

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

CONNECTIVE TISSUE

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Connective tissue

Tissue that binds, connects and protects other tissues of the body is called a connective tissue

Classification of connective tissue

CONNECTIVE TISSUE

EMBRYONAL

MESENCHYMAL

MUCOUS

CT PROPER

DENSE

LOOSE

ELASTIC

SPECIALIZED

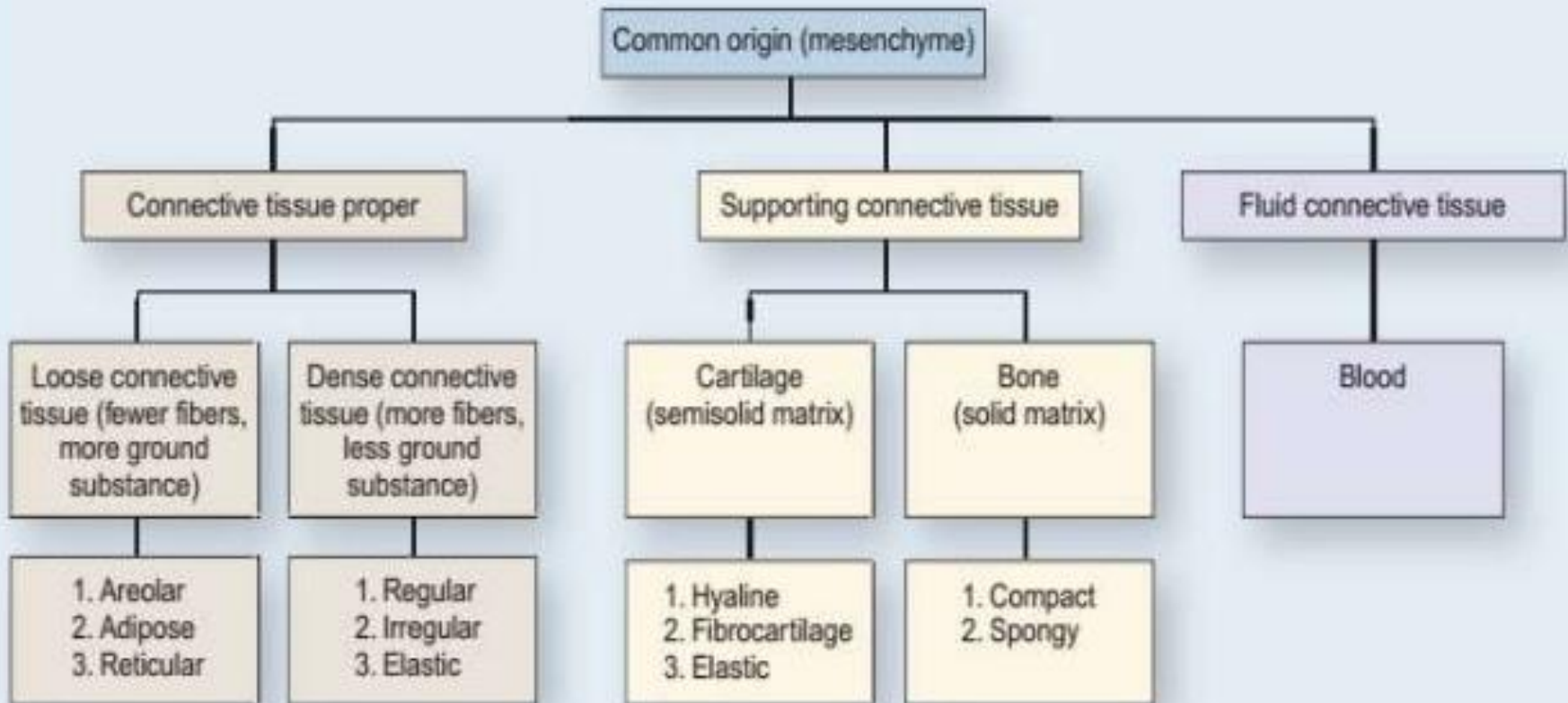
CARTILAGE

BONE

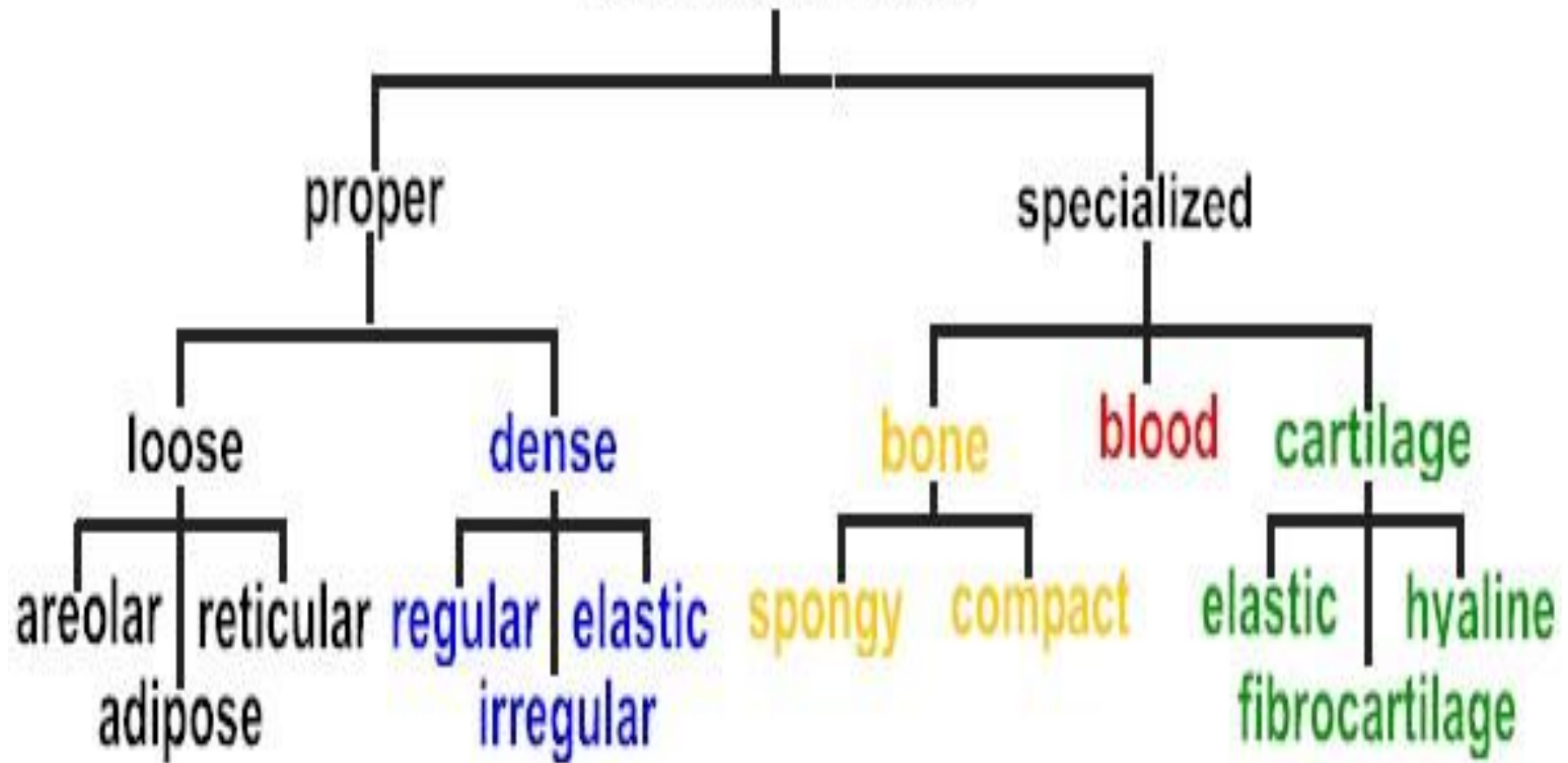
BLOOD

Classification of connective tissue

Connective Tissue Classification



Connective Tissue



Components of a connective tissue

1. Connective tissue **Cells**
2. Connective tissue **Fibers**
3. Connective tissue **Matrix**

Cell Types

Cells of CT may either be fixed in place (resident cells) or they may be wandering cells
Examples of fixed cells Fibroblasts Secrete protein fibers into matrix. Mast Cells Secrete histamine & heparin into blood .

Wandering cells move throughout the tissues.
Example of a wandering cell: Macrophages actively move about during infection phagocytizing bacteria & debris. macrophages

CONNECTIVE TISSUE CELLS

1. Fibroblasts
2. Macrophages
3. Leukocytes
4. Adipose cells
5. Mast cells
6. Plasma cells
7. Undifferentiated mesenchymal cells



Fibroblast



Fat globule

Adipose cell



Plasma cell



Mast cell



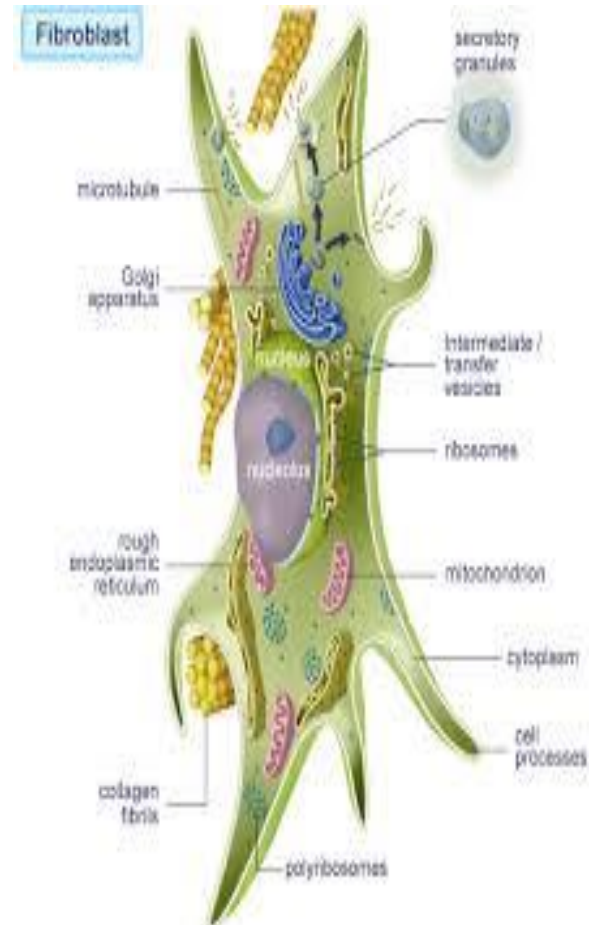
**Macrophage or
histocyte**

Fibroblasts

- Most abundant cells
- Spindle shaped ,branched cells
- Size depends on stage of activity
- Pale staining cytoplasm with well developed RER and rich Golgi complexes.

Function:

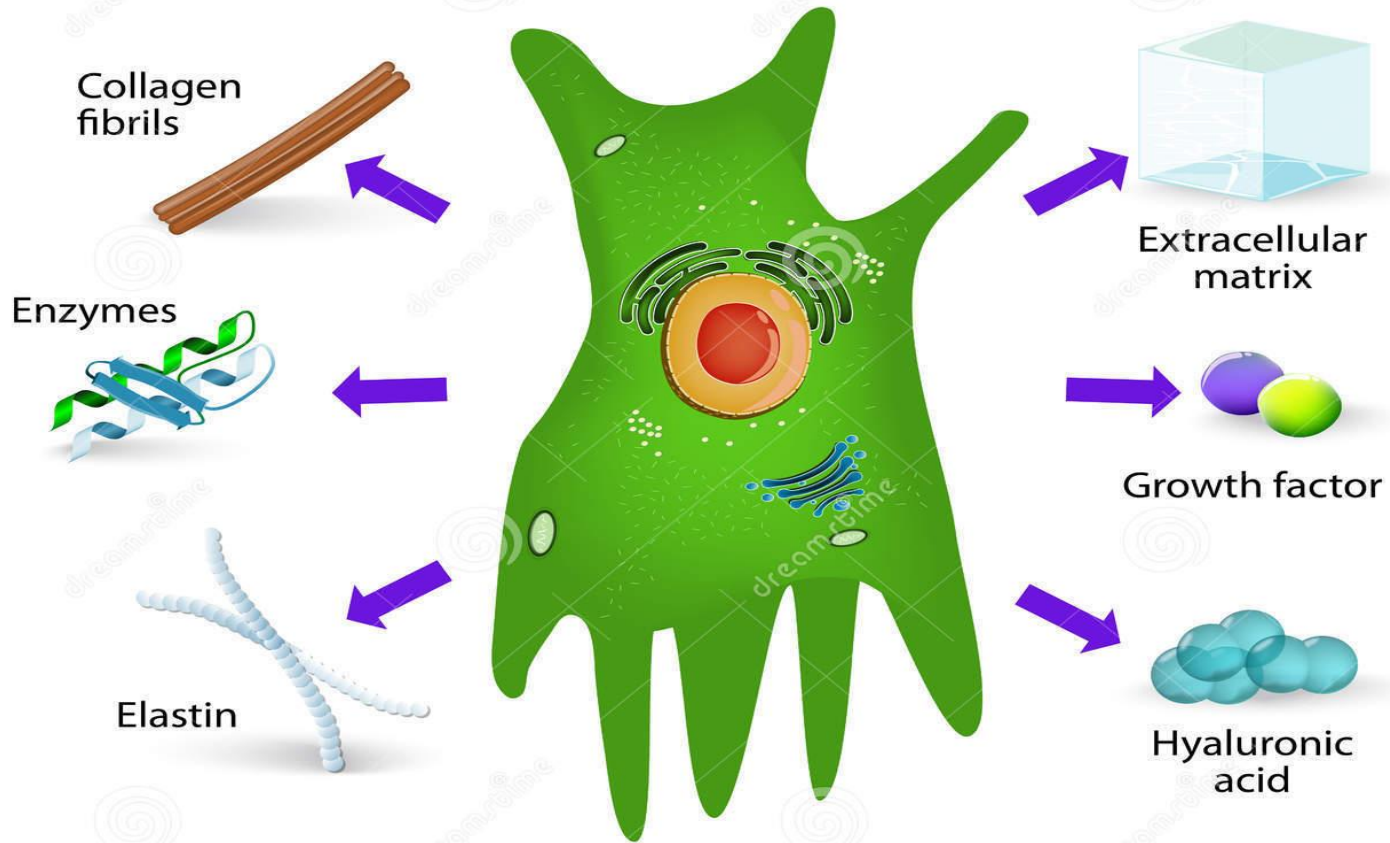
Fibroblasts produce the glycosaminoglycans, collagens, elastic fibers, reticular fibers and glycoproteins that can be seen in the extracellular matrix. When tissue damage has occurred, the fibrocytes are stimulated to undergo mitosis or multiplication by replication and division.



FUNCTUIONS OF FIBROBLASTS

- In some cases, epithelial cells may also produce fibroblasts, a process which is referred to as epithelial–mesenchymal transition (EMT). Conversely, fibroblasts sometimes undergo mesenchymal–epithelial transition (MET) to produce epithelia. This process is seen as part of normal development, tissue repair and tumor growth.
- Inactive fibroblasts are called fibrocytes. Active fibroblasts are rich in endoplasmic reticulum and have a branched cytoplasm that surrounds an oval, spotted nucleus whereas fibrocytes are smaller and spindle-shaped.

FIBROBLAST



MACROPHAGES (the mononuclear phagocyte system)

- Term macrophage means BIG EATER
- Derived from blood monocytes
- Highly phagocytic cells
- Stellate or spindle shaped cells
- Nuclei are small and centrally located
- Zoologist and anatomist Metchnikoff elaborated the concept of phagocytosis

Macrophages are widely distributed in the body being essential components of many tissues, In particular the blood cells forming tissues.

- Tissues- Tissue Histeocytes
- Liver- Kupffer's cells
- Lungs- Alveolar macrophages/dust cells
- bone- Osteoclasts
- CNS- Microglial cells
- Epidermis- Langerhans cells

Leukocytes

- Frequently found in connective tissue
- Migrate from blood to the connective tissues ,through walls of the capillaries by a process called diapedesis.
- Diapedesis increases during inflammation.
- Leukocytes found in CT are:
lymphocytes, Neutrophils, Eosinophils and Basophil.

White blood cells



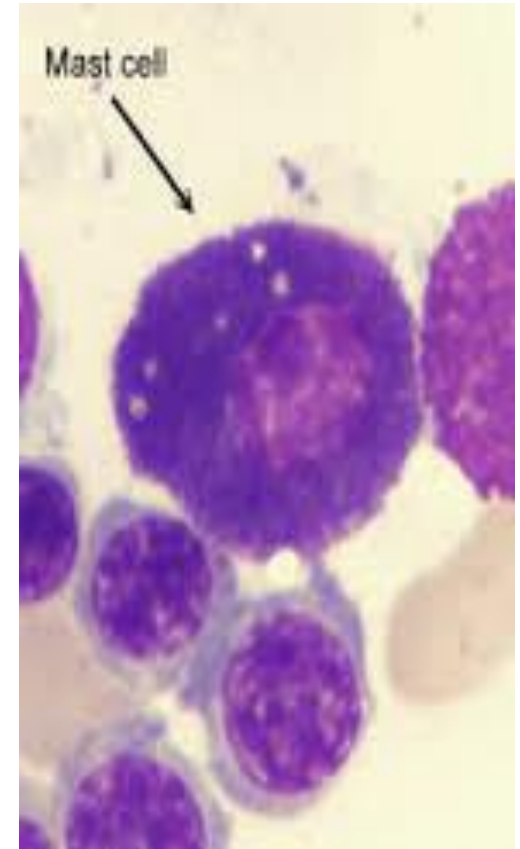
neutrophil eosinophil basophil monocyte lymphocyte

Plasma cells

- Large ovoid cells with basophilic cytoplasm
- Nucleus is spherical and eccentrically placed
- Numerous in sites subject to penetration by bacteria and foreign particles and in areas of chronic inflammation.
- Derived from B lymphocytes.
- Responsible for the synthesis of antibodies.
- Antibodies are immunoglobulins produced in response to antigens.
- Average life is 10 -20 days.

Mast cells

- Originate from stem cells in the bone marrow
- Surface of mast cells contain specific receptors for IgE
- Widespread in the body but are particularly abundant in the dermis, digestive and respiratory tracts.
- Release histamine, neutral proteases, Eosinophil chemotactic factors for anaphylaxis and Leukotrienes.



Cell Type	Major Product or Activity
Fibroblasts (fibrocytes)	Extracellular fibers and ground substance
Plasma cells	Antibodies
Lymphocytes (several types)	Various immune/defense functions
Eosinophilic leukocytes	Modulate allergic/vasoactive reactions and defense against parasites
Neutrophilic leukocytes	Phagocytosis of bacteria
Macrophages	Phagocytosis of ECM components and debris; antigen processing and presentation to immune cells; secretion of growth factors, cytokines, and other agents
Mast cells and basophilic leukocytes	Pharmacologically active molecules (eg, histamine)
Adipocytes	Storage of neutral fats

Matrix of connective tissue (GROUND SUBSTANCE)

- Component of a connective tissue between the cells and fibers.
- The ground substance may be viscous (as in blood), semisolid (as in cartilage), or solid (as in bone).
- Supports cells, binds them together, stores water, and provides a medium for exchange of substances between the blood and cells.
- Plays an active role in how tissues develop, migrate, proliferate, and change shape.
- It primarily consists of protein and carbohydrate molecules and variable amounts of water.
- The protein and carbohydrates are mainly present in form of proteoglycans and glycoproteins. Proteoglycan = Protein core + glycosaminoglycan . Glycoprotein= Protein + oligosaccharide
- Also present in the ground substance are adhesion proteins , which are responsible for linking components of the ground substance to one another and to the surfaces of cells. E.g. fibronectin which bind collagen fiber and ground substance together

Connective tissue Fibers

1. Collagen fibers
2. Elastic fibers
3. Reticular fibers

1: Collagen fibers

- Made up of collagen.
- Collagen fibers are tough and only slightly elastic.
- They often occur in bundles with the fibers parallel to one another, which gives great tensile strength.
- Make different association in different tissues., as in cartilage molecular arrangement allows it to draw more water as compared to bone.
- Collagenous fibers forms the bulk of ligaments & tendons Most abundant protein in mammals
- Ligaments connect bone to bone, Tendons connect muscle to bone
- Collagen is found in most connective tissues, esp. bone, tendons, and ligaments.

2.Elastic Fibers

- Composed of a spring-like protein, called elastin and glycoprotein framework called fibrilin.
- They are very stretchy and branch and join to form a network.
- Elastic fibers are weaker than collagen, but exhibit elastic recoil Elastic fibers can be easily stretched or deformed and they retain their shape.
- Can stretch up to 150 times its relaxed size
- Locations: vocal cords, respiratory tract(lungs), blood vessels, skin.

3.Reticular Fibers

- Reticular Fibers Consist of thin strands of collagen fibers
- Made up of collagen but are thinner as compared to collagen fibers and are arranged in branching network (not in parallel rows as are collagen fibers) .
- They form a sponge like framework , stroma, for such organs as the spleen and lymph nodes
- Also present in blood vessels, nervous tissue, muscles and adipose tissue where it provide support
- Reticular fibers fill the spleen, liver, and lymph nodes

Macrophage

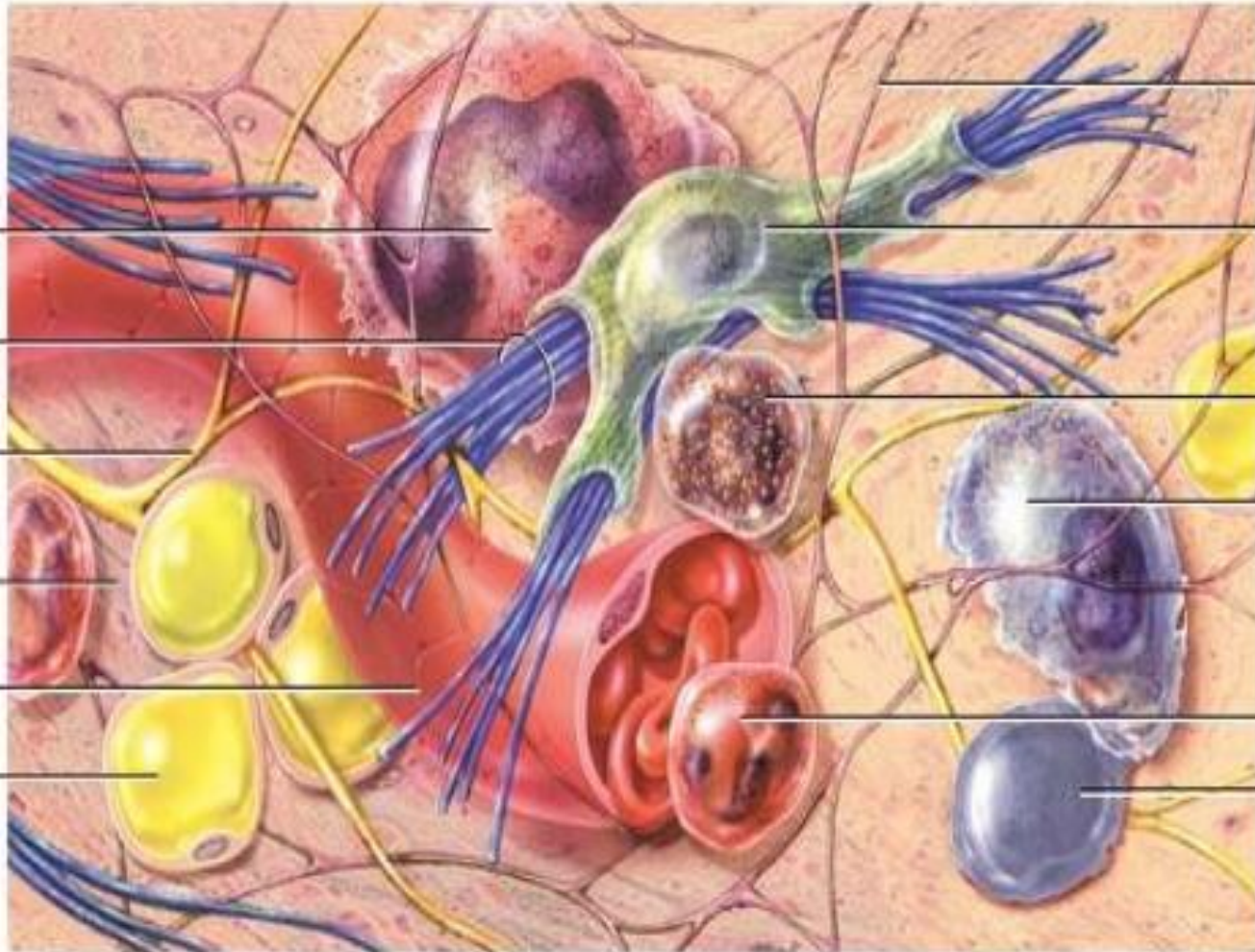
Collagen
fiber

Elastic
fiber

Ground
substance

Blood vessel

Adipocyte



Reticular
fiber

Fibroblast

Eosinophil

Mast cell

Neutrophil

Plasma cell

Types of connective tissue

Connective tissue proper

- Includes those types of connective tissues that exhibit a variable mixture of both connective tissue cell types and extracellular protein fibers suspended within a viscous ground substance.
- It generally has high protein fiber content.
- These CT types differ with respect to their numbers and types of cells and the relative properties and proportions of their fibers and ground substance.
- Its main function is to bind cells and tissues into organs and organ systems.

Types of connective tissue proper :

1. Loose connective tissue
2. Dense connective tissue

Loose connective tissue

1. Loose Areolar tissue
2. Adipose tissue
3. Reticular tissue

Loose Areolar connective tissue

- Gel like matrix with all the three fibers types.
- Cells – fibroblasts, macrophages, mast cells and some WBCs.

Functions

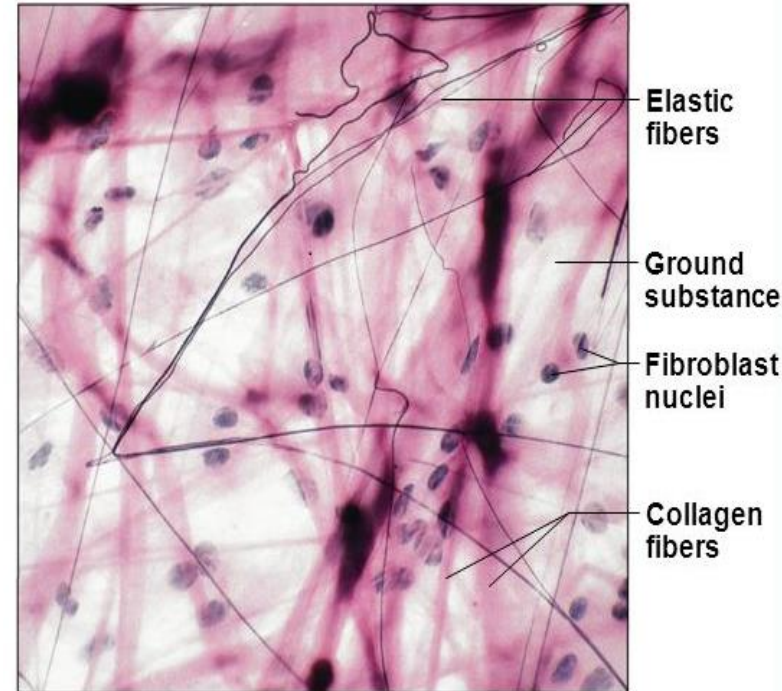
Soft packing tissue of the body.

Wraps and cushions organs.

Its macrophages phagocytize bacteria plays an important role in inflammation.

Location

- Widely distributed in the body under epithelia as lamina propria of mucous membranes.
- subcutaneous layer of skin between muscles
- Surrounds capillaries.
- Packages organs.



Photomicrograph: Areolar connective tissue

Adipose (fat) tissue

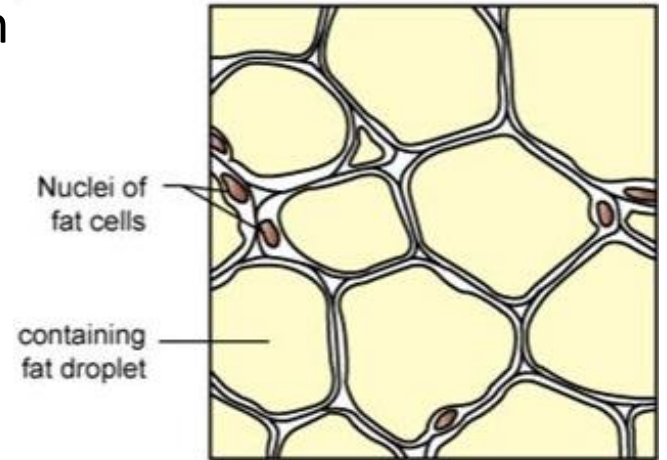
- Adipose Tissue (fat) Structure Precursor cells resemble fibroblasts, but as they accumulate fat droplets in the cytoplasm they become adipocytes.
- Cygnet ring appearance

Functions

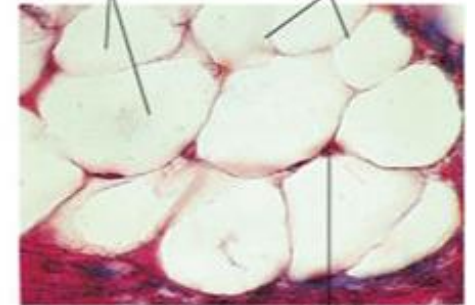
- stores energy
- insulation
- cushions organs
- secretes estrogens

Locations

- Beneath the skin – subcutaneous fat
- Within abdominal cavity– visceral fat
Surrounds kidneys & eyeballs
Surface of heart



Storage area for fat Plasma membrane



Nucleus of adipose cell

Adipose tissue

- Adipose tissue is essentially loose connective tissue containing large numbers of adipocytes. There are two types of adipose tissue, which derive their names from the color of the tissue (white or brown) and the number of lipid droplets found in the adipocytes.
- Adipocytes of *white, unilocular adipose tissue* contain one large lipid droplet.
- Adipocytes of *brown, multilocular adipose tissue* contain many lipid droplets.

- White adipose tissue does not only function in the storage of lipids. For example, in the palms of the hands, on the plantar surface (sole) of the feet and in the gluteal region (buttocks) it has a structural, cushioning function. In these regions, accumulations of adipocytes are surrounded by strong connective tissue fibres.
- Also, the distribution of white adipose tissue is different in males and females and is part of the secondary sexual characteristics.
- The storage and mobilization of lipids does require quite some metabolic activity of the tissue. Consequently, adipose tissue has a rich supply of capillaries.

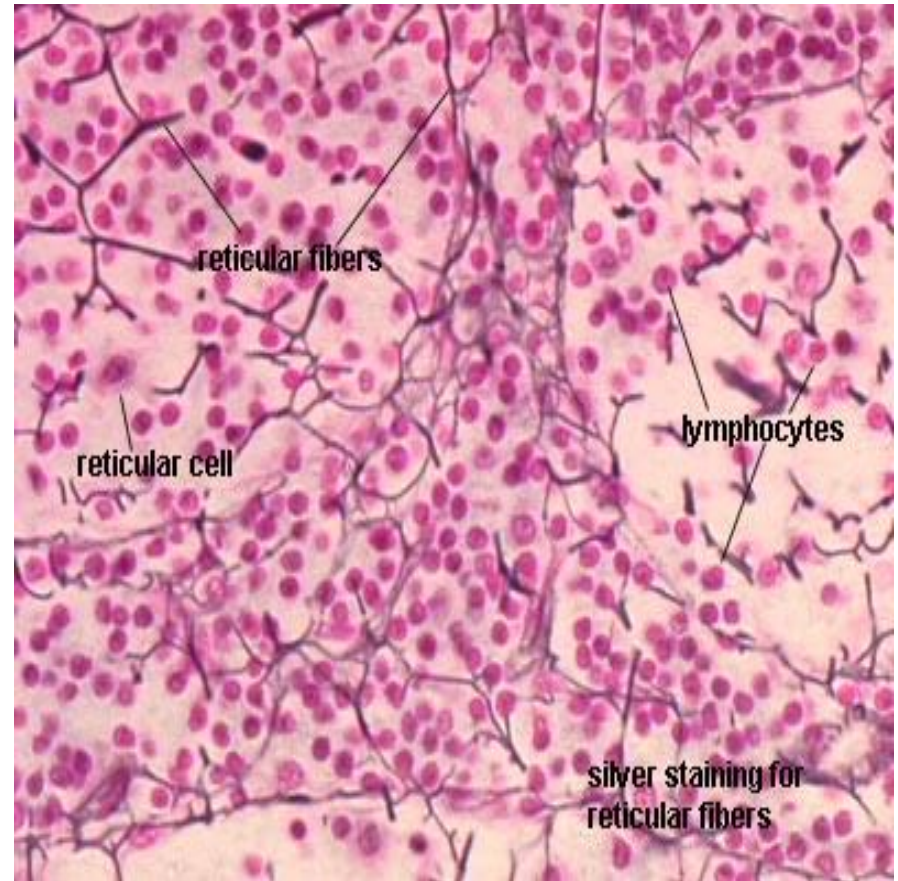
- Brown adipose tissue occurs mainly during development and may account for 2 - 5 % of the body weight in a newborn. In adult individuals most of the brown fat has further differentiated into white fat. Adipocytes in brown fat contain plenty of mitochondria. A very rich capillary supply and the cytochromes found in the mitochondria give the tissue its characteristic colour. A protein (UCP-1 or thermogenin) found in these mitochondria *decouples the oxidation of fatty acids from the generation of ATP. Instead, these cells generate heat.*
- The location of the brown fat reflects its heat-generating function. It is located in the axilla (armpits), between the shoulder blades, in the region of the neck and along large blood vessels. The heat generated by the brown fat warms the blood which supplies nearby organs or which re-enters the trunk from the limbs.

Reticular Connective Tissue

Reticular CT contains fibroblasts along with a network of thin collagenous fibers arranged into a reticulum.

Locations include the framework of Spleen Liver Lymph nodes

Functions of reticular CT forms the framework of some organs reduces the flow of fluid through an organ



Dense Connective Tissue

Dense Connective Tissue Fibrous elements are more numerous and densely packed.

Increase in fiber population Decrease in the number of cells, ground substance and densities of blood and lymphatic vessels.

When the fibers are arranged into dense masses with specific orientation, the tissue is said to be regularly arranged DENSE CT ,otherwise it is designated as irregularly arranged DENSE CT.

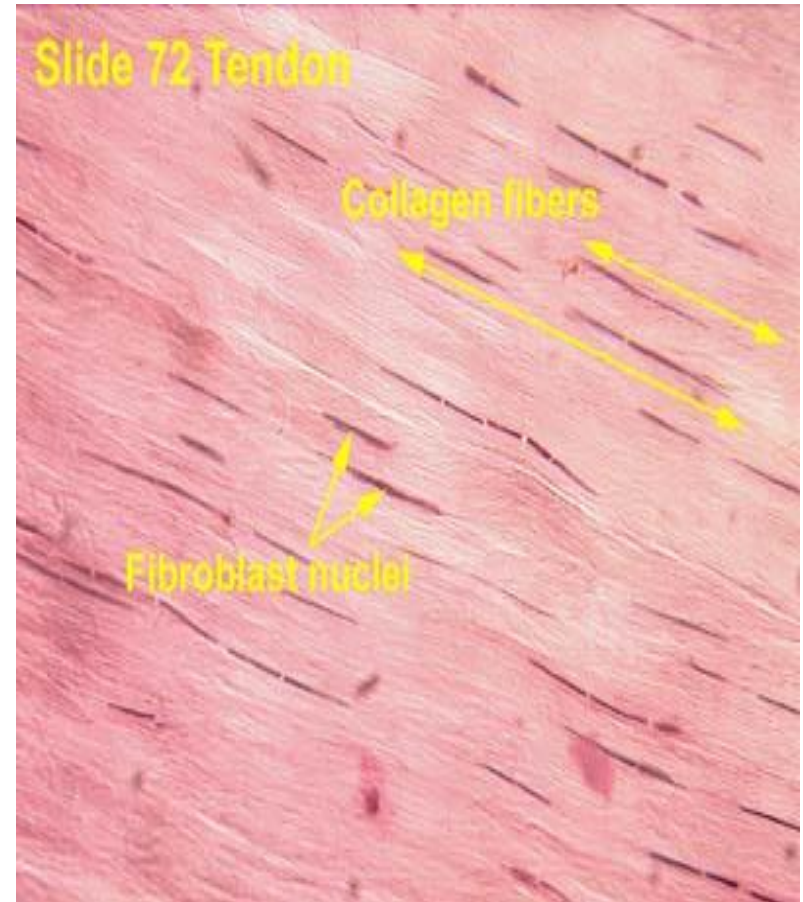
Dense regular Connective Tissue

Dense Regular CT contains relatively few fibroblasts with densely packed collagenous fibers in parallel arrangement.

Functions: Great tensile strength that withstands pulling forces especially in one direction

Locations: Tendons & Ligaments and the fasciae and aponeuroses of muscles.

Note: Dense CT has a poor blood supply so they are slow to heal following an injury.



Dense Irregular Connective Tissue

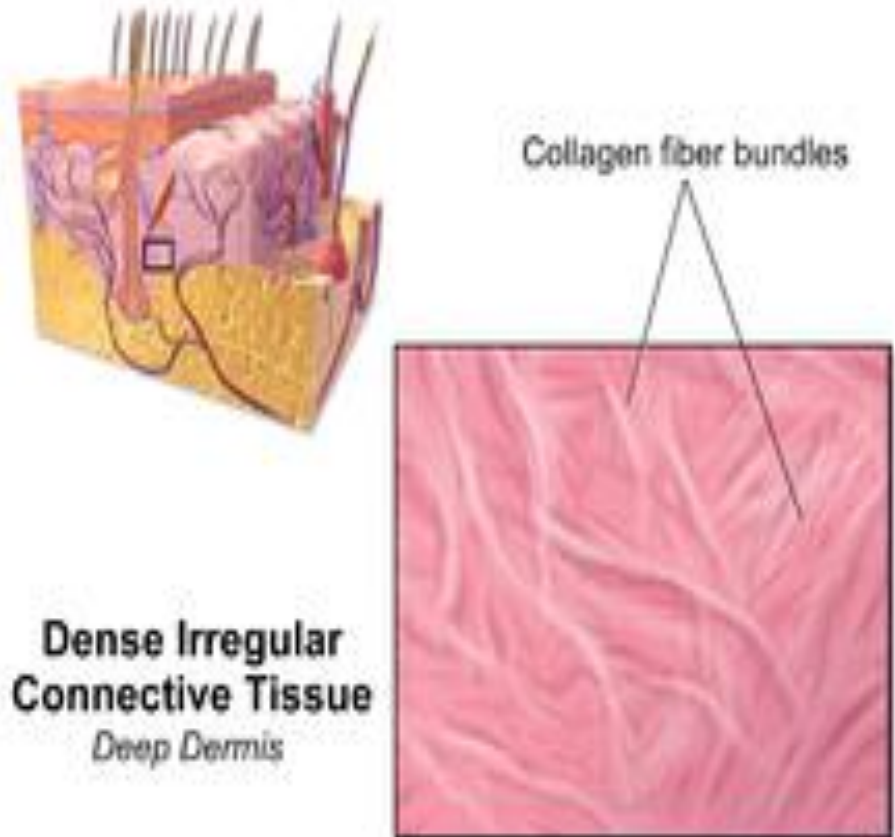
Dense Irregular CT contains fibroblasts with a dense network of interwoven collagenous fibers

The fibers do not show a clear orientation within the tissue

Functions:- Dense Irregular CT withstands pulling forces in all directions

Location:- Dermis of skin Dermis (deep layer) of skin and capsule of certain organs, and joints.

- Epinuerium
- Epimysium
- Periosteum
- Pericardium
- Dura matter
- Tunica albugenia of testis
- sclera



Elastic Connective Tissue Structure

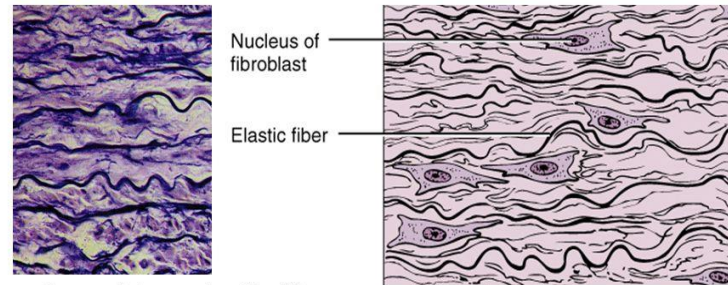
Elastic CT contains fibroblasts along with a dense arrangement of elastic fibers, with a few collagen fibers.

Functions:- Elastic recoil

Locations:- Walls of larger arteries and the respiratory tract

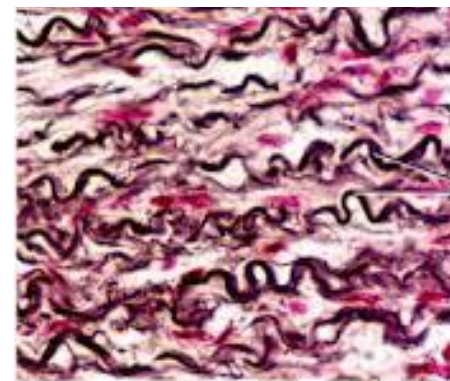
- Fascia of ant abdominal wall
- Ligamentum nuchae
- Ligamentum flavum

Elastic Connective Tissue



- Branching elastic fibers and fibroblasts
- Can stretch & still return to original shape
- Lung tissue, vocal cords, ligament between vertebrae

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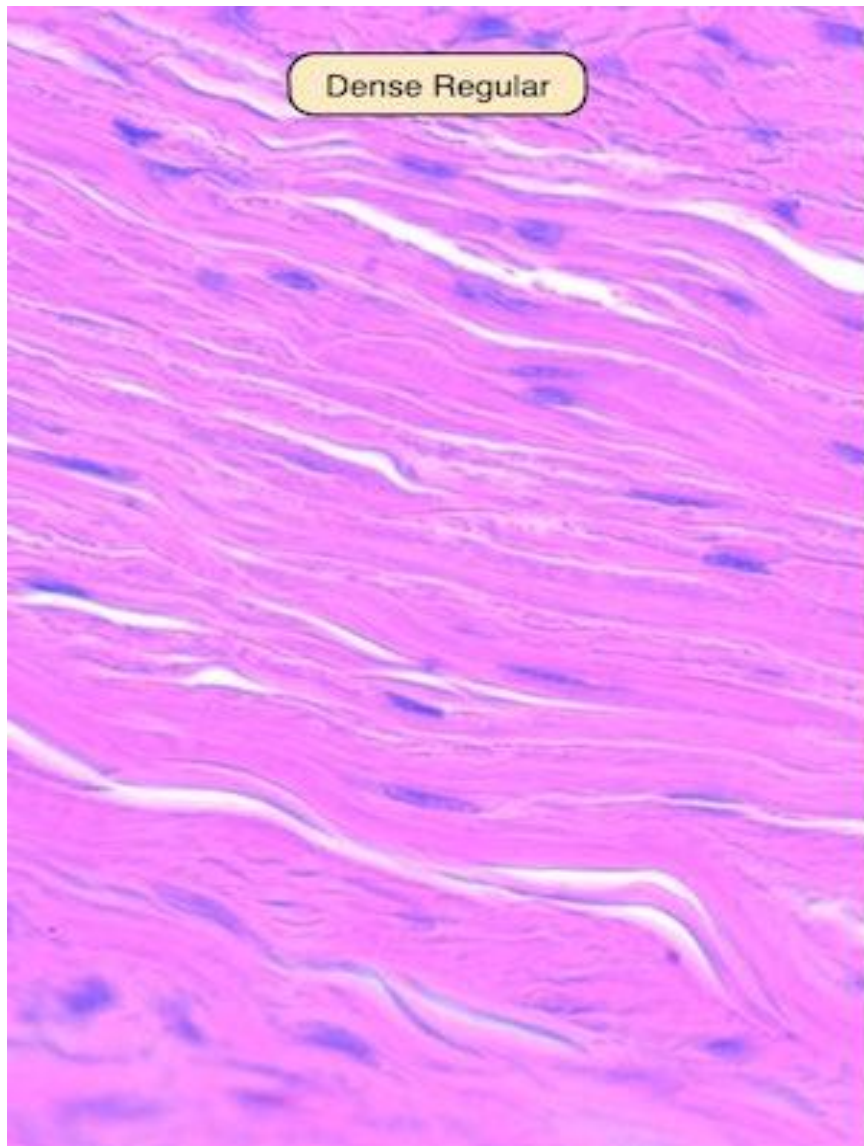
Elastic lamellae
(sheets of
elastic material)

LM 435x

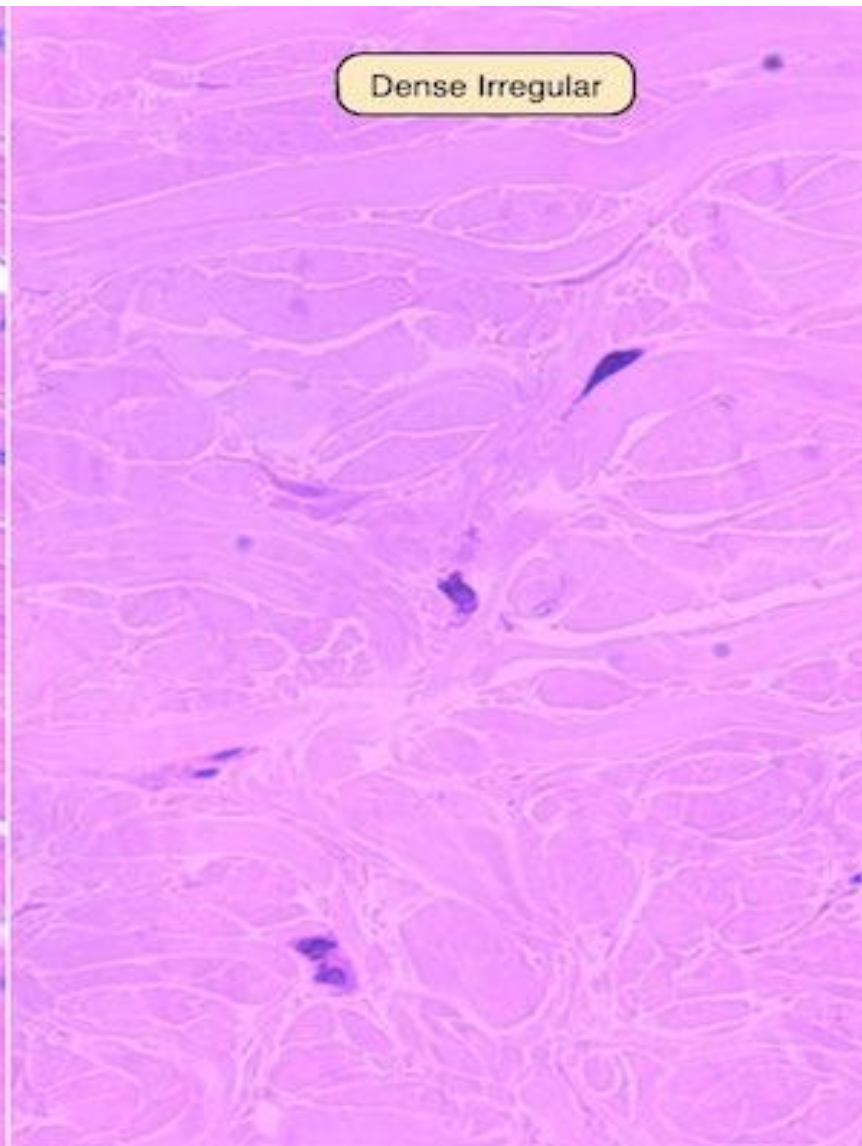
Sectional view of elastic connective tissue
of aorta

Courtesy Michael Ross, University of Florida

Dense Regular



Dense Irregular



Cartilage

- Cartilage is a specialized type of dense connective tissue designed to give support ,bear weight withstand tension, torsion and bending.

General features of cartilage

- Cartilage supports regions of the body that require flexibility,
- 60-80% water which helps with compression.
- Avascular
- non nervous structure
- Poor regenerative capacity
- Growth takes place by two methods-appositional growth and interstitial growth
- Externally covered by a dense connective tissue sheath called perichondrium except the articular cartilage and the fibro cartilage.
- Perichondrium has two layers outer fibrous (vascular) layer and inner chondrogenic (cellular) layer .
- Has cells which can regrow cartilage to some extent if it is damaged.

Cartilage

Functions

- Provides attachments
- Protects tissue Structural model for developing bone

General structure of cartilages

Mature cartilage cells are called chondrocytes The extracellular matrix of cartilage consists of

1. An abundance of collagen fibers
2. a gel-like ground substance
3. Lacunae = cavities containing chondrocytes In addition, each of the three types of cartilages have unique characteristics.

Cells of the cartilage

- They are derived from undifferentiated mesenchymal cells.
- Young cells are small with branched cytoplasmic processes known as chondroblasts, they multiply to chondrocytes.
- Older and mature cells are called chondrocytes.
- Chondroblasts are bigger in size and are found in spaces, called lacunae.
- They are found in groups of 2-4 cells together known as cell nest.
- They are responsible for the production of fibers and ground substance of the cartilage.
- Older mature cells are incapable of multiplication.
- The group of cells descended from a single paternal cells, located in lacunae and surrounded by special capsule are called *Isogenous group of the cells(IGC)*.

Histological features Hyaline Cartilage

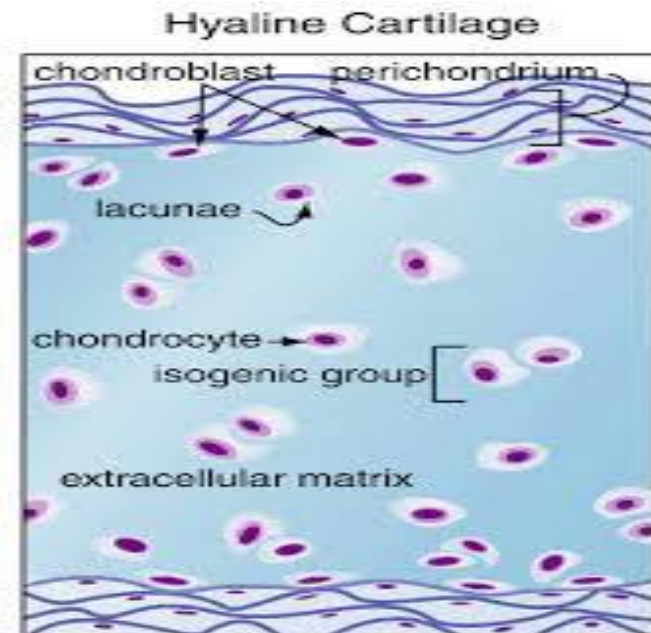
- Hyaline cartilage contains very fine collagenous fibers and the ground substance gives hyaline cartilage a glossy appearance.
- Appears homogeneous as the collagen fibers present in them have the same refractive index as ground substance.
- Highly basophilic homogeneous matrix
- Perichondrium present
- Isogenous group of cells present
- Matrix around the cells is brighter and deep in color as compared to other areas ,this matrix is called *territorial matrix* .
- Two groups of cells are separated by a lighter colored matrix known as, *inter -territorial matrix*

Functions:

Hyaline cartilage provides durable protection and supports movable joints

Locations

- End of Bones
- Embryonic Skeleton
- Costal Cartilages of the Ribs
- End of the nose

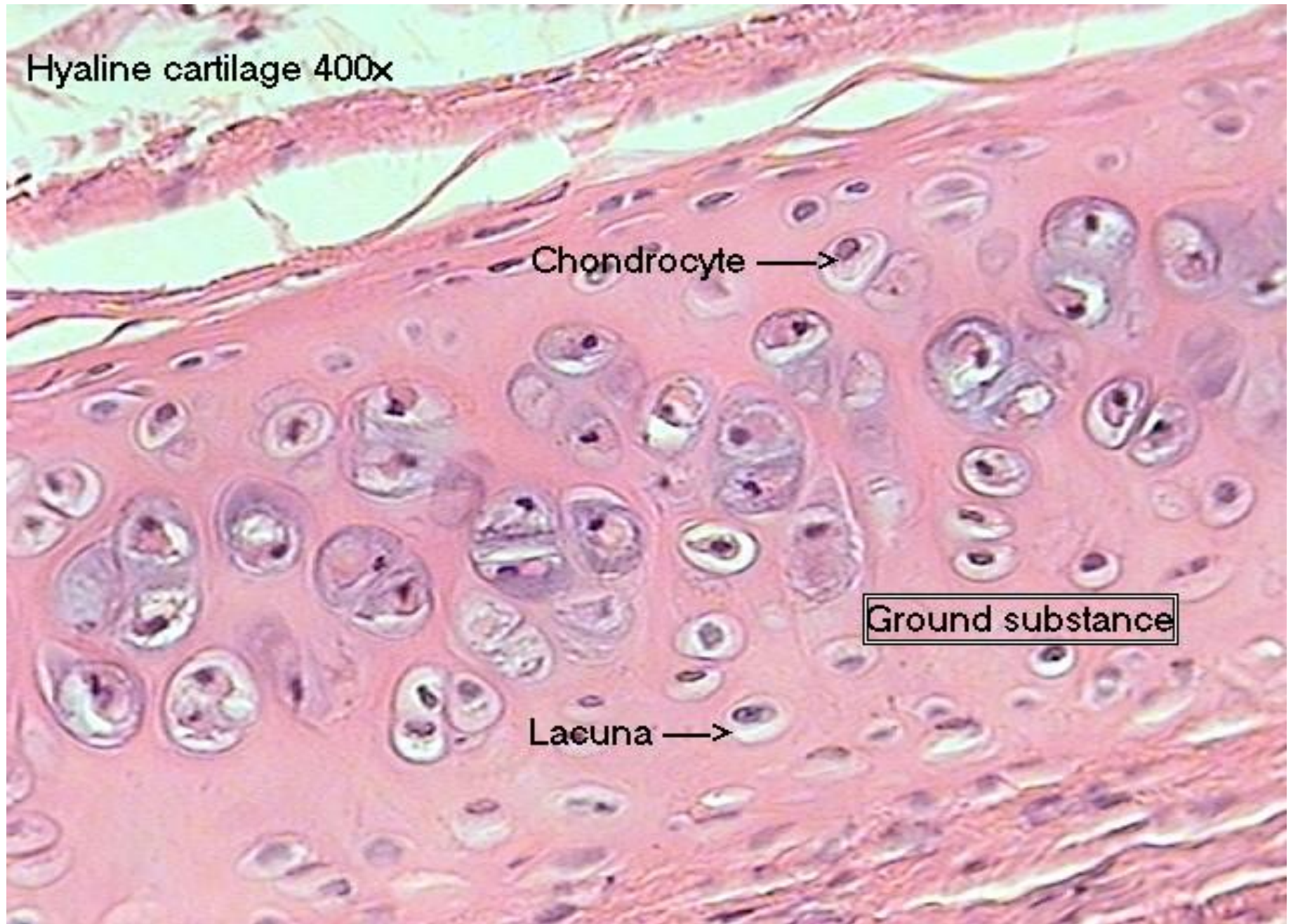


Hyaline cartilage 400x

Chondrocyte →

Ground substance

Lacuna →



Elastic Cartilage

Elastic cartilage contains a *dense network of elastic fibers* in its extracellular matrix in addition to the gel-like ground substance and collagen proteins.

Perichondrium present.

Chondrocytes are larger than those of hyaline cartilage and are present singly.

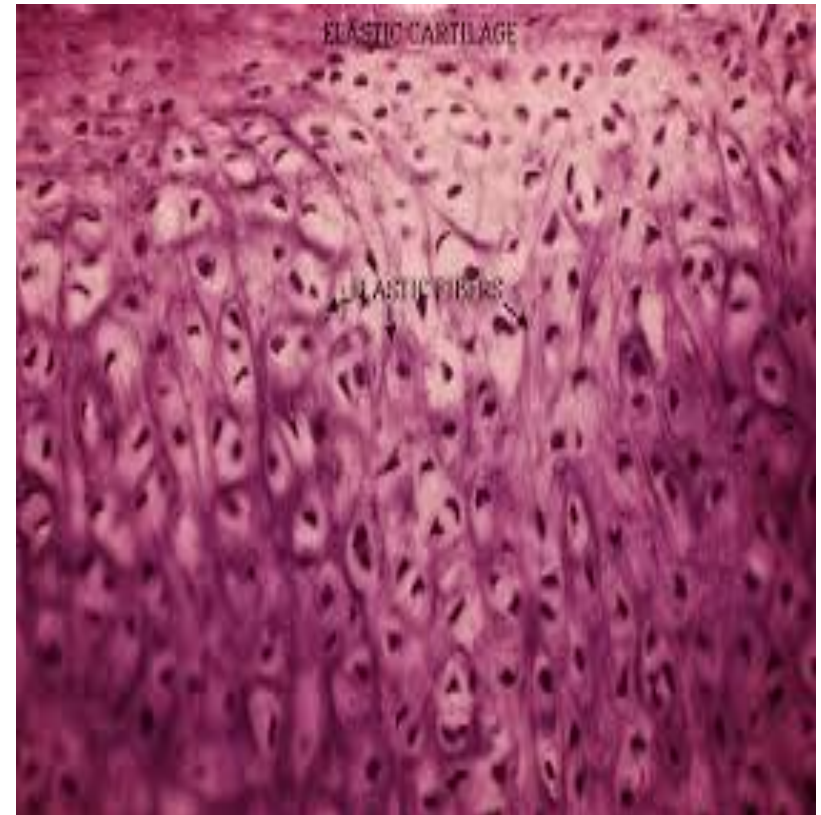


Function

Elastic cartilage provides flexible support that helps maintain the shape of the organs.

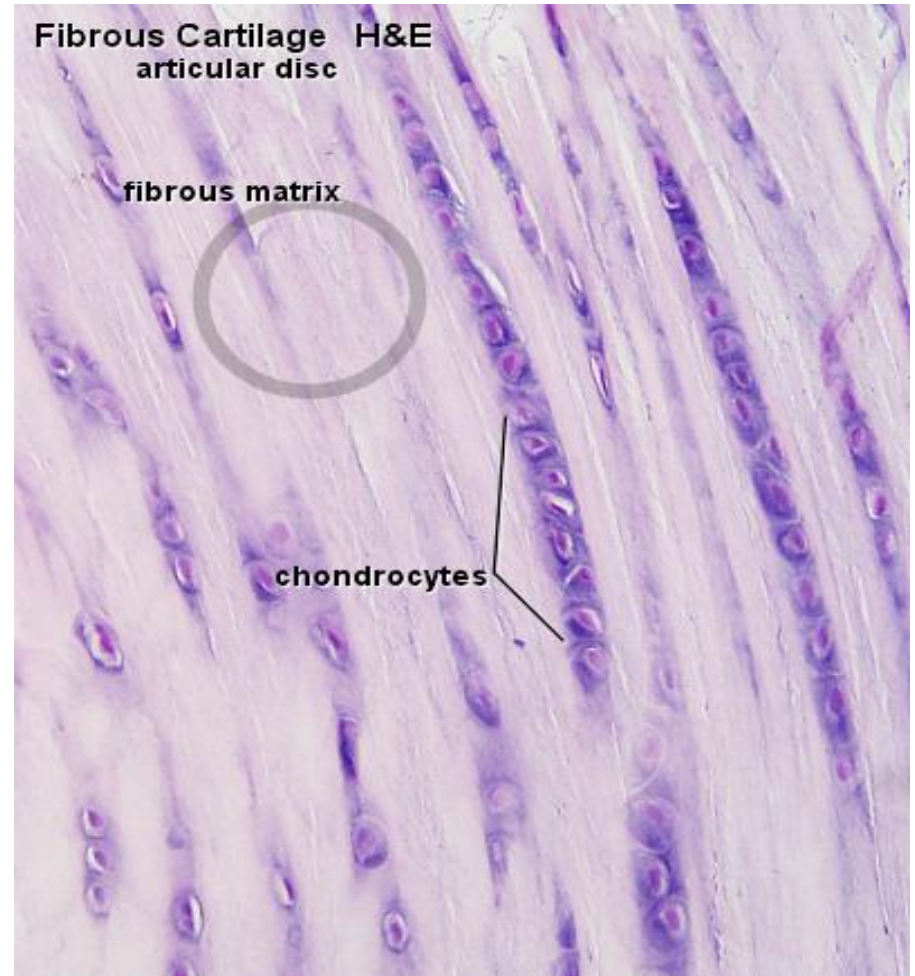
Locations

framework of external ear and portions of the larynx



Fibrocartilage

- Perichondrium is characteristically absent.
- Has thick bundles of collagen fibers
- Chondrocytes are present singly, in narrow rows between the bundles of collagen fibers.



Function :

Fibrocartilage acts like a shock absorber

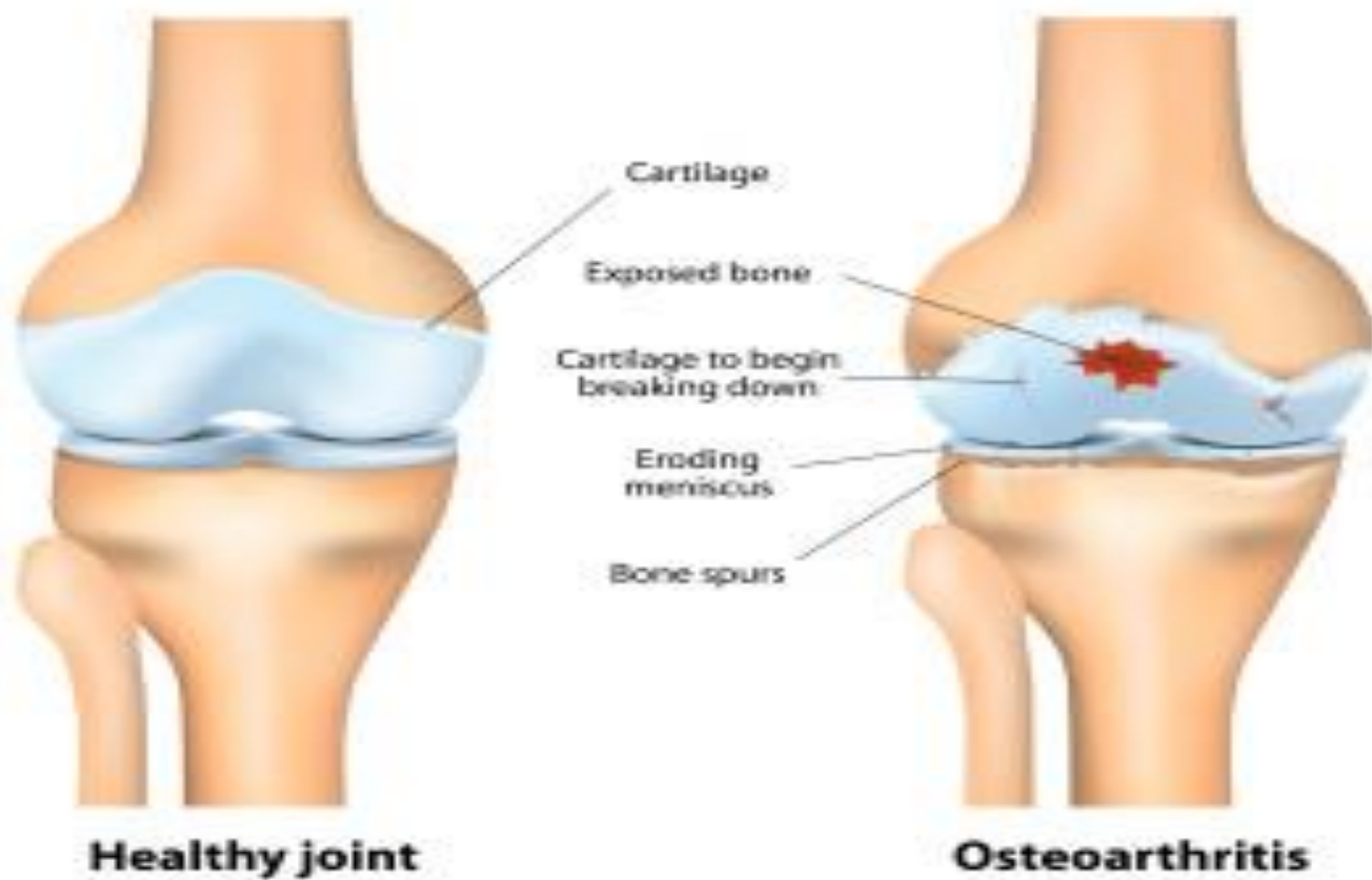
Locations:

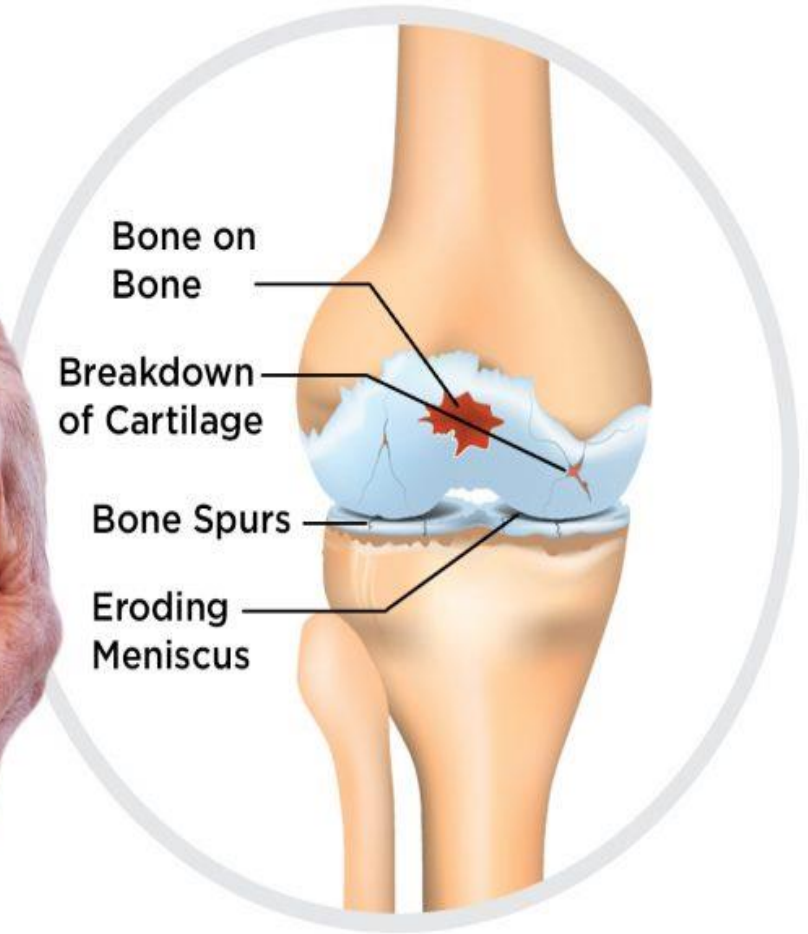
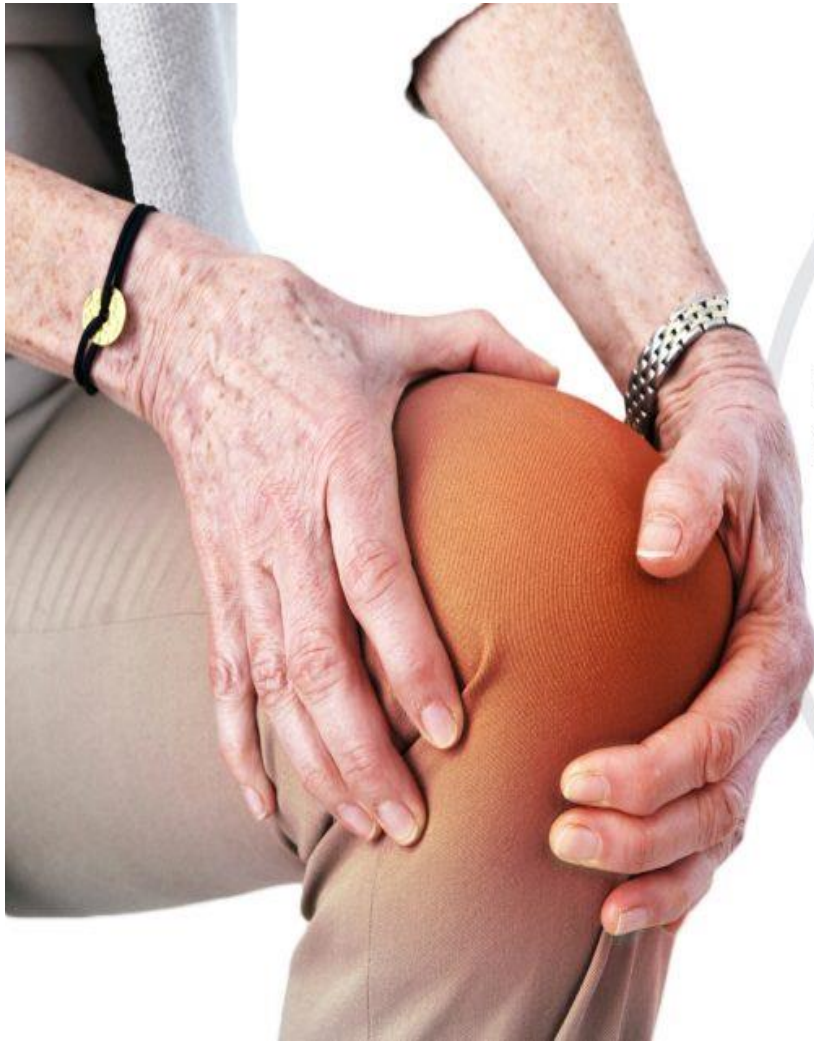
- Within intervertebral discs
- Meniscus of the knees
- Pubic symphysis

Applied Histology

- Osteoarthritis
- Slip disc (herniated disc)
- Hyaline cartilage have a tendency to ossify with age.

OSTEOARTHRITIS





Normal spine



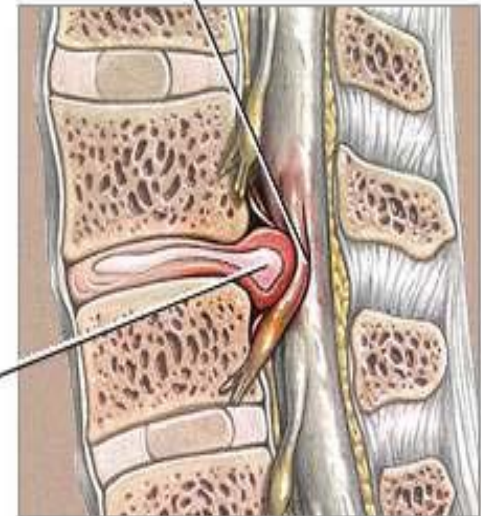
Osteoarthritic spine





Compressed lumbar spinal nerve

Herniated disc



What Is A Prolapsed Disc?

Bulging disc pressing on nerve

Herniated or Prolapsed Disc Causes and Risk Factors

Herniated discs are caused by aging, degeneration of the disc (disc disease) or injury to the spine. Disc disease may result from tiny tears or cracks in the outer capsule of the disc, called the annulus. The jelly-like material inside the disc (nucleus) may be forced out through the tears or cracks in the capsule. This causes the disc to bulge, break open or break into sections.





Figure shows calcifications involving cricoid and thyroid cartilages which occur upon ageing.