

BIO 211:
ANATOMY & PHYSIOLOGY I



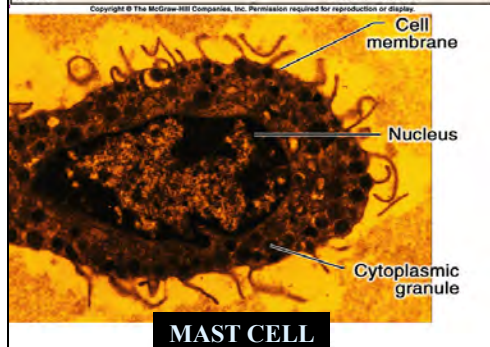
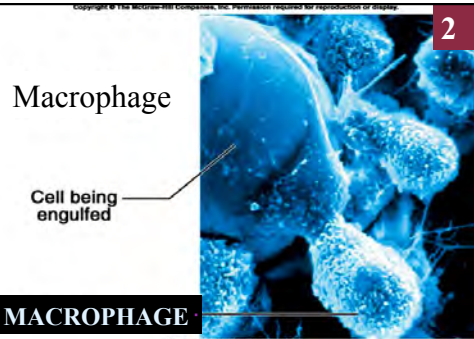
CHAPTER 05
Histology:
CONNECTIVE
TISSUE

Dr. Lawrence G. Altman
www.lawrencegaltman.com
Some illustrations are courtesy of McGraw-Hill.



Table 5.6 Components of Connective Tissue

| Component | Characteristic | Function |
|-----------------------------------|--|--|
| Fibroblast | Widely distributed, large, starshaped cells | Secrete proteins that become fibers |
| Macrophages | Motile cells sometimes attached to fibers | Clear foreign particles from tissues by phagocytosis |
| Mast cells | Large cells, usually located near blood vessels Think HISTAMINE !! | Release substances that may help prevent blood clotting and promote inflammation |
| Collagenous fibers (white fibers) | Thick, threadlike fibers of collagen with great tensile strength | Hold structures together |
| Elastic fibers (yellow fibers) | Bundles of microfibrils embedded in elastin | Provide elastic quality to parts that stretch |
| Reticular fibers | Thin fibers of collagen | For supportive network within tissues |



OVERVIEW of CONNECTIVE TISSUE:

3

Functionally diverse, CONNECTIVE TISSUE:

- binds organs**
- provides support**
- facilitates movement**
- protects**
- provides immune defense**
- stores energy and minerals**
- helps to produce heat**
- transports within the bloodstream.**

Early embryonic tissue gives rise to mesenchyme, which in turn, produces most of the permanent connective tissue (+ muscle).

A *second* embryonic connective tissue is mucous connective tissue that is limited to Wharton's jelly that fills and supports tissues of the umbilical cord. It is a temporary tissue.

OVERVIEW of CONNECTIVE TISSUE:

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Components of Fibroconnective Tissue:

CELLS

- a. **Fibroblasts** are the most common cells of connective tissue. They are large, flat, branching cells that produce fibers and ground substance.
- b. **Histiocytes** are the macrophages of connective tissue.
- c. **Leukocytes**, esp. neutrophils, reside in connective tissue/react against bacteria, toxins, & foreign matter.
- d. **Plasma cells** produce antibodies and are only found in inflamed tissue and the wall of the digestive tract.
- e. **Mast cells**, found near blood vessels, produce heparin and histamine.
- f. **Adipocytes** (fat cells) appear in some types of fibroconnective tissues.

OVERVIEW of CONNECTIVE TISSUE:

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Components of **Fibroconnective** Tissue:

FIBERS

Fibers are made of **protein**. **Three types** are found in CT:

1. **Collagenous fibers** are tough, flexible, and resist stretching. Collagen constitutes 25% of the body's protein. These are also called **white fibers**.
2. **Reticular fibers: thin collagen fibers** in reticular CT.
3. **Elastic fibers** are made of the stretchy protein **elastin**. These are also called **yellow fibers**.

Ground Substance

Components: **tissue fluid, minerals, and proteoglycans**, the especially large colloidal particles that form a viscous tissue gel.

In **bone**, tissue gel is made up of **chondroitin sulfate**;

In **fibroconnective tissue**, **hyaluronic acid** comprises the gel tissue.

OVERVIEW of CONNECTIVE TISSUE:

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There are **two** broad types of **FIBROCONNECTIVE Tissue**:

1. Loose Connective Tissue



- a. AREOLAR
- b. RETICULAR
- c. ADIPOSE

2. Dense Connective Tissue

- a. DENSE REGULAR
- b. DENSE IRREGULAR

LOOSE CONNECTIVE TISSUE: AREOLAR

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"loose" = *relatively scarce fiber distribution.*

ATLAS: Figure 12b (Morton & Perry, 1998)

Gel – like matrix with *all 3 fiber types:*

reticular reticulin = non-banded form of collagen

elastic often referred to as **yellow fibers**

collagen often referred to as **white fibers**

| | | |
|---------------|---------------------------|--|
| Cells: | <u>fibroblasts</u> | production of connective tissue proper, matrix- i.e., all CT except cartilage, blood and bone |
| | <u>macrophages</u> | phagocytize bacteria |
| | <u>Mast cells</u> | histamine release; increased capillary permeability |
| | <u>WBCs</u> | a few |

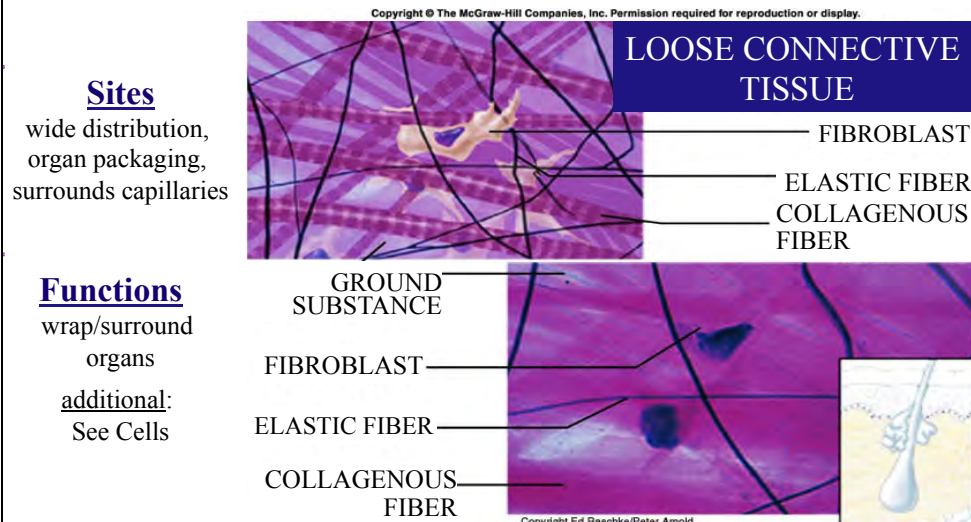
1. Loose Connective Tissue
 - a. AREOLAR
 - b. RETICULAR
 - c. ADIPOSE
2. Dense Connective Tissue
 - a. DENSE REGULAR
 - b. DENSE IRREGULAR

LOOSE CONNECTIVE TISSUE: AREOLAR

8

"loose" = *relatively scarce fiber distribution.*

ATLAS: Figure 12b (Morton & Perry, 1998)



LOOSE CONNECTIVE TISSUE: AREOLAR

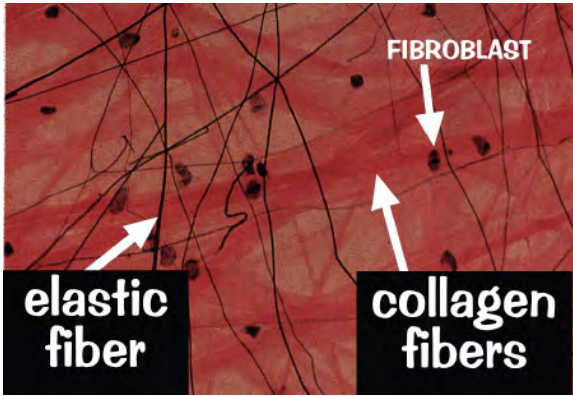
“loose” = *relatively scarce fiber distribution.*

ATLAS: Figure 12b (Morton & Perry, 1998)

Bands of collagen and elastic fibers run in all directions through intercellular spaces of subcutaneous tissue; permit flexible resistance to mechanical stress. (x100)

Lab Atlas of A&P
Eder et al.
Mosby, 1994

Another View:



The micrograph shows a network of fibers. A white arrow points to a dark, spindle-shaped cell labeled 'FIBROBLAST'. Another white arrow points to thin, dark lines labeled 'elastic fiber'. A third white arrow points to thicker, more prominent lines labeled 'collagen fibers'.

LOOSE CONNECTIVE TISSUE: RETICULAR

“loose” = *relatively scarce fiber distribution.*

ATLAS: Figures 14 b, c and d (Morton & Perry, 1998)

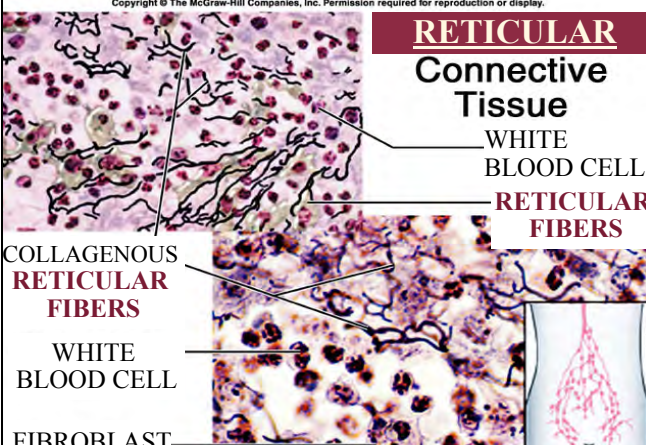
Distinctive *fiber type*: **reticular** NOTE: *fibers may branch!*
reticulin = non-banded form of collagen; sometimes called “fine collagen.”

1. Loose Connective Tissue

- a. AREOLAR
- b. RETICULAR
- c. ADIPOSE

2. Dense Connective Tissue

- a. DENSE REGULAR
- b. DENSE IRREGULAR



RETICULAR Connective Tissue

WHITE BLOOD CELL

RETICULAR FIBERS

COLLAGENOUS RETICULAR FIBERS

WHITE BLOOD CELL

FIBROBLAST

Cells: *reticular* predominate

Functions:
fibers form a soft, internal skeleton that support other cell types.

Sites:
hematopoietic; lymphoid tissues:
spleen, lymph nodes, and bone marrow.

LOOSE CONNECTIVE TISSUE: RETICULAR

11

"loose" = *relatively scarce fiber distribution.*

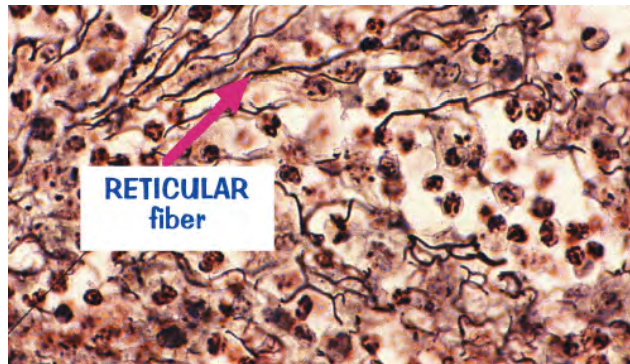
ATLAS: Figures 14 b, c and d (Morton & Perry, 1998)

1. Loose Connective Tissue
 - a. AREOLAR
 - b. RETICULAR
 - c. ADIPOSE
2. Dense Connective Tissue
 - a. DENSE REGULAR
 - b. DENSE IRREGULAR

Another View:

Mesh of reticular fibers appear as dark lines; provides scaffold for cellular organization.

From lymph node (X250)



Lab Atlas of A&P
Edet. et al.
Mosby, 1994

LOOSE CONNECTIVE TISSUE: ADIPOSE

12

"loose" = *relatively scarce fiber distribution.*

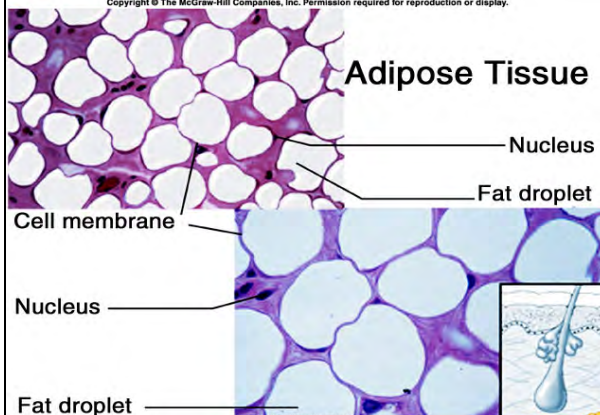
ATLAS: Figures 13 c, d and e (Morton & Perry, 1998)

Brown adipose + description: Figure 14 a

1. Loose Connective Tissue
 - a. AREOLAR
 - b. RETICULAR
 - c. ADIPOSE
2. Dense Connective Tissue
 - a. DENSE REGULAR
 - b. DENSE IRREGULAR

Adipocytes: matrix as in areolar but sparse;
Cells tightly packed fat cells (adipocytes)
show **nuclei pushed to side of a large fat droplet!**

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Functions:

Reserve fuel
Organ support/protection
Insulation against heat loss

Sites:

under skin
around kidneys/eyeballs
in bones
within abdomen
in breasts

LOOSE CONNECTIVE TISSUE: ADIPOSE

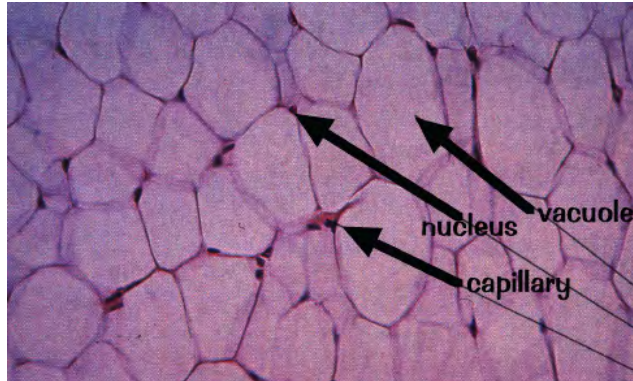
13

“loose” = *relatively scarce fiber distribution.*

ATLAS: Figures 13 c, d and e (Morton & Perry, 1998)
Brown adipose + description: Figure 14 a

Another View:

Large, polyhedral vacuoles dominate
small, displaced nuclei of
adipocytes.
Fine capillaries run through tissue
(x100)



Lab Atlas of A&P
Eder et al.
Mosby, 1994

DENSE CONNECTIVE TISSUE: REGULAR

14

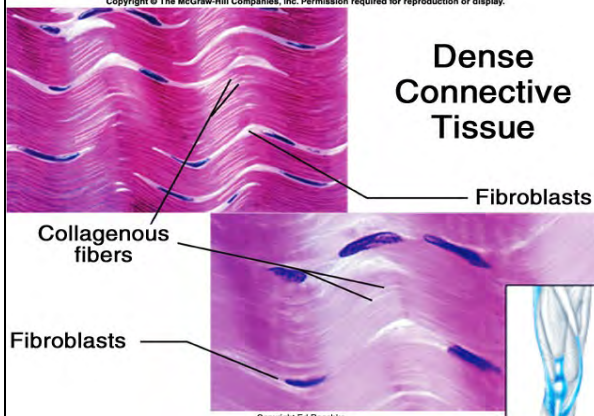
DENSE = *high fiber distribution;*
dense connective tissues are also known as “fibrous”
fibrous usually denotes mostly collagen fibers

ATLAS: Dense Regular White: Figure 12 d (Morton & Perry, 1998)
Dense Regular Elastic: Figure 13 a (Morton & Perry, 1998)

1. Loose Connective Tissue
 - a. AREOLAR
 - b. RETICULAR
 - c. ADIPOSE
2. Dense Connective Tissue
 - a. DENSE REGULAR
 - b. DENSE IRREGULAR

Major Arrangement: **parallel collagen fibers**, some elastic; **many fibroblasts**

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Dense Connective Tissue

Functions:

increased tensile strength when force applied in one direction.

Sites:

Tendon: muscle to bone

Aponeuroses: muscle to muscle

Ligaments: bone to bone
across a joint (most)

NOTE: *dense regular elastic:*

same arrangement but elastic fibers predominate:
some ligaments, arterial wall
and the larynx (voicebox).

DENSE CONNECTIVE TISSUE: REGULAR
15

DENSE = *high fiber distribution;*
dense connective tissues are also known as "fibrous"
fibrous usually denotes mostly collagen fibers

ATLAS: ▶ Dense Regular White: Figure 12 d (Morton & Perry, 1998)
 Dense Regular Elastic: Figure 13 a (Morton & Perry, 1998)

1. Loose Connective Tissue

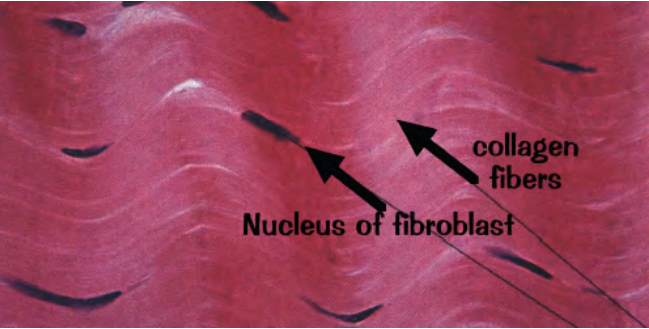
- a. AREOLAR
- b. RETICULAR
- c. ADIPOSE

2. Dense Connective Tissue

- ▶ a. DENSE REGULAR
- b. DENSE IRREGULAR

Another View:

Thicker bands of collagen running in **regular, parallel rows** resist mechanical stress mainly along course of fibers. Monkey tendon (x250)



collagen fibers

Nucleus of fibroblast

NEXT 2 Slides: Dense Regular ELASTIC >>>

Lab Atlas of A&P Eder et al. Mosby, 1994

DENSE CONNECTIVE TISSUE: REGULAR
16

DENSE = *high fiber distribution;*
dense connective tissues are also known as "fibrous"
fibrous usually denotes mostly collagen fibers

ATLAS: ▶ Dense Regular White: Figure 12 d (Morton & Perry, 1998)
 Dense Regular Elastic: Figure 13 a (Morton & Perry, 1998)

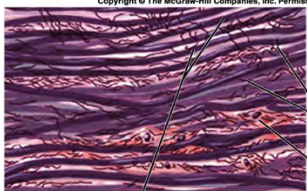
1. Loose Connective Tissue

- a. AREOLAR
- b. RETICULAR
- c. ADIPOSE

2. Dense Connective Tissue

- ▶ a. DENSE REGULAR
- b. DENSE IRREGULAR

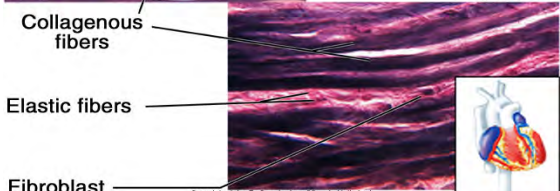
NOTE: *dense regular ELASTIC:* same arrangement but **elastic fibers** predominate
SITES: some **ligaments**, **arterial wall** and the **larynx** (voicebox).



Elastic Connective Tissue

Elastic fibers

Fibroblast



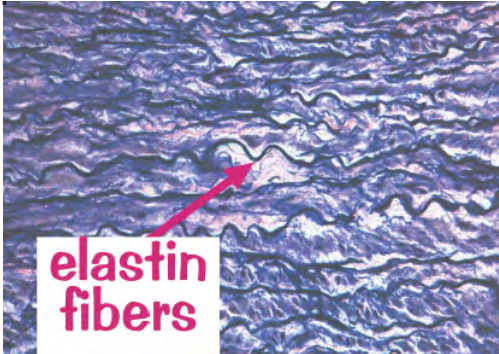
Collagenous fibers

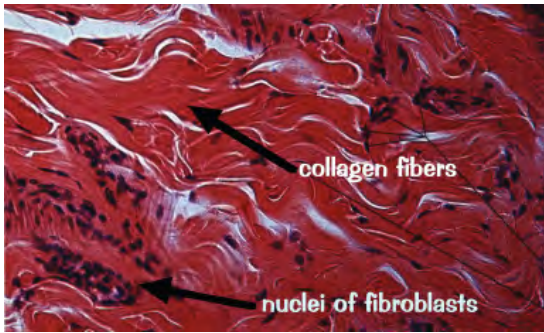
Elastic fibers

Fibroblast

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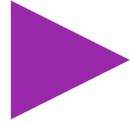
| | | |
|--|--|--|
| DENSE CONNECTIVE TISSUE: REGULAR | | 17 |
| DENSE = <i>high fiber distribution;</i> <i>dense connective tissues are also known as "fibrous"</i> <i>fibrous usually denotes mostly collagen fibers</i> | | 1. Loose Connective Tissue a. AREOLAR b. RETICULAR c. ADIPOSE 2. Dense Connective Tissue a. DENSE REGULAR b. DENSE IRREGULAR |
| ATLAS: | Dense Regular White: Figure 12 d (Morton & Perry, 1998) Dense Regular Elastic: Figure 13 a (Morton & Perry, 1998) | |
| NOTE: | <i>dense regular ELASTIC:</i> same arrangement but elastic fibers predominate SITES: some ligaments, arterial wall and the larynx (voicebox). | |
| <p>Another View:</p> <p>Extracellular elastin fibers running parallel in a plane. Structure permits tissue elasticity and recoil.</p> <p>From aorta (X100)</p> |  | |
| | | <small>Lab Atlas of A&P</small> |

| | | |
|---|--|---|
| DENSE CONNECTIVE TISSUE: IRREGULAR | | 18 |
| DENSE = <i>high fiber distribution;</i> <i>dense connective tissues are also known as "fibrous"</i> <i>fibrous usually denotes mostly collagen fibers</i> | | 1. Loose Connective Tissue a. AREOLAR b. RETICULAR c. ADIPOSE 2. Dense Connective Tissue a. DENSE REGULAR b. DENSE IRREGULAR |
| ATLAS: | Dense Irregular: Figure 12 c (Morton & Perry, 1998) | |
| Major Arrangement: <i>non - parallel collagen fibers</i> , many fibroblasts | | |
| <p>Thicker bands of collagen running in irregular rows give multidirectional tensile strength. Collagen - secreting fibroblasts appear throughout. from Aponeurosis (x100)</p> <p>Lab Atlas of A&P Eder et al. Mosby, 1994</p> |  | <p>Functions: structural strength able to withstand tension from <u>many</u> directions</p> <p>Sites: fibrous capsules: organs/joints dermis of the skin submucosa of the digestive tract</p> |
| | | |

CONNECTIVE TISSUE: CARTILAGE

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There are **three** major types of **CARTILAGE**:



1. **HYALINE CARTILAGE**
2. **ELASTIC CARTILAGE**
3. **FIBROCARTILAGE** (one word)

CARTILAGE: **HYALINE** (smooth, glassy)

20

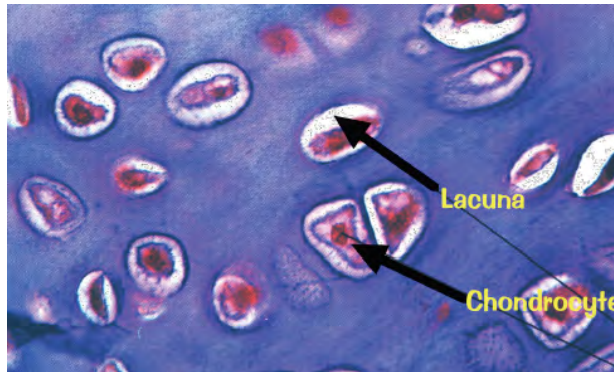
*unlike the connective tissue proper (fibroblast - derived), cartilage matrix is formed by **chondroblasts***

1. **HYALINE CARTILAGE**
2. **ELASTIC CARTILAGE**
3. **FIBROCARTILAGE** (one word)

ATLAS: Hyaline cartilage: Figure 15 a and b (Morton & Perry, 1998)

collagen fiber network, while present, is *often imperceptible*
firm but amorphous matrix

chondroblasts ----> **chondrocytes (found in lacunae)**
secrete the matrix



Functions:

resilient cushioning properties
resists compressive stress
support

Sites:

most of the embryonic skeleton
ends of long bones
in joint cavities
costal cartilage of the ribs
(between sternum and bony rib)

Cartilage of the:

Nose, Trachea (windpipe)
Larynx (voicebox)

CARTILAGE: HYALINE

(smooth, glassy) ▶ **1. HYALINE CARTILAGE**
2. ELASTIC CARTILAGE
3. FIBROARTILAGE (one word)

*unlike the connective tissue proper (fibroblast - derived), cartilage matrix is formed by **chondroblasts***

21

ATLAS: Hyaline cartilage: Figure 15 a and b (Morton & Perry, 1998)



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Image donated by: Dr Peter Brown
 Donor organisation: University of Bristol, Department of Pathology & Microbiology
 Identifier: BRISBIO-CLV00184
 Summary: Fibrillation, finely granular articular surface

Speciality (UMLS): Pathology, Veterinary
 Body system (UMLS): Musculoskeletal System
 Disease (UMLS): Osteoarthritis Joint Diseases
 Body part (UMLS): Cartilage, Articular

CARTILAGE: ELASTIC

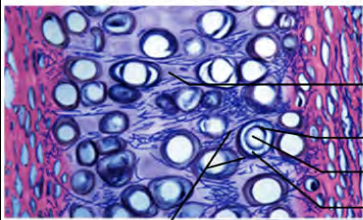
*unlike the connective tissue proper (fibroblast - derived), cartilage matrix is formed by **chondroblasts***

22

ATLAS: Elastic cartilage: Figure 15 c (Morton & Perry, 1998)

Similar to hyaline cartilage but with a **higher amount of elastic fibers** in the matrix

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Elastic Cartilage

- Intercellular material
- Nucleus
- Chondrocyte
- Lacuna

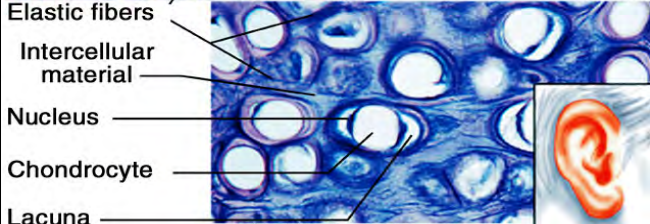
Functions:

shape maintenance while allowing great flexibility

Sites:

supports the **PINNA:** (external ear)

EPIGLOTIS: (flap over the trachea)



CARTILAGE: ELASTIC

unlike the connective tissue proper (fibroblast - derived), cartilage matrix is formed by *chondroblasts*

ATLAS: Elastic cartilage: Figure 15 c (Morton & Perry, 1998)

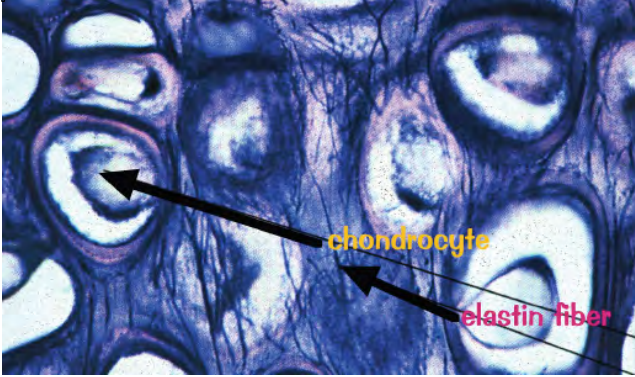
23

1. **HYALINE CARTILAGE**
2. **ELASTIC CARTILAGE**
3. **FIBROCARTILAGE** (one word)

Another View:

Extracellular matrix contains **elastic fibers** that confer elastic recoil to the tissue. (x250)

Lab Atlas of A&P
Eder et al.
Mosby, 1994



chondrocyte

elastin fiber

CARTILAGE: FIBROCARTILAGE

unlike the connective tissue proper (fibroblast - derived), cartilage matrix is formed by *chondroblasts*

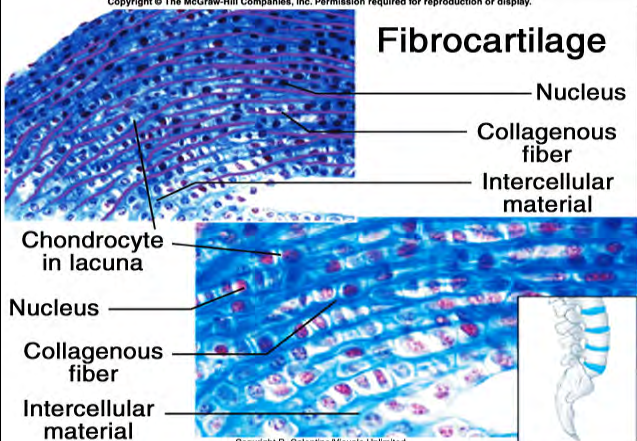
ATLAS: Fibrocartilage: Figure 15 d (Morton & Perry, 1998)

24

1. **HYALINE CARTILAGE**
2. **ELASTIC CARTILAGE**
3. **FIBROCARTILAGE** (one word)

Similar to hyaline cartilage but matrix is less firm thick collagen fibers predominate

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Fibrocartilage

Nucleus

Collagenous fiber

Intercellular material

Chondrocyte in lacuna

Nucleus

Collagenous fiber

Intercellular material

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Functions:
shape maintenance while allowing great flexibility

Sites:
intervertebral discs
pubis symphysis
discs of the knee joint

CARTILAGE: FIBROCARILAGE

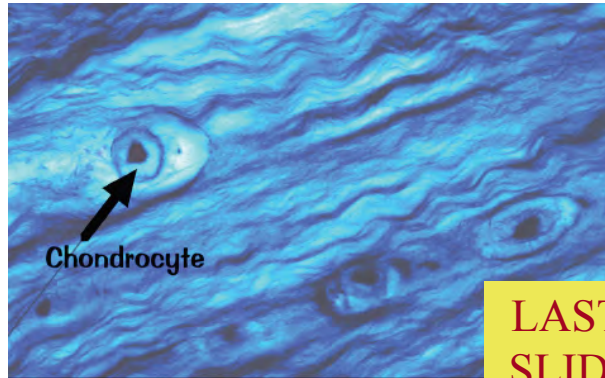
unlike the connective tissue proper (fibroblast - derived), cartilage matrix is formed by chondroblasts

1. **HYALINE CARTILAGE**
2. **ELASTIC CARTILAGE**
- ▶ 3. **FIBROCARILAGE** (one word)

ATLAS: Fibrocartilage: Figure 15 d (Morton & Perry, 1998)

Another View:

Cell nest of chondrocytes in territorial matrix surrounded by coarse extracellular fibers. (x250)



Lab Atlas of A&P
Eder et al.
Mosby, 1994

**LAST
SLIDE**