Histology

faculty of medicine - JU2015

Lecture8

Cartilage

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- Cartilage is a tough durable form of supporting CT characterized by an ECM with high concentrations of GAGs and proteoglycans interacting with collagen and elastic fibers
- Structural features of its matrix make cartilage ideal for a variety of mechanical and protective roles within the adult skeleton and elsewhere
- The ECM of the cartilage is a firm jelly material that is composed of 60-80 % of water, high amount of proteoglycans and hyaluronic acid which gives the ECM this jelly like structure
- Fibers give it strength (collagen) and elasticity (elastic)

Features

- ECM is a semisolid structure, not as hard as bones and not as loose as CT proper
- The best way to understand the nature of the cartilage is to manipulate the tip of the nose, it's firm , tough and flexible structure

Histologically:

- it's avascular (neither blood vessels run through it nor nerves). So it's with very poor metabolic rate and regeneration

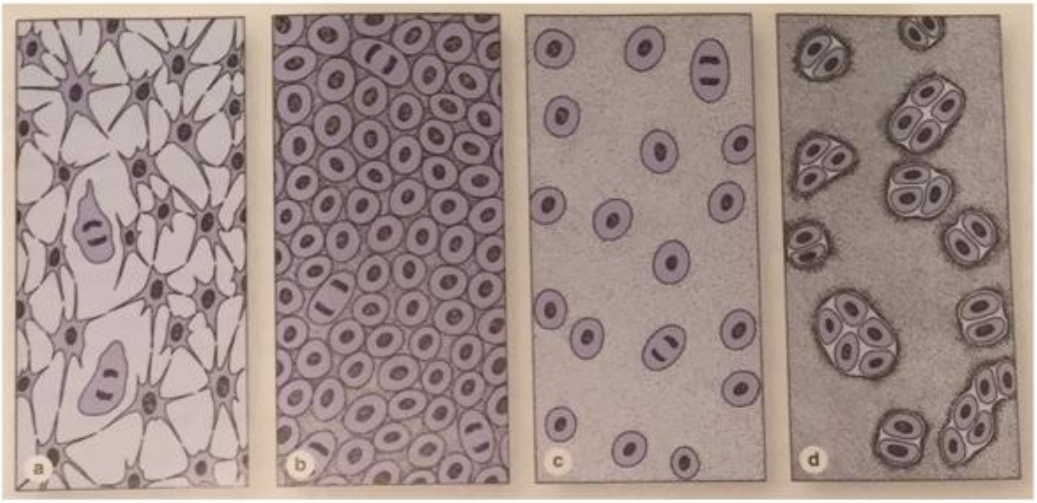
Main function

- Giving shape and support for certain structures such as external ear and respiratory tract (trachea which is a tube like structure. Tracheal wall is composed of C shaped cartilages to keep it opened all the time to provide a passage way for air
- Shock absorbing as in the intervertebral disk and the pad of cartilage in the knee joint cavity (meniscus) which is located between the two articulating bones, the meniscus bears the body weight and resists the compressional forces without distortion
- Smooth surface for smooth sliding movement of the joint. For example,Elbow joint is formed by articulation of 3 bones, a layer of cartilage covers the articular surface of each bone. The articulating surfaces of the proximal end of radius, proximal end of ulna and distal end of humerus are all covered by a thin layer of cartilage which allows smooth frictionless movement
- Bones are essential for growth. Most of our bones (humerus, radius, ulna , femur…) were cartilages in the fetus and gradually replaced by bones during development

Components

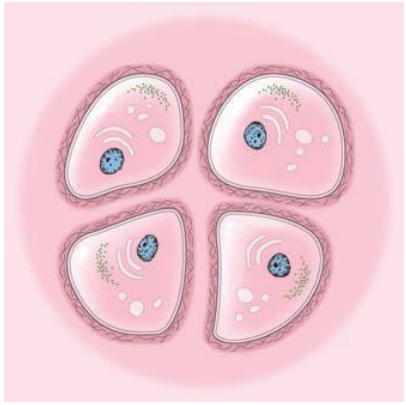
- Cells + ECM (chondrin), Chondro means cartilage
- Chondroblasts : active cells that synthesis ECM of cartilage
- Chondrocytes : inactive , mature , retired cells that have finished synthesis of ECM but still living cells important for maintenance of cartilage matrix
- Chondronectin is an example of glycoprotein in cartilage (adhesive protein). Nectin means connect Connection of chondroblasts to the components of ECM (collagens and proteoglycans)
- Chondrocytes are located within chambers or space called lacunae
- ECM is homogeneous
- Cartilage is surrounded by dense irregular type of CT termed PERICHONDRIUM (composed of collagen type I)
- Collagen type II is found in the ECM of cartilage (fibrils)
- Collagen fibrils and ground substance have the same optical density (same refractive index) that's why we can't discriminate in the ECM of cartilage between collagen fibrils type II and the ground substance. The matrix appears homogenous

Chondrogenesis: formation of cartilage



The origin of cartilage is mesenchymal CT. the mesenchymal cells differentiate into chondroblasts which will synthesize ECM so these cells will become separated from each other then each cell will undergo mitosis, daughter cells will synthesize ECM and become separated again and this is how cartilage grows , when the growth stops we see single cells or cells arranged into groups (isogenous group) representing the last mitotic division

Matrix surrounding the cells (territorial) looks darker than the matrix away from the cells (interterritorial)



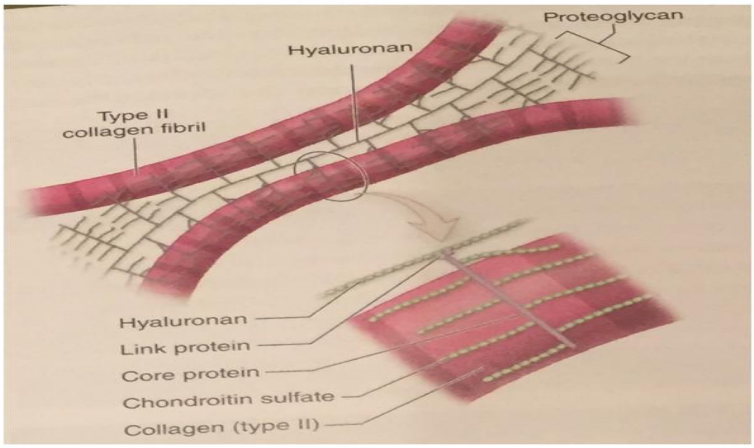
Different staining properties of ECM are due to different molecular composition. Around the cells we have high amount of proteoglycans and GAGs, and as we go away we find more collagen type II than GAGs
Surrounding the cells we have high negative charges so the matrix around the cells will stain more basophilic than the matrix away from the cells
In the living cartilage, the chondroblast is filling most of the space (lacuna).
With H&E , ECM of cartilage appears basophilic

- Most of the bones in the fetus skeleton are cartilages and are going to be replaced by bones in a process called ENDOCHONDRAL OSSIFICATION (formation of bone within cartilage)
- We usually find cartilage in thin plates because it's avascular and cartilage cells get their nutrients from PERICHONDRIUM by diffusion from blood vessels. If it is thick, cells in the center will die due to lack of O_2 and nutrients

Composition of Perichondrium

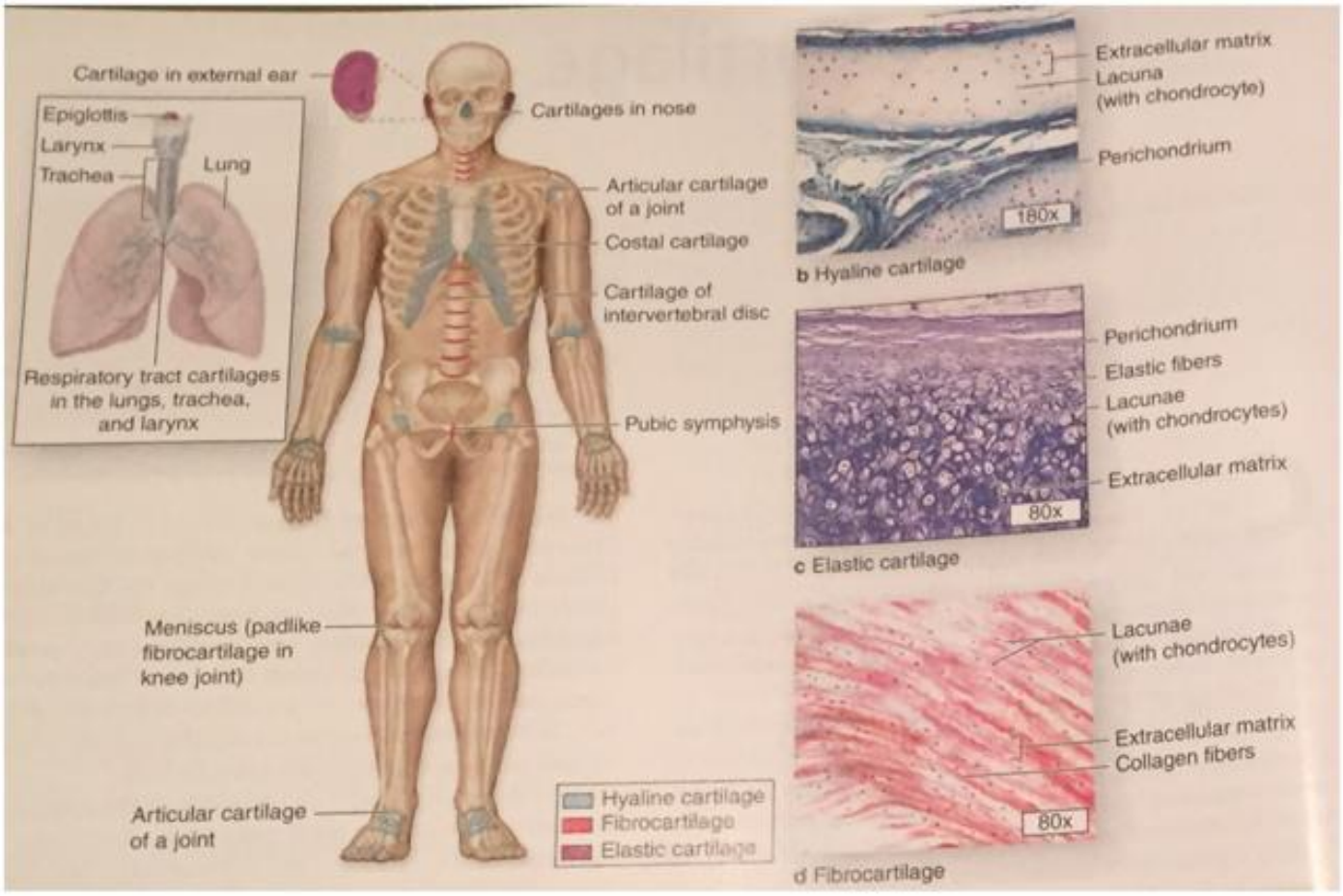
- Outer layer is fibrous, it is mainly composed of flat nuclei of fibroblasts and collagen type I (acidophilic)
- Inner cellular layer is mainly composed of CHONDROGENIC cells (undifferentiated cells that can become chondroblasts)

Growth of cartilage occurs in 2 ways:
From inside the cartilage or peripherally from the chondrogenic cells in the inner cellular layer of perichondrium

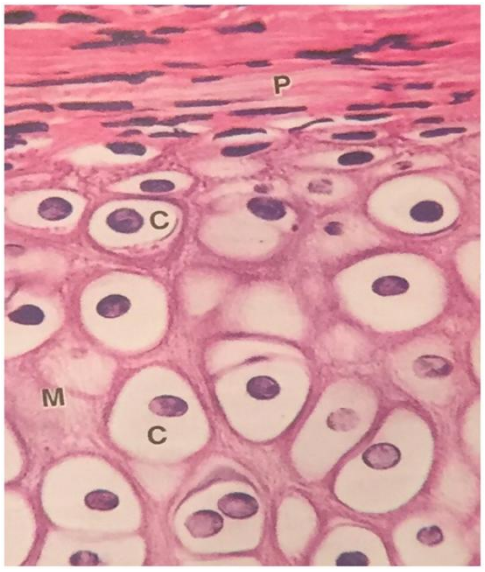


EM: Granular matrix, no specific shape, collagen fibrils appear as very thin fibrils
The ground substance is rich in proteoglycan called aggrecan (very large: single aggrecan could contain 150 GAGs) which means it attracts more amount of water and produces the firm jelly structure
GAGs are mainly chondroitin sulfates and keratan sulfates

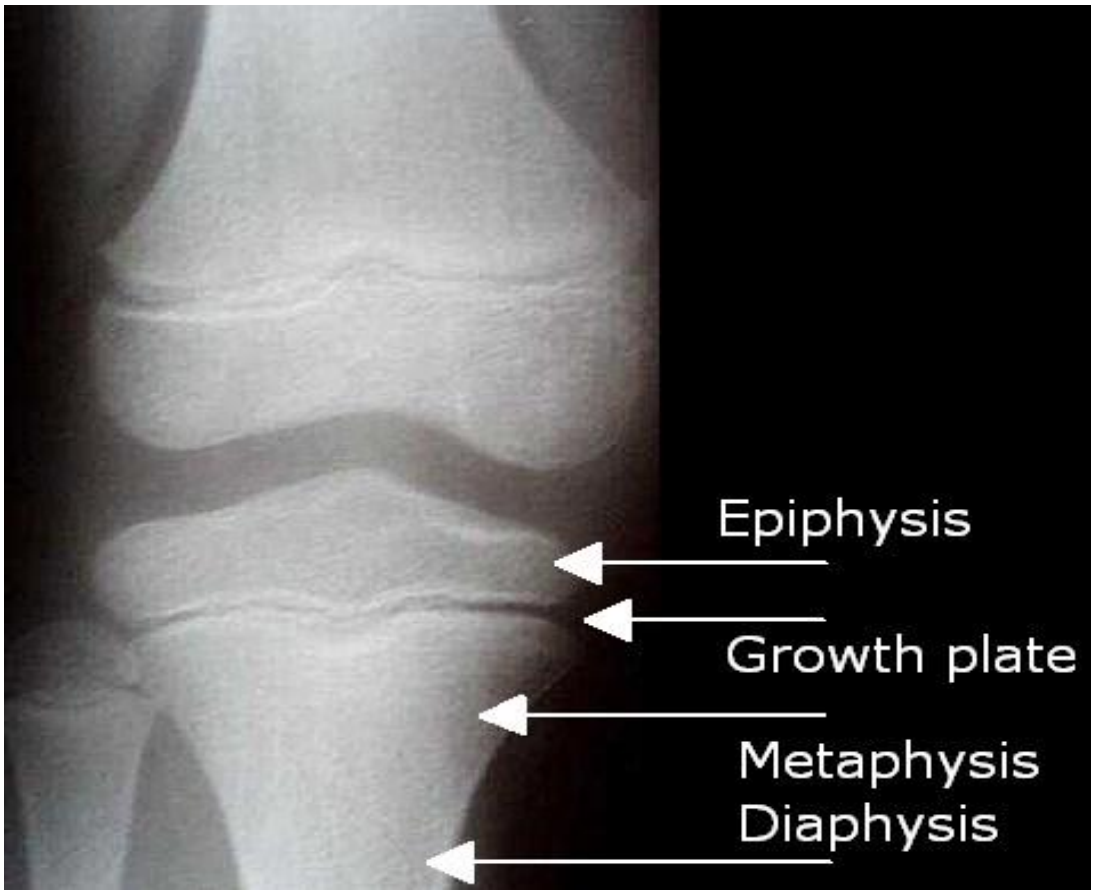
Types of Cartilage



Hyaline Cartilage



- The most common type, forms most of the embryonic skeleton
- All the cartilage will be replaced by bone except in certain places:
- nasal septum
- respiratory tract (trachea, bronchi, laryngeal cartilages as Adam's apple)
- anterior ends of ribs
- articular surfaces of long bones
- Cartilage has the major role in embryonic life than adult's life
- Fresh hyaline appears glassy (hyalos=glassy)



- X-ray from the knee joint: we see 2 colors in the x-ray:

1. Radiopaque, where the bone appears whitish.
2. Radiolucent, which is the black area.
   -This depends on the passage of the x-ray beam.
   - For example: the bone is dense so the x-ray beam doesn't pass through it, so it appears white, but the cartilage is not mineralized, so the x-ray beam pass through it, and it appears dark (black).

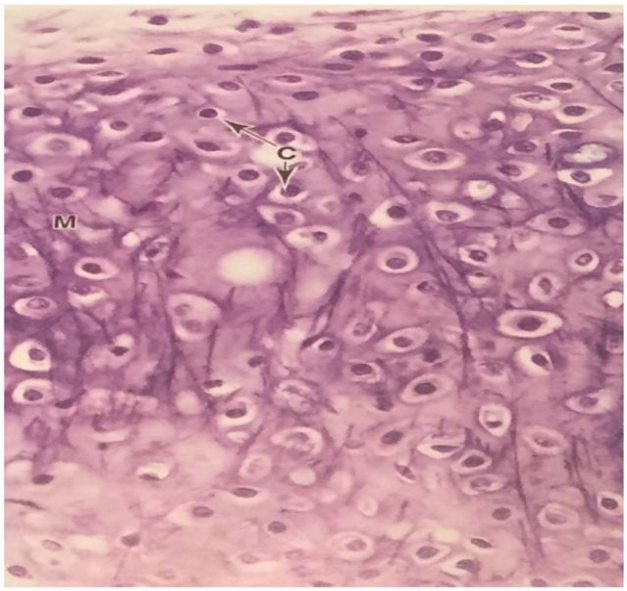
➢ **Epiphyseal plate:**
-Diaphysis: It is the shaft of the long bone.
-Epiphysis: proximal and distal ends of the long bone.
-There is a radiolucent area between the diaphysis and the epiphysis, this area is filled with cartilage

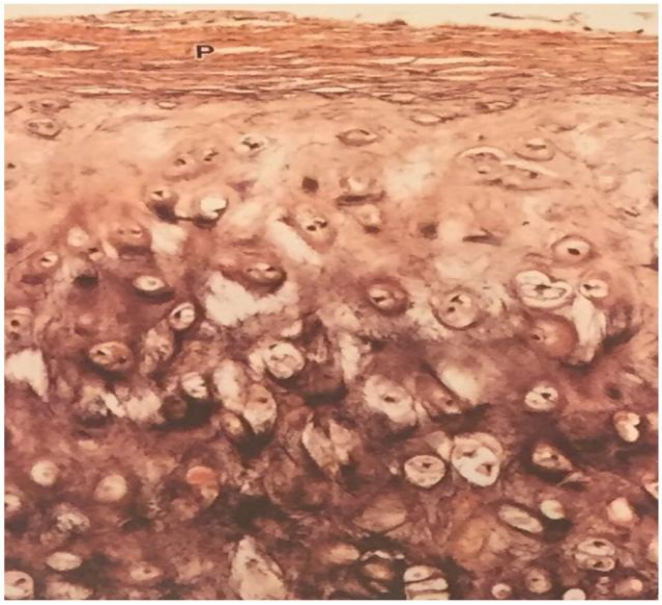
➢ It is very important for our bone to be originally cartilage because the cartilage can grow by interstitial growth and by appositional growth. Step by step, a replacement of the cartilage with the bone occurs and this is how we grow in height until late adolescence is reached and then the growth stops, the cartilage of growth plate will disappear.

- **Epiphyseal plate**: a thin layer of cartilage between the epiphysis and the bone shaft (diaphysis). The new bone forms along the plate. Epiphyseal plates remain open until late adolescence. Also it is called growth plate. We can find it in a developing long bone.

➢ When the plate of cartilage in between epiphysis and diaphysis disappears, the growth in height stops and we can estimate the age from the presence of epiphysis plate

Elastic Cartilage





➢ ECM is the same as hyaline EXCEPT of the high amount of elastic fibers
➢ We use the special elastin stain in order to see elastic fibers
➢ If we use H&E we can't differentiate easily between hyaline and elastic cartilages
➢ Location:

External ear
External auditory tube
Eustachian tube
Epiglottis [All start with E]

➢ Always elastic cartilage is surrounded by perichondrium. Hyaline is surrounded by perichondrium EXCEPT the articular cartilage which gets nutrients from the synovial fluid in the space of the joint

FibroCartilage

- Consists mainly of pink (acidophilic) bundles of collagen type I
- To differentiate between it and dense regular CT, cells of fibrocartilage are located within lacunae while the nuclei of dense regular CT are flat naked nuclei
- Location:

  Intervertebral disk which acts as rubbery material to resist compressional forces

  Disk in the knee (meniscus)

  Note fibrocartilage presents in areas subjected to high mechanical or tensile forces

  Pubic symphysis: the 2 hip bones articulate anteriorly at the slightly mobile pubic symphysis joint, which provides firm attachment between the two articulating bones

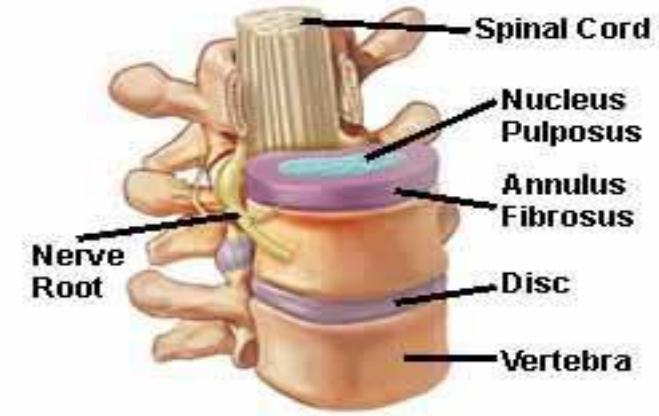
Growth

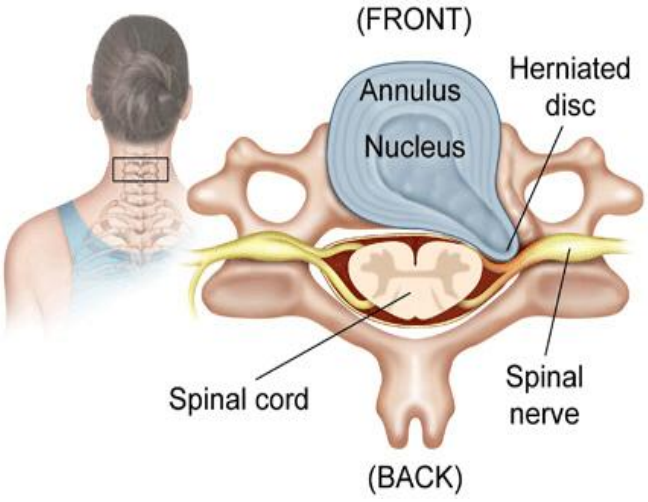
Interstitial: from within immature cartilage
Involving mitotic division of preexisting chondroblasts
Appositional: occurs in mature and immature cartilage
Involving chondroblasts differentiation from progenitor cells in the perichondrium

Fibrocartilage is the strongest type, while elastic cartilage is the most flexible + never ever calcify with aging. Hyaline cartilage has features intermediate between them and could calcify with aging

Clinical applications

1. **Herniation of intervertebral disk**





- The intervertebral disc is composed of 2 parts. Nucleus pulposus is the soft, central gelatinous material rich in hyaluronan covered with a tough membrane/ring called annulus fibrosus (fibrocartilage)
- With aging, degeneration of fibrocartilage could take place, resulting in crack formation of the annulus fibrosus. The inner soft material bulges out and compresses the spinal cord and the spinal nerves emerging from it, resulting in pain radiating into the regions served by affected nerve roots. This condition is also called slipped disc or ruptured disc

2. **Chondroma / Chomdrosarcoma** : tumor in cartilage

Cells of cartilage can give rise to either benign (chondroma) or malignant (chondrosarcoma) tumors in which cells produce normal matrix components. Chondrosarcoma seldom metastasize and are generally removed surgically.

3. **Osteoarthritis (degeneration of the joint):**

The articulating surfaces of long bones are covered by a layer of articular cartilage (hyaline), this articular cartilage is smooth to allow smooth sliding movement, again with aging, degeneration happens inside this articular cartilage, it wears down over time. It is caused by mechanical stress on the joint. It is characterized by pain and stiffness of the joint. It is common in knee joint.

Medical school is the only place where one could hope to find the means to study life, its nature, its origin and its ills