LECTURE 1:
CARTILAGE & BONE

- **Objectives:**

  By the end of this lecture, the student should describe the microscopic structure, distribution and growth of the different types of:

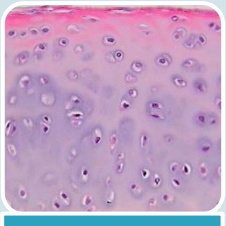
  - **Cartilage.**
  - **Bone.**

Overview

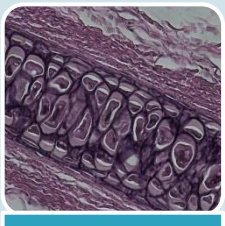
CARTILAGE

- **Cartilage is a specialized type of C.T. with a rigid matrix.** [Flexible - Not loose nor hard, it's in between "Rubbery"]
- **Cartilage is usually nonvascular (avascular).** [no blood vessels = no pain or bleeding when injured = healing is not easy – the pain & blood when it is injured come from the skin covering it]

3 Types



Hyaline Cartilage



Elastic Cartilage

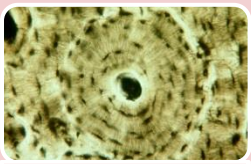
Fibro-cartilage

Note:
- Matrix= ground substances + fibers:
- CARTILAGE G.S.: Basophilic (stained blue) → Type II collagen
- BONE G.S.: Acidophilic (stained pink) → Type I collagen

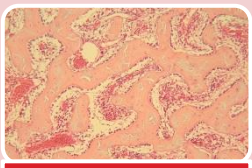
BONE

- **Bone is a specialized type of C.T. with a hard matrix.** [Not flexible] **hard because it is calcified (Calcium salts). It contains type I collagen fibers** [which makes the bone eosinophilic – pink]. **It forms bone lamellae and trabeculae.**
- **Functions:**
  - **Body support.**
  - **Protection of vital organs as brain & bone marrow.**
  - **Calcium store.** [it is the most important function. Why? Because calcium causes muscles to contract. The most important muscles: Heart & Respiratory muscles]

2 Types



Compact

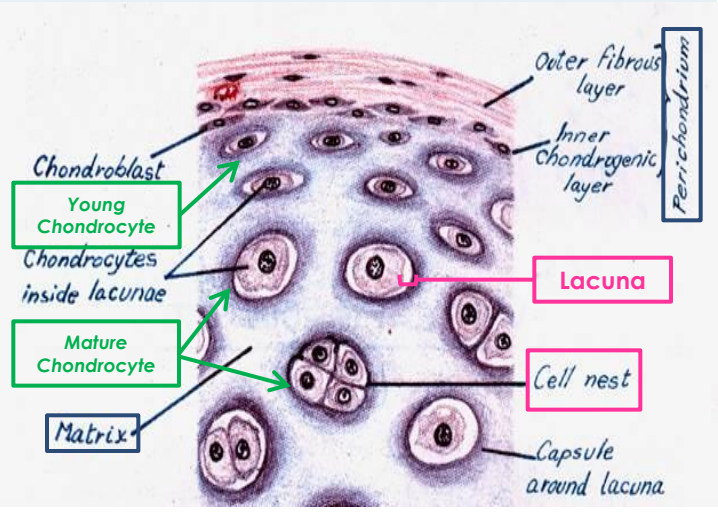


Spongy

Components

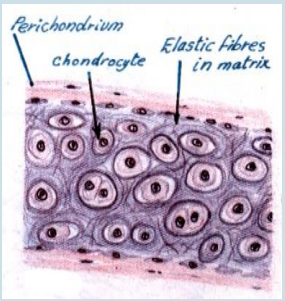
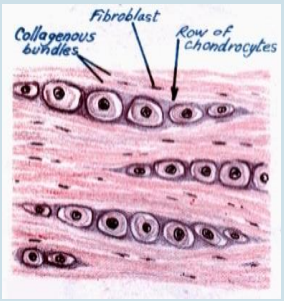
- Bone cells
  - Osteogenic Cells
  - Osteoblasts
  - Osteoclasts
  - Osteocytes
- Bone Matrix
- Periosteum
  - Covers the bone
- Endosteum
  - Covers the bone marrow cavity

Hyaline Cartilage:

Components	1) PERICHONDRIUM	2) MATRIX	3) CELLS: CHONDROCYTES
Characteristics:	**Vascular C.T. membrane that wraps the cartilage** Composed of 2 layers: ***a) Outer fibrous layer:*** **Dense Fibrous C.T.** ***b) Inner chondrogenic layer:*** **Contains chondroblasts (No lacunae) they secrete cartilage matrix and give rise to chondrocytes**	• **Homogeneous and basophilic.** • **Contains collagen type II.** [makes the cartilage basophilic – blue]	• **Found in spaces called lacunae.** [it's the space between the cell membrane & capsule (which is formed of condensed matrix)] • ***Young chondrocytes*: are small & present singly in their lacunae.** • ***Mature chondrocytes*: are large, and are found singly or in groups of 2, 4 or 6 cells in their lacunae (cell nests).**
Function:	• **Nutritive function: by diffusion from its blood vessels because it is vascular.** • **Chondrogenic function.** [Chondroblast is the active cell that gives the Chondrocyte] • **Gives attachment to muscles & tendons.**		

Site	Function
Fetal skeleton	**Forms the skeleton of the fetus**
Articular surfaces of bones (in joints)	• **To protect the bones surfaces** • **To smoothen movement**
Upper respiratory tract: noes-trachea-bronchi	**Keeps the tract open**
Costal cartilage	/

Elastic Cartilage & Fibrocartilage:

	ELASTIC CARTILAGE	FIBROCARTILAGE
Microscopic view:		
Characteristics:	**Same as hyaline cartilage but this contains elastic fibers in the matrix**	• **No perichondrium.** • **Rows of chondrocytes in lacunae separated by parallel bundles of collagen fibers (type I).**
Sites:	**1. External ear.** **2. Epiglottis.** **[It moves = it need elasticity "لسان المزمار"]**	**Intervertebral Disks**

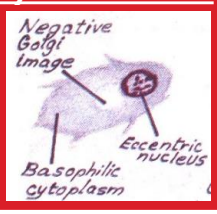
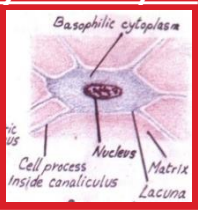
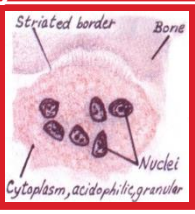
Note:

- Differentiation between hyaline and elastic cartilage in appearance of matrix in microscope:
- Hyaline: The collagen type II has the same refractory index as the ground substance so we can't see it (A person wearing blue pants and a blue shirt will look like he is wearing a blue jumper).. if we want to see the collagen type II we need a special stain, but then, the cartilage won't show.
- Elastic: Elastic fibers have a different refractory index than the ground substance, that's why we can see it (A person wearing black pants and a white shirt)

Note:

- Fibro = rich in Collagen type I
- Collagen type I is tough (like in tendons)
- The nuclei in the collagenous bundles come from the fibroblasts and fibrocytes
- Rows on chondrocyes: rare to find cell nests, restricted in the form of rows in collagen bundles, very little matrix

Bone Cells:

Bone cells:	1) Osteogenic Cells	2) Osteoblasts	3) Osteocytes	4) Osteoclasts
				
Features:	**In periosteum & endosteum**	**In periosteum & endosteum**	• **Branched cells** • **Present singly in lacunae.** • **Their branches run in the canaliculi**	• **Large multinucleated cells on bony surfaces, in Howship's lacunae** • **The have striated or ruffled boarder.** • **Cytoplasm is rich in lysosomes**
Function:	/	**They secrete the bone matrix & deposit Ca salts in it.**	**They maintain the bone matrix** [by continuous deposition of calcium salts]	**Bone resorption**
Origin:	/	**Osteogenic cells**	**Osteoblasts**	**Blood monocytes**
Fate:	**Give rise to Osteoblasts (Mother Cell)**	**Change to osteocytes**	/	/

*Just like chondrocytes; osteocytes are found in lacunae and are surrounded by a capsule. The capsule here is made of condensed hard bone.
*Then how can the cell live? The presence of CANALICULI (they are like tunnels or canals)
*Inside the canaliculi we have: Cell processes "cytoplasmic processes" → transport of nutrients between the cells ((we don't need this in cartilage because the perichondrium nurtures it by diffusion))

- The first 3 cells are called: bone forming cells
- The Osteoclasts: bone destructing cells [Clast = destruct]
- More than 50 monocytes can fuse together and give me one large osteoclast
- Function: bone resorption
  → Mainly remodeling.
  → destruction of bone cause Ca++ to leave the bone and become free in the circulation (source of calcium)
- How does it destroy bone?
- By secretion of: Acids & Enzymes → dissociation of calcium
- ((Rich in lysosomes because monocytes are rich in lysosomes))

Compact Bone:

- **Found in: Diaphysis of long bones**
- Very thick with little or no spaces
- **Contains:**

*Bone is highly vascular.
*If someone suffers from bone fraction they are told not to move. Why? To prevent:
1) neurogenic shock that causes pain.
2) Bleeding – because the fractured bones have sharp edges that can cut blood vessels & nerves.

Periosteum

- *Outer fibrous layer*
- *Inner osteogenic layer*

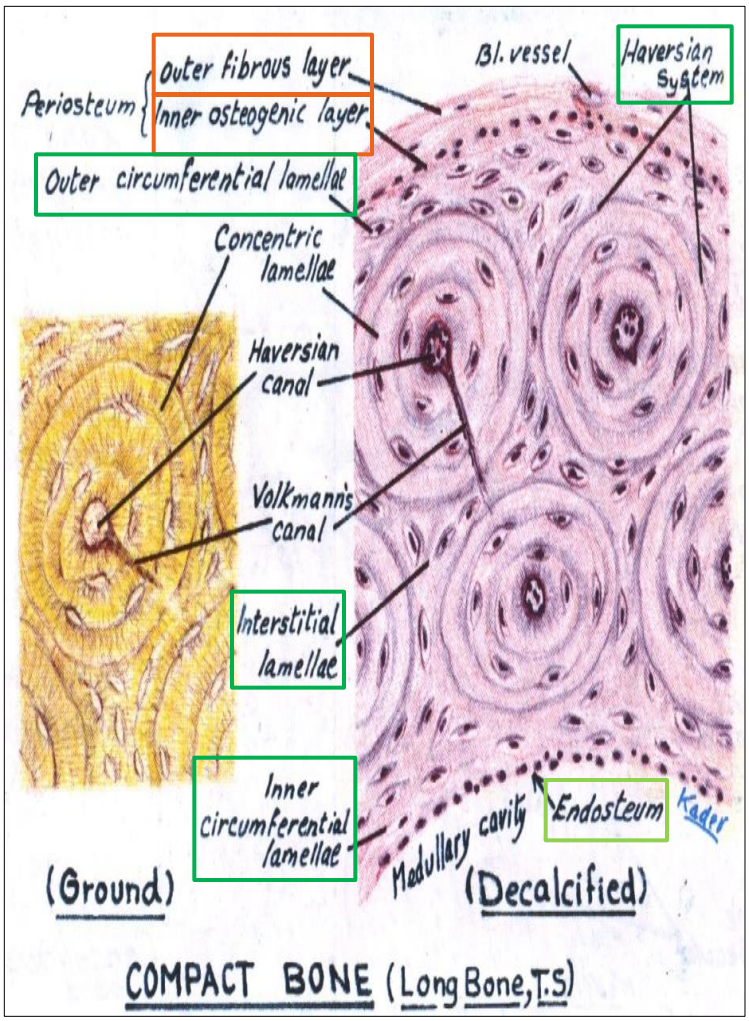
Endosteum

Bone lamellae

- *Haversian system (osteons)*
- *External Circumferential Lamellae.*
- *Internal Circumferential Lamellae.*
- *Interstitial Lamellae*

Bone Cells

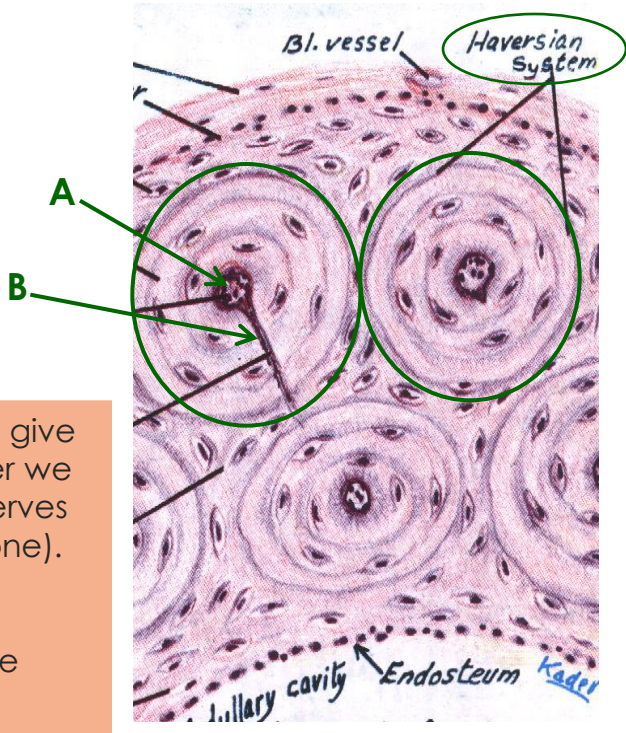
- *Osteogenic cells*
- *Osteoblasts*
- *Osteocytes*
- *osteoclasts*



Compact Bone:

Bone Lamellae

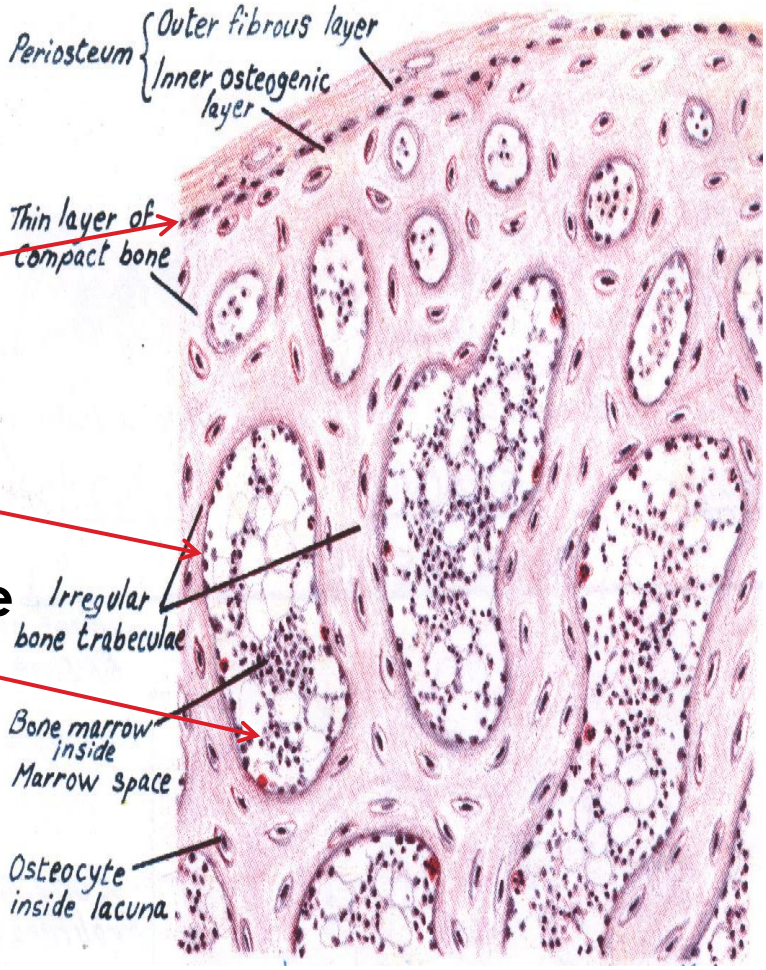
- **Haversian System (Osteons)**
  - Longitudinal cylinders.
  - Each is formed of concentric bone lamellae & a Haversian canal **(A)**, running in the center.
  - Volkmann's canals **(B)**: connect the Haversian canals together. They run obliquely or transversely.
- **External Circumferential Lamellae**
- **Internal Circumferential lamellae**
- **Interstitial Lamellae**



It is made up of: Haversian system (Osteons) – they give support. They are cylindrical columns. In the center we have canals called **Haversian Canals** that carry nerves and blood vessels (they run longitudinally in the bone). Around it we have ground substance
Canaliculi between the osteocytes in the same haversian system: (Osteocytes near the canal have arms that reach the blood vessels, and the further osteocytes have arms that reach the previous osteocytes, then the furthest osteocytes have arms that reach the previous osteocyte.)
Volksman's Canals between the harvisian canals from different systems. (the run transversely in the bones)

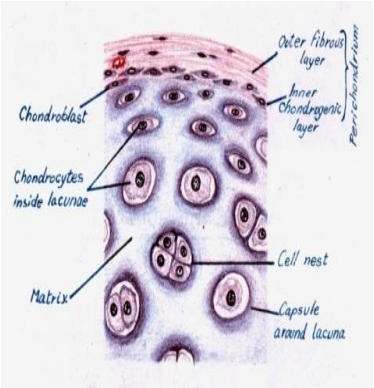
Spongy (Cancellous) Bone:

- **Found in**: In **flat bones & epiphysis of long bones**.
- **Consists of:**
  - Periosteum.
  - Endosteum.
  - Irregular bone trabeculae.
  - Many irregular bone marrow spaces.
  - Bone Cells.
- **No Haversian systems** (no osteons).



Growth of Cartilage

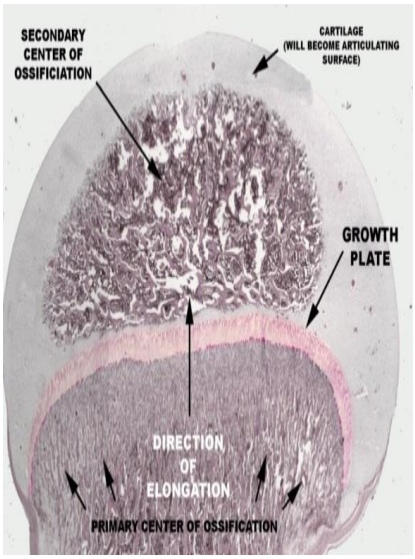
- **Appositional growth:**
  - Is produced by the activity of Chondroblasts in the inner chondrogenic layer.
  - It leads to increase in width.
- **Interstitial growth:**
  - Is produced by division and activity of mature chondrocytes.
  - It leads to increase in length.



- Appositional growth = additional growth from the outside layer of the cartilage (in perichondrium) due to: increase in chondroblast: 5,6,8.. Layers
- Interstitial growth = due to division from the core of the cartilage

Growth of Bone

- **Appositional growth:**
  - Is produced by the activity of osteoblasts.
  - It leads to increase in width.
- **Growth in length:**
  - Is produced by the activity of epiphyseal plate of cartilage.



- Appositional growth: Actual growth of the bone, by: Cartilage & Bones
- Growth in length by: Cartilage (After ossification the growth become restricted and the growth in length stops. Usually at the age of 21)

MCQs

1)the cartilage is a specialized type of smooth tissue

a)True b)False

2)the perichondrium of hyaline cartilage has a non vascular connective tissue membrane

a)True b)False

3) The matrix of bone is:

a)Loose b)Flexible c)Rigid d)Hard

4)appositional growth of bone is produced by:

a)Osteoblasts b)osteoclasts c)Osteocytes d)Osteogenic cells

5) all of the following are located in periosteum and endosteum of bone except :

a)Osteogenic Cells b)Osteoblasts c)Osteoclasts

6)Interstitial growth of cartilage leads to:

a)Increase in width b)Increase in length c)decrease in length

7)Elastic cartilage is found in:

a)External Ear b)Trachea & Bronchi c)Intervertebral disks

8)Fibrocartilage is rich with which type of cartilage?

a)Elastic fibers b)collagen type I c)collagen type II

9)Osteoclasts are rich in:

a)Mitochondria b)lysosomes c)ER

10)The central canal in compact bone that runs longitudinally is called:

a)Haversian canal b)Volkmann's canal c)Lamellae

Answers: 1)b 2)b 3)d 4)a 5)c 6)b 7)a 8)b 9)b 10)a

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Good Luck! ☺