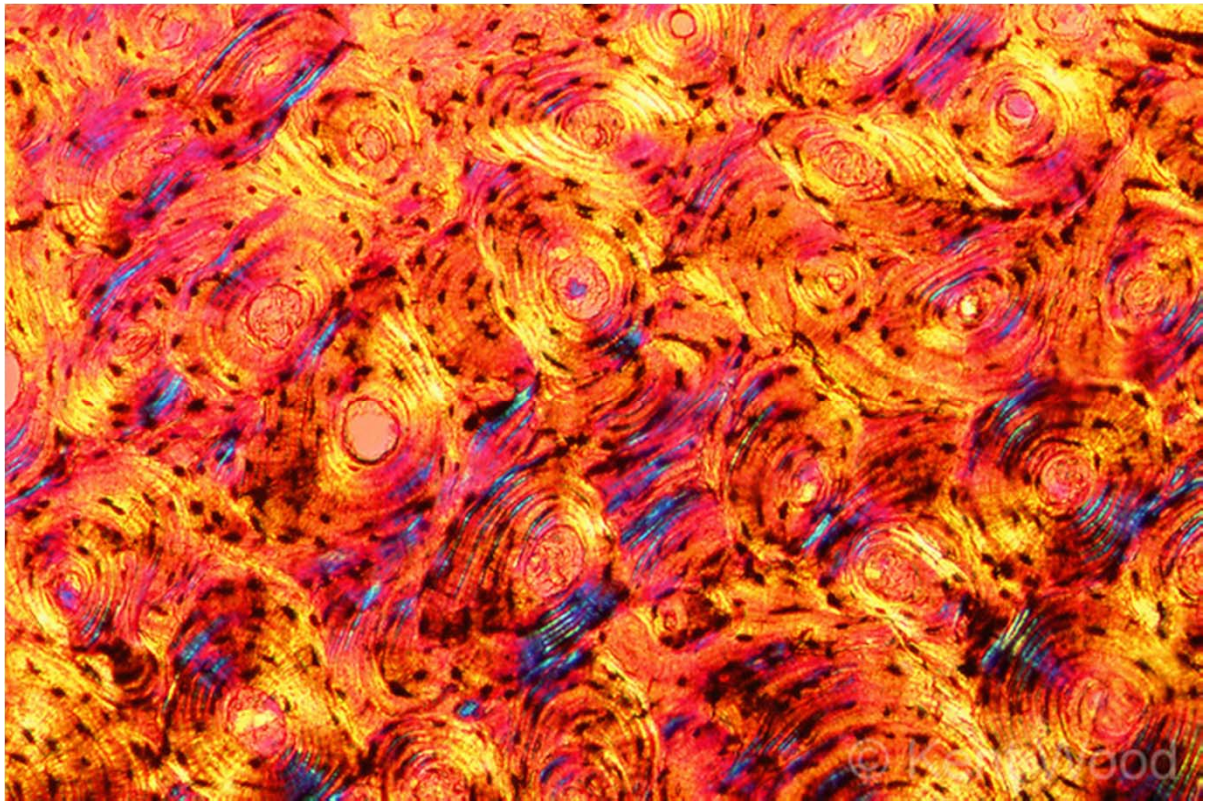
Lab 6 – Cartilage and Bone

A560 – Fall 2015

Cartilage and Bone



Light micrograph of human bone in cross section under polarized light – Kent Wood Photography

Lab 6 – Cartilage and Bone

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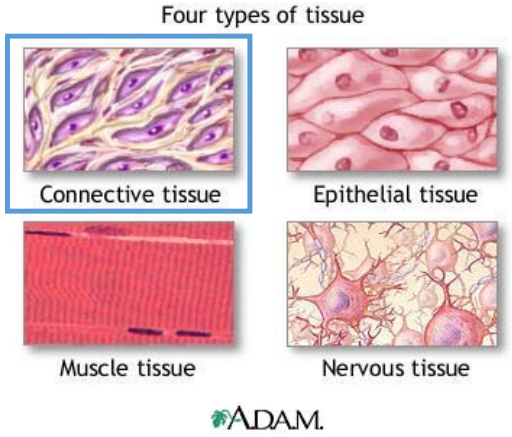

Cartilage and Bone

1. **Cartilage** is a specialized type of solid connective tissue which, along with bone, is distinguished by its relative rigidity of the extracellular matrix (ECM); it is distinguishable from bone by its *avascularity*

2. Types of cartilage (hyaline, fibrocartilage, elastic) are distinguished by the characteristics of their matrix (e.g., the dominant type of protein fiber)

3. **Bone** is a specialized type of solid connective tissue characterized by a *mineralized ECM* that stores calcium and phosphate

4. Woven (immature) bone differs from lamellar (mature) bone in its collagen fiber arrangement; woven bone is replaced by lamellar bone in adults, with few exceptions

Lab 6 – Cartilage and Bone

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Learning Objectives

1. Understand the variations in structure and function of the three major types of cartilage, with regard to both the cellular and extracellular elements.

2. Understand the key ultrastructural features of the chondroblast and how they relate to function.

3. Understand the structural features and functions of osteogenic cells: osteoblasts, osteocytes, and osteoclasts.

4. Know the major differences in structure and function between woven and lamellar bone, and between compact and cancellous bone.

5. Understand the structure and composition of an osteon and how it is formed.

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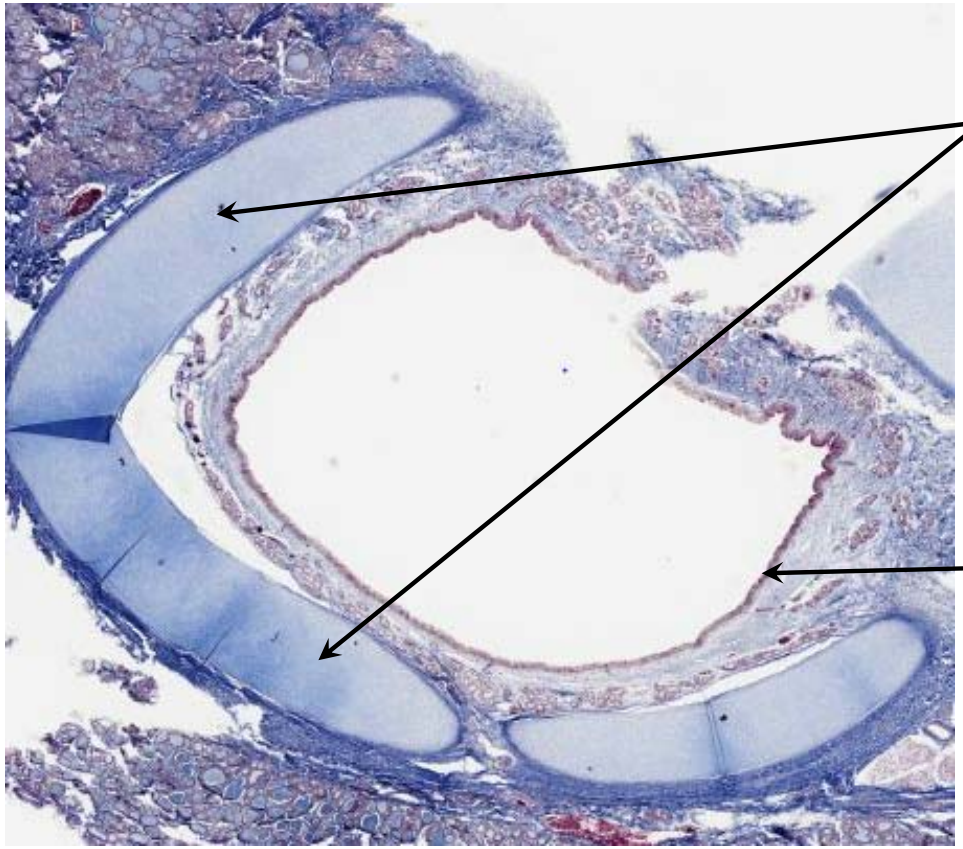
I. Introduction
II. Learning Objectives
III. **Slides and Micrographs**
  A. **Cartilage**
    1. **Hyaline**
    2. Fibrocartilage
    3. Elastic
  B. Bone
    1. Woven
    2. Lamellar
      a. Compact
      b. Cancellous (seen later)
IV. Summary

Slide 2: Trachea, Trichrome



Look here for **hyaline cartilage**

What kind of epithelium is present here?

Lab 6 – Cartilage and Bone

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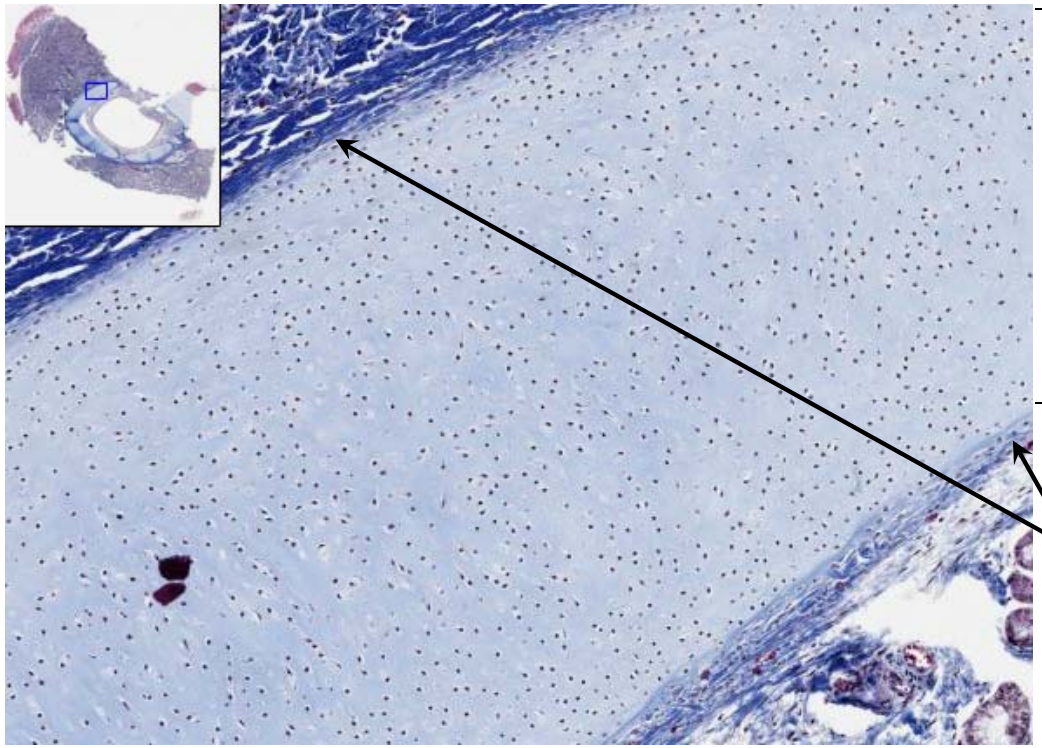
IV. Summary

Slide 2: Trachea, Trichrome



Hyaline cartilage, the most common type, contains the smallest proportion of fibers in the ECM – giving it a homogenous, glassy appearance; it is rich in *Type II collagen* and *aggrecan* complexes (chondroitin sulfate and keratan sulfate) with bound water

Lab 6 – Cartilage and Bone

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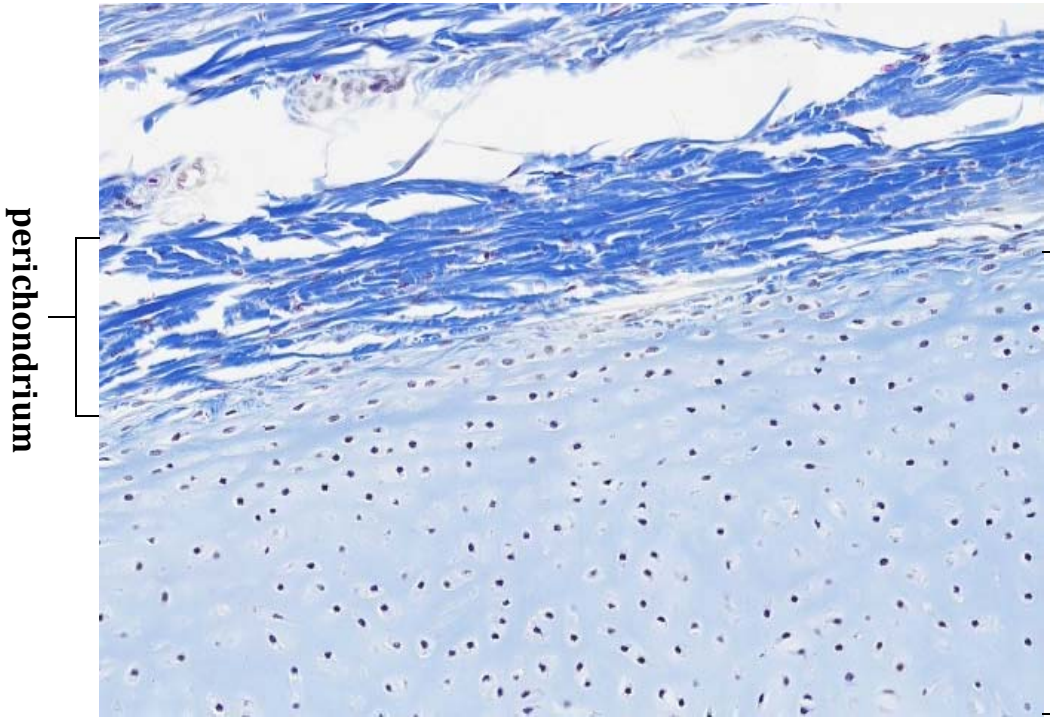
Slide 2: Trachea, Trichrome



Perichondrium is dense CT essential for the growth and maintenance of cartilage; it consists largely of *Type I collagen* and fibroblasts, which act as progenitor cells for chondroblasts that divide and differentiate into chondrocytes; *hyaline is generally surrounded by perichondrium expect as articular cartilage and at epiphyseal plates; elastic cartilage also has perichondrium, but fibrocartilage does not*

Lab 6 – Cartilage and Bone

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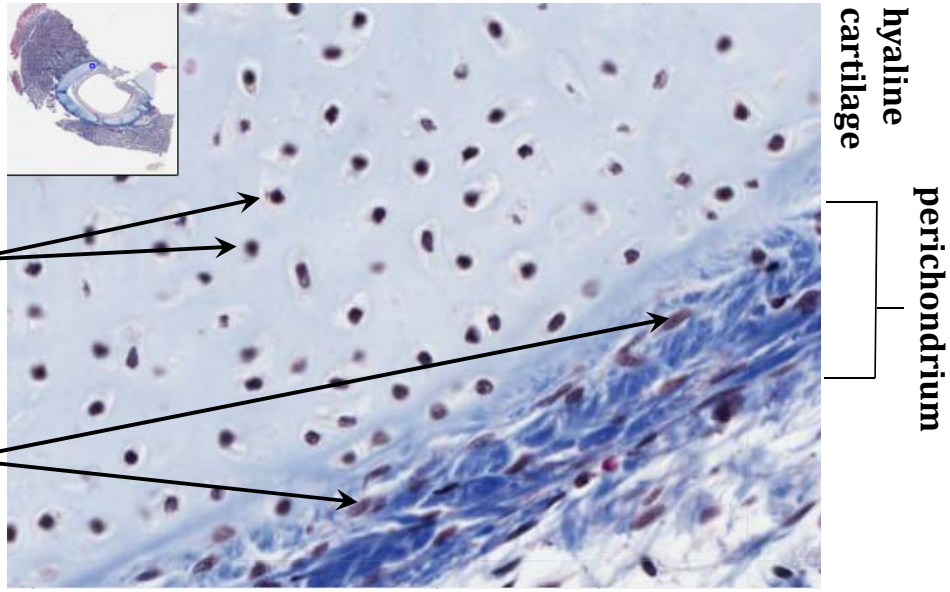
Slide 2: Trachea, Trichrome



Dividing cells are called **chondroblasts** and **chondrocytes** once proliferation has ceased; both have *basophilic cytoplasm rich in rER* for collagen synthesis; production of the ECM encloses the cells in their lacunae (Lt. "*little lake*"); chondrocytes synthesize and maintain ECM components

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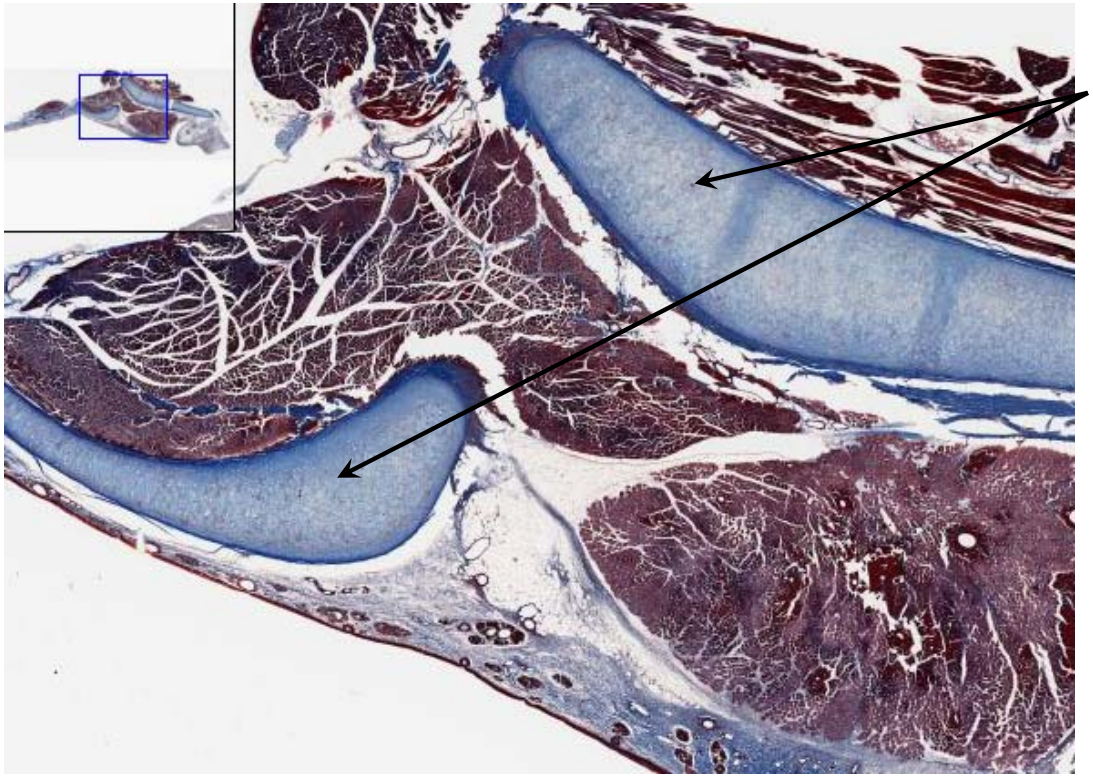
IV. Summary

Slide 7: Larynx, Trichrome



look here for
hyaline cartilage

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      a. Compact
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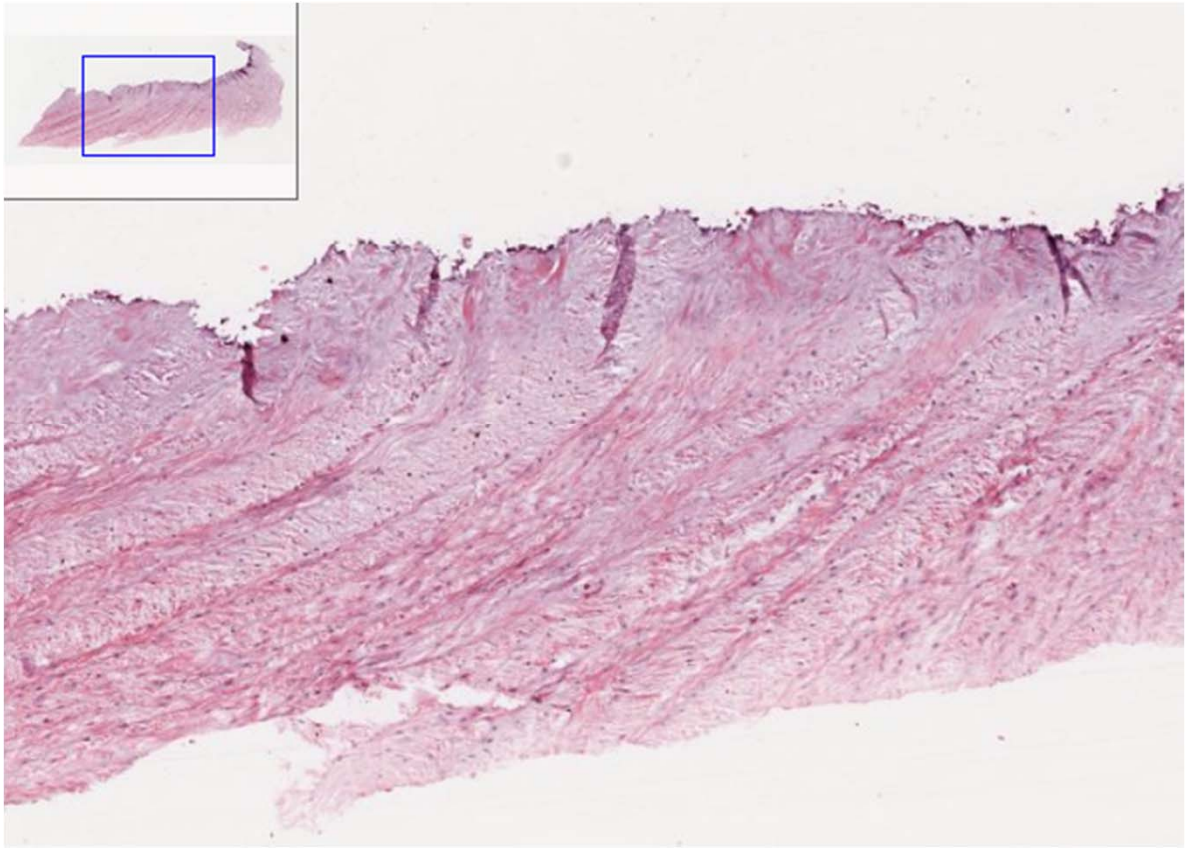
IV. Summary

Slide 131: Fibrocartilage, H&E



Lab 6 – Cartilage and Bone

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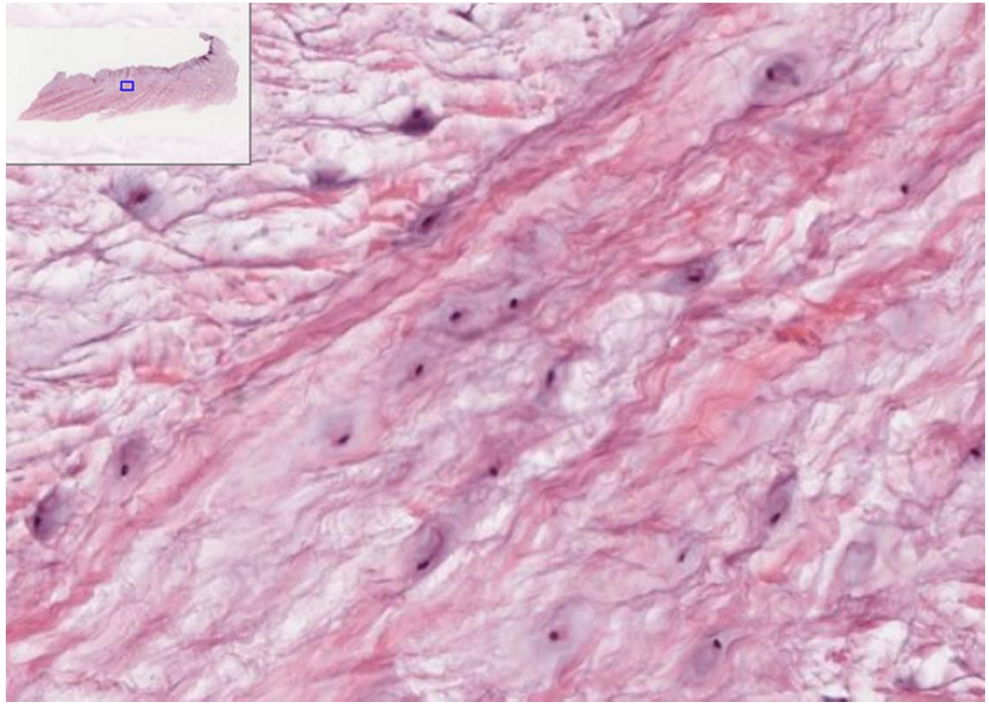
IV. Summary

Slide 131: Fibrocartilage, H&E



Fibrocartilage is characterized by a matrix containing a *combination of dense CT (Type I/II collagen fibers) and hyaline cartilage*; relative scarcity of proteoglycans makes the matrix of fibrocartilage *more acidophilic than that of hyaline or elastic cartilage*; there is *no distinct surrounding perichondrium* in fibrocartilage; it is found in intervertebral discs, in attachments of certain ligaments, and in the pubic symphysis

Lab 6 – Cartilage and Bone

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Slide 56: Elastic Cartilage, H&E, AF

Look here for **elastic cartilage**

Elastic cartilage is *essentially similar to hyaline cartilage* except that it contains an abundant network of elastic fibers in addition to Type II collagen; visualization of the elastic fibers usually requires special stains; it is found in the auricle of the ear, the walls of the external auditory canals, the auditory (Eustachian) tubes, the epiglottis, and the cuneiform cartilage in the larynx

Lab 6 – Cartilage and Bone

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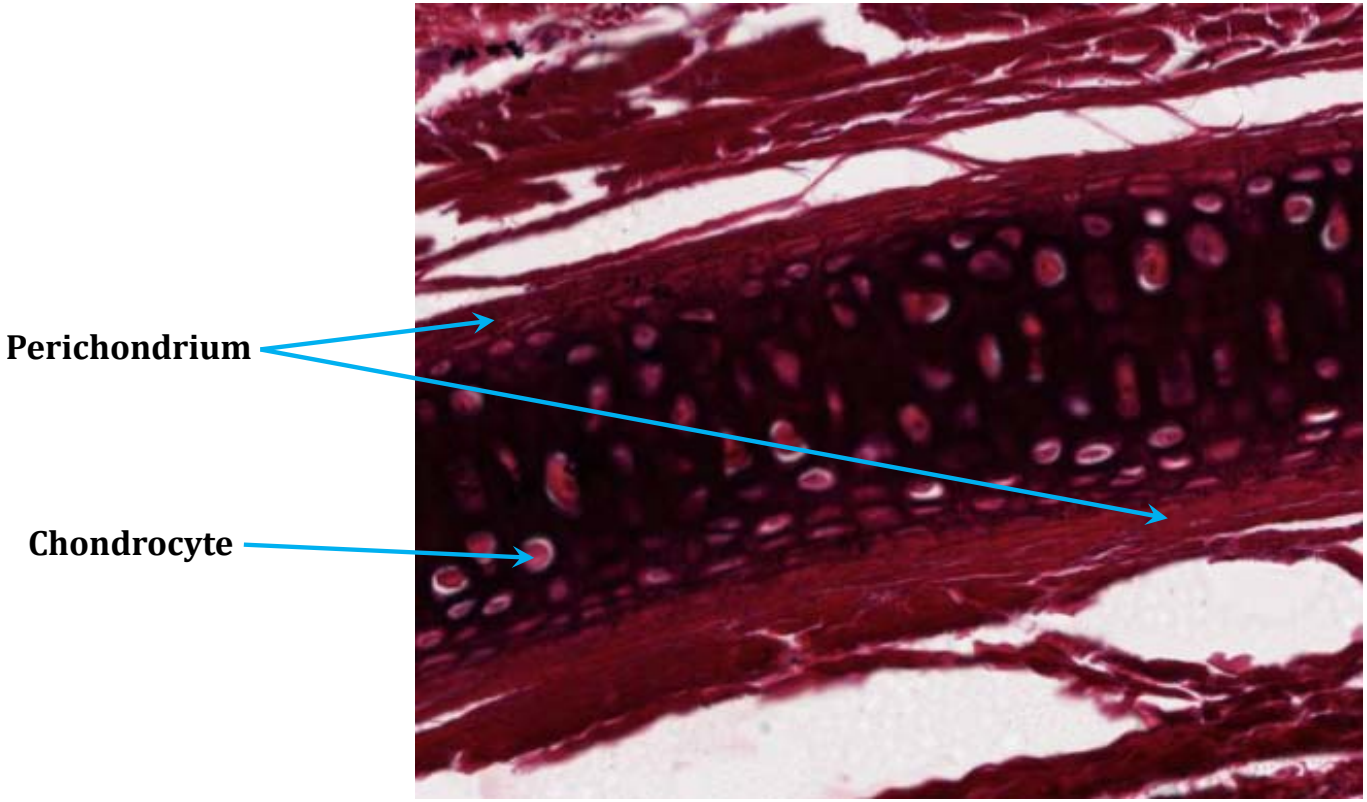
Slide 56: Elastic Cartilage, H&E, AF



Lab 6 – Cartilage and Bone

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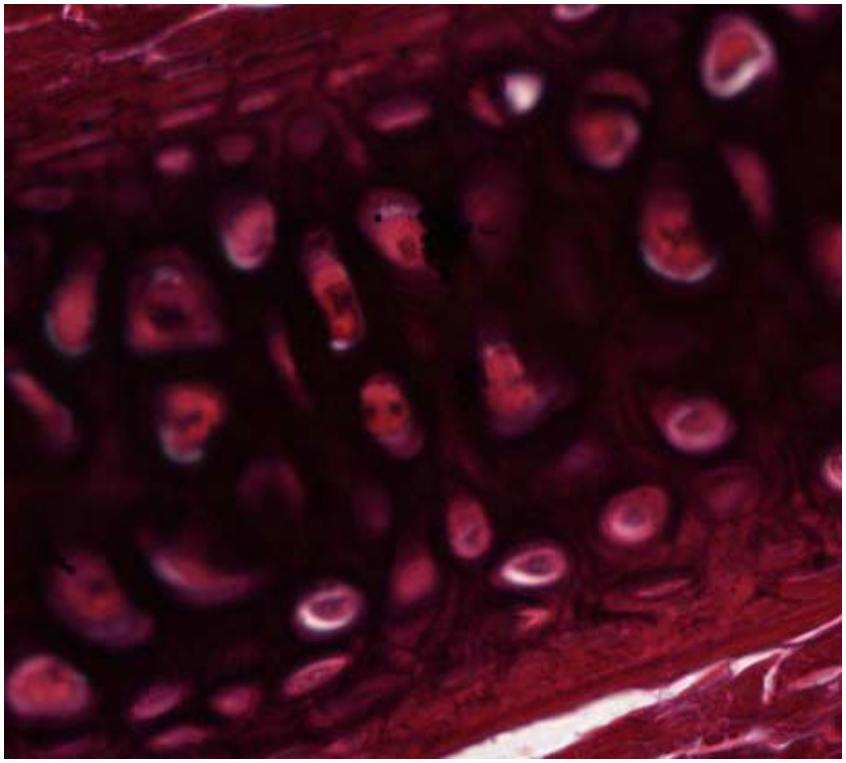
Slide 56: Elastic Cartilage, H&E, AF

Dark area around cells = **elastic fibers**



Lab 6 – Cartilage and Bone

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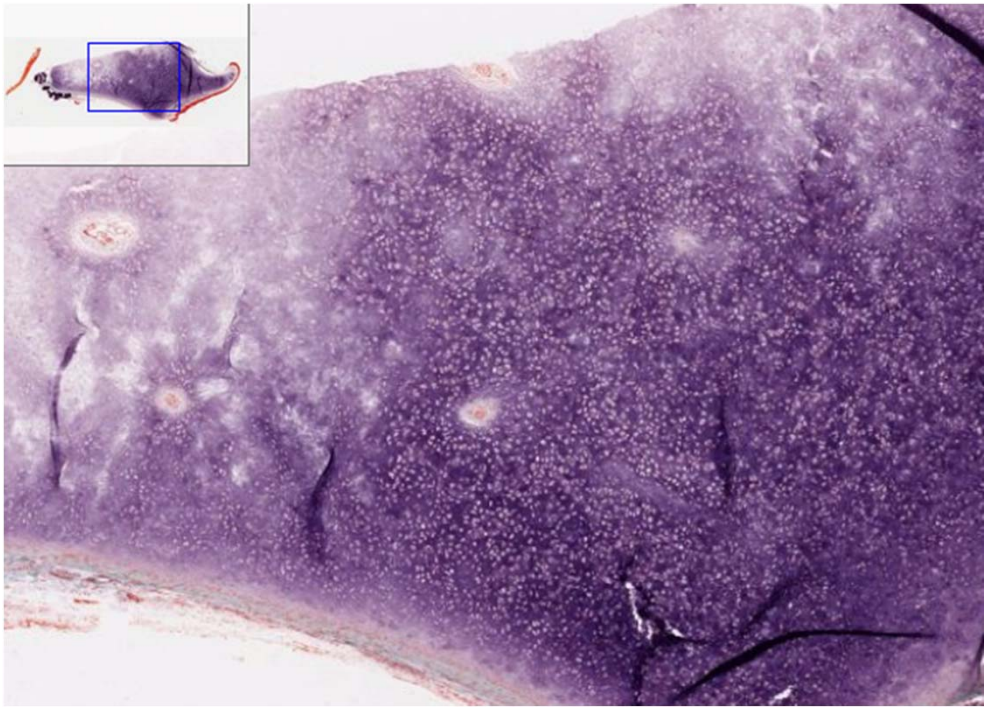
Slide 87: Epiglottis, Masson AF



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I. Introduction
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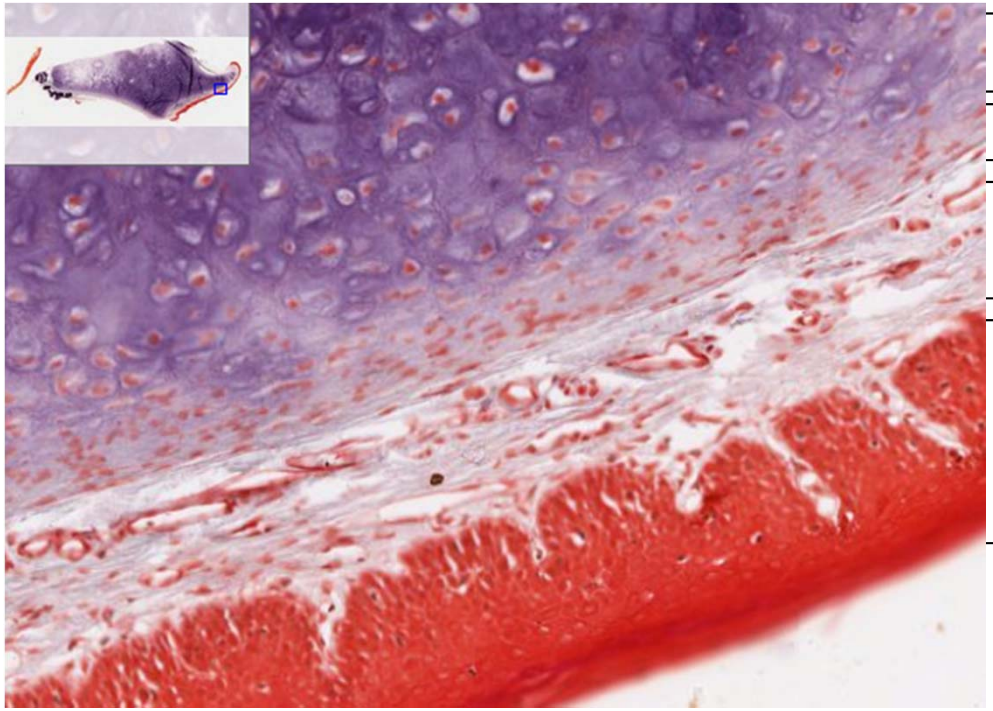
    3. **Elastic**
  B. Bone
    1. Woven
    2. Lamellar
      a. Compact
      b. Cancellous (seen later)
IV. Summary

Slide 87: Epiglottis, Masson AF



Lab 6 – Cartilage and Bone

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  A. Cartilage
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  B. **Bone**
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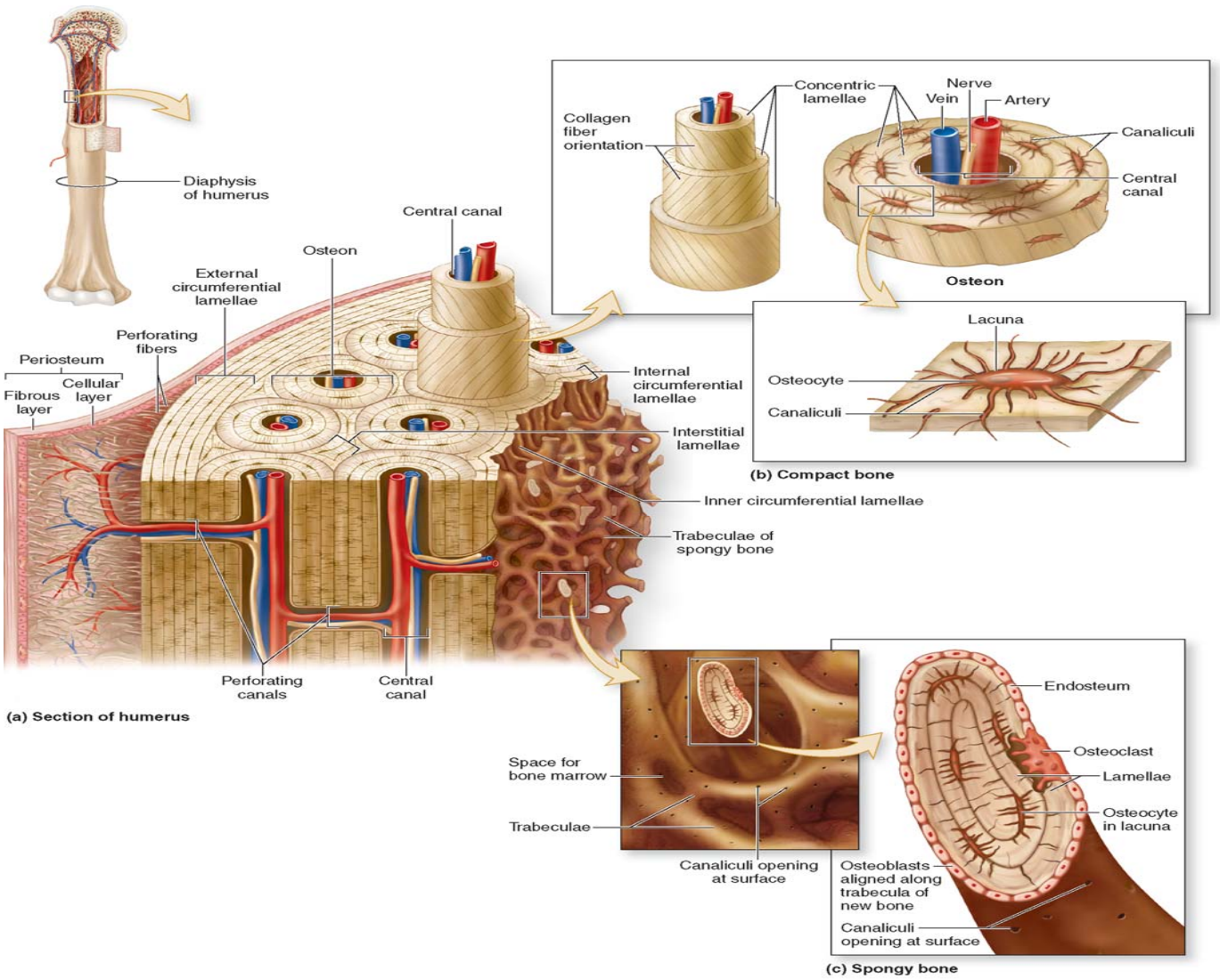

Lab 6 – Cartilage and Bone

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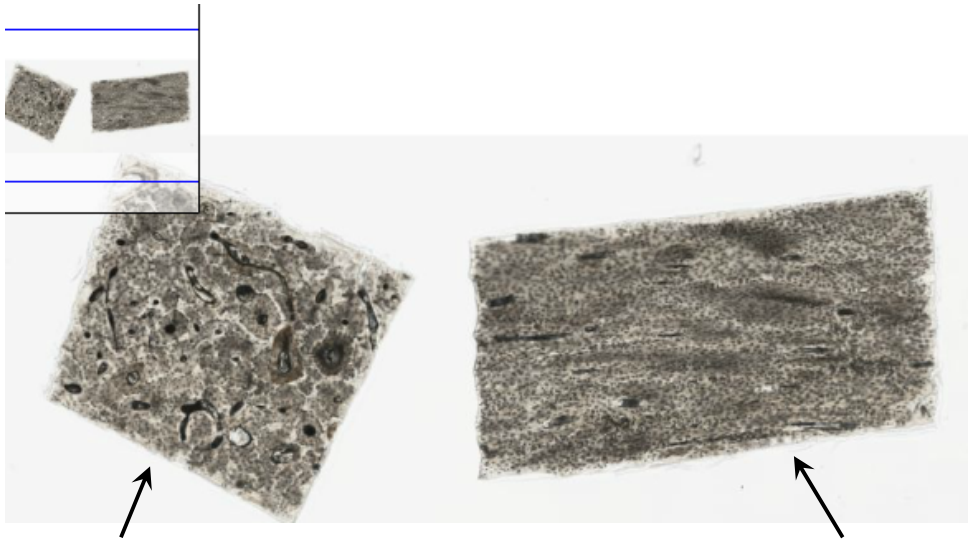
Slide 32: Ground Bone



Transverse section

Longitudinal section

Lab 6 – Cartilage and Bone

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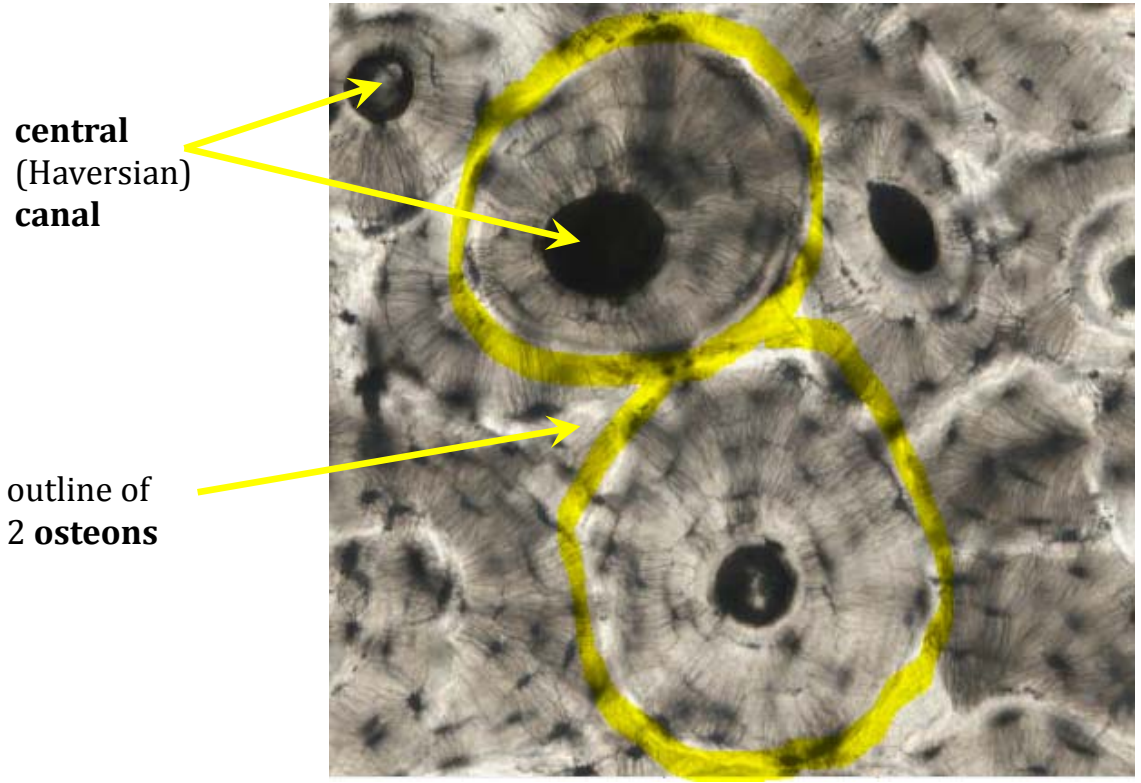
Slide 32: Ground Bone

Transverse section



Most **lamellar bone** (remodeled from woven bone; matrix deposited in distinct layers with parallel collagen bundles) consists of lamellae organized concentrically around small **central canals** containing blood vessels and nerves; this organization is called an **osteon** or **Haversian system**

Lab 6 – Cartilage and Bone

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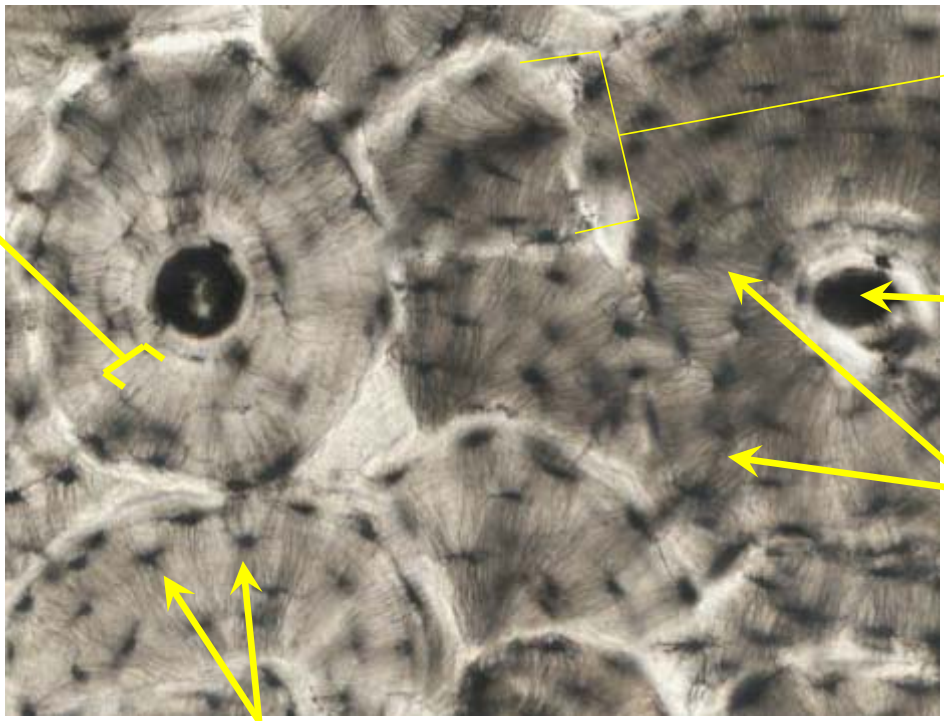
Slide 32: Ground Bone

Transverse section



Within each **osteon**, osteocytic **lacunae** occur *between the lamellae*, with **canaliculi** (Lt. "*small channels*") radiating through the lamellae, which *allow all cells to communicate with the central canal*; interstitial lamellae are remnants of osteons partially resorbed during bone remodeling

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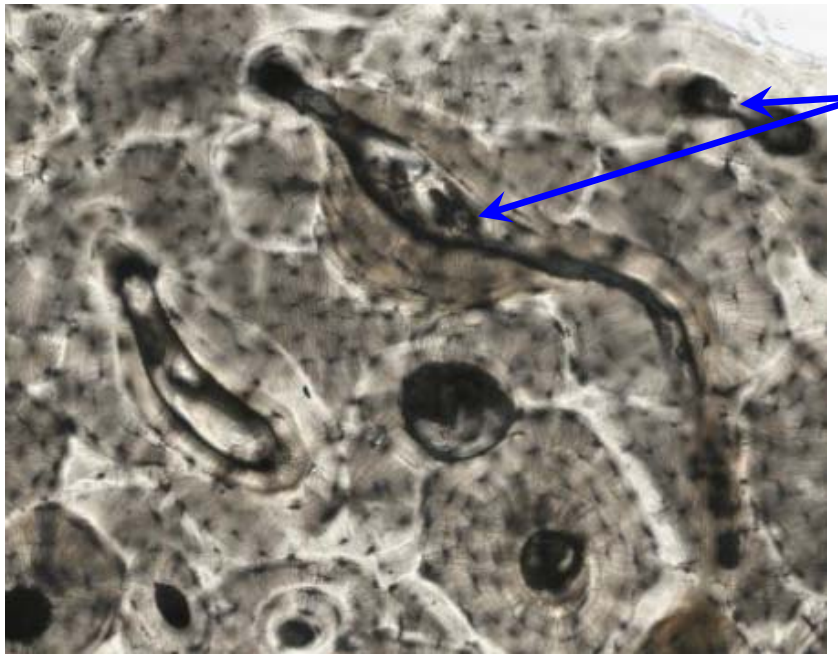
Slide 32: Ground Bone

Transverse section



Perforating canals carry neurovascular bundles from the periosteum into the bone and provide *links between central (haversian) canals*

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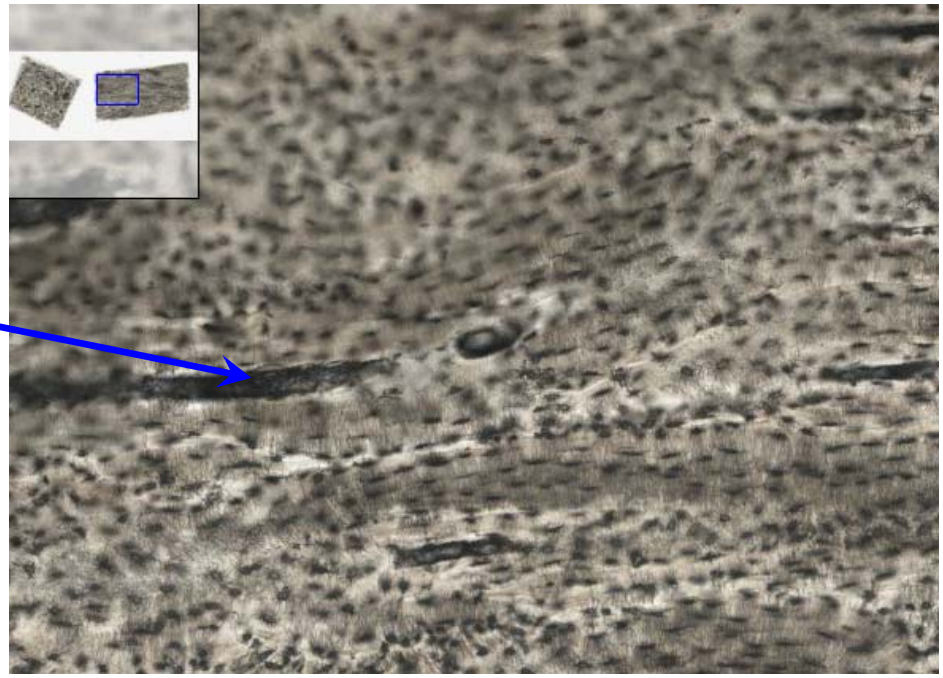
   B. **Bone**
      1. Woven
      2. Lamellar
         a. **Compact**
         b. Cancellous (seen later)
IV. Summary

Slide 32: Ground Bone

Longitudinal section

central canal



Lab 6 – Cartilage and Bone

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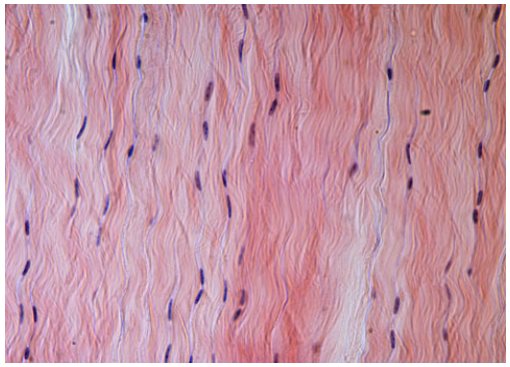
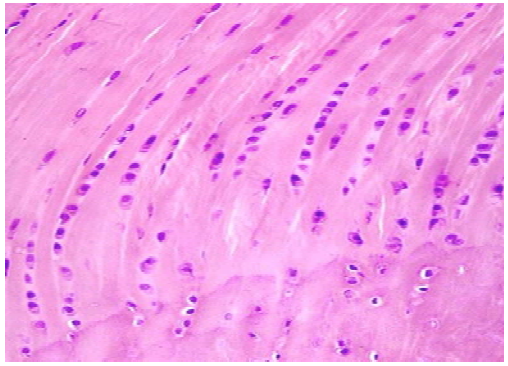
Common Confusion:
Dense regular CT vs. Fibrocartilage



Dense regular CT

Dense regular connective tissue: prominent in tendons and ligaments; collagen bundles and fibroblasts aligned in parallel for resistance to prolonged or repeated stresses

Look for: (1) parallel, closely packed bundles of collagen separated by very little ground substance; (2) fibroblasts are relatively sparse and have elongated nuclei lying parallel to the fibers; (3) cytoplasm of fibroblasts is rarely revealed in H&E stains



Fibrocartilage

Fibrocartilage: found in intervertebral discs, in attachments of certain ligaments, and in the pubic symphysis; essentially a combination of hyaline cartilage and dense connective tissue

Look for: (1) chondrocytes usually appear in linear clusters surrounded by cartilage matrix; (2) nuclei are more oval/round and euchromatic; (3) perinuclear cytoplasm is evident; (4) *lacunae* are usually visible

Lab 6 – Cartilage and Bone

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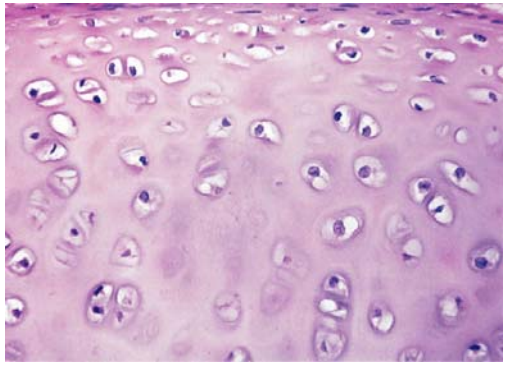
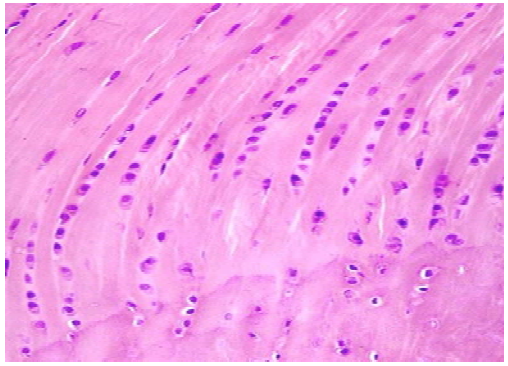
Common Confusion:
Hyaline vs. Fibrocartilage



Hyaline cartilage

Hyaline cartilage: most common form of cartilage; located in the articular surfaces of movable joints, in the walls of larger respiratory passages, in the ventral ends of ribs, and in the epiphyseal plates of long bones

Look for: (1) homogenous, slightly basophilic matrix; (2) lacunae often contain two or more chondrocytes (isogenous group); (3) lacunae immediately rimmed with basophilic matrix (less collagen, more GAGs); (4) generally surrounded by perichondrium (not seen here)



Fibrocartilage

Fibrocartilage: found in intervertebral discs, in attachments of certain ligaments, and in the pubic symphysis; essentially a combination of hyaline cartilage and dense connective tissue

Look for: (1) collagen fibers in eosinophilic matrix; (2) usually only individual chondrocytes in lacunae; (3) lacunae arranged in rows or clusters; (4) lack of perichondrium

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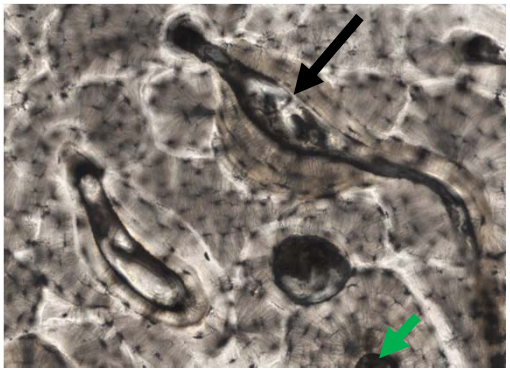
Common Confusion:
Central vs. Perforating canals



Slide 32, Ground bone, Transverse

Transverse section: sectioned perpendicular to osteons, so long canals (black arrow) are perforating canals connecting central canals of osteons

Look for: (1) *lamellae* surrounding central canals of osteons (green arrow); (2) osteocytes (lacunae) are oriented in multiple directions representing multiple different lamellae and osteons

Slide 32, Ground bone, Longitudinal

Longitudinal section: sectioned parallel to osteons, so long canals (black arrow) are central canals of osteons

Look for: (1) *lack of lamellae*; (2) osteocytes (lacunae) may appear in straight lines all of which are generally parallel to the canal

Lab 6 – Cartilage and Bone

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Summary

1. **Cartilage** is a specialized type of solid connective tissue that, along with bone, is distinguished by its relative rigidity of the extracellular matrix (ECM); it is distinguishable from bone by its avascularity, also lacking lymphatics and nerves

2. Mesenchymal cells differentiate into **chondroblasts** which begin secreting cartilage matrix; once surrounded, they are called **chondrocytes**, each occupying a lacuna (space in the matrix)

3. Types of cartilage (**hyaline**, **fibrocartilage**, **elastic**) are distinguished by the characteristics of their matrix (e.g., the dominant type of protein fiber); except for fibrocartilage, most cartilage is surrounded by dense CT called **perichondrium**

4. **Bone** is a specialized type of solid connective tissue characterized by a mineralized ECM that stores calcium and phosphate

5. Woven (immature) bone differs from lamellar (mature) bone in its collagen fiber arrangement; woven bone is replaced by lamellar bone in adults, with few exceptions

6. The functional unit of compact bone is the **osteon**, consisting of a **central canal** (containing a neurovascular bundle) and concentric rings of bony matrix called **lamellae** (osteocytes occupy lacunae between lamellae)

Lab 6 – Cartilage Memory Matrix

	Hyaline Cartilage	**Elastic Cartilage**	**Fibrocartilage**
Locations			
Function			
Perichondrium?			
Cell Types Present			
ECM Characteristics			