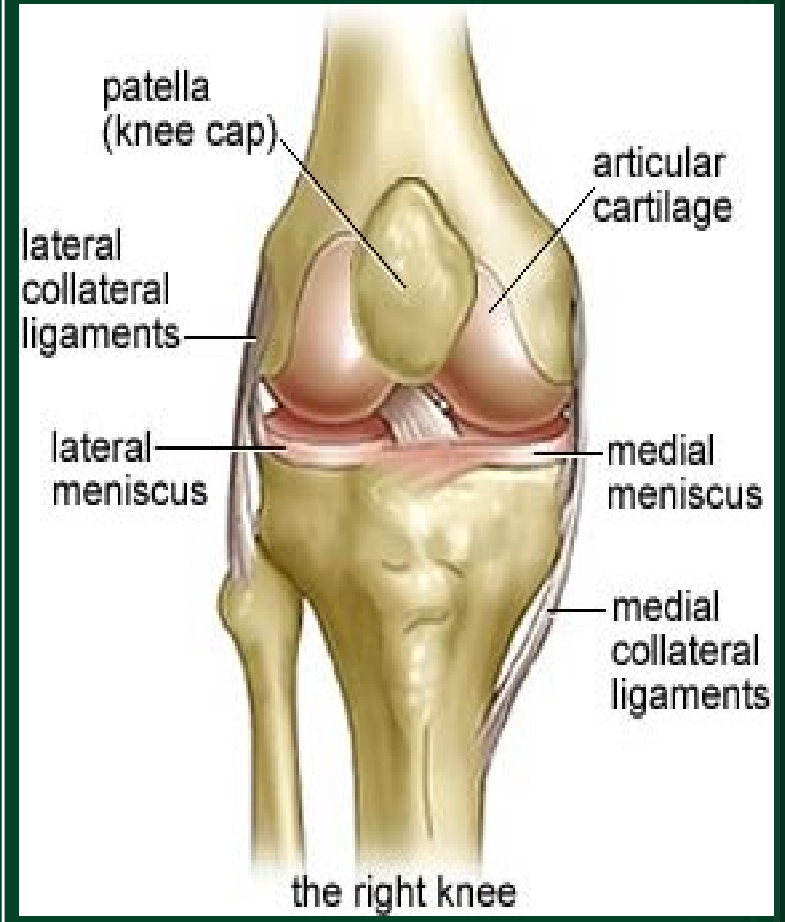
Yellow Elastic Tissue:

- The yellow elastic tissue consists mainly of a loose network of yellow elastic fibres.
- These elastic fibres are much thicker but similar to those of areolar tissue.
- This tissue combines strength with great flexibility. It also has 2 forms: cords and sheets.
- The **cords** formed by this tissue are called **ligaments.** ***Ligaments serve to bind the bones together.***

Ligaments:

- They are formed of bundles of yellow fibres
- They bind two different bones at the joints.
- They play a very important role in preventing dislocation of bones and at the same time providing flexibility to joints.

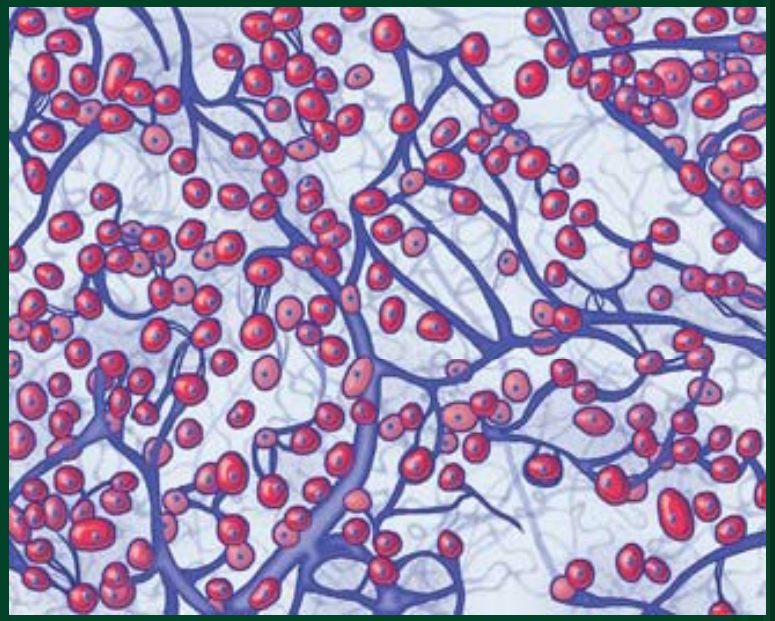
- As **sheets** formed by this tissue, they occur in the walls of the blood vessels, lungs and bronchioles.
- **Recovery of these organs after expansion** is due to this tissue's presence.



Connective tissue proper → Reticular Connective tissue

RETICULAR TISSUE :

- The reticular tissue consists of star-shaped **reticular cells**, the protoplasmic processes of which join to form a cellular network.
- **Reticular fibres** are superimposed on the reticular cells. They are composed of a protein called **reticulin**.
- They are branched and inelastic.
- This tissue forms the supporting framework of lymph glands, spleen and bone marrow.
- The reticular cells are ***phagocytic*** and form **defence mechanism of the body.**

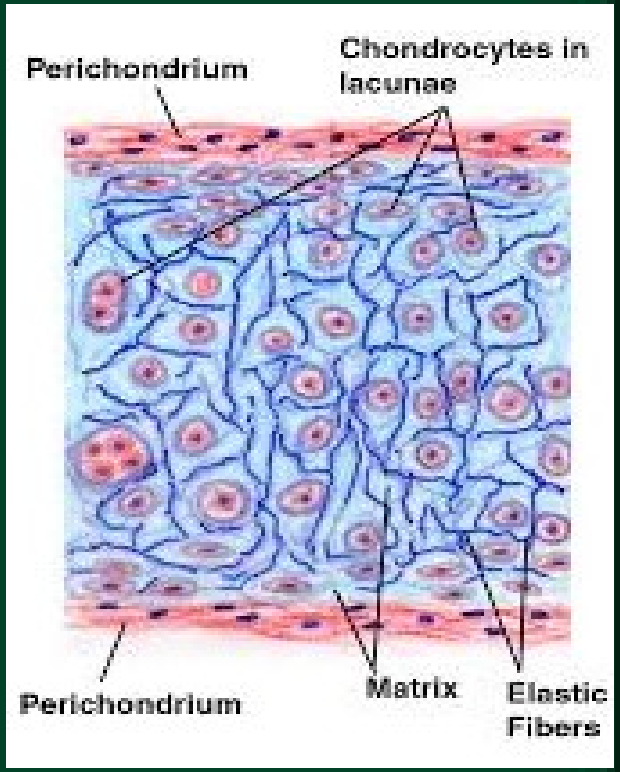


Skeletal Tissue → Cartilage

The cartilage is a solid, semi-rigid connective tissue. It is tough, flexible tissue which forms the endoskeleton in large number of vertebrates.

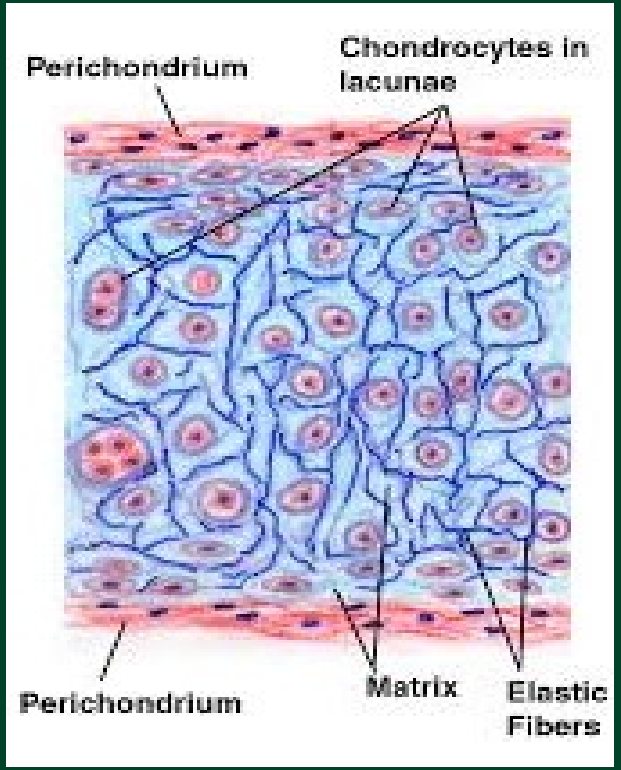
Structure:

- The cartilage is enclosed in a sheath of white fibrous tissue called **perichondrium.** It consists of blood vessels and nerve fibres.
- The perichondrium encloses a semi-solid matrix called **chondrin.**
- Towards the periphery or the inner margin of the perichondrium, a layer of small immature cartilage cells called **chondroblasts** are seen. The matrix is secreted by the chondroblasts.
- A chondroblast lies in a fluid-filled space, the cartilage **lacuna**, in the matrix.
- During growth of the cartilage, the chondroblasts divide and the cells formed by division keep lying in groups of two or more in the same lacuna



Skeletal Tissue → Cartilage

- . In the matrix near the perichondrium, the chondroblasts are small and young and they lie close together. Later, they become large, rounded, and mature and occur in groups. Here, they are called **chondrocytes.**
- These chondrocytes are enclosed within lacunae and are seen scattered in the matrix.
- Each lacuna contains 2 to 8 chondrocytes.
- The exchange of materials (nutrients) between the chondrocytes and the matrix takes place with **simple diffusion** from blood vessels present in the perichondrium.



Depending on the nature of the matrix, cartilage is classified as:

1. Hyaline Cartilage
2. Fibrous Cartilage
3. Elastic Cartilage
4. Calcified Cartilage

Skeletal Tissue → Cartilage → Hyaline cartilage

Hyaline Cartilage:

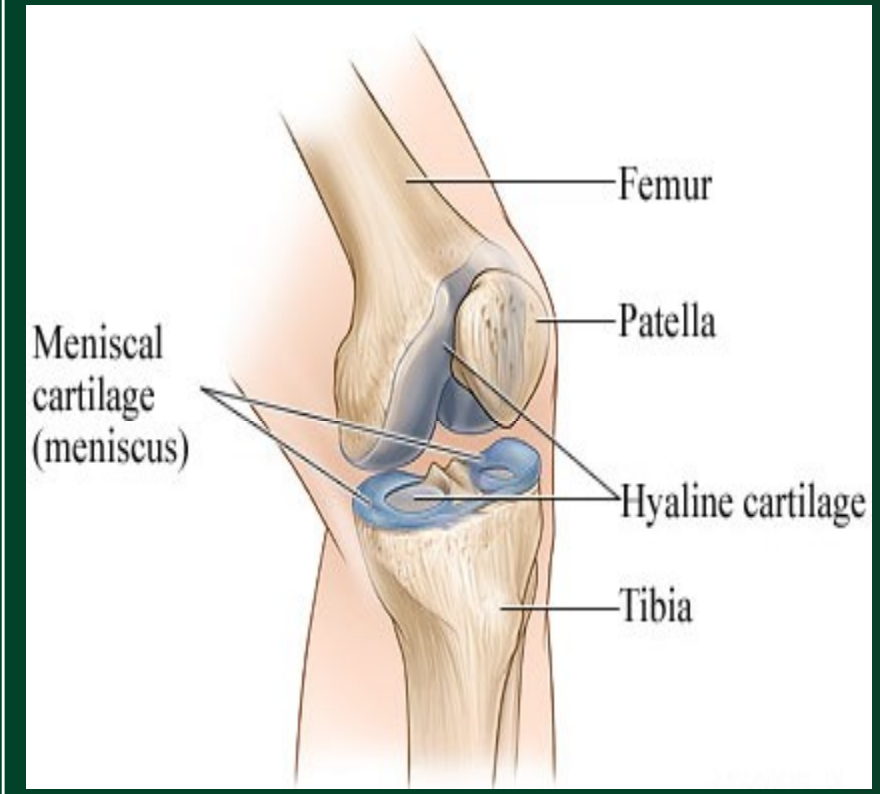
It is the weakest of the four types or cartilages.

Origin: It is found at the ends of long bones, anterior ends of ribs, nose tip, larynx, and bronchial tree, foetal and embryonic skeleton.

Structure: It is compressible and elastic in nature. It is surrounded by perichondrium. The matrix, i.e. chondrin, is bluish-white and gel-like (transparent). It contains very fine collagen fibres and chondrocytes (2 to 8 in each lacuna).

Functions:

- It provides flexibility and supports the body.
- It helps in reducing friction.
- It also acts as a good shock absorber.



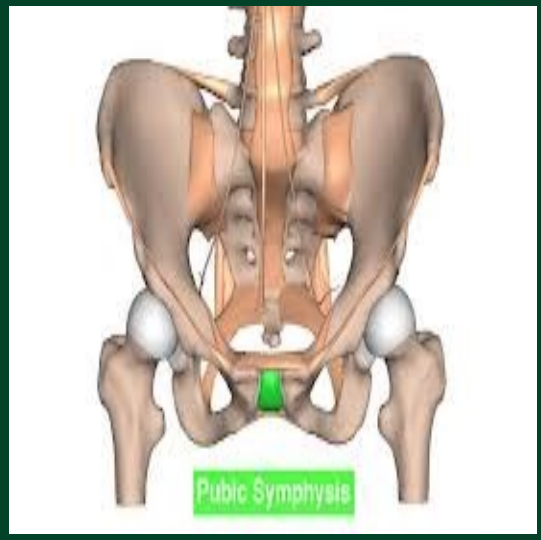
Skeletal Tissue → Cartilage → Fibrous cartilage

Fibrous Cartilage:
It is the strongest and the most rigid cartilage in the body.

Origin: It is found in the pubic symphysis, intervertebral discs, etc.

Structure: It is not surrounded by the perichondrium. It has little matrix and abundant white collagen fibres. This combines the flexibility of the cartilage with the firmness of the white fibres.

Functions:
- It acts as a cushion in the intervertebral discs.
- In the pubic symphysis
- It helps to support and aids fusion of different organs of the body.



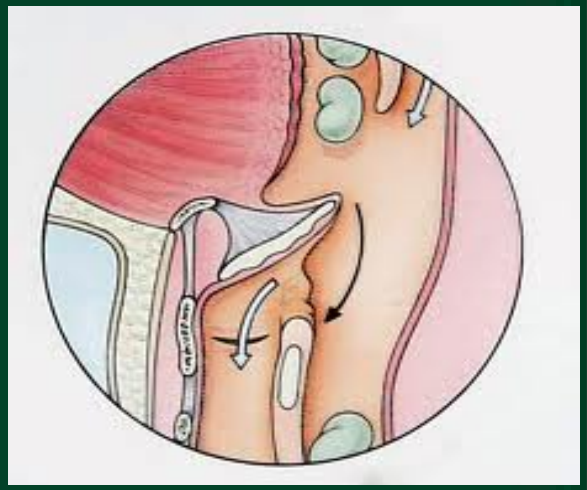
Skeletal Tissue → Cartilage → Elastic Cartilage

Elastic Cartilage:

Origin:
It is found in the epiglottis (lid on top of the larynx), external ear (auricle), trachea etc.

Structure:
It is surrounded by perichondrium. The matrix (chondrin) contains a thread-like network of elastic fibres.. It has abundant network of yellow fibres in addition to white fibres. Chondrocytes are few in number and are seen encircled with elastic fibres. It is opaque and yellowish in appearance. It readily recovers its shape after distortion.

Functions:
It gives support and maintains shape of the body.



Skeletal Tissue → Cartilage → Elastic Cartilage

Calcified Cartilage:

- It is formed due to deposition of various salts in the matrix.
- Due to this deposition, the cartilage becomes very hard and inelastic and loses it flexibility.
- This condition is found in old age where the joints lose their mobility.
- It is also found in the suprascapula of the frog and the vertebrae of sharks.

Hyaline Cartilage	Fibrous Cartilage	Elastic Cartilage
1) It is bluish green, translucent in appearance.	1) It is whitish, opaque in appearance.	1) Is yellowish, opaque in appearance.
1) Has fewer, very thin white fibres in the matrix.	2) Has an abundant white fibres in the matrix.	2) Has an abundant yellow fibres in the matrix.
2) It is flexible.	3) It is firm.	3) It is very flexible.
3) Perichondrium is present.	4) Perichondrium is absent.	3) Perichondrium is present.
3) Occurs in sternal ribs, tracheal and bronchial rings, laryngeal wall and nasal septum.	4) Occurs in intervertebral discs and pubic symphysis.	4) Occurs in pinna, external auditory meatus, nose tip and epiglottis.

Skeletal Tissue → Bone

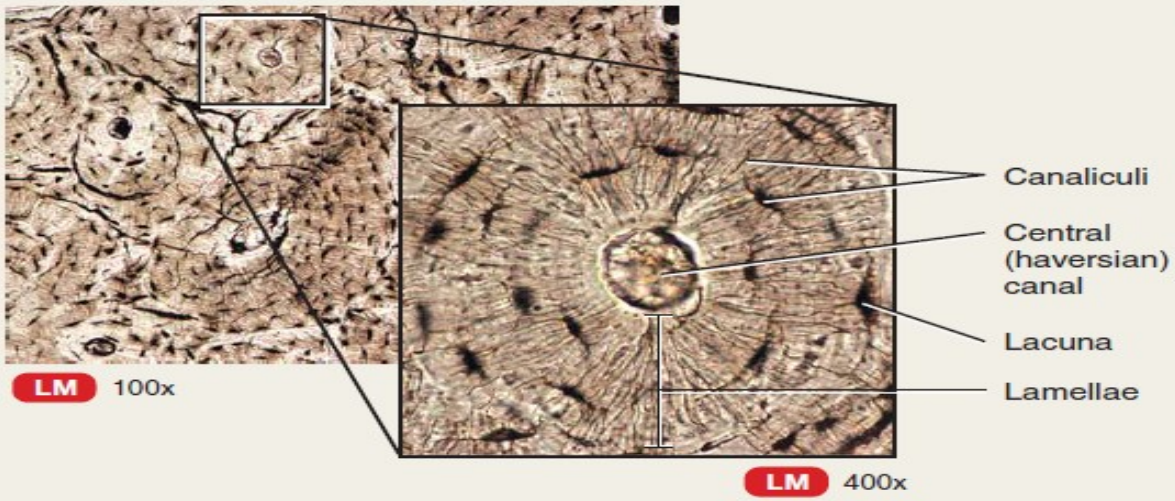
BONE :

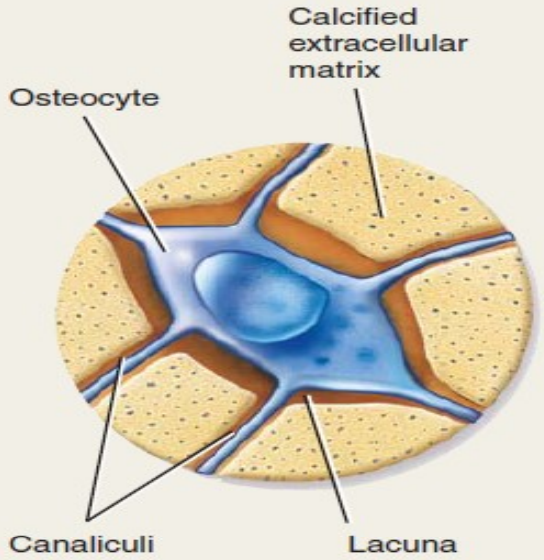
Bone is the hardest tissue in the body.

Bone is the main constituent of the skeleton. Bone shows the presence of hard, solid, calcified matrix called **ossein**.

The hardness is due to deposition of inorganic mineral salt called **hydroxyl-apatite** [$Ca_{10}(PO_4)_6(OH)_2$].

Skeletal Tissue → Bone



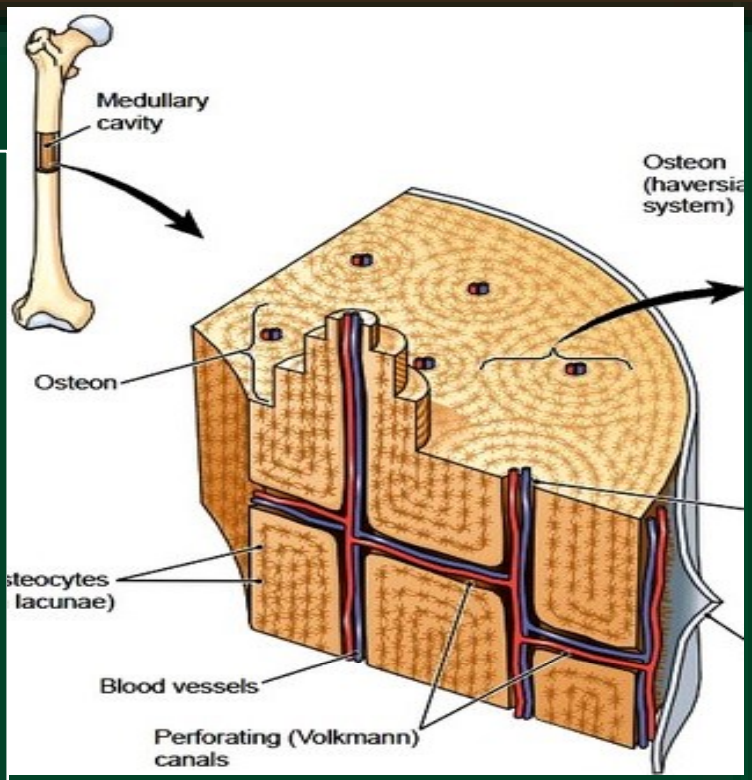


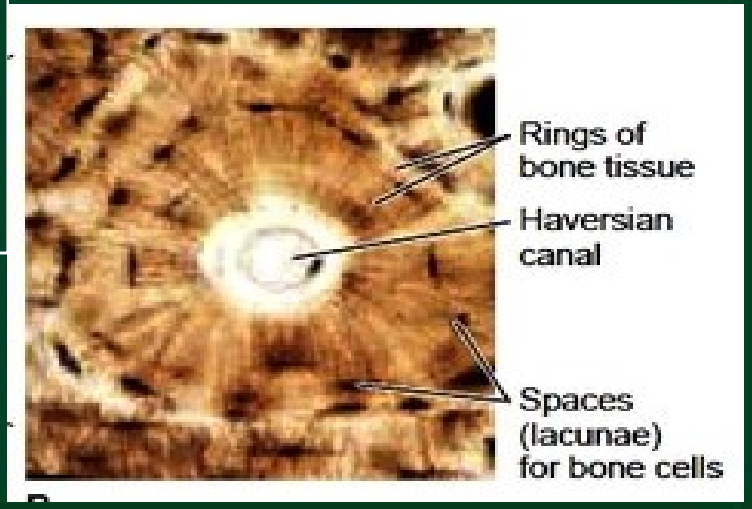
Structure:

- Bone is enclosed in a thin layer of white fibrous connective tissue (i.e. collagen fibre) called **periosteum.**
- Blood vessels and nerves pierce through the periosteum. The periosteum is internally lined by **endosteum** which surrounds the marrow cavity.
- The matrix is arranged in concentric circles called **lamellae**.
- These lamellae contain a large number of living cells called **osteoblasts or osteocytes** which are present in a fluid filled cavity called **lacuna**.
- Osteoblasts are *active* bone cells and osteocytes are *inactive* bone cells. Each lacuna has fine cytoplasmic extensions called **canaliculli** which pass through the lamellae and makes connection with the adjacent lacunae

Skeletal Tissue → Bone

- The **structural unit of bone** is the **Haversian system** or **osteon.**
- Presence of a Haversian system is the characteristic of a mammalian bone.
- Haversian system shows a **Haversian canal** in the centre.
- Haversian canal consists of blood vessels of arteries and veins, lymph vessels and nerves as well.
- Lacunae containing osteoblasts or osteocytes are arranged in concentric circles around the Haversian canal.
- The two adjacent Haversian systems are interconnected by transverse channels, the **Volkmann's canal.**





Skeletal Tissue → Bone

Functions:

- It is the supporting and protective tissue of vertebrates which protects the internal soft and delicate tissues.
- Besides providing support, bones have a metabolic and protective role too.
- It forms the base for attachment of muscles.
- In long bones, the yellow marrow cavity helps in storage of reserve food material.
- The red marrow cavity in the long bones is useful in haemopioesis

Skeletal Tissue → Bone

Spongy bone:

Origin:
It is seen in the expanded ends (epiphyseal region) of long bones.

Structure:
The matrix or ossein is web-like containing columns of bones called trabeculae with many small spaces between them. These spaces contain a soft tissue called **red bone marrow** which is responsible for heamopiosis. It *lacks the Haversian system.*

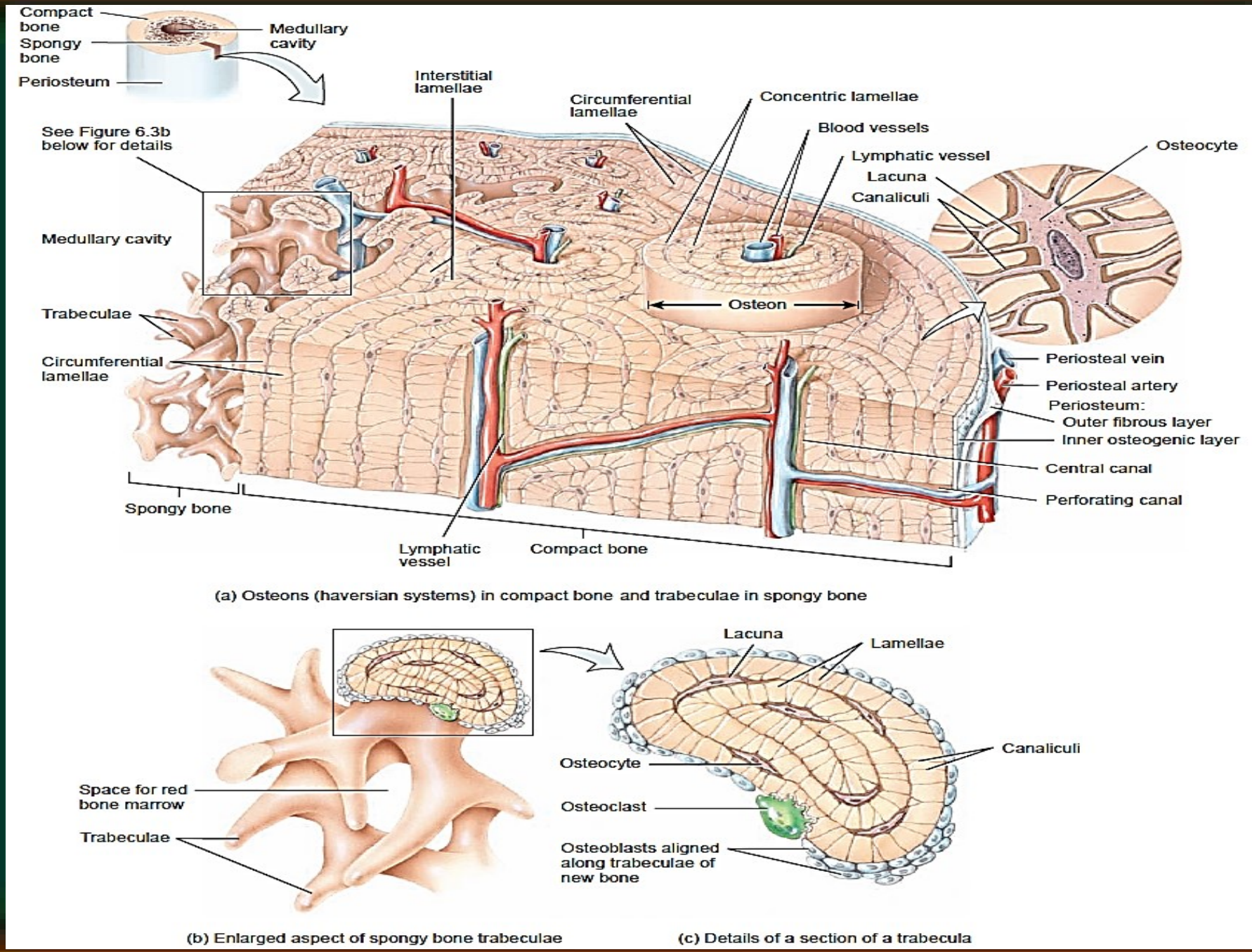
Functions:
The spongy bones provide considerable strength with minimum of weight.

Compact bone:

Origin: It is seen in the shaft (diaphysis) of long bones.

Structure: The matrix is hard, solid, and dense and without spaces in-between. It is filled with a fatty tissue called the **yellow marrow** which stores fat cells. It *has many Haversian systems.*

Functions: The compact bone stores fat and produces blood corpuscles in emergencies.


Compact bone
Spongy bone
Periosteum
Medullary cavity
Interstitial lamellae
Circumferential lamellae
Concentric lamellae
Blood vessels
Lymphatic vessel
Lacuna
Canaliculi
Osteocyte
See Figure 6.3b below for details
Medullary cavity
Trabeculae
Circumferential lamellae
Osteon
Periosteal vein
Periosteal artery
Periosteum:
Outer fibrous layer
Inner osteogenic layer
Central canal
Perforating canal
Spongy bone
Lymphatic vessel
Compact bone
(a) Osteons (haversian systems) in compact bone and trabeculae in spongy bone
Lacuna
Lamellae
Canaliculi
Osteocyte
Space for red bone marrow
Osteoclast
Trabeculae
Osteoblasts aligned along trabeculae of new bone
(b) Enlarged aspect of spongy bone trabeculae
(c) Details of a section of a trabecula

MUSCULAR TISSUE

Origin:

The muscle tissue arises from the embryonic **mesoderm**. It makes up about 40% of a mammals body weight.

General Structure:

- Muscular **tissue** is made up of thin, elongated, contractile **muscle fibres**; hence it is also called *contractile tissue*.
- The fibres have the ability to contract due to the presence of protein filaments of **myosin** and **actin**. Hence, they play an important role in locomotion and movement.
- Muscle fibres are thin, elongated cells with one or many nuclei.
- The plasma membrane or the outer covering of a muscle fibre is called **sarcolemma**.
- The cytoplasm of a muscle fibre is called **sarcoplasm**. The sarcoplasm is largely occupied by longitudinal, parallel protein threads, called **myofibrils**, arranged along the axis of the fibre. These protein threads contain **myosin** and **actin**.
- The muscular tissue is innervated (supplied) with **nerve fibres**. They are vascular and are supplied with **blood vessels** which carry nutrients and take away the metabolic waste.

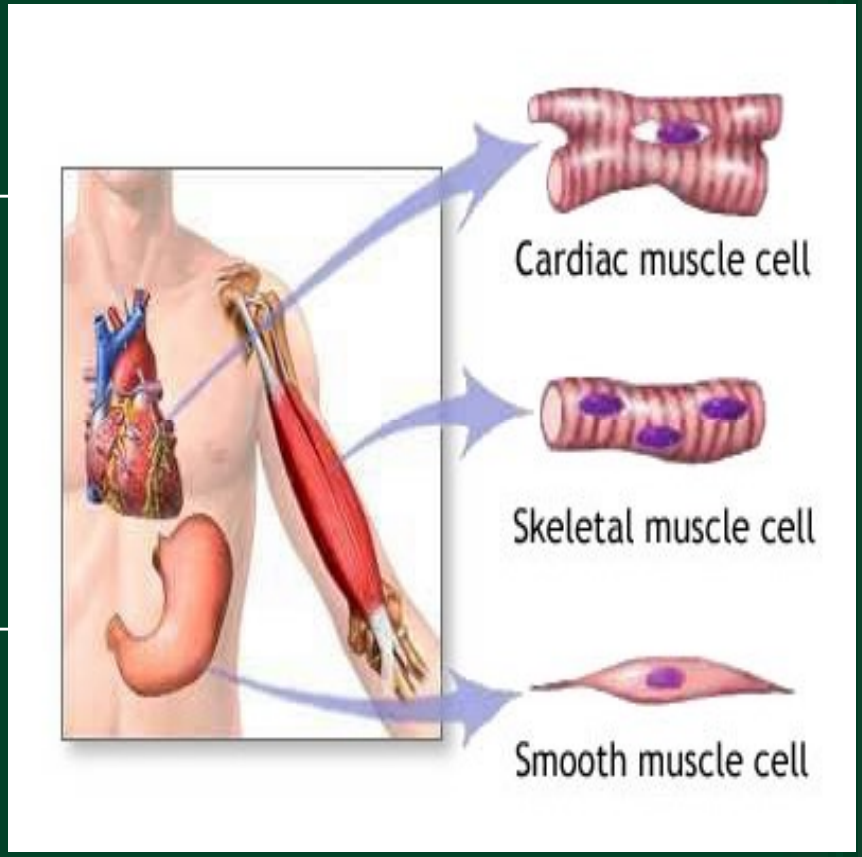
Functions:

- It brings about movements of the body parts and **locomotion** of the organism.
- Many muscles **support bones** and other structures.
- **Facial** expressions and gestures also depend on muscles.
- Muscles are responsible for the **heartbeat**, for the **flow of blood** through the vessels, for the **passage of food** through the alimentary canal, for the **flow of air** through the respiratory tract, for the production of **sound**, and for the release of **secretions** and **waste products** through the ducts.
- Muscles are required for taking food, **passing urine and faeces**, **mating**, **delivering** a baby, **feeding** a young one, maintenance of **equilibrium** and a favourable resting **posture**.

Types of Muscle Tissues:

Based on their structure, location and function, the muscles tissue is categorized into three types:

1. Striated or striped muscles
2. Non-striated or unstriped or smooth muscles
3. Cardiac muscles



Muscular Tissue → Striated Muscle

Location:

- These are seen attached to bones in the *head, trunk and limb* region and so they are also called **skeletal muscles**.

Structure:

- presence of cross striations in the form of **light and dark bands**.
- large number of peripherally placed nuclei.
- **fibres** are placed parallel to one another and are connected together by means of connective tissue to form small muscle **bundles**.
- Muscle fibres contain a large number of **myofibrils** within the **sarcoplasm** covered with a thick membranous sheath called **sarcolemma.**
- These myofibrils are marked by the presence of distinct cross-striations in the form of *alternately arranged light and dark bands*. Hence they are called striated muscle fibres
- The *light band* is also called the **"I-band" or Isotropic band**. They allow the light to pass through them and so appear light.
- A narrow dark line is seen in the light band and is called **"Z-line" or Krause's membrane**.
- The dark band or **"A-band" or Anisotropic band** does not allow light to pass through and so it appears dark. The dark band is interrupted with narrow light line called **"H-Line" or Hensen's line**.
- The portion between two "Z-lines" is called **sarcomere.**

Muscular Tissue → Striated Muscle

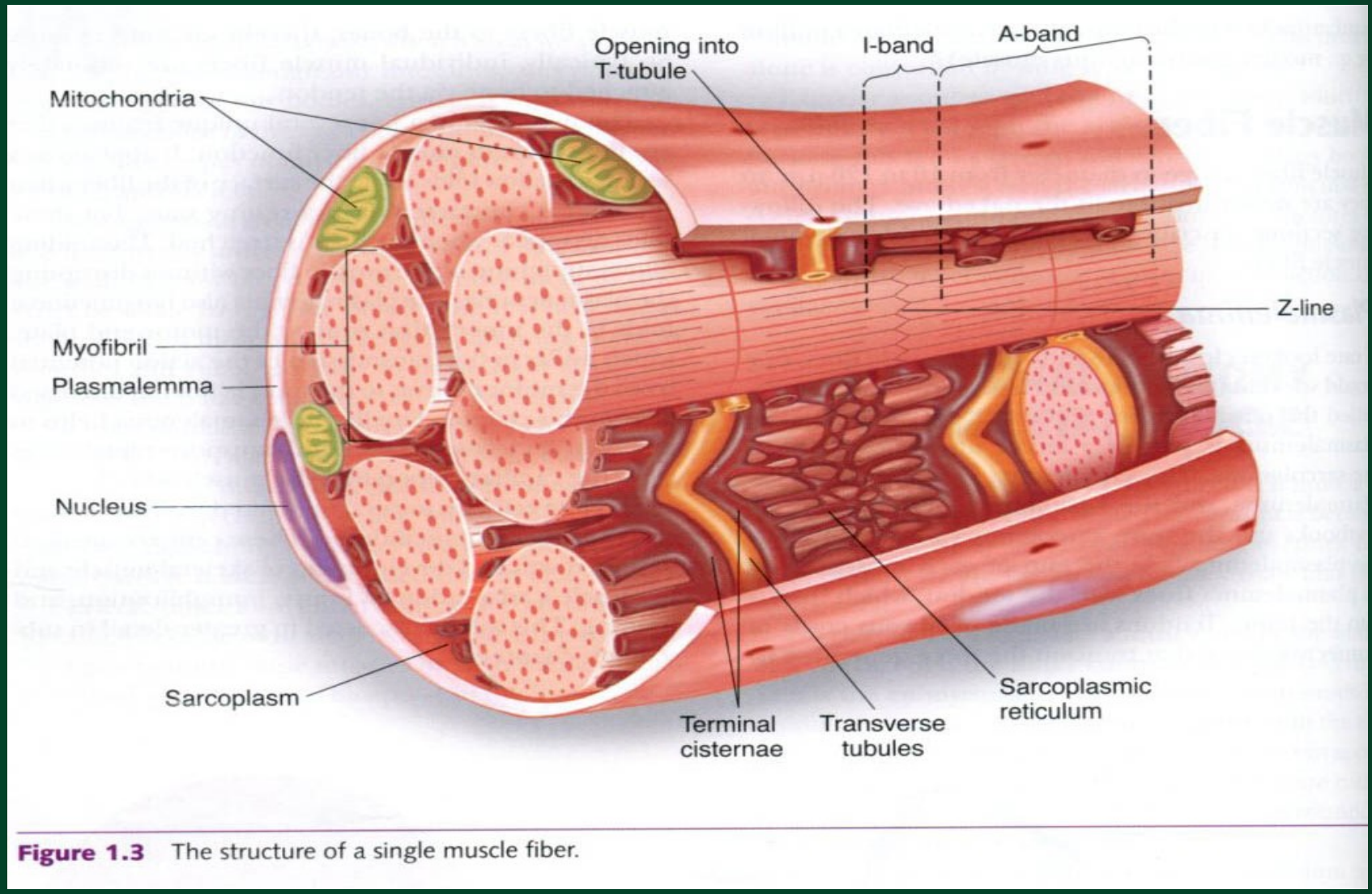
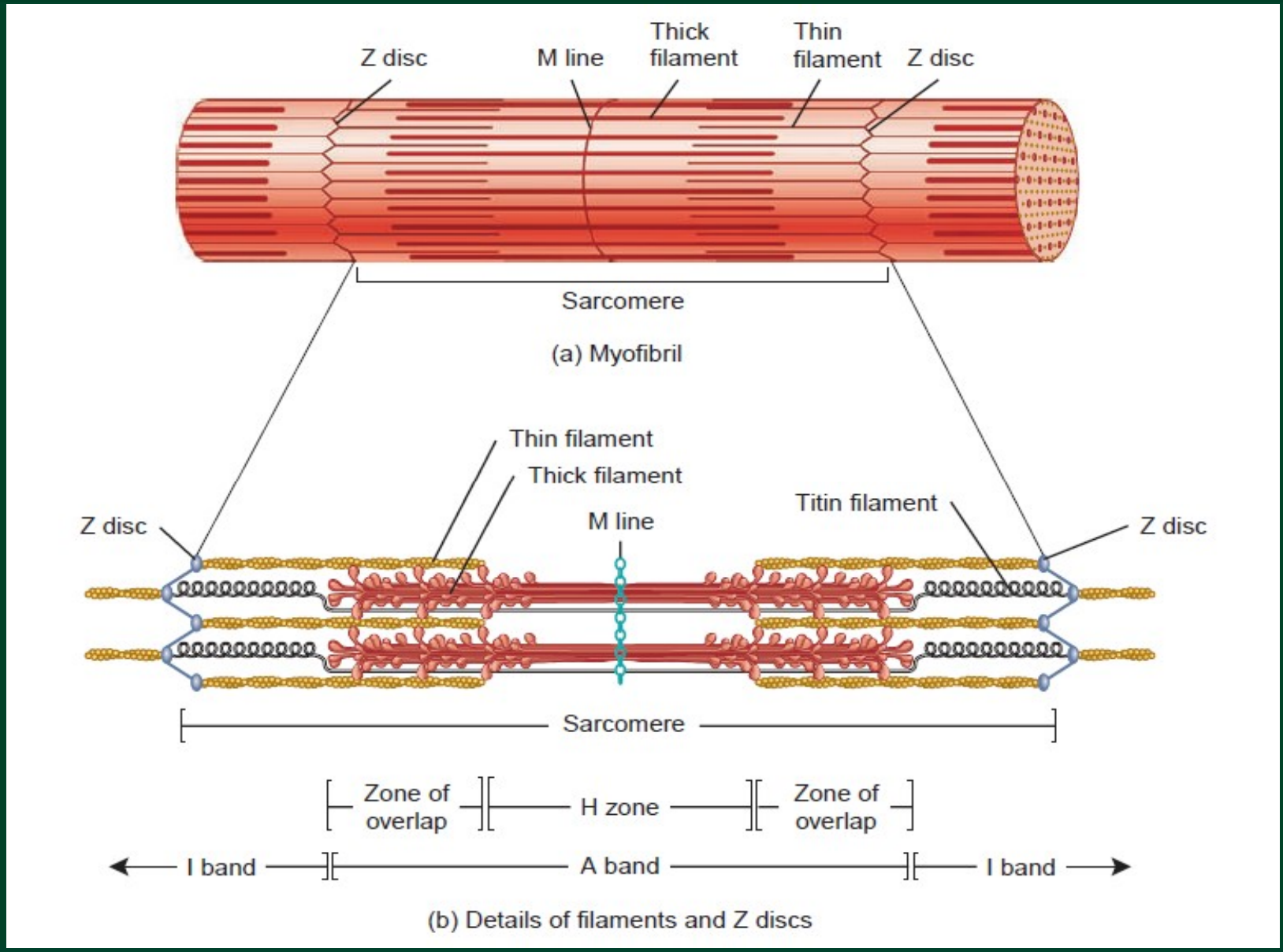


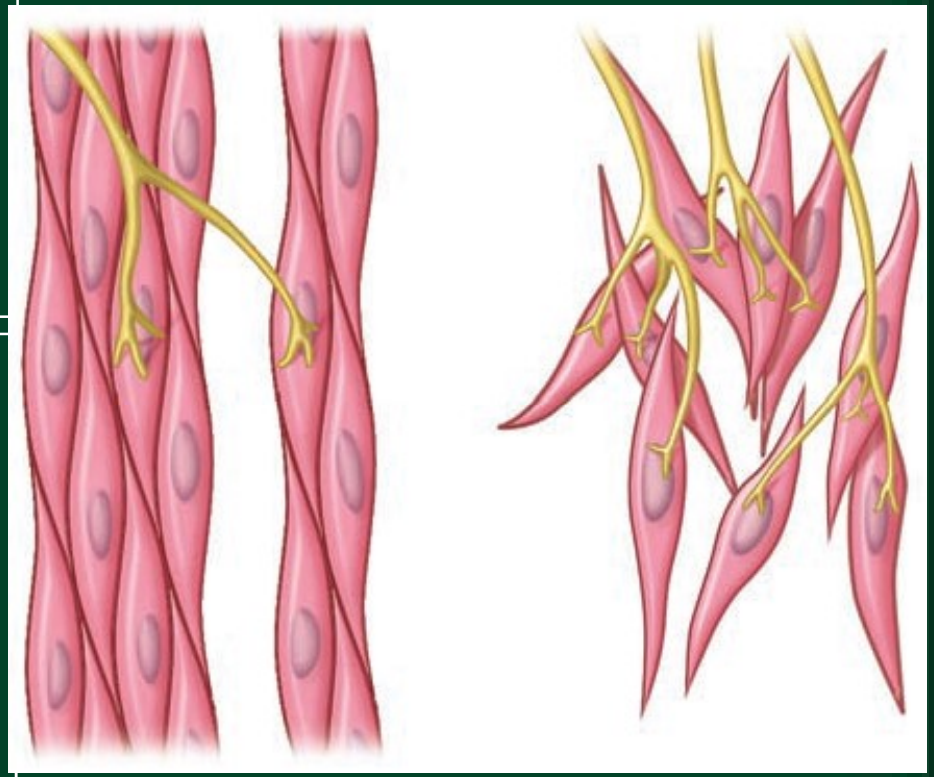
Figure 1.3 The structure of a single muscle fiber.


Z disc
M line
Thick filament
Thin filament
Z disc
Sarcomere
(a) Myofibril
Thin filament
Thick filament
Titin filament
Z disc
M line
Z disc
Sarcomere
Zone of overlap
H zone
Zone of overlap
I band
A band
I band
(b) Details of filaments and Z discs

Muscular Tissue → Smooth Muscle

Origin:

- These are seen in the walls of all visceral organs like stomach, intestine, reproductive and urinary systems etc.
- Therefore, they are also called **visceral muscles**. They are **involuntary** in nature, i.e. their contractions are not controlled by our will



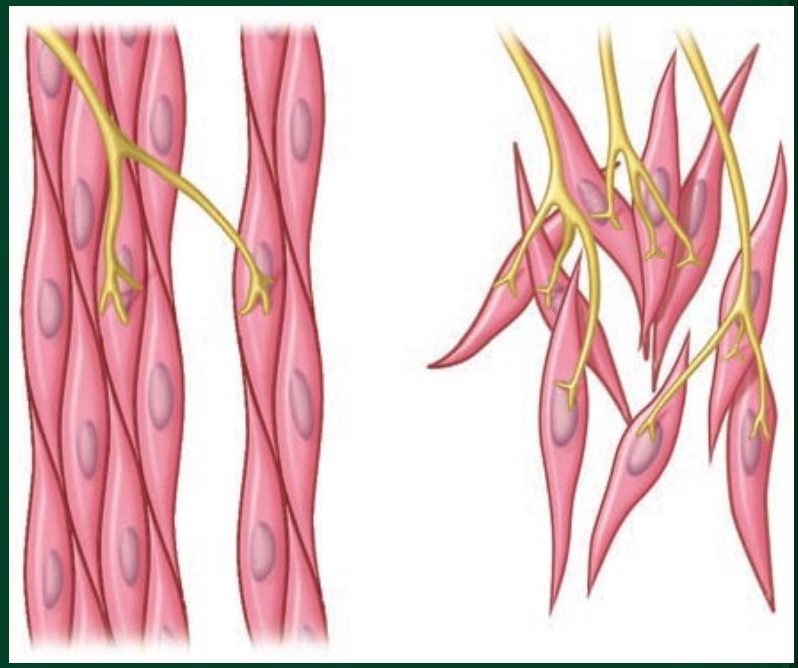
Structure:

- elongated, slender and **spindle** shaped with tapering ends.
- arranged in sheets or layers and are bound by sarcolemma.
- Cross-striations are absent within the sarcoplasm.
- centrally placed, single, large and oval nucleus.
- Each muscle fibre contains many fine contractile myofibrils arranged longitudinally.
- These myofibrils are innervated by the **autonomous nervous system (sympathetic and parasympathetic).**

Muscular Tissue → Smooth Muscle

Functions:

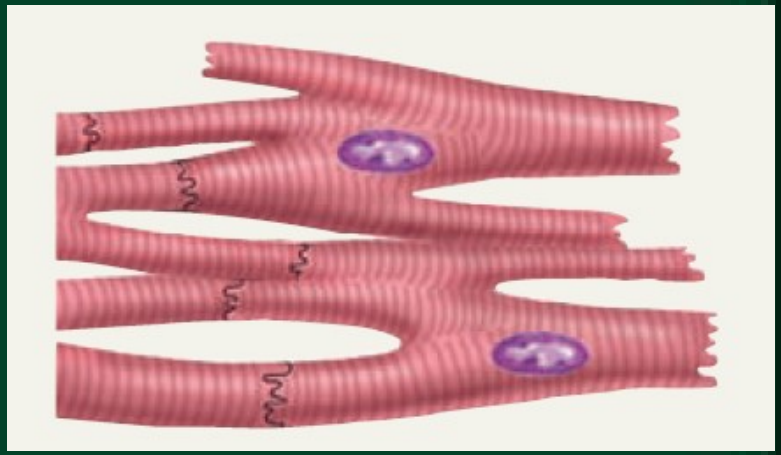
- These muscle fibres are **involuntary** in nature.
- They undergo prolonged but slow contractions and relaxations.
- The frequency and intensity of contractions varies.
- They are responsible for the **peristaltic** movements which help in the passage of food in the digestive tract



Muscular Tissue → Cardiac Muscle

Origin:

- These involuntary muscles are found only in the wall of the heart or in the **myocardium**.
- It also occurs in the pulmonary veins and the superior vena cava.
- The unique ability of the heart is to generate its own wave of excitation that can pass directly from fibre to fibre.



Structure:

- An individual fibre is intermediate between striated and un-striated muscle fibres.
- These are short, branched fibres with ill-defined sarcolemma.
- The fibres are uni-nucleated but as they are joined together by neighbouring cardiac muscle fibres. Thus they appear multi-nucleated.
- The branches of different fibres join to form a network.
- The place where these fibres unite is marked by the presence of special zig-zag junctions called **intercalated discs**. Intercalated discs are the unique feature of cardiac muscles. They are formed by transverse thickenings of the sarcolemma. They show the presence of alternate light and dark bands.
- The contraction of the cardiac muscles is initiated from a particular point in the heart itself which is known as the **pacemaker**. Such a type of a heart is called ***myogenic*** (i.e. of muscular origin).
- Cardiac muscles in some animals are sometimes seen innervated (supplied) with **nerve fibres** which are responsible for triggering the contraction. This type of a heart is known as ***neurogenic*** (i.e. controlled by nervous tissue).

NERVOUS TISSUE

Origin:

The nervous tissue arises from the ***ectoderm*** of the embryo.

Special Properties:

- The cells of the nervous tissue (i.e. neurons) provide the quickest means of communication within the body and help the body to give response to the external stimulus.
- Thus, the cells of the nervous tissue (i.e. neurons) are considered as *impulse* ***generating*** and *impulse* ***conducting*** unit.
- Neurons possess two important basic properties: **excitability and conductivity**.
- **Excitability** is excitation by external stimulus by changing the action potential of their membrane.
- **Conductivity** is to carry a wave of electric impulse from the dendron to axon.

General structure:

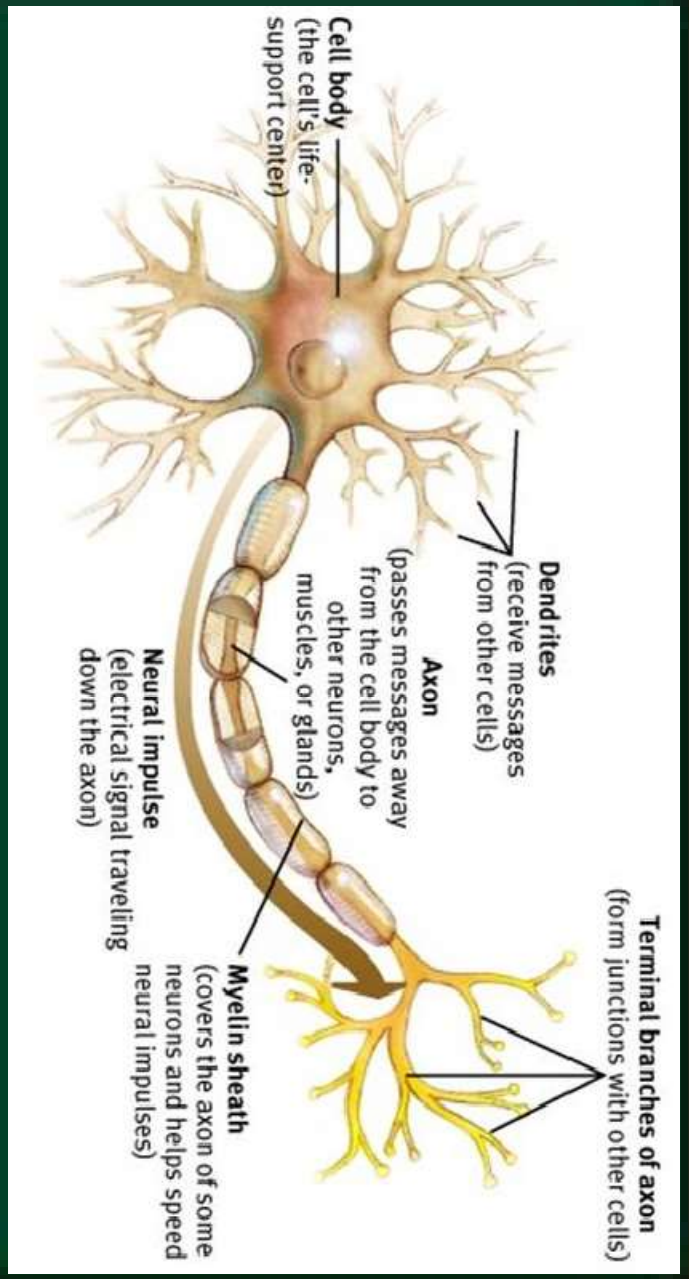
- Nervous system is made up of nervous tissue.
- Nervous tissue is composed of *nerve cells or* ***neurons*** and *supportive cells* called ***neuroglia*** *or glia cells*.

Nervous Tissue → Structure

Neuron is covered by **neurilemma** and is made up of two distinct regions:
cyton and **cytoplasmic extensions**

- **Cyton or cell body** is also called **perikaryon or soma**
- contains granular cytoplasm with large number of network of neurofibrils, various cell organelles like mitochondria, Golgi complex, RER (Rough Endoplasmic Reticulum) and centrally placed nucleus.
- The granules present in cytoplasm are conical, rich in RNA and are involved in *protein synthesis*. These are called **Nissl's granules**

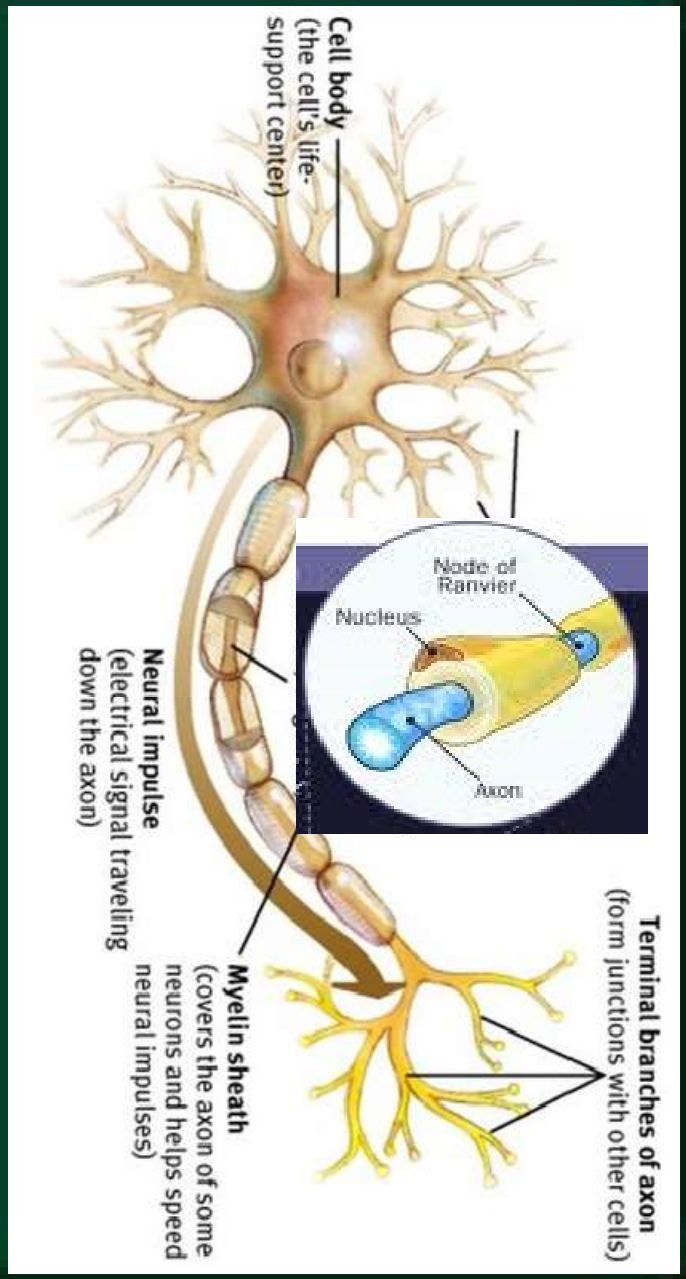
cytoplasmic extensions seen arising from the cyton namely:
dendrons and axon.



Nervous Tissue → Structure

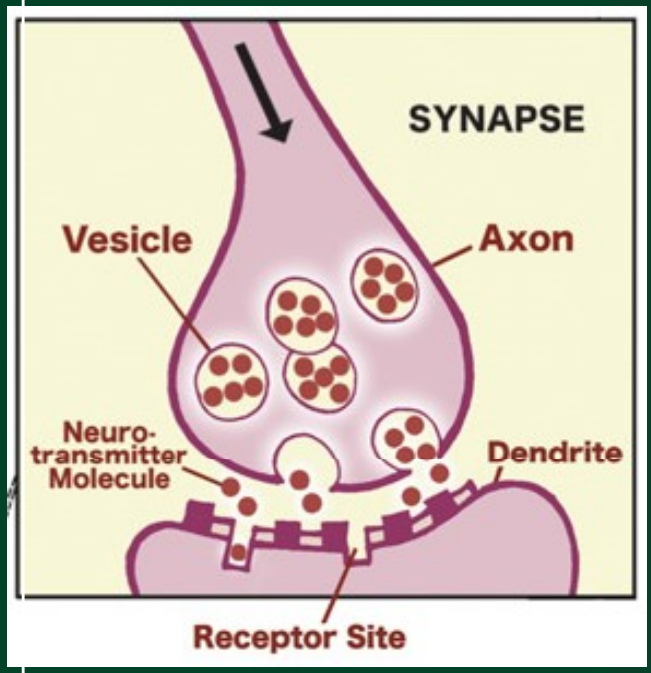
- **Dendrites** are thin, **small** cytoplasmic extensions seen in the periphery of the cyton.
- These are many in number and break into numerous fine branches which help to carry impulse ***towards*** the cell body and are provided with few of the neurofibrils.

- **Axon** is the **single, longest** cytoplasmic process useful in conduction of impulse ***away*** from the cell body. I
- t is lined by axonal membrane and encloses cytoplasm called **axoplasm**.
- It contains large number of mitochondria, RER and neurofibrils but lacks Nissl's granules and Golgi complex.
- The axon, throughout the length is wrapped by **Schwann cells.** The Schwann cells secrete a lipid covering which *forms an* ***insulating myelin sheath***.
- The terminal end of the axon in both myelinated and non-myelinated neurons shows presence of many swollen knob-like structures called **telodendrons**
- They are filled with *neurosecretory material* (***acetylcholine and adrenaline***) which acts as a **neurotransmitter**



Nervous Tissue → Synapse

- Stimuli reach the cyton or cell body through dendrites and the impulses are passed on from cyton towards axons.
- The telodendron of the axon one neuron comes in close functional apposition between dendrites of another neuron.
- This type of *functional contact between* ***axons and dendrites of two different neurons*** *is called a* ***synapse*****.**
- The impulse from one neuron passes to another neuron only through a synapse.
- The space enclosed between the telodendron of the first neuron and the cyton of second neuron forms *synaptonemal complex*.
- In this region the end bulb of the first neuron releases its content i.e. *neurotransmitter*, on excitation.
- The impulse is passed usually in a a “one-way" direction through this complex.

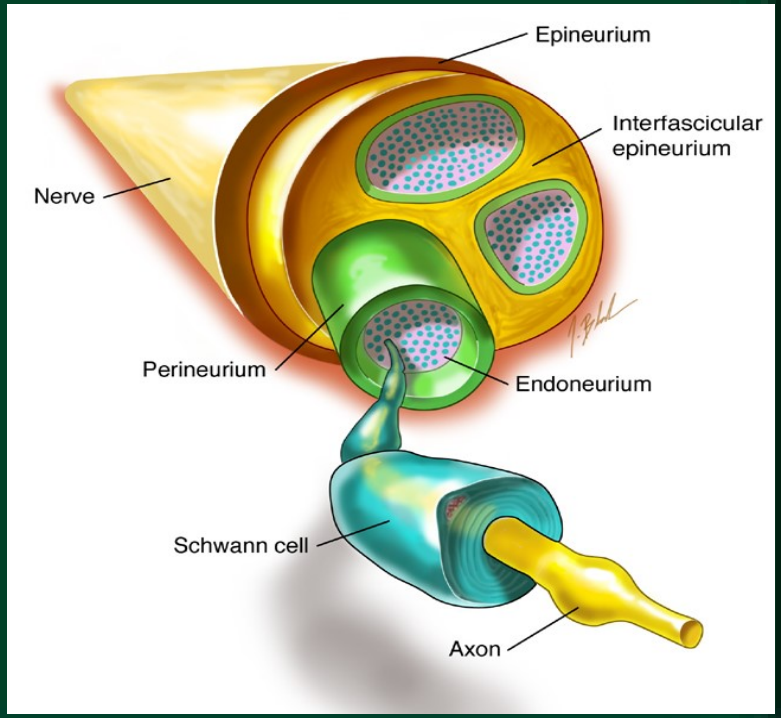


Nervous Tissue

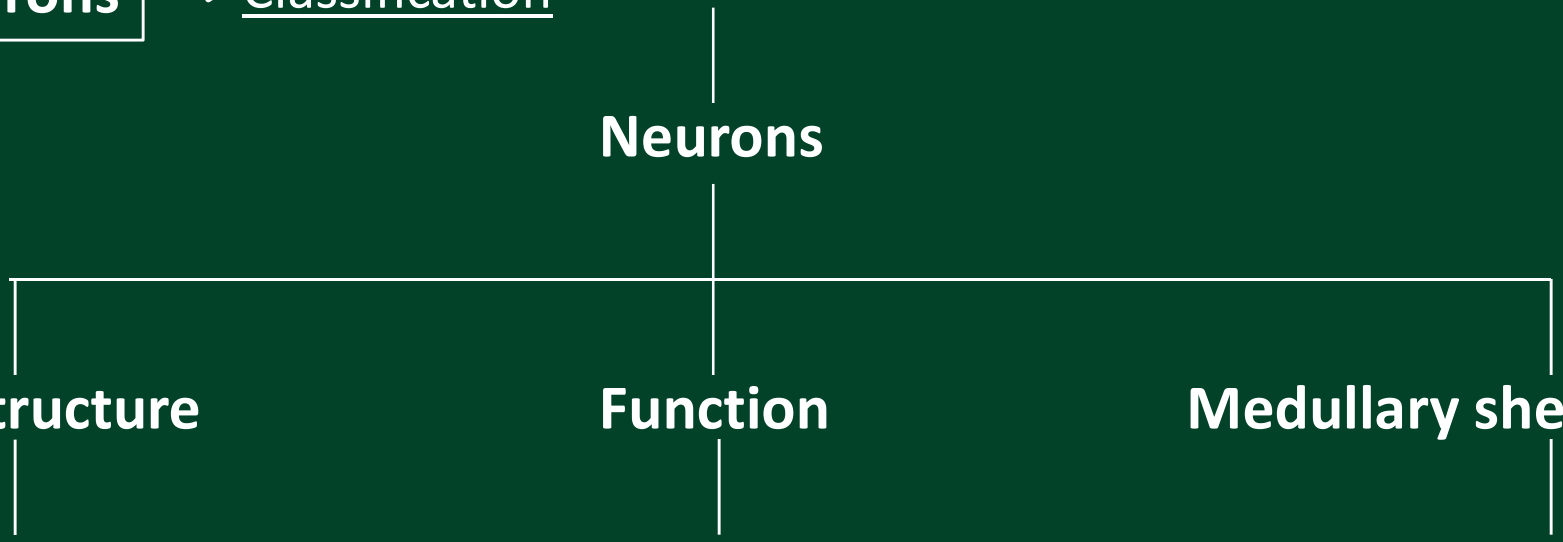
Neuroglia cells:

- In the central nervous system, the inter-neuronal space is filled with large amount of supporting non-nervous cells called neuroglia cells (or **microglial cells** or **oligodendrocytes).**
- These cells are **more** in number as compared to the neurons.
- They are capable of **regeneration and division** which is lacking in nerve cell.
- The glial cells are useful in ***supporting*** *the neurons*, providing ***nourishment*** *of neurons* and provide ***protection*** *to neurons* by engulfing foreign particles (phagocytosis).

- **Nerves** consist of several **bundles (fasciculi).**
- Each bundle is made up of many nerve **fibres**.
- Each **fibre** in a fasciculum or bundle is surrounded and held to the others by a thin layer of connective tissue called **endoneurium.**
- Each **bundle** or fasciculum is enclosed by a coat of white fibrous tissue termed **perineurium**.
- Each **nerve** consisting of all these bundles are enveloped by another coat of white fibrous tissue called **epineurium**.)



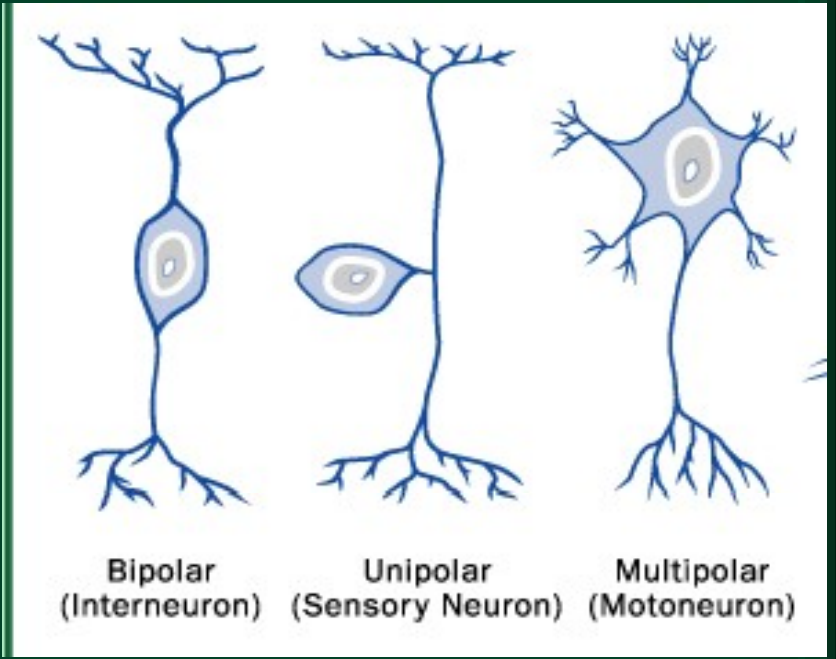
Neurons → Classification



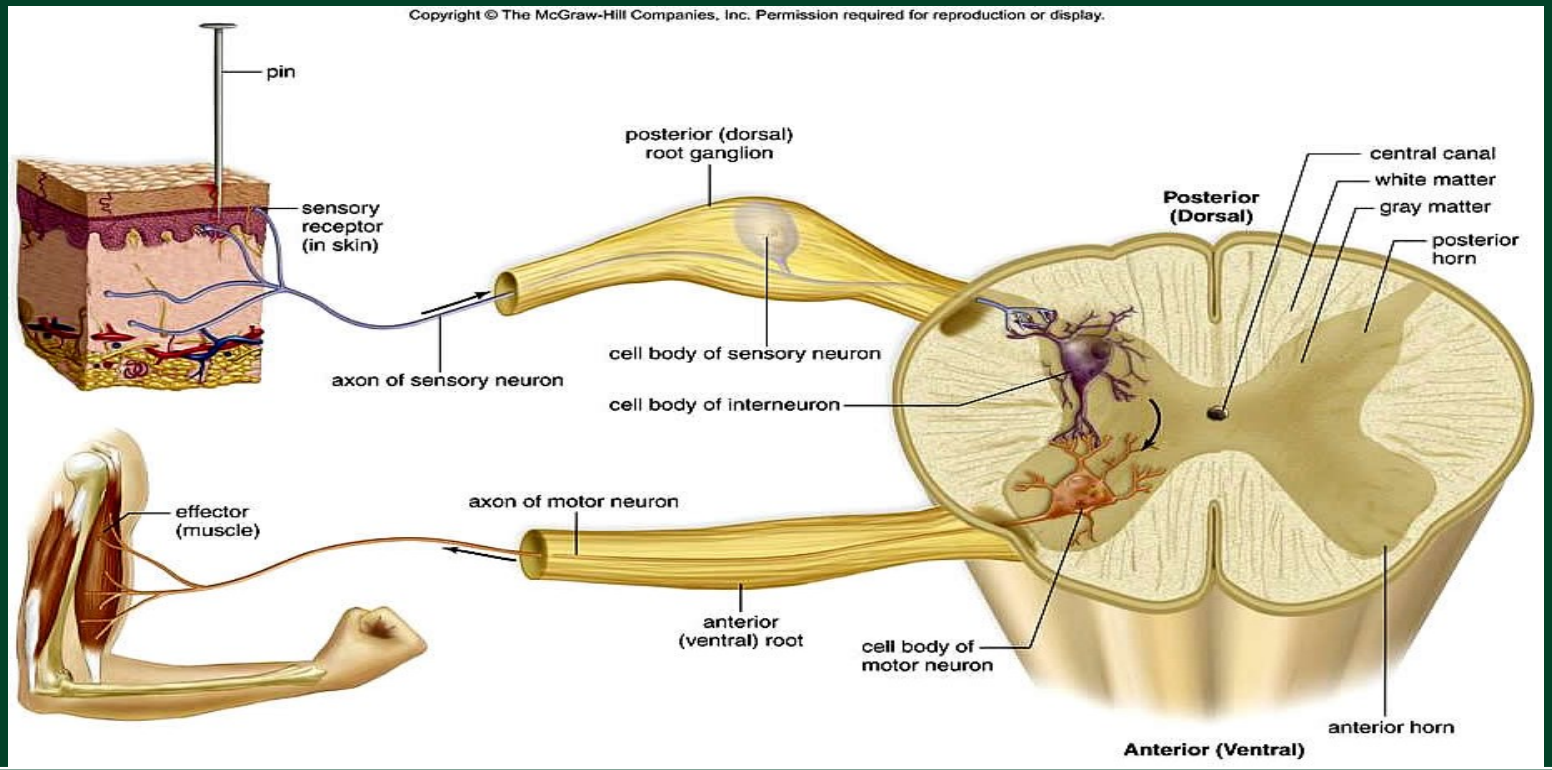
Neurons → Structure

Depending on the **number** and **arrangement** of cytoplasmic extensions, the neurons are classified as:

- *Unipolar* neuron has *single process*. It is also called **monopolar neuron**.
- *Bipolar* neurons have *two processes* originating from opposite poles of the cyton.
- *Multipolar* neurons have *more than two processes*.



Neurons → Function



- *Sensory neuron* responds to *external stimulus* and carries impulse **towards** the central nervous system.
- The axonal parts of sensory neurons terminate in the *intermediate neurons* which are *seen in brain and spinal cord*. These are stimulated by the impulses that are received from the sensory neuron.
- *Motor neurons carry impulses* **from** *the central nervous system towards the* effector organ *which brings about the response.*

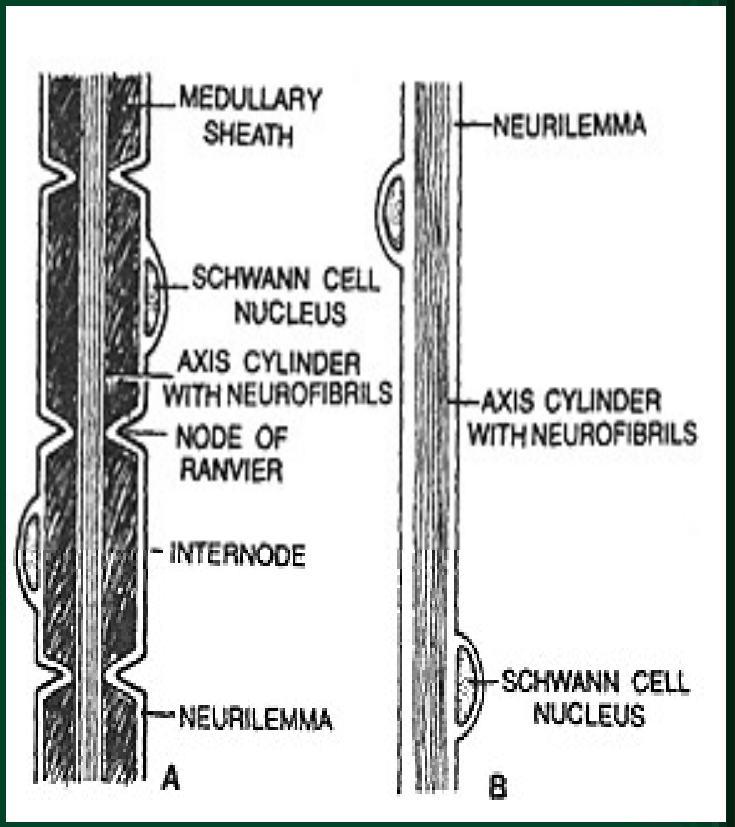
Neurons → Medullary sheath

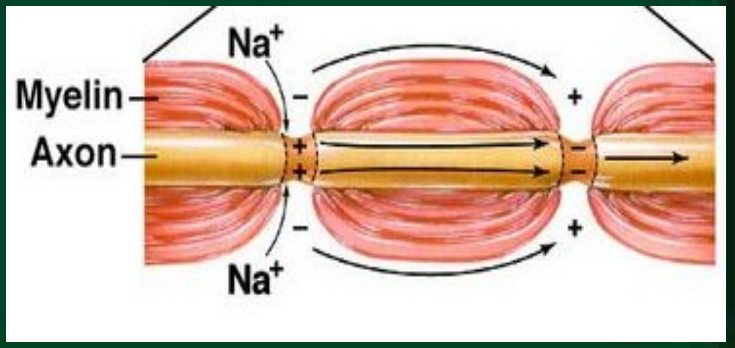
Myelinated or Medullated nerve fibre:

- ***Schwann cells*** secrete an *insulating fatty layer* around the nerve fibre which forms *myelin sheath*.
- It is *interrupted* at regular intervals called ***Nodes of Ranvier.***
- A thin delicate membrane called ***neurilemma*** surrounds the axon.
- Cranial nerves of vertebrates are of this type.
- Myelinated or *Medullated nerve fibres are useful in conducting impulse at a faster rate*.
- As the impulse jumps from one Node of Ranvier to another, it is called **Saltatory conduction**.

Non-myelinated or non-medullated nerve fibre:

- The axon of this nerve fibre ***lacks*** *the myelin sheath* as the Schwann cells present around the nerve fibre does not secrete the sheath.
- These are present in the ***autonomous*** nerves of vertebrates and invertebrate nervous system.
- These nerve fibres also help in the *conduction of impulses* but at much ***slower rate*** *as compared to myelinated nerve fibres*.





THANK YOU