
الجمهورية الجزائرية الديمقراطية الشعبية
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HISTOLOGY

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BONE TISSUE

Introduction

Bone tissue (BT) is a rigid connective tissue consisting of cells (osteocytes) and a calcified ECM (collagen + mineralized ground substance), providing it with strength and essential biological functions.

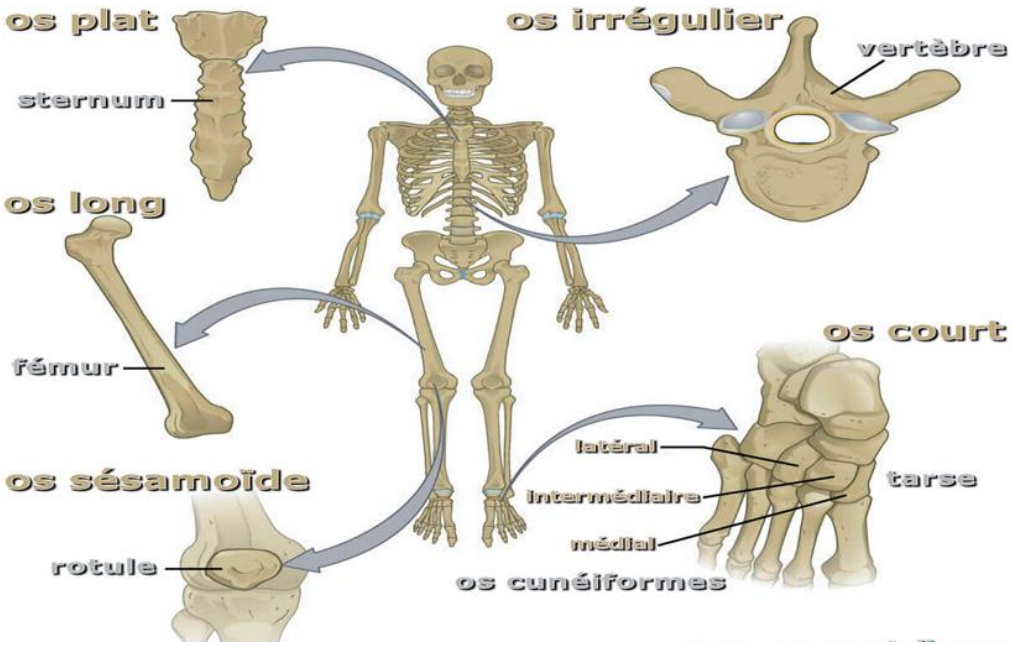
B.T = Cells + Calcified ECM (collagen fibres + ground substance)

Role of Bone Tissue

- Support of the body.
- Protection of the central nervous system (cranial vault and vertebrae).
- Control of phosphocalcic metabolism (jointly with the intestine and kidneys, it ensures the release or storage of mineral salts under mechanical pressure).
- Site of haematopoiesis (proliferation of haematopoietic marrow giving rise to the three blood cell lineages).
- Movement (it is dynamic).

Anatomy of Bone Tissue

Several types of bone pieces can be distinguished:



Histology of Bone Tissue

Two substances can be distinguished in bone tissue:

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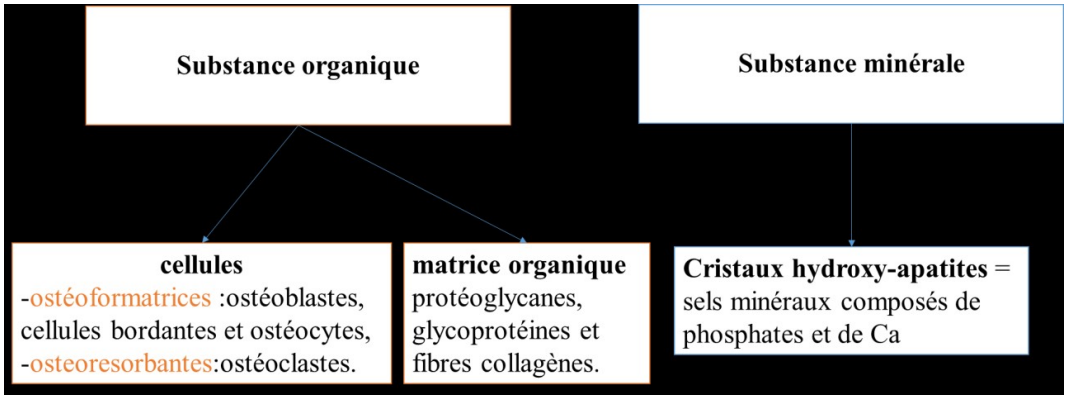


1) Cells

a. Osteoblasts


Osteoblast

■ Origin: mesenchymal cells or lining cells.

■ Shape: ovoid and elongated.

■ Organisation: arranged as a carpet of adjoining, communicating cells via gap junctions.

■ Cytoplasm: strongly basophilic, rich in RER.

Role

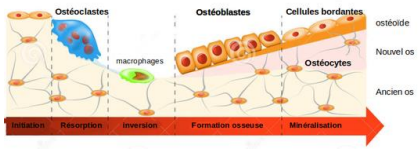
• They elaborate the protein precursors of the pre-osseous matrix.

• They deposit the protein precursors of the pre-osseous matrix around themselves.

• They subsequently calcify the pre-osseous matrix by depositing hydroxyapatite crystals.

• The pre-osseous matrix ultimately becomes osseous matrix.

b. Lining Cells



■ Flattened, elongated cells with few organelles.

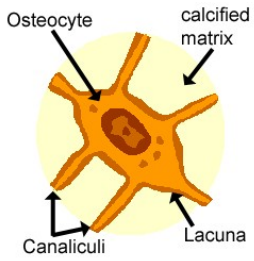
■ They are quiescent osteoblasts.

■ They can transform into active osteoblasts.

■ An osteoblast can revert to a lining cell.

■ They line osseous surfaces and protect bone against osteoclast attack.

c. Osteocytes

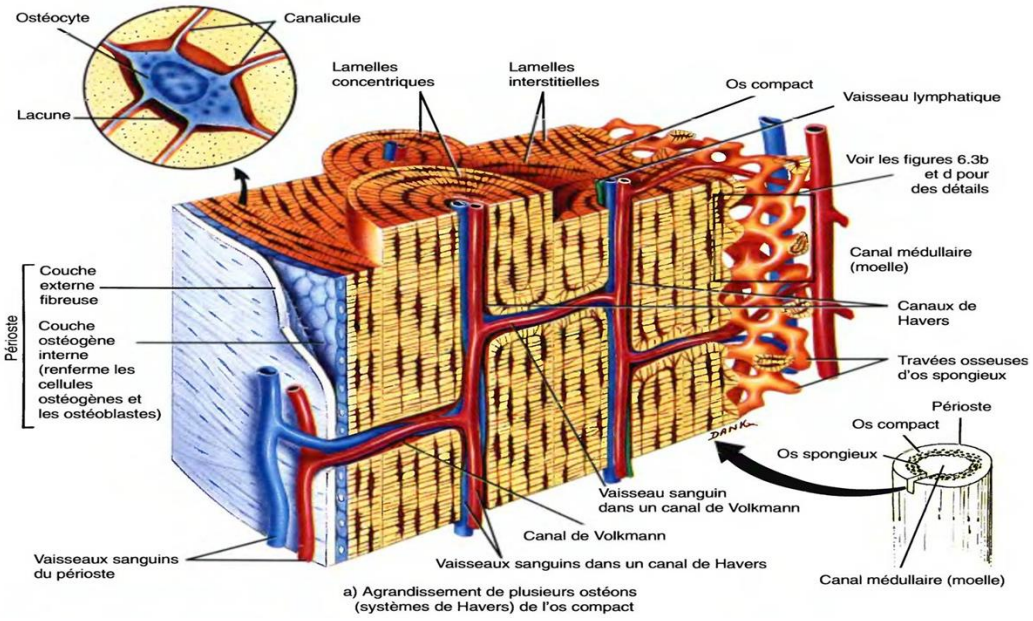


■ They derive from osteoblasts.

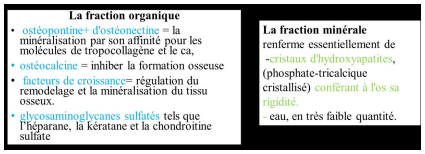
■ They are cells surrounded by a mineralised bone matrix, therefore incapable of dividing. They are lodged in osteoplasts (lacunae), from which anastomosing canaliculi containing cytoplasmic extensions radiate.

■ Osteocytes ensure nutrition and communication with the periosteum and endosteum.

■ Role: they elaborate a very small quantity of protein precursors of the pre-osseous matrix, which they calcify.



d. Osteoclasts



■ **Origin**: haematopoietic monocytic lineage.

■ **Structure**: giant cells, ruffled border (brush border), multinucleated, acidophilic cytoplasm rich in lysosomes and enzymes.

■ Highly mobile on the surface of bone trabeculae, hollowing out cylindrical cavities called **"Howship's lacunae"**.

■ **Role – Osteoclasia**: destruction of old bone tissue by: exocytosis of acids and hydrolases, resorption of the bone matrix, phagocytosis via the ruffled border, digestion by lysosomes, exocytosis of digested products.

2) The Extracellular Matrix

The extracellular matrix is composed of:

– type I collagen fibres (type I collagen molecules).

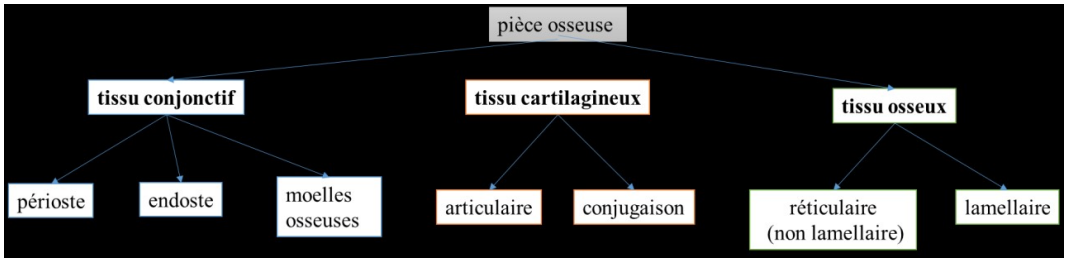
– a ground substance of solid, rigid consistency.

The ground substance includes:

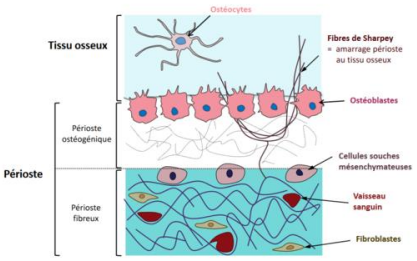
The organic fraction	The mineral fraction
• osteopontin + osteonectin = mineralisation through affinity for tropocollagen molecules and Ca; • osteocalcin = inhibits bone formation; • growth factors = regulation of remodelling and mineralisation of bone tissue; • sulphated glycosaminoglycans such as heparan, keratan, and chondroitin sulphate.	Essentially contains: – hydroxyapatite crystals (crystallised tricalcium phosphate) conferring rigidity to bone; – water, in very small quantities.

Tissue Varieties of Bone Pieces

Three tissue varieties can be distinguished:



❖ The Periosteum



– Peripheral CT sheet covering all bone pieces except at articular surfaces (mature hyaline cartilage).

– Composed of 2 layers:

• **External**: tendiniform (collagen fibres), vascularised.

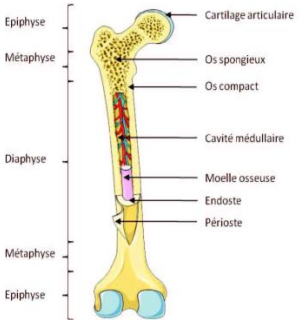
• **Internal**: osteogenic layer of Ollier.

– **Role**:

• Nutrition (outer, vascularised layer).

• Appositional growth (osteoblasts of the inner layer) by elaboration of periosteal bone tissue (external fundamental system – EFS) on which the periosteum rests.

❖ The Endosteum



– Structure and role identical to the periosteum but thinner and less active.

– Localisation: lines the medullary cavity of long bones.

– Its osteogenic layer elaborates the IFS (internal fundamental system) = periosteal bone tissue associated with the endosteum.

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❖ Bone Marrows

■ Origin: mesenchymal.

■ Localisation: areolae of spongy bone + medullary cavity of the diaphysis of long bones.

■ Structure: varies according to localisation and the age of the subject.

The following types can be distinguished:

➤ **Red haematopoietic bone marrow (R.H.B.M)** in all bones. Contains reticular CT harbouring stem cells of the various blood lineages; it is therefore the site of haematopoiesis.

➤ **Red osteogenic bone marrow (R.O.B.M)**: appears in ossification centres during osteogenesis, bone growth, or repair. Composed of reticular CT + rich in osteoblasts.

➤ **Yellow bone marrow**: very rich in adipocytes. Results from the fatty transformation of red marrow throughout growth.

➤ **Grey bone marrow**: found in elderly individuals. Irreversible fibrous degeneration of yellow marrow, composed of fibrous connective tissue.

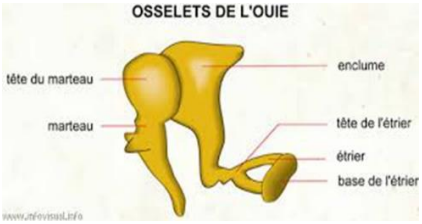
❖ Reticular Bone Tissue (Non-lamellar)

– It is a primary fibrous bone tissue, weakly mineralised and non-lamellar.

– The collagen framework has no orientation.

– It is the first bone tissue elaborated in the foetus.

– It is mechanically fragile.



In adults, it is found in the ossicles of the middle ear and in fracture calluses, because in other bone pieces it is replaced by lamellar or secondary bone tissue.

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✦ Lamellar Bone Tissue

• It replaces reticular (primary) bone tissue.

• Collagen fibres are parallel to one another, giving the tissue its lamellar appearance.

• It is mechanically strong.

• It is represented by:

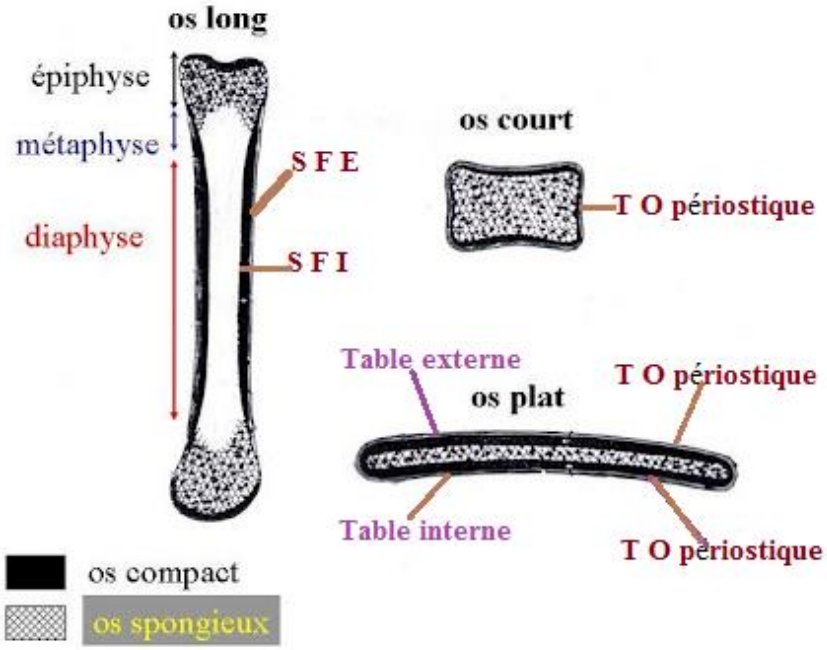
1. periosteal bone tissue
2. dense Haversian bone tissue
3. areolar Haversian bone tissue.

1. Periosteal Bone Tissue

■ It constitutes the External Fundamental System (EFS) at the periphery of the diaphysis and the Internal Fundamental System (IFS) around the medullary cavity of the long bone.

■ It constitutes the periosteal BT of short bones.

■ It constitutes the external and internal tables of flat bones.



2. Dense Haversian Bone Tissue

■ Localisation: situated between the EFS and IFS of the diaphysis of the long bone.

■ It is constituted by:

– Haversian systems,
– intermediate systems,
– Volkmann's canals.

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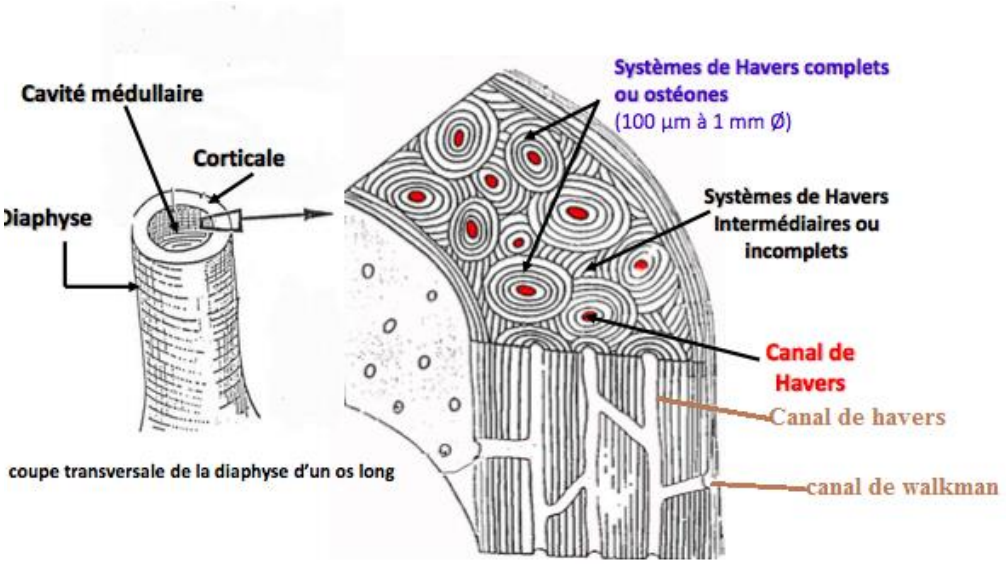


Structure

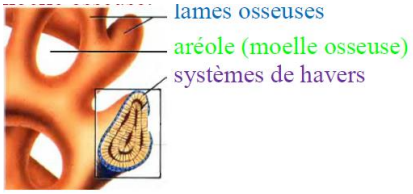
- Haversian systems:
  - formed of concentric lamellae,
  - present a central Haversian canal through which capillaries and nerves circulate,
  - parallel to one another,
  - run along the longitudinal axis of the diaphysis.
- Intermediate systems:

These are partially resorbed Haversian systems.

- Volkmann's canals:

– they are perpendicular to the Haversian systems.

3. Areolar / Spongy / Trabecular Haversian Bone Tissue

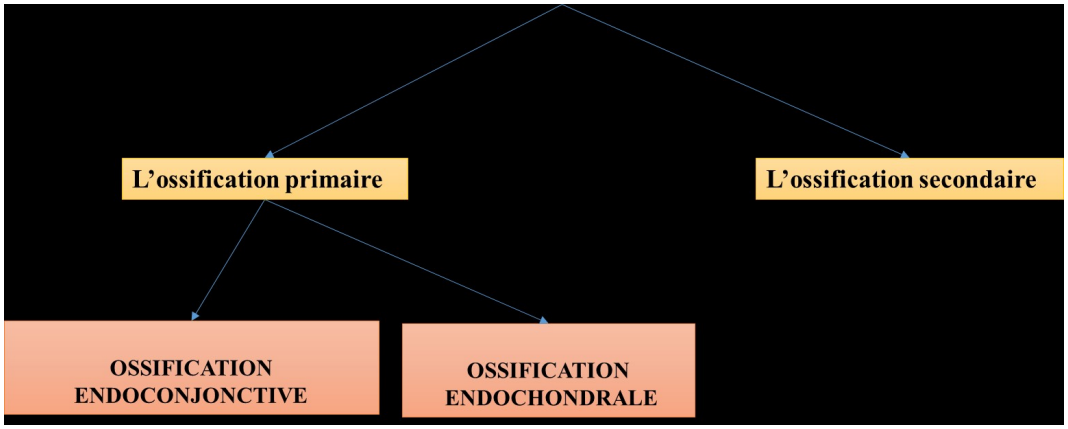


- Localised at the epiphyses of long bones, short bones, and the diploe of flat bones.
- Constituted by bone lamellae presenting Haversian systems.
- Between the bone lamellae lie areolae containing bone marrow.

Ossification and Remodelling of Bone Tissue

Ossification is a process of: construction, resorption, growth, and remodelling of bone tissue.

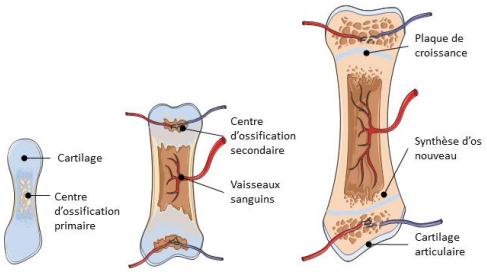
Ossification occurs in two successive stages:



1) Primary Ossification

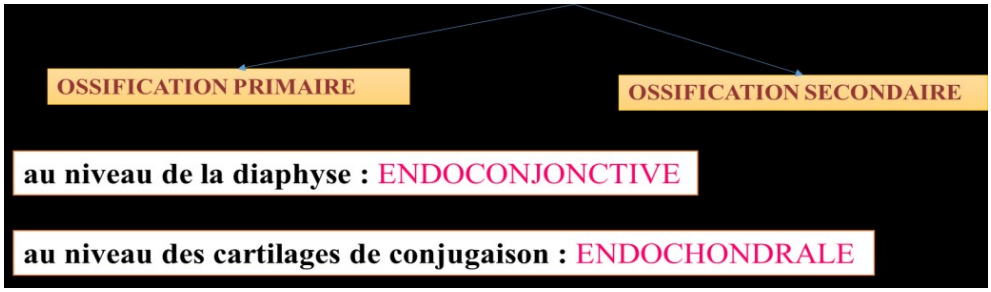
a. Endoconjunctive Ossification

Formation of a periosteal bone sleeve (primary BT) from the periosteum.



b. Endochondral Ossification

Formation of enchondral bone tissue from the hyaline growth plate cartilage.



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2) Secondary / Endo-osseous Ossification

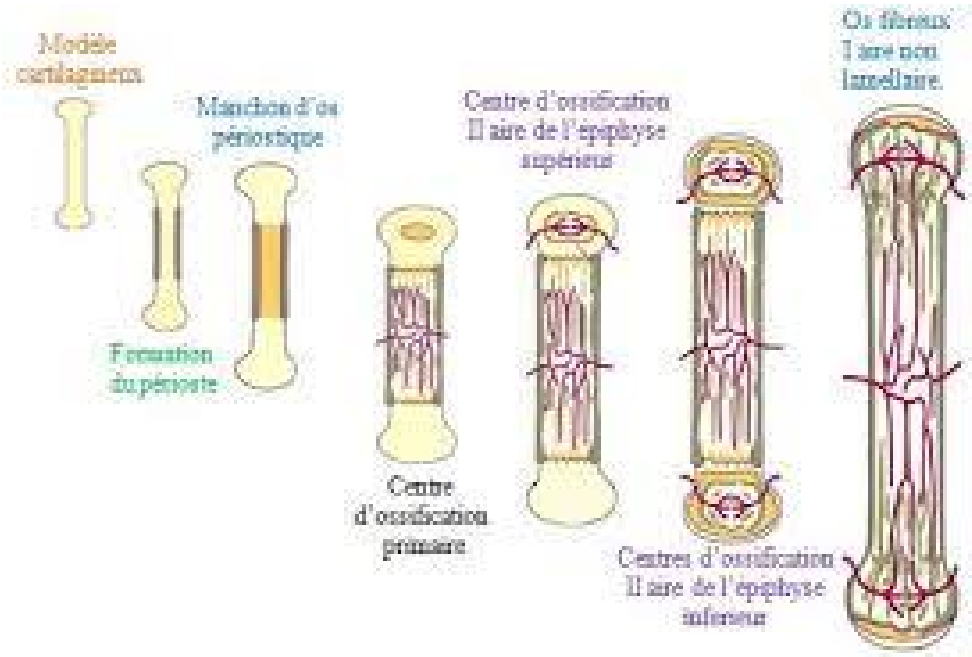
Formation of secondary, lamellar, and definitive bone tissue in place of the primary bone tissue (periosteal bone sleeve):

– dense Haversian bone tissue.

– areolar Haversian bone tissue.

– periosteal bone tissue.

Ossification of a Long Bone



Primary Ossification

A – At the level of the diaphysis: ENDOCONJUNCTIVE

1 – the perichondrium transforms into the periosteum from the diaphysis to the epiphyses.

2 – the periosteum elaborates a periosteal bone sleeve (primary BT) around the immature hyaline cartilage.

3 – formation of osteoclasts and chondroclasts at the level of the periosteum.

4 – osteoclasts hollow out canals in the periosteal bone sleeve.

5 – chondroclasts hollow out a small cavity in the immature hyaline cartilage.

6 – conjunctivo-vascular buds (B.C.V) (blood vessels and connective tissue from the periosteum) penetrate through these canals into the cavity.

7 – chondrocytes of the immature hyaline cartilage hypertrophy (hypertrophied cartilage).

8 – the cartilaginous matrix calcifies (calcified hypertrophied cartilage).

9 – atrophy of chondrocytes (deprived of nutrients): calcified atrophied cartilage.

10 – death of chondrocytes and formation of empty cavities.

11 – chondroclasia of the cartilaginous floor of the cavities.

12 – formation of corridors (along the longitudinal axis of the diaphysis) into which the B.C.V penetrate.

13 – triggering of the fundamental process of ossification.

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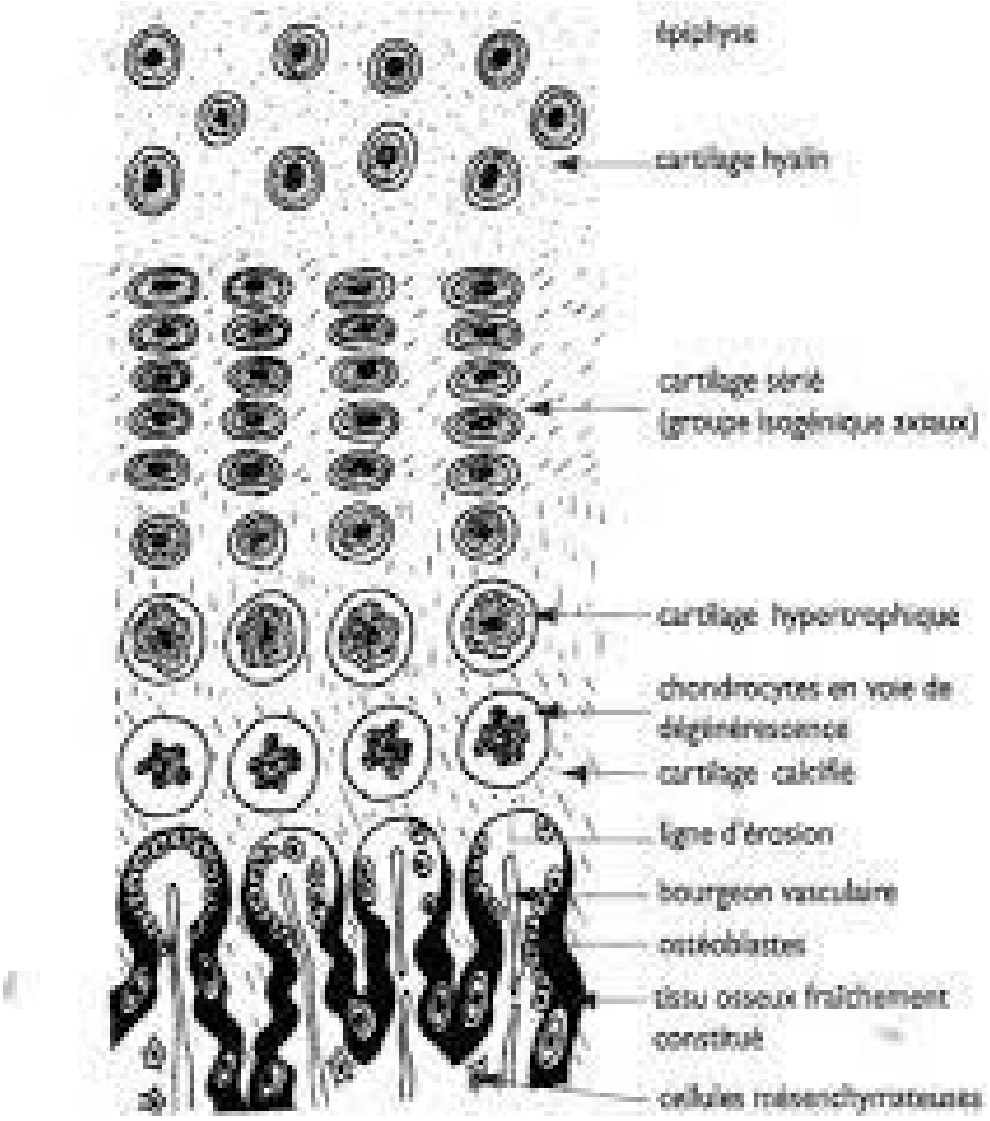


B – At the level of the inferior and superior growth plate cartilages: ENDOCHONDRAL

1 – formation of axial isogenic groups: serialised (columnar) cartilage.

2 – chondrocyte hypertrophy: hypertrophied cartilage.

3 – calcification of the cartilaginous matrix: calcified hypertrophied cartilage.

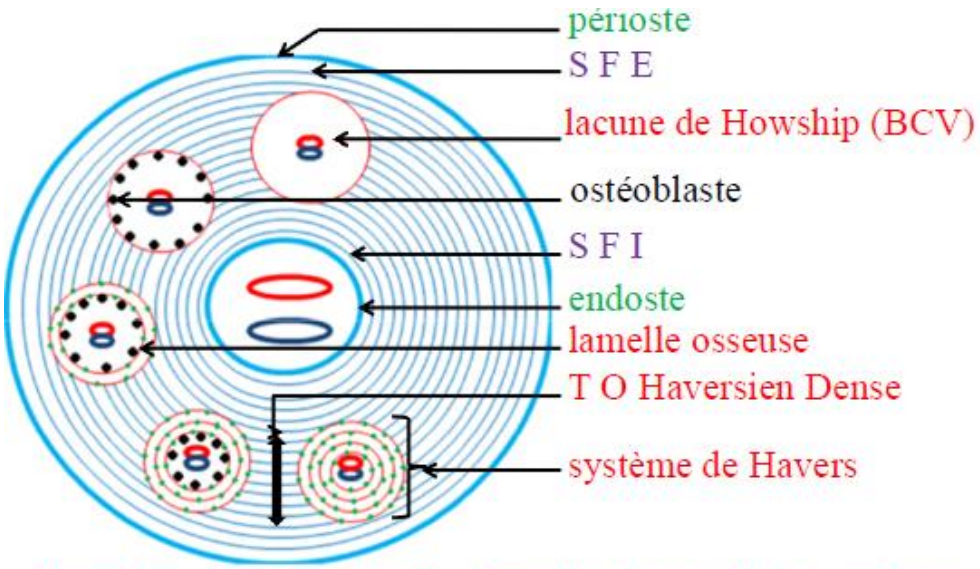
4 – chondrocyte atrophy: calcified atrophied cartilage.

5 – death of chondrocytes and formation of empty cavities.

6 – chondroclasia of the cartilaginous floor of each cavity along an erosion line.

7 – formation of corridors into which the B.V.C engage.

8 – triggering of the fundamental process of ossification.



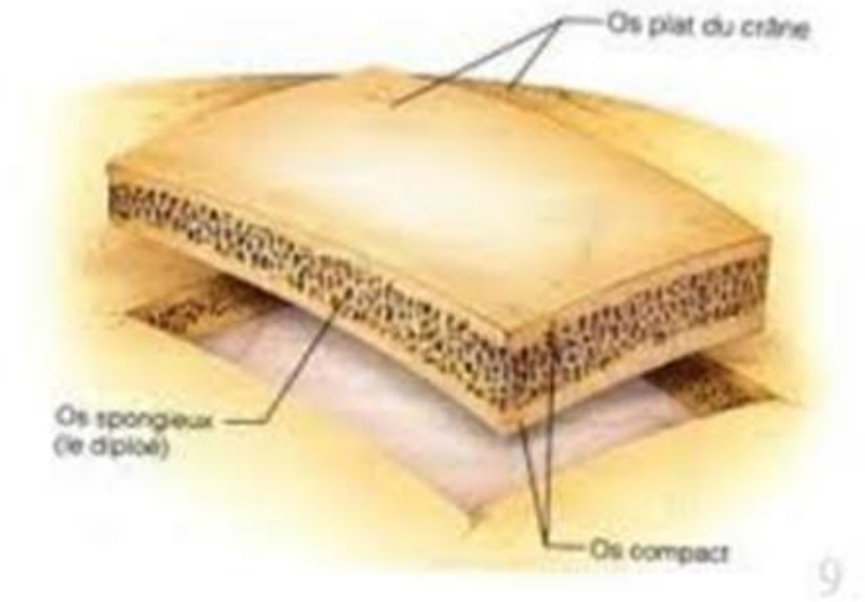
Formation du tissu osseux haversien dense et des systèmes fondamentaux de la diaphyse.

Secondary Ossification

Replacement of primary bone tissue (periosteal bone sleeve) by secondary lamellar bone tissue.

1. Osteoclasia of the periosteal bone sleeve (primary BT).
2. Formation of temporary secondary bone tissue.
3. Osteoclasts, formed in the medullary cavity and the periosteum, hollow out Howship's lacunae in the temporary secondary bone tissue: – perpendicular to the longitudinal axis of the diaphysis (future Volkmann's canals); – then parallel to the longitudinal axis of the diaphysis (future Haversian systems). Simultaneously, B.C.V penetrate into the Howship's lacuna. Subsequently, through the fundamental process of ossification, the Haversian systems are established: dense Haversian bone tissue.

• The periosteum and endosteum successively appose the external and internal fundamental systems.



Formation of dense Haversian bone tissue and the fundamental systems of the diaphysis.

C – At the Level of the Epiphyses

• **At birth**: formation of the secondary ossification centre that becomes established in the superior epiphysis.

• **Two years after birth**: formation of the secondary ossification centre that becomes established in the inferior epiphysis.

Ossification of Short Bones

• For truly short bones, such as those of the wrist (carpus), ossification occurs as in the epiphysis.

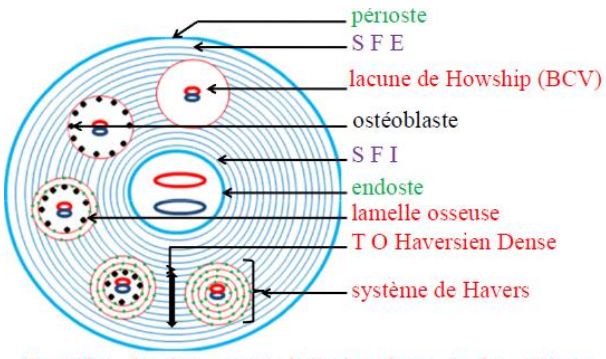
• It begins from a cartilaginous model.

• For long-type short bones (metacarpals), ossification occurs in the same manner as that of long bones: – For the extremities of short bones: see epiphyses, – For the body of the short bone: see diaphysis.

Ossification of Flat Bones

• It occurs from a connective tissue: the periosteum. It is an endoconjunctive ossification.

• It allows the formation of flat bones such as those of the cranial vault.



Formation du tissu osseux haversien dense et des systèmes fondamentaux de la diaphyse.

Growth of Bone Tissue

• Longitudinal growth occurs through the activity of the growth plate cartilages.

• Width growth occurs through the activity of the periosteum.