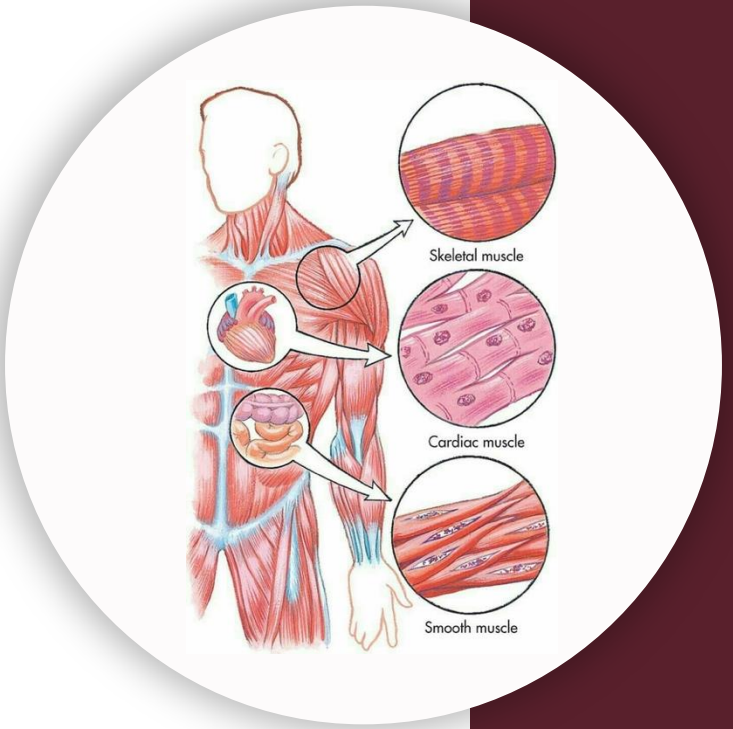
بسم الله الرحمن الرحيم

Histology – Final 5

Bone tissue Pt.3



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Types Of Bone, Minerlization, Remodeling, And Osteogenesis.

it's less strong than the lamellar bone in adults because the collagen is not well organized and it is not as strongly calcified as the one in the lamellar bone

Types Of Bone

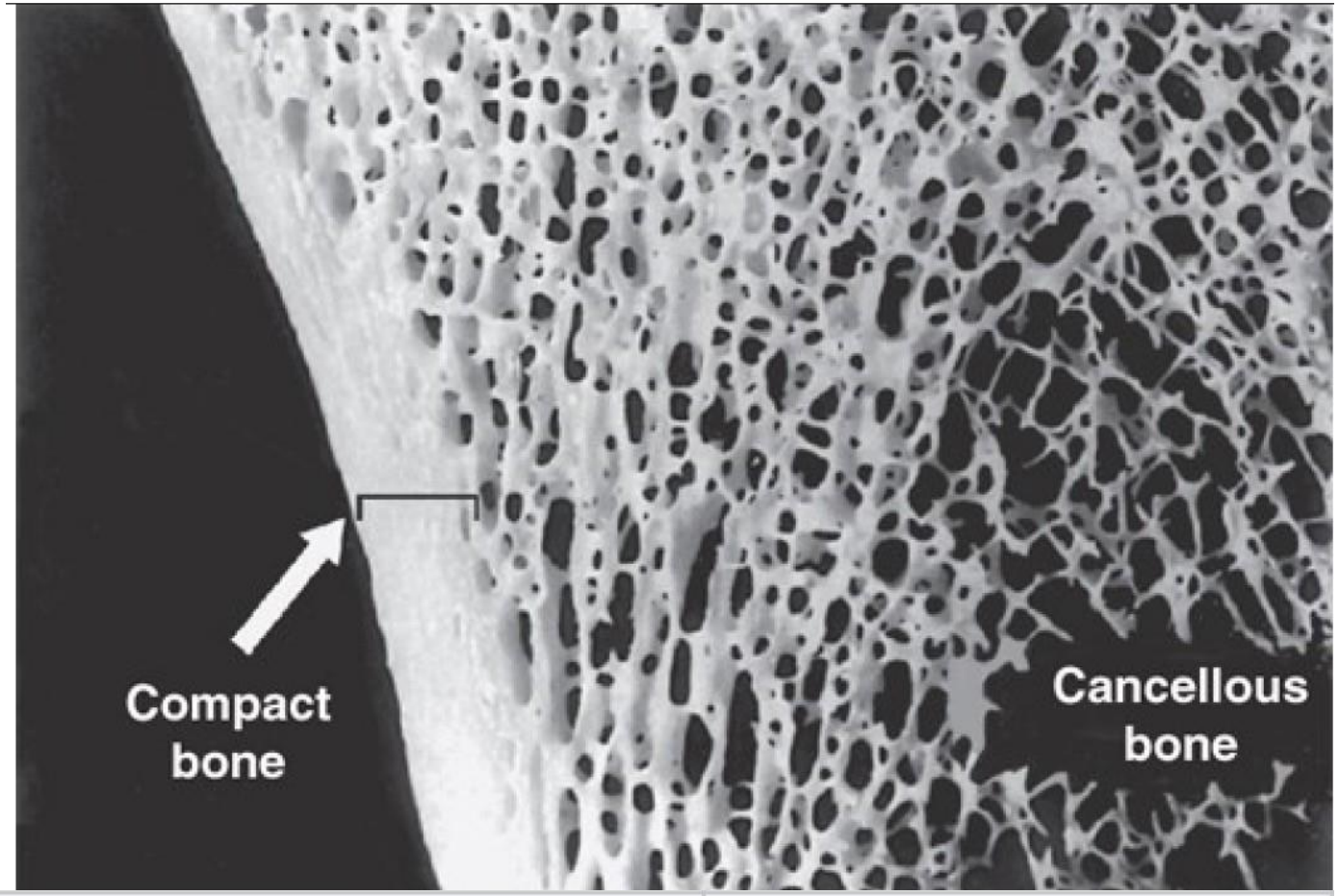
Type of Bone	Histological Features	Major Locations
Woven bone, newly calcified	Irregular and random arrangement of cells and collagen; lightly calcified (The very 1st bone being formed in humans, we did talk about that bone if u go back some steps)	Developing and growing bones; hard callus of bone fractures
Lamellar bone, remodeled from woven bone	Parallel bundles of collagen in thin layers (lamellae), with regularly spaced cells between; heavily calcified	All normal regions of adult bone
Compact bone, ~80% of all lamellar bone	Parallel lamellae or densely packed osteons, with interstitial lamellae	Thick, outer region (beneath periosteum) of bones
Cancellous bone, ~20% of all lamellar bone	Interconnected thin spicules or trabeculae covered by endosteum	Inner region of bones, adjacent to marrow cavities

Where bone marrow (which produces blood cells) resides

In adults we have these 2 types

Compact Bone

- Compact : the outer, thicker as u can see in the pic
- Where Cancellous is the inner and spongy one (more spaces)



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An calcified image

Calcified image: inorganic and organic components present
Decalcified image: inorganic components are absent(extracred)

Compact Bone- **Osteons**

Bone is harder than the other types of tissue as we all know, that's why we use "**ground specimens**" or "**ground images**"

تمام يعني ؟ شفتوا العظم بنضلنا نحف فيه بال

Sand paper, to reach thin sections of bone specimens.

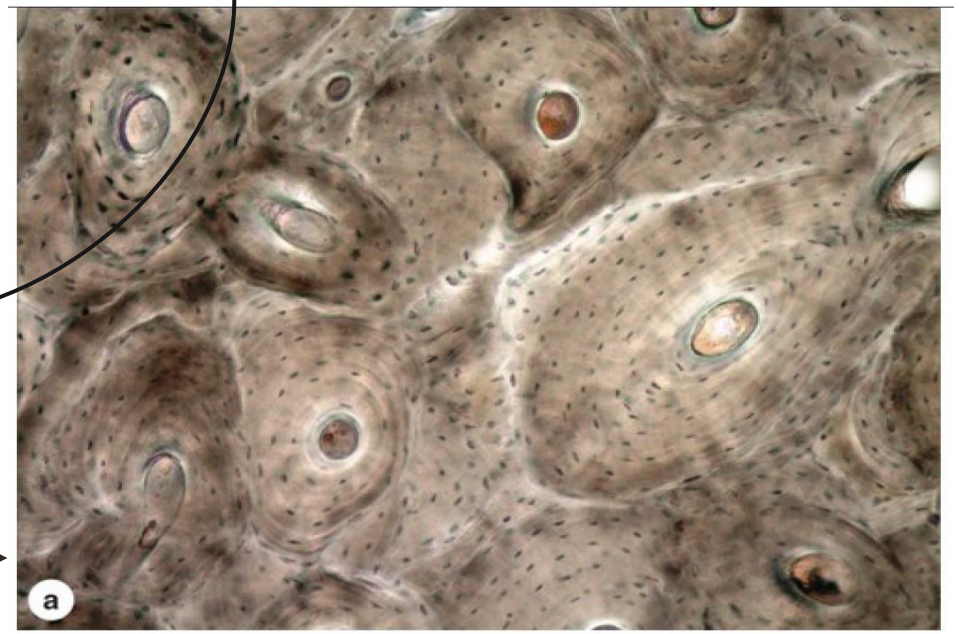
O : osteon

CC : central canal of the osteon

L : lamellae, the lightly colored ones

The dark colored ones are the lacuna

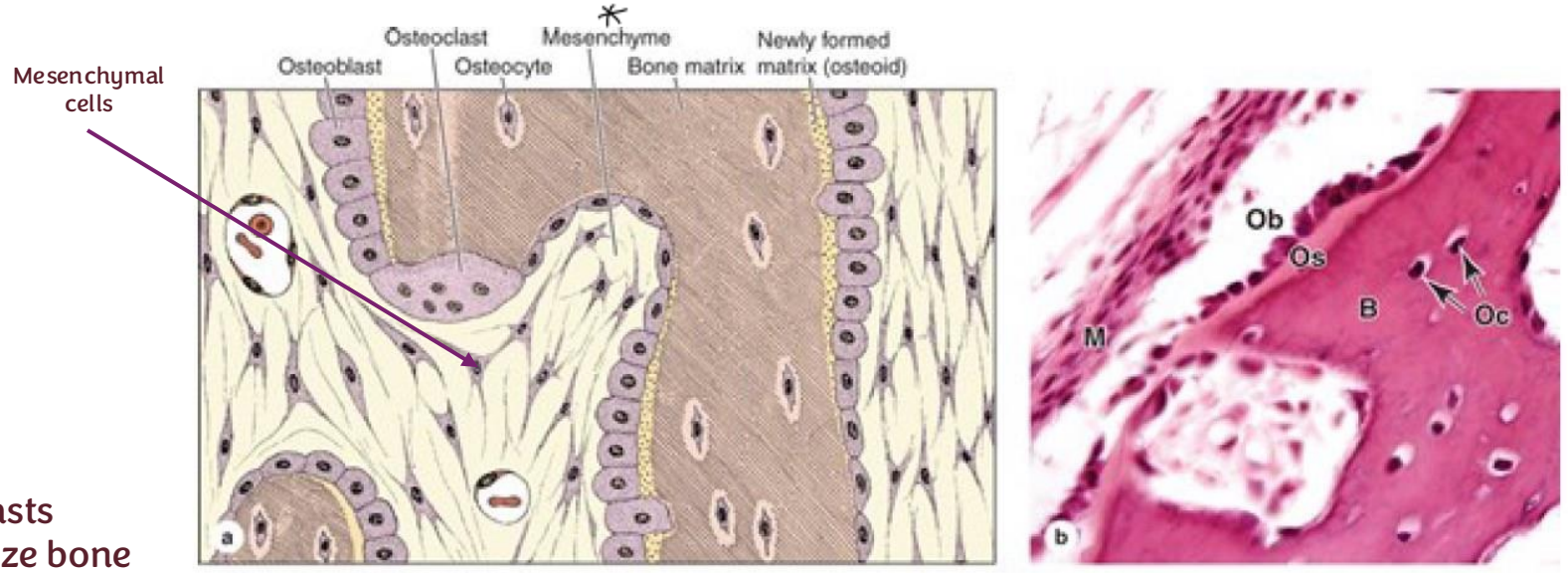
canaliculi :
الخيوط الصغيرة في الصورة
(يصعب التأشير عليها)



*Different osteons with different sizes

Mineralization in bone matrix

Mineralization: adding non organic components to organic components.



- **Osteoid** Collagen I ++++

  Glycoproteins proteoglycans

Osteoblasts synthesize bone matrix but it isn't in its final state

Organic components synthesized by osteoblasts

- **Osteocalcin**

  Vit. K-dependant polypeptide

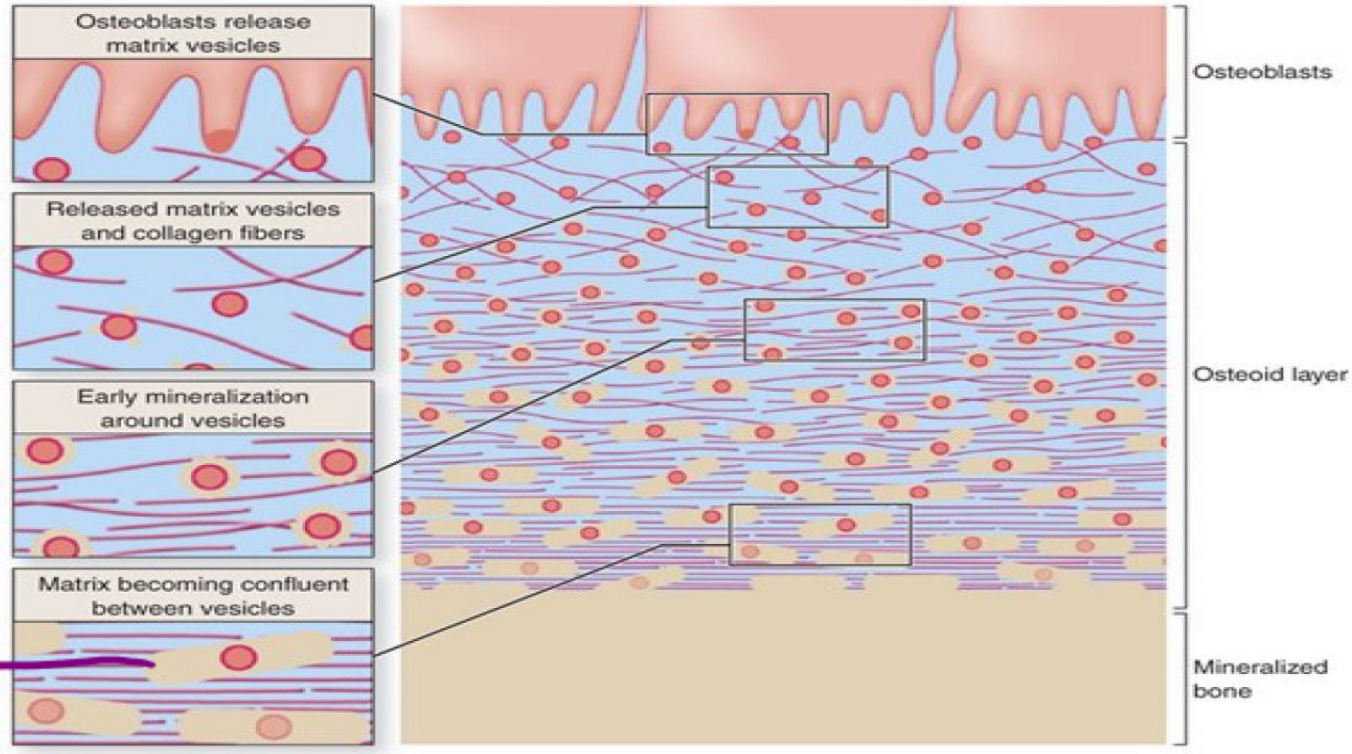
  Binds Ca^{2+} (with other GPs)

- **Matrix vesicles. (For increasing the phosphates)**

  Rich with Alkaline phosphatase (an enzyme).

  Raises $PO4^{3-}$

  Formation of hydroxyapatite (crystals)



Osteogenesis—bone formation

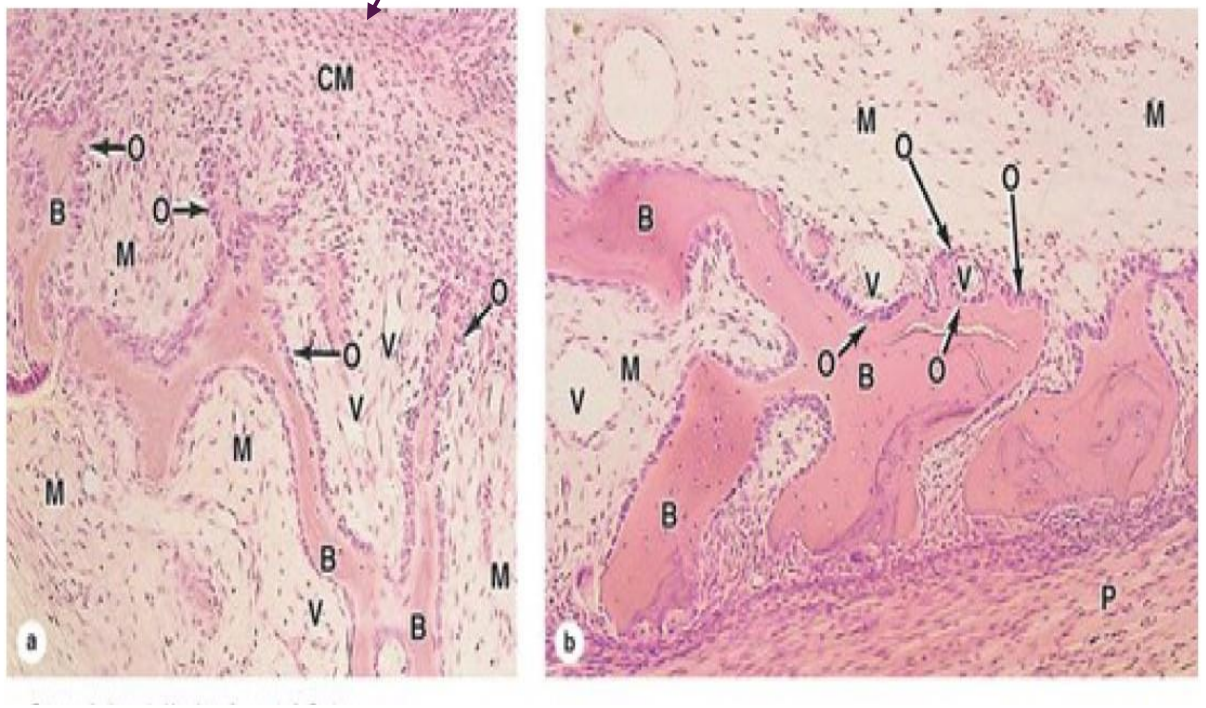
- **Intramembranous ossification** (the doctor calls it the direct method)**: osteoblasts differentiate directly from mesenchyme**
- **Endochondral ossification** (the doctor calls it the indirect method)**: a preexisting matrix of hyaline cartilage is eroded and invaded by osteoblasts** (from its name u can see that there is an intermediate stage between mesenchyme and bone witch is actually hyaline cartilage)

Intramembranous Ossification

All images are from the book

- Most flat bones form this way (bones of the skull (cranial bones), jaws (maxilla & mandible), scapula and clavicle)
- Within the condensed mesenchyme begins in ossification centers—osteoblasts around developing capillaries—–

Osteoid—Calcification—woven bone with osteocytes in lacunae and canaliculi.



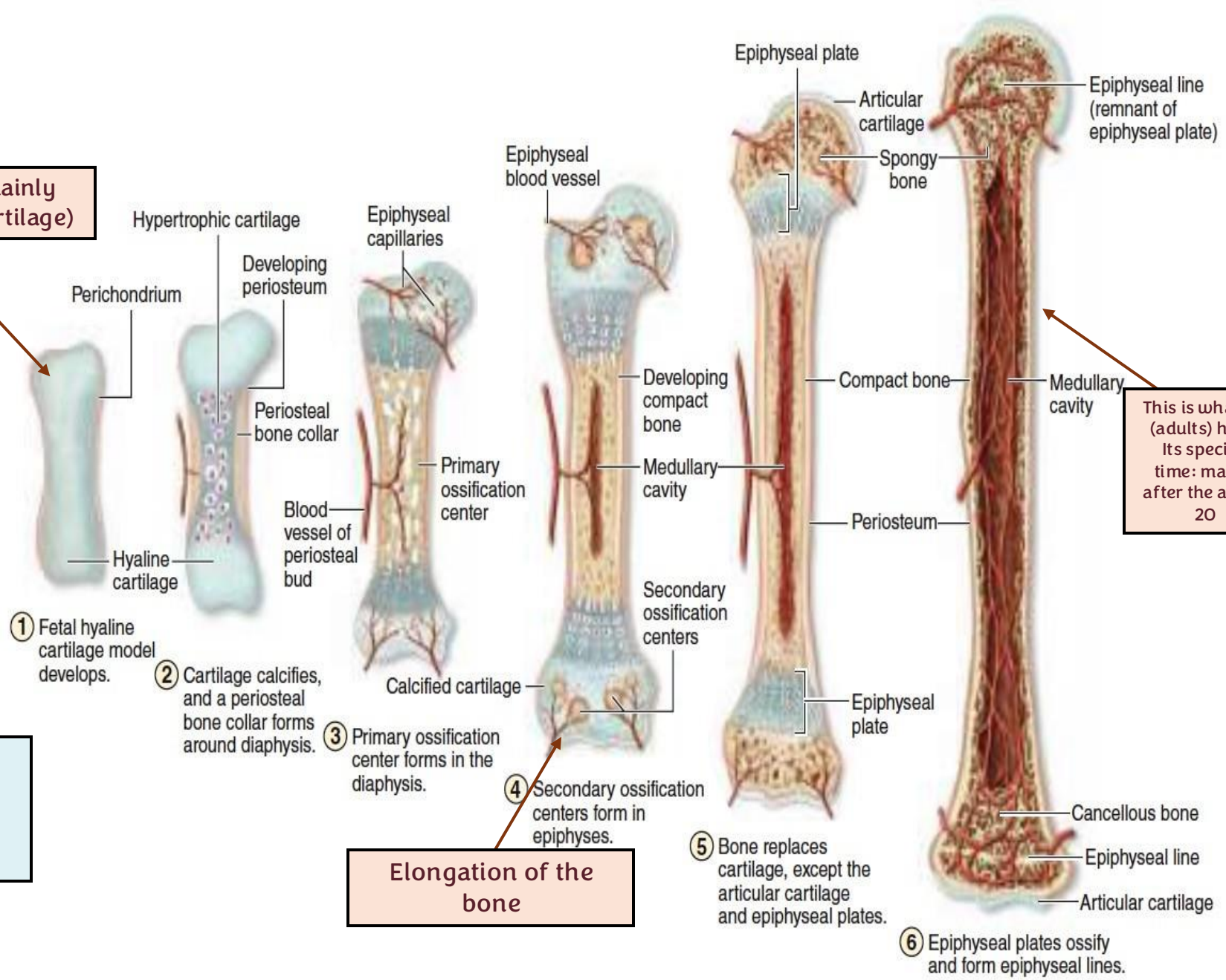
The image on the right (b) shows an advanced stage, u do see more bone that that being formed inside
Also u see the periosteum outside (P letter)

- The anatomical bone forms gradually as woven bone matrix is replaced by compact bone that encloses a region of cancellous bone with marrow and larger blood vessels.
- Mesenchymal regions that do not undergo ossification give rise to the endosteum and the periosteum.
- The **fontanelles** (Recall anatomy mid material) or "soft spots" on the heads of newborn infants are areas of the skull in which the membranous tissue is not yet ossified.

When two fontanelles meet, they will form sutures

Endochondral ossification

Embryo skeleton (mainly formed by hyaline cartilage)



This is what we (adults) have, Its specific time: mainly after the age of 20

Elongation of the bone

The 2nd type, slightly more complex cuz it's the indirect one

Endochondral ossification

- Takes place within hyaline cartilage shaped as a small version of the bone to be formed.
- Forms most bones of the body (well studied in developing long bones).
- First occurs within a bone collar (osteoblasts that differentiate within the perichondrium (transitioning to periosteum)).

  Osteoblasts start secreting bone matrix (osteoid) around the shaft of the cartilage model and this form the bone collar
- The collar impedes diffusion of oxygen/nutrients into the underlying cartilage–local chondrocytes hypertrophy (swelling of cells) – compress the matrix—calcification (osteocalcin and alkaline phosphatase) of matrix—death (chondrocytes).

Endochondral ossification

- The hypertrophic chondrocytes eventually die, creating empty spaces within the calcified matrix.
- Primary ossification center: blood vessels from the perichondrium (periosteum) penetrate the bone collar— osteoprogenitor cells— produce woven bone (first trimester)

Proliferation of cells in epiphyseal plate will make the bone longer

After birth:

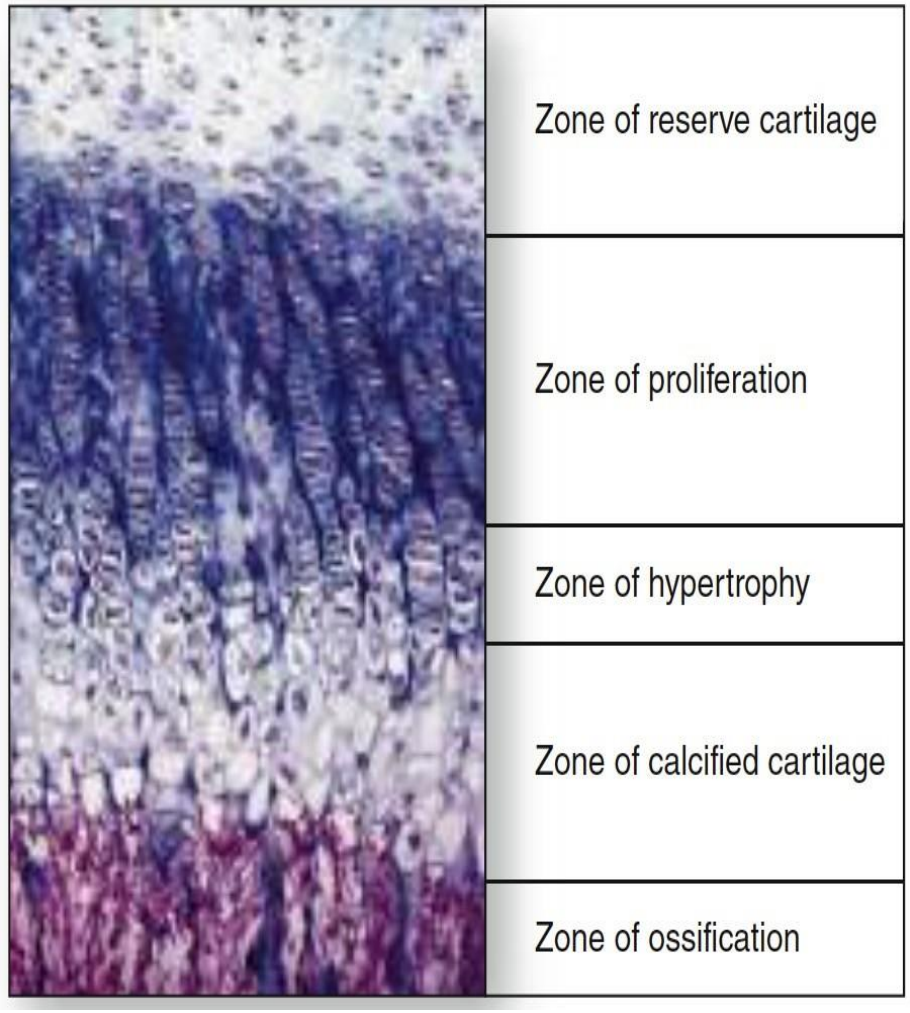
- Secondary ossification centers: appear later at the epiphyses.

Cartilage remains as:

- Articular cartilage: persists through adult life.
- Epiphyseal cartilage (epiphyseal plate or growth plate): connects each epiphysis to the diaphysis— longitudinal growth. Ossify lately at adult life

Epiphyseal plate

Stained by H&E



Zone of reserve cartilage:

- Composed of typical hyaline cartilage.

Chondrocytes in its lacunae

Proliferative zone:

- The cartilage cells divide—enlarge– matrix release.
- Become organized into columns.

Zone of ossification:

- <u>Bone tissue first appear</u>
- Capillaries and osteoprogenitor cells invade the vacant chondrocytic lacunae.
- Osteoblasts settle in a layer over the spicules of calcified cartilage matrix and secrete osteoid (becomes woven bone)
- Woven bone is then remodeled as lamellar bone.

Zone of hypertrophy:

- Contains swollen terminally differentiated chondrocytes.
- Compressed matrix and stiffened by collagen X.
- Increased vascularization.

Staining becomes less because of shrinkage and calcification of matrix

Zone of calcified cartilage:

- Chondrocytes about to undergo apoptosis.
- Release matrix vesicles and osteocalcin—calcification.

This wouldn't happen without vascularization increase in hypertrophy of cells

Bone remodeling

- Bone growth involves: 1) the continuous resorption of bone tissue formed earlier, and 2) the simultaneous laying down of new bone at a rate exceeding that of bone removal. In adults it is more balanced
- The sum of osteoblast and osteoclast activities in a growing bone constitutes osteogenesis or the process of bone modeling, which maintains each bone's general shape while increasing its mass.
- 5-10% of bone turns over annually.

Some osteons will be removed and new osteons will appear

Bone remodeling

- Bone turnover: is very active in young children, where it can be 200 times faster than that of adults.
- Bone remodeling: in adults the skeleton is also renewed continuously, which involves the coordinated, localized cellular activities for bone resorption and bone formation——tissue remains plastic and capable of adapting its internal structure in the face of changing stresses

Bone tissue exhibits plasticity, allowing it to adapt to internal and external stresses, and as a result, the final shape and structure of the bone are determined by the nature and magnitude of these stresses.

Bone repair

This means that if a bone is fractured, it can form a gap that will eventually be bridged and healed.

- Excellent capacity for repair:

1. It contains osteoprogenitor stem cells in the periosteum, endosteum, and marrow.

2. Is very well vascularized.

- **The major phases that occur typically during bone fracture repair include initial formation of fibrocartilage and its replacement with a temporary callus of woven bone.**

Osteoporosis

- Frequently found in immobilized patients Paralysed and high obesed people and in postmenopausal women.
- Is an imbalance in skeletal turnover so that bone resorption exceeds bone formation—calcium loss—reduced bone mineral density (BMD).

Less and lighter bones

- Individuals at risk are routinely tested for BMD by dual-energy x-ray absorptiometry (DEXA scans).

Osteopetrosis

- Genetic disease. Rare
- Characterized by dense, heavy bones (marble bones).
- The osteoclasts lack ruffled borders and bone resorption is defective.
- Overgrowth and thickening of bones—obliteration of the marrow cavities—depressing blood cell formation—anemia and the loss of white blood cells.

›› MEDICAL APPLICATION

The network of dendritic processes extending from osteocytes has been called a "mechanostat," monitoring areas within bones where loading has been increased or decreased, and signaling cells to adjust ion levels and maintain the adjacent bone matrix accordingly. **Lack of exercise** (or the weightlessness experienced by astronauts) leads to **decreased bone density**, due in part to the lack of mechanical stimulation of these cells.

›› MEDICAL APPLICATION

Osteogenesis imperfecta, or "brittle bone disease," refers to a group of related congenital disorders in which the osteoblasts produce deficient amounts of type I collagen or defective type I collagen due to genetic mutations. Such defects lead to a spectrum of disorders, all characterized by significant fragility of the bones. The fragility reflects the deficit in normal collagen, which normally reinforces and adds a degree of resiliency to the mineralized bone matrix.

For any feedback, scan the code or click on it.

Corrections from previous versions:

Versions	Slide # and Place of Error	Before Correction	After Correction
V0 → V1			
V1 → V2			

رسالة من الفريق العلمي:

"وَلَا تَيْأَسُوا مِن رَّوْحِ اللَّهِ ۖ إِنَّهُ لَا يَيْأَسُ مِن رَّوْحِ اللَّهِ إِلَّا الْقَوْمُ الْكَافِرُونَ "