MSK block
Bone fracture and healing

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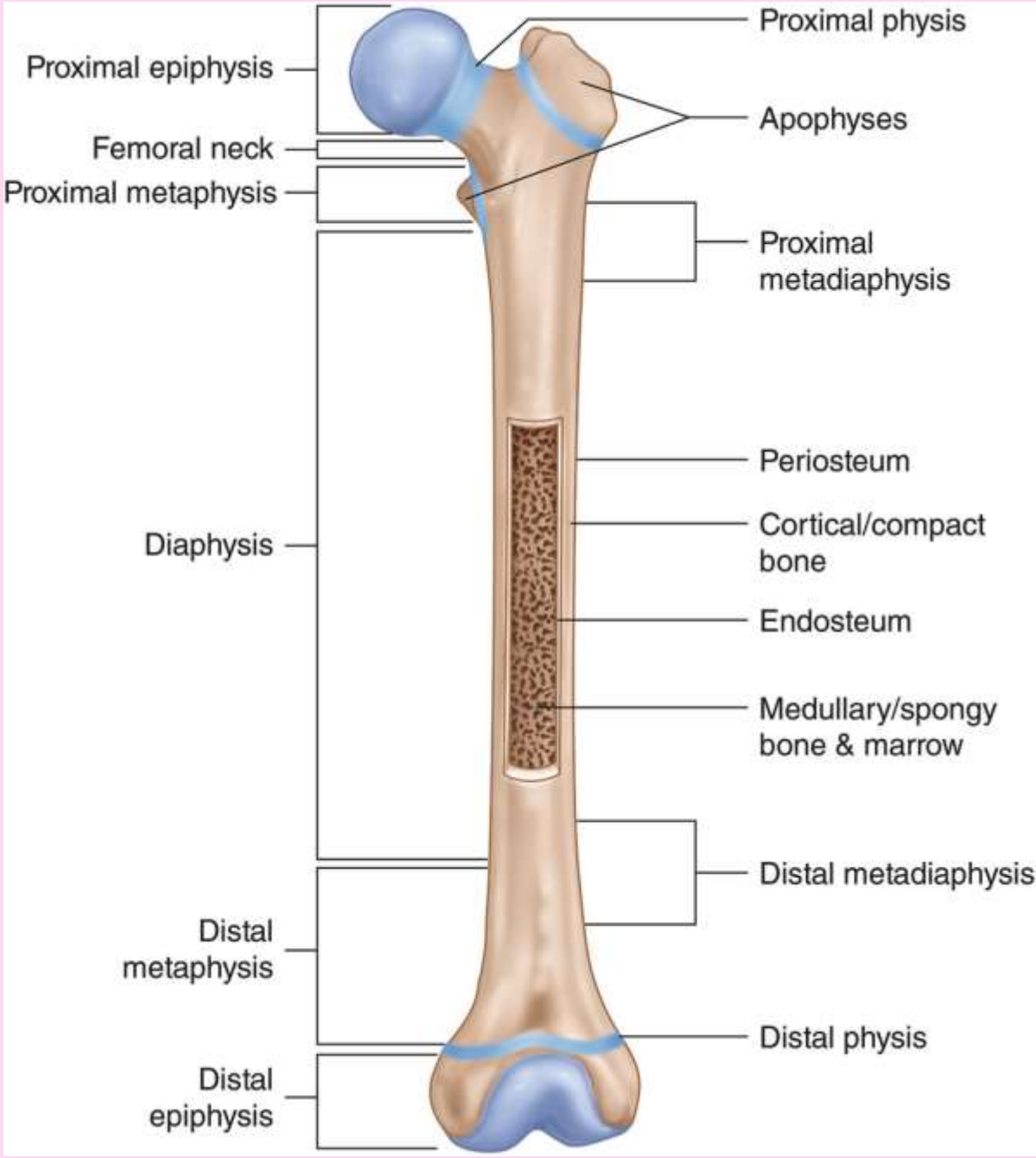
- Objectives of this lecture:
  - Know the different **types** of fractures
  - Be aware of the **mechanism and stages** of fracture healing process
  - Know **the factors affecting healing** process and the possible **complications** of healing process
  - Understands the difference between trauma induced and pathological fractures
  - Appreciate the importance of Motor Vehicle Accidents (MVA) as a major cause of disability in Saudi Arabia

1- Epiphysis: ends of bone, partially covered by articular cartilage.

2- Physis: the growth plate.

3- Metaphysis: junction of diaphysis and epiphysis.

4- Diaphysis: the shaft.

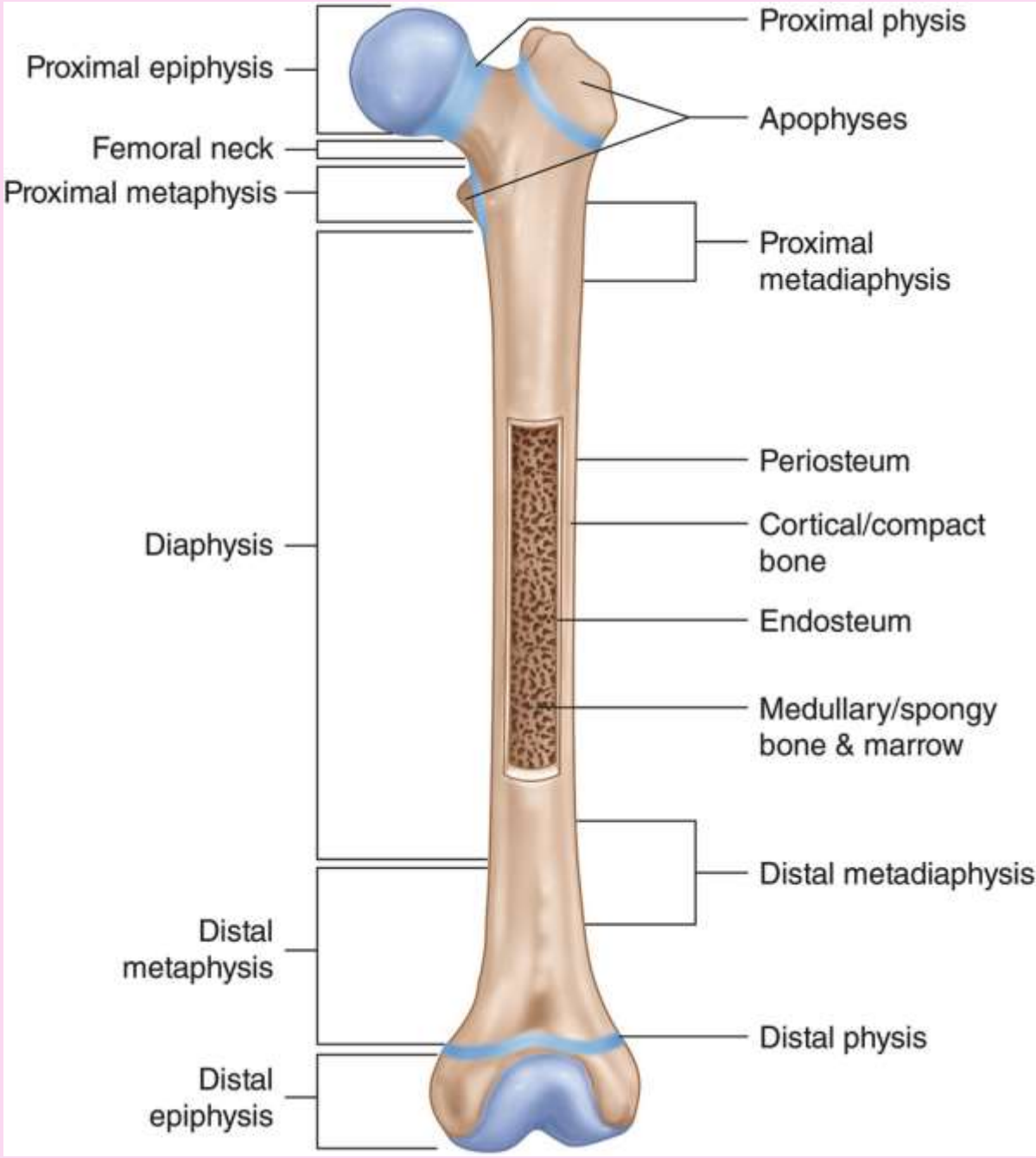


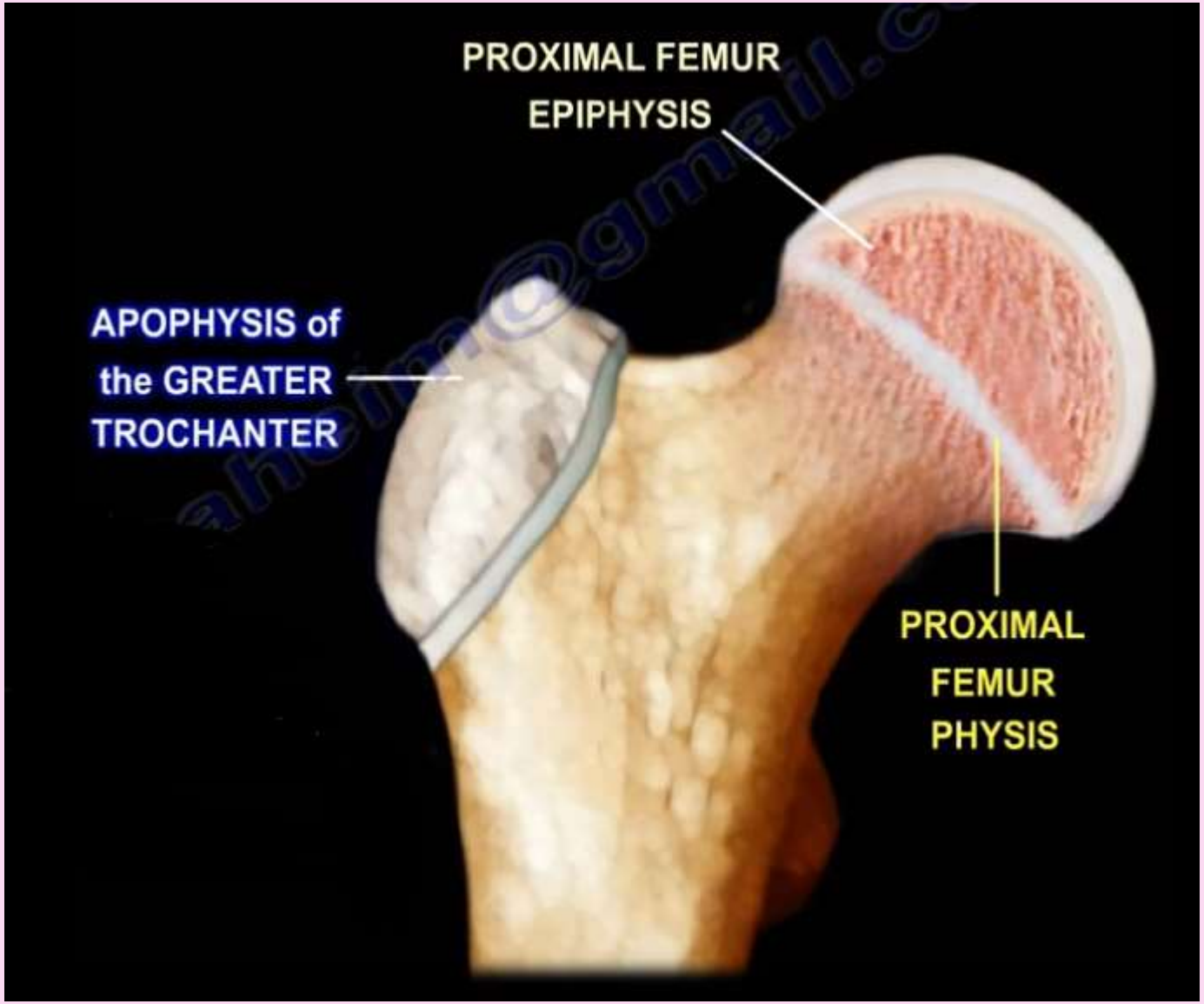
1- Periosteum.

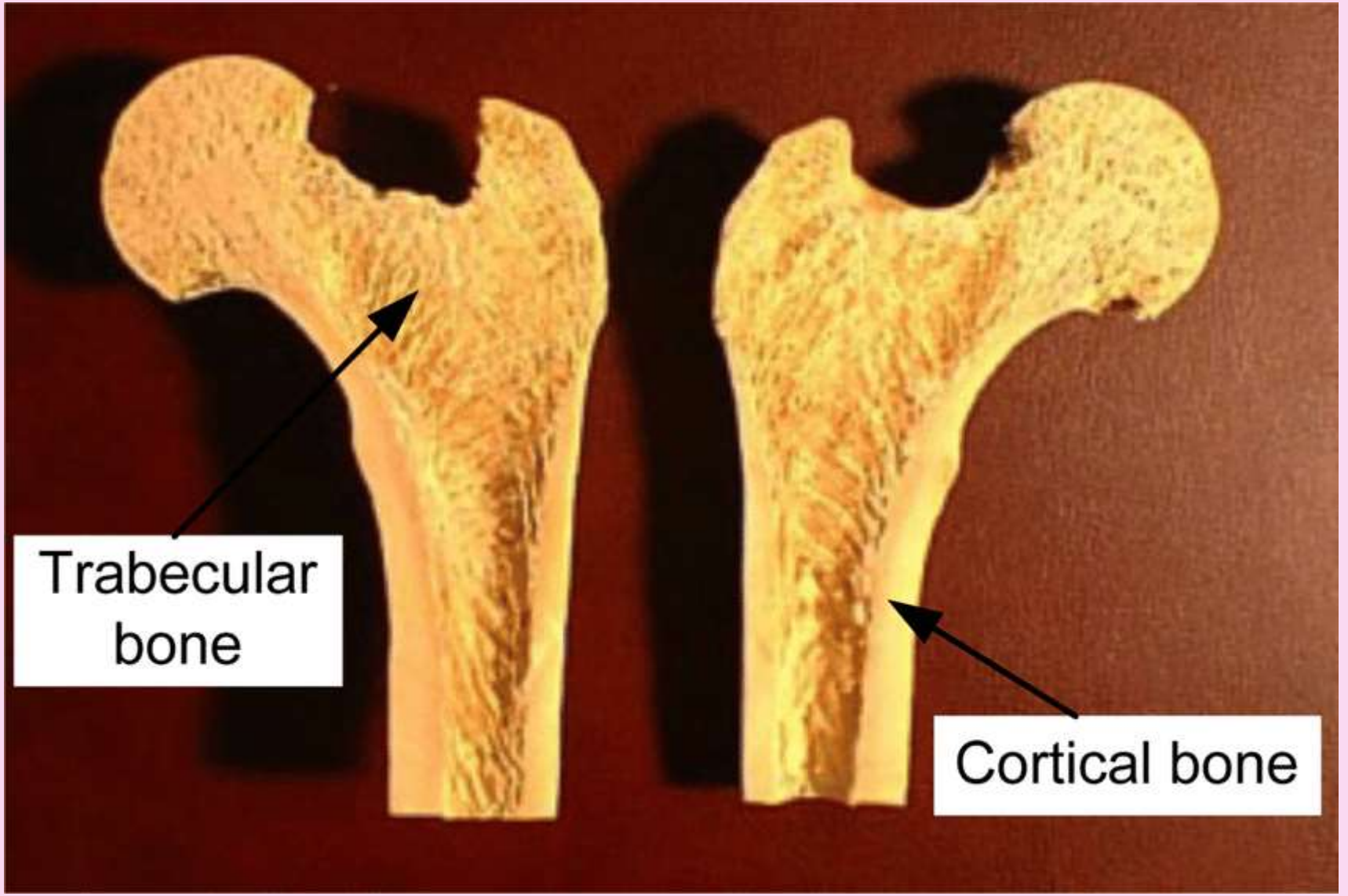
2- Cortex: Cortical/ Compact bone.

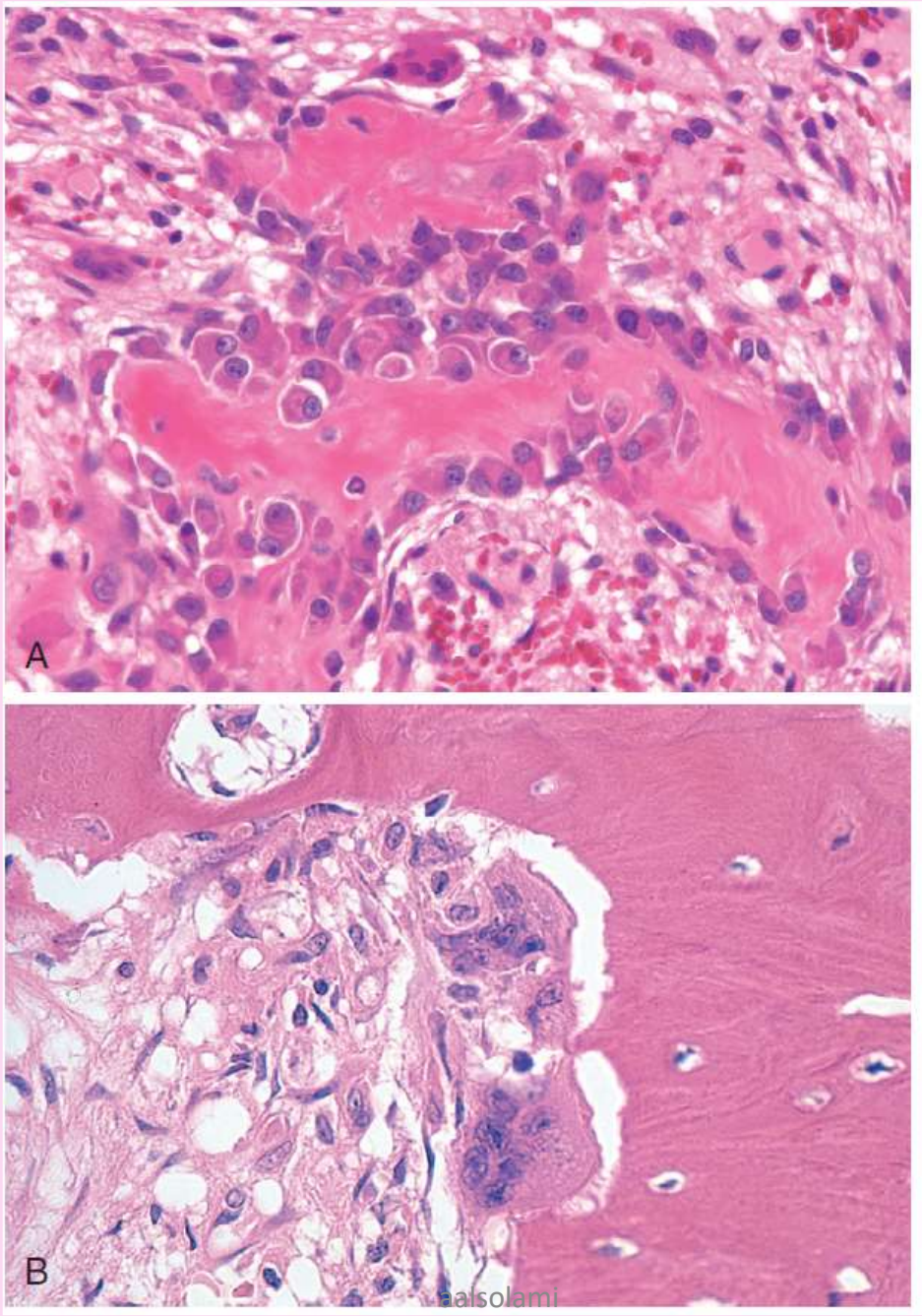
3- Endosteum.

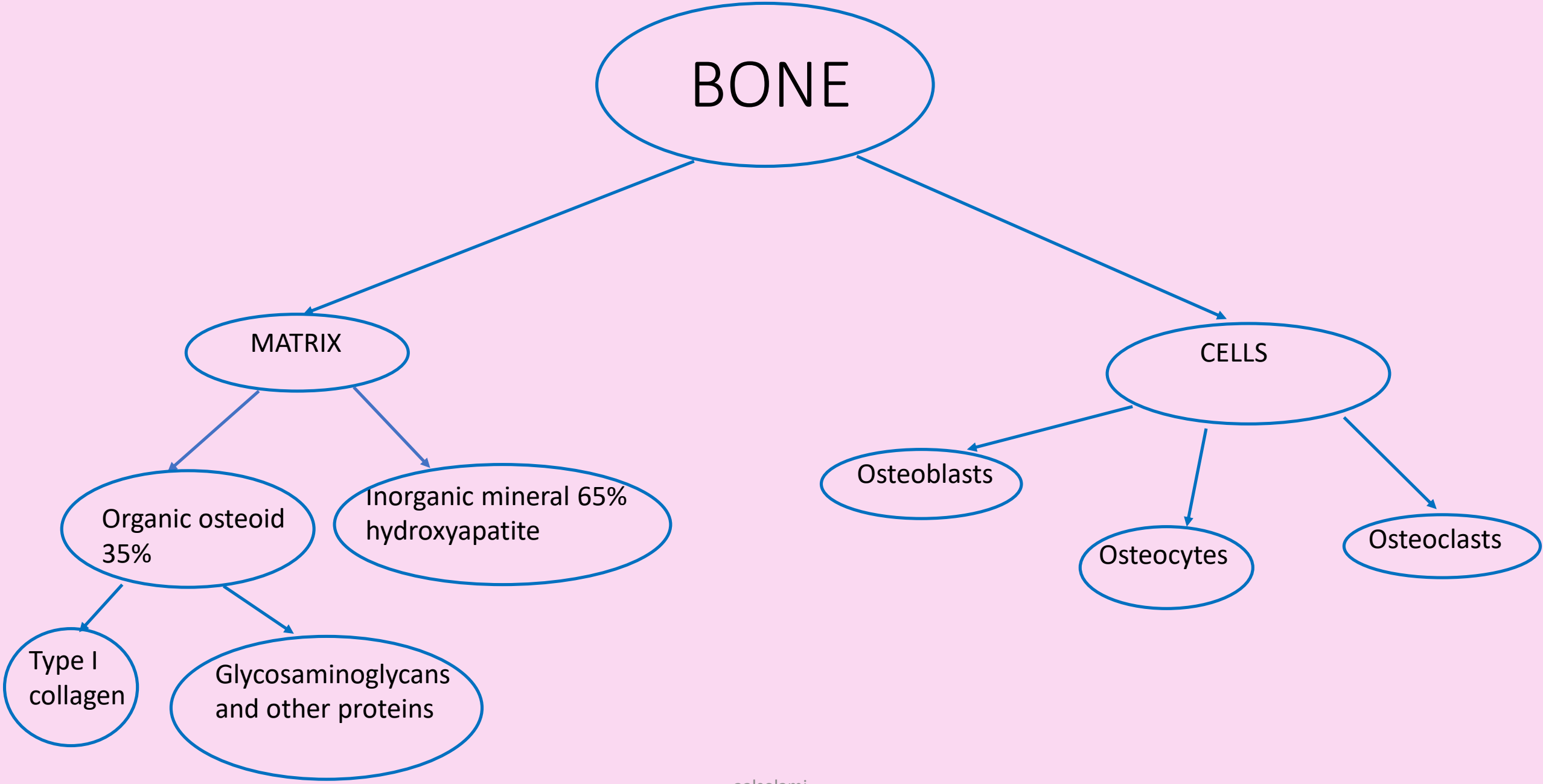
4- Medullary space: Cancellous/ Spongy bone.

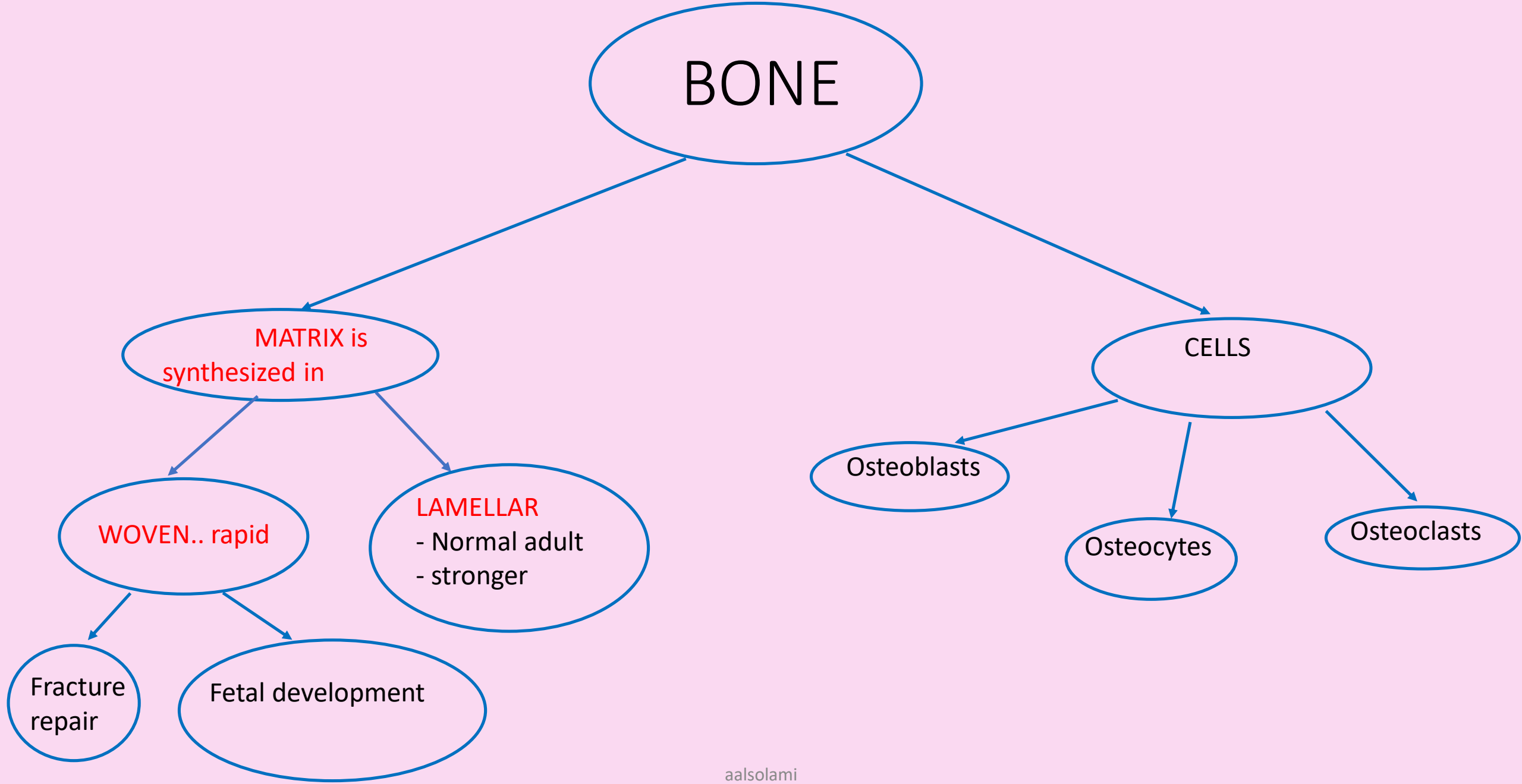


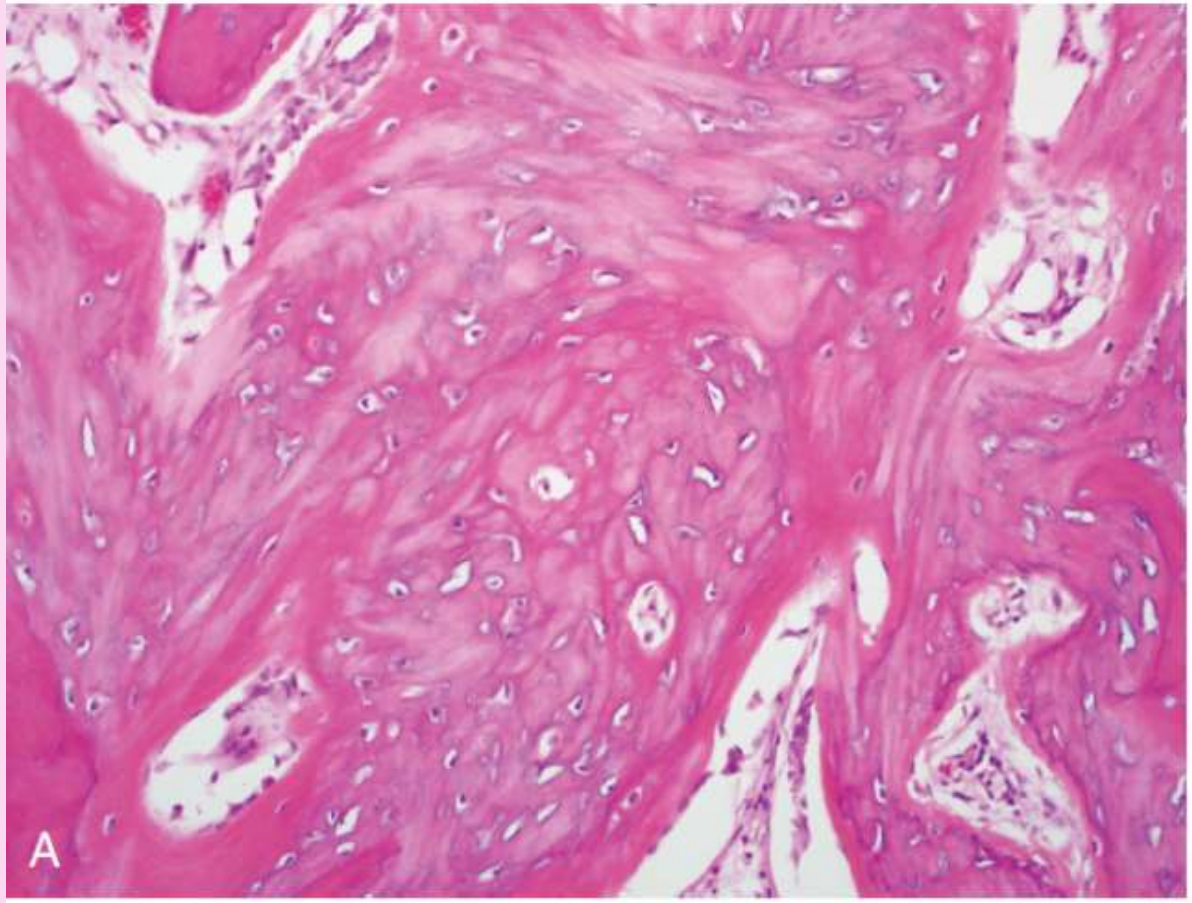

PROXIMAL FEMUR
EPIPHYSIS
APOPHYSIS of
the GREATER
TROCHANTER
PROXIMAL
FEMUR
PHYSIS

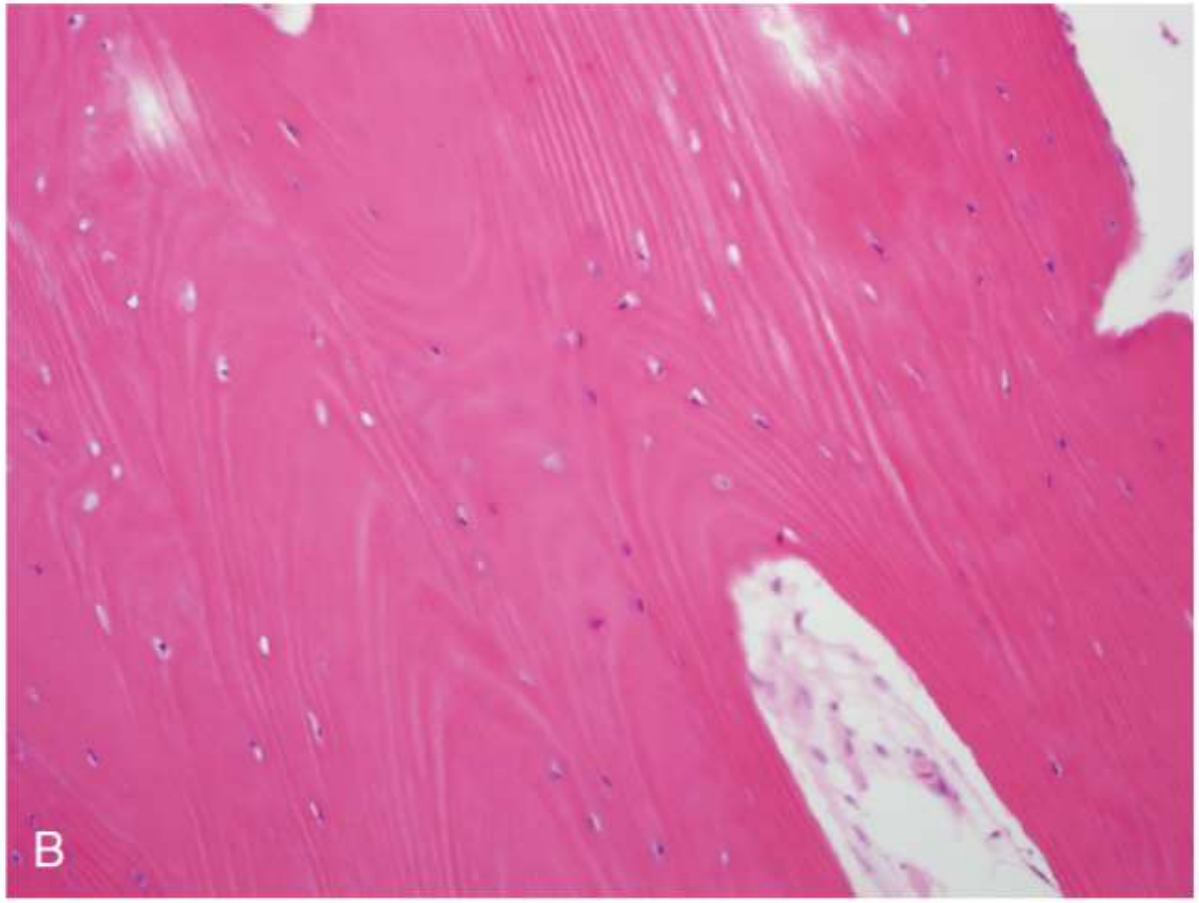





BONE
MATRIX
CELLS
Organic osteoid 35%
Inorganic mineral 65% hydroxyapatite
Osteoblasts
Osteocytes
Osteoclasts
Type I collagen
Glycosaminoglycans and other proteins


BONE
MATRIX is synthesized in
CELLS
WOVEN.. rapid
LAMELLAR
- Normal adult
- stronger
Osteoblasts
Osteocytes
Osteoclasts
Fracture repair
Fetal development





BONE

CELLS

Osteoblasts

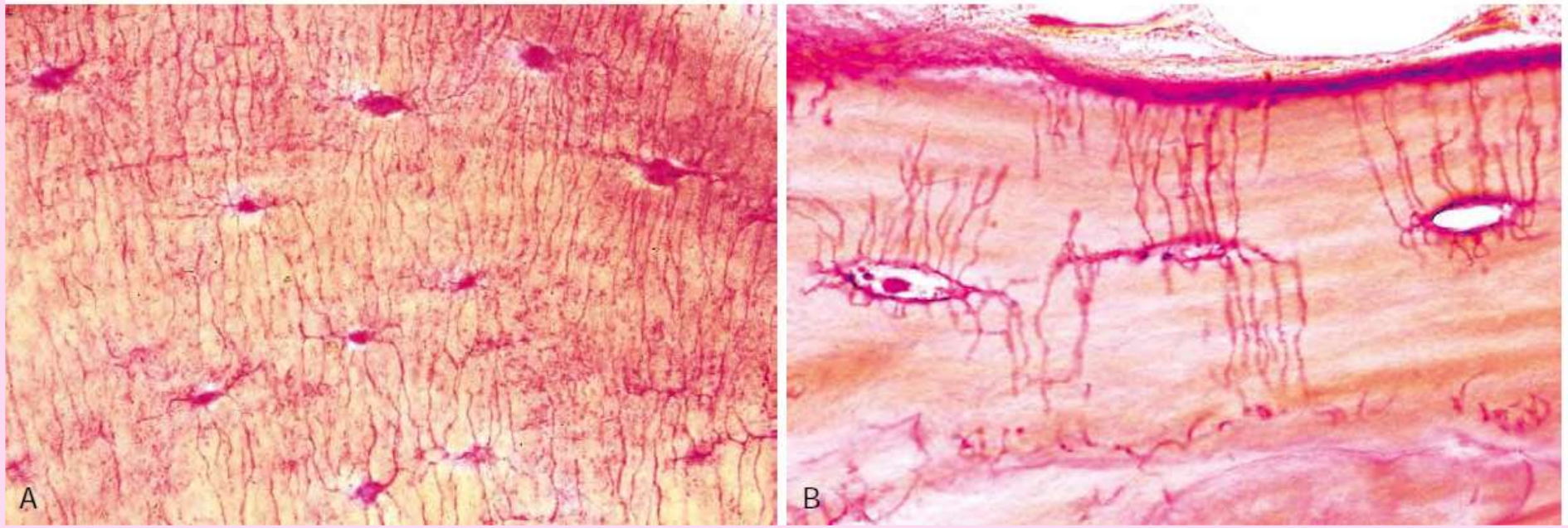
- On surface of bone matrix (synthesize, transport and regulate mineralization).
- From mesenchymal stem cells, under periosteum (early), medullary space (later)

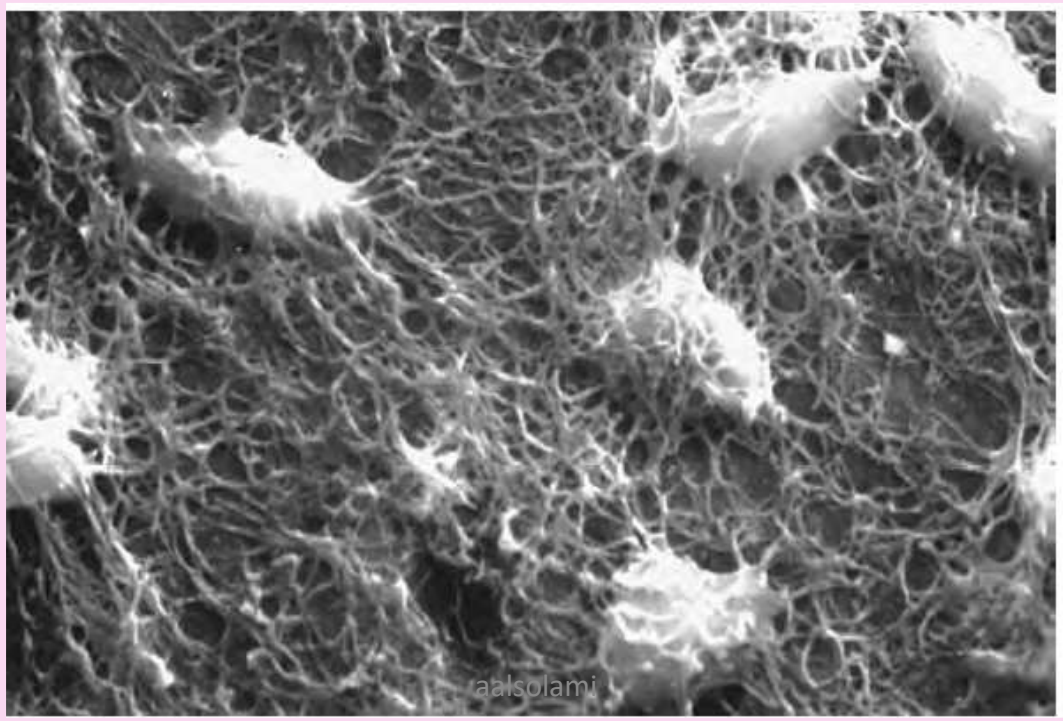
Osteocytes

- Within the bone.
- Interconnected, network of cytoplasmic processes through tunnels (canaliculi).
- Help control Ca and Ph, detect mechanical forces and translate them into biologic activity (mechanotransduction)

Osteoclasts

- On surface of bone.
- Specialized multinucleated macrophages..circulating monocytes.
- Bone resorption.
- Attach to bone matrix, sealed extracellular trench (resorption pit), secrete acid and neutral protease/MMPs, reosorb bone


A
B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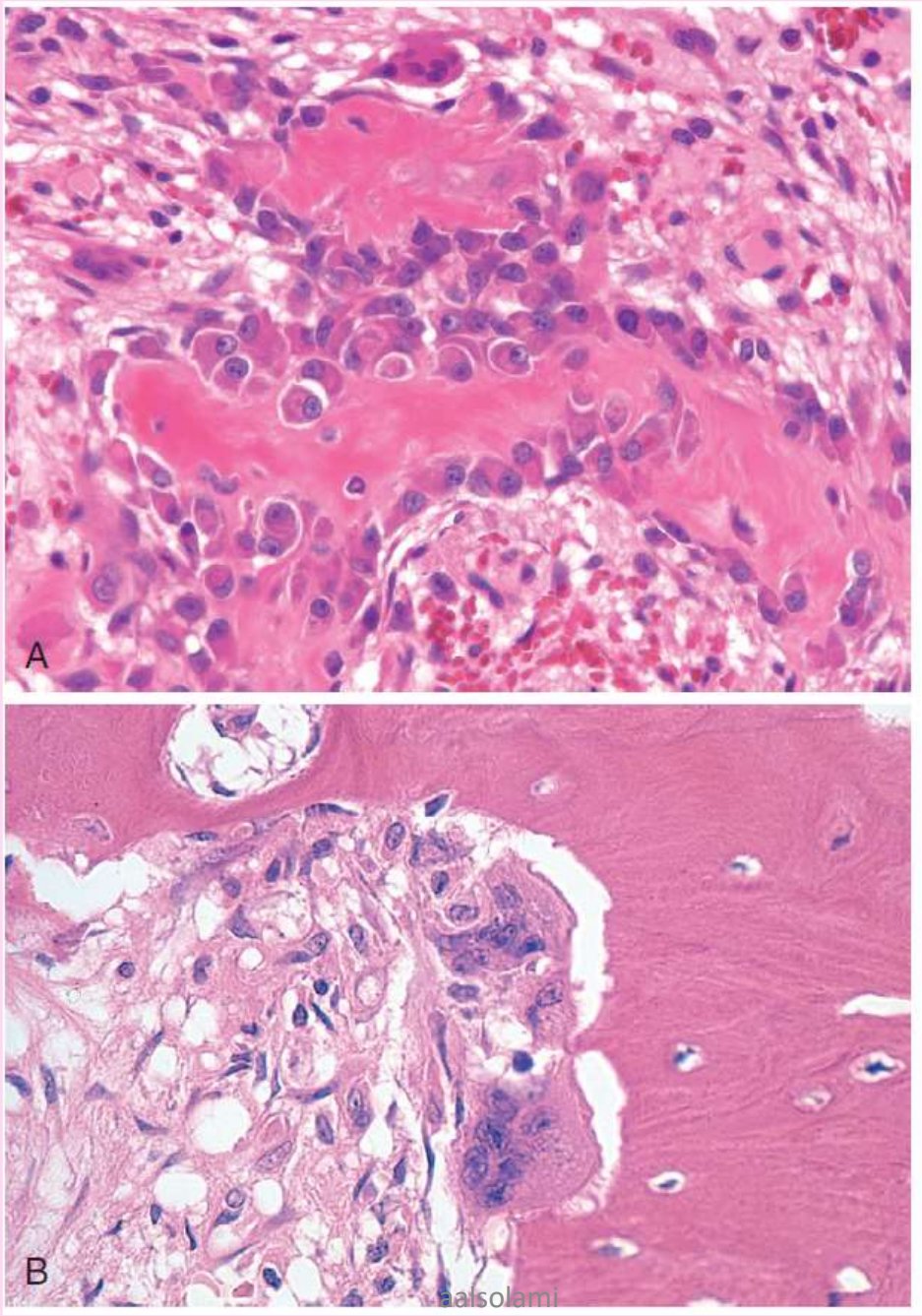


Fracture..break in continuity of bone

- Loss of bone integrity resulting from mechanical injury and/or diminished bone strength.

Types of fracture

1- Simple: the overlying skin is intact

Closed

2- Compound: the bone communicates with the skin surface

Open

INFECTION!

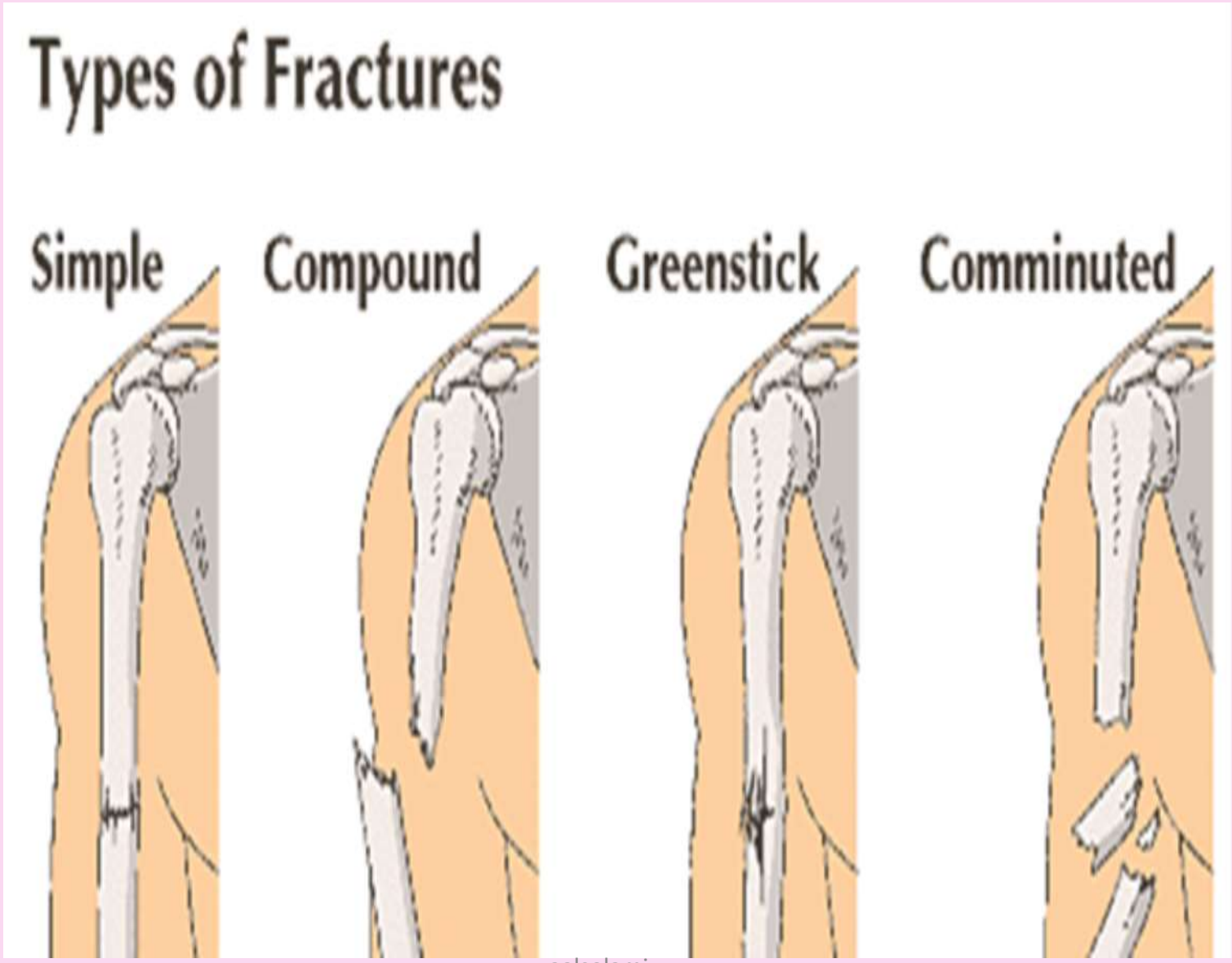
3- Comminuted: The bone is fragmented.

4- Displaced: the ends of the bone at the fracture site are not aligned

5- Stress: a slowly developing fracture that follows a period of increased physical activity in which the bone is subjected to repetitive loads

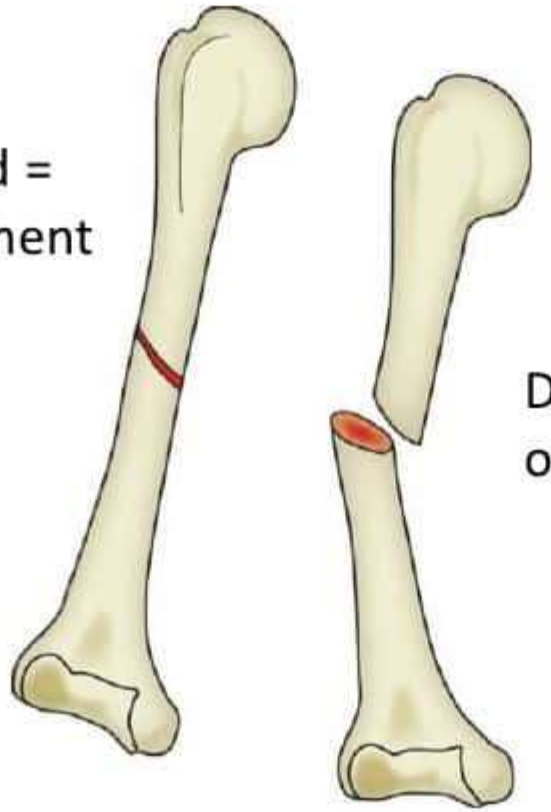
6- Greenstick: extending only partially through the bone, common in infants when bones are soft

7- Pathologic: involving bone weakened by an underlying disease process, such as a tumor


Types of Fractures
Simple
Compound
Greenstick
Comminuted

Displaced and Non displaced

Non displaced =
normal alignment



Displaced = pulled out
of normal alignment

Fig. 1 Complete fracture

Fig. 2 Incomplete fracture

- Complicated fracture:

Associated with damage to nerves, vessels or internal organs

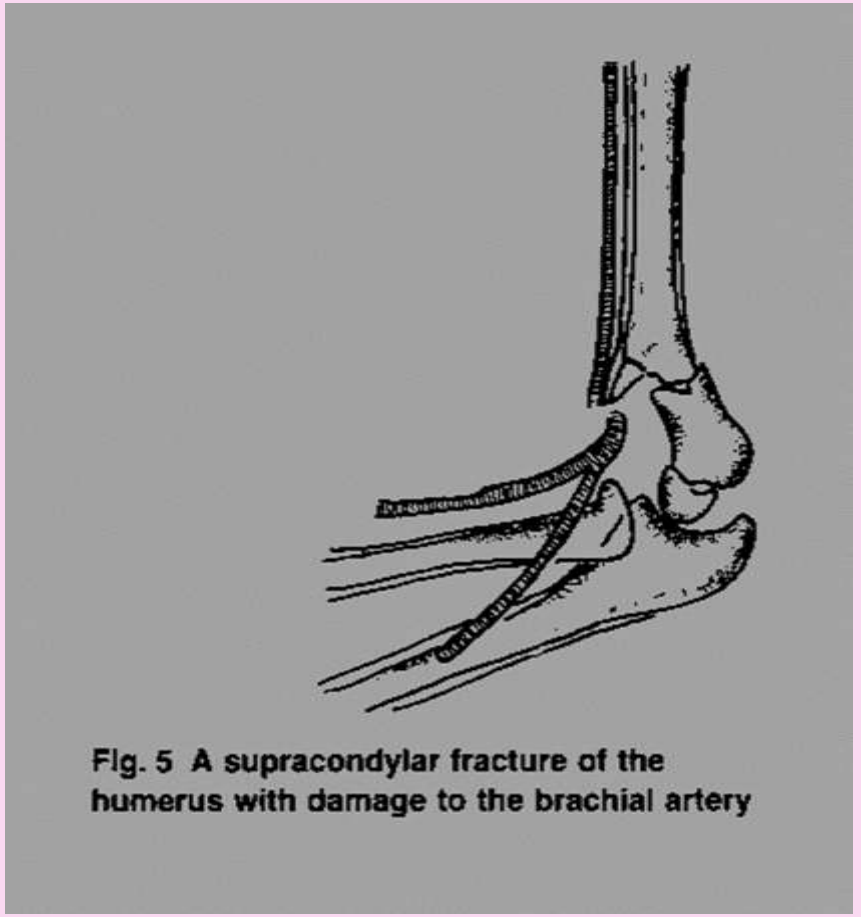
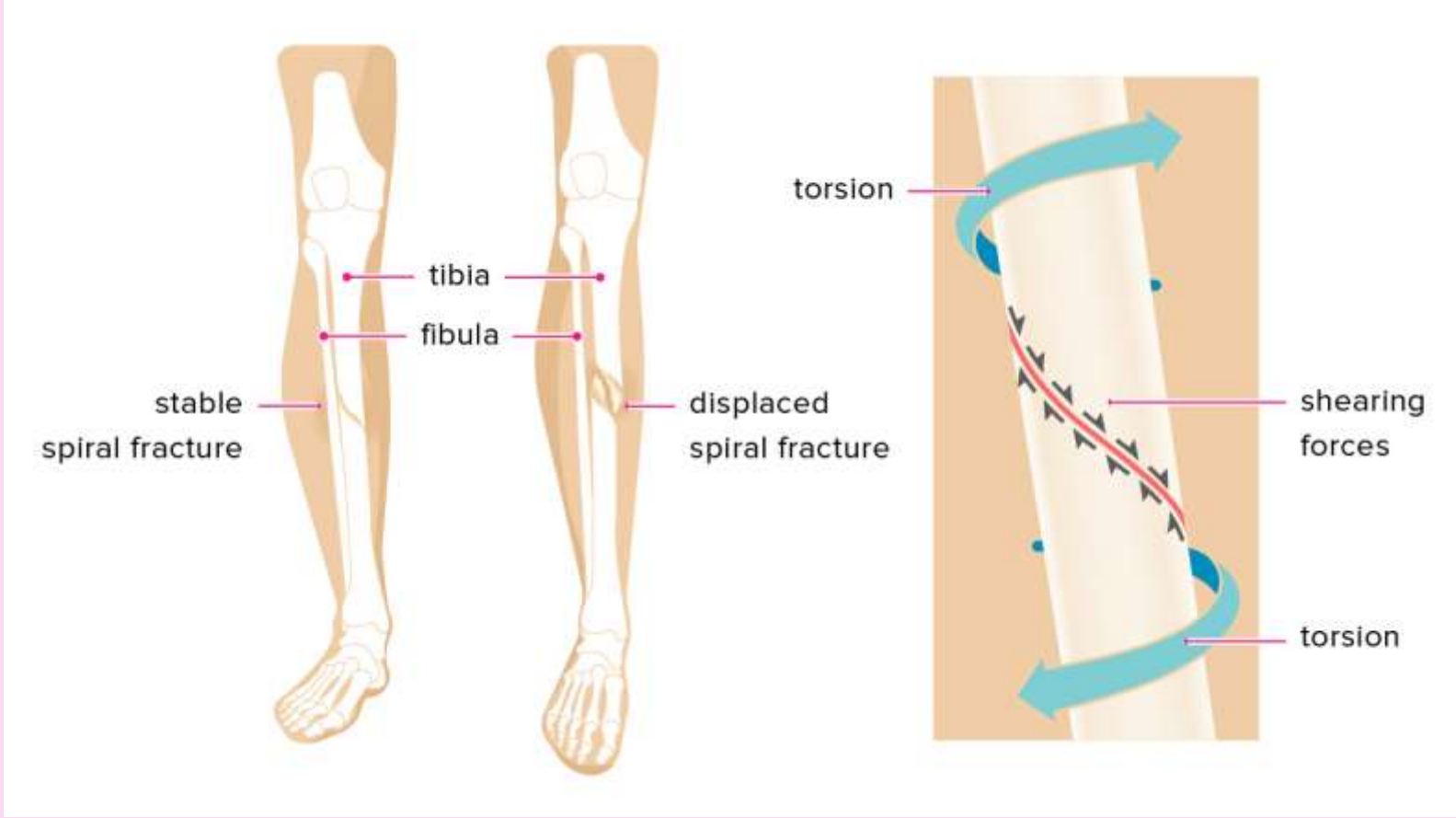


Fig. 5 A supracondylar fracture of the humerus with damage to the brachial artery

- Spiral fracture:

Twisting force




a
R
b

Causes of fracture

1-
TRAUMATIC:
Severe trauma e.g. MVA

2-
PATHOLOGIC:

3-
STRESS:

Causes of fracture

2-
PATHOLOGIC:
- Minimal trauma.
- The underlying bone is abnormal..

e.g. Osteoporosis
Osteomalacia
Paget's disease of bone
Tumor (primary or metastasis)
Congenital bone diseases (e.g. Osteogenesis Imperfecta).

Causes of fracture

3-
STRESS:

- Slowly over time.
- Collection of microfractures associated with increased physical activity (new repetitive mechanical loads on bone).
- most common in the weight-bearing bones of the lower leg and foot.
- athletes and military recruits who carry heavy packs over long distances are particularly susceptible

Healing of fracture

1- Reactive phase:

a) Hematoma and inflammatory phase.

b) Granulation tissue formation.

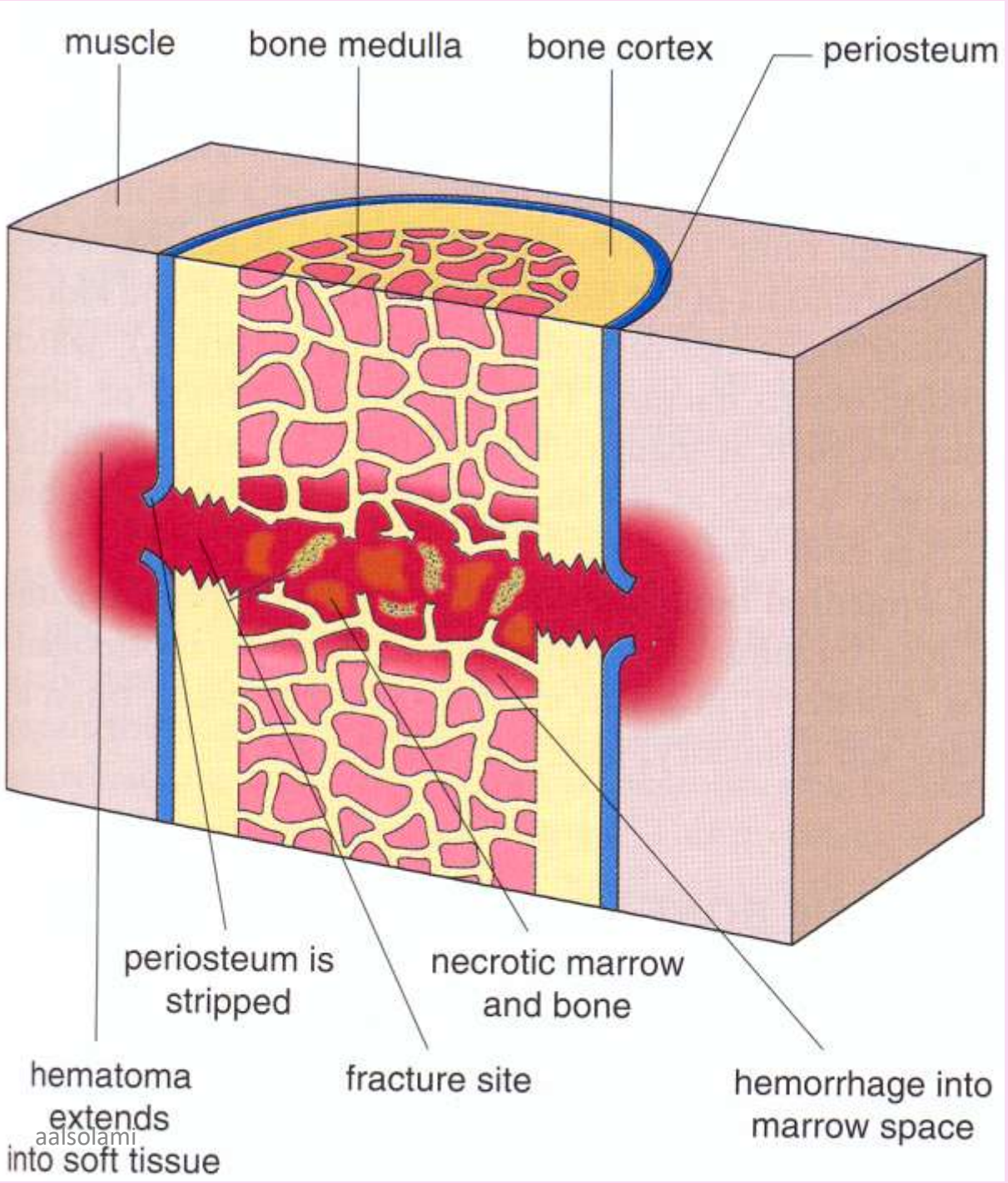
2- Reparative phase:

Callus formation (soft and bony).

3- Remodeling phase:

Remodeling to original bone contour

1- Reactive phase

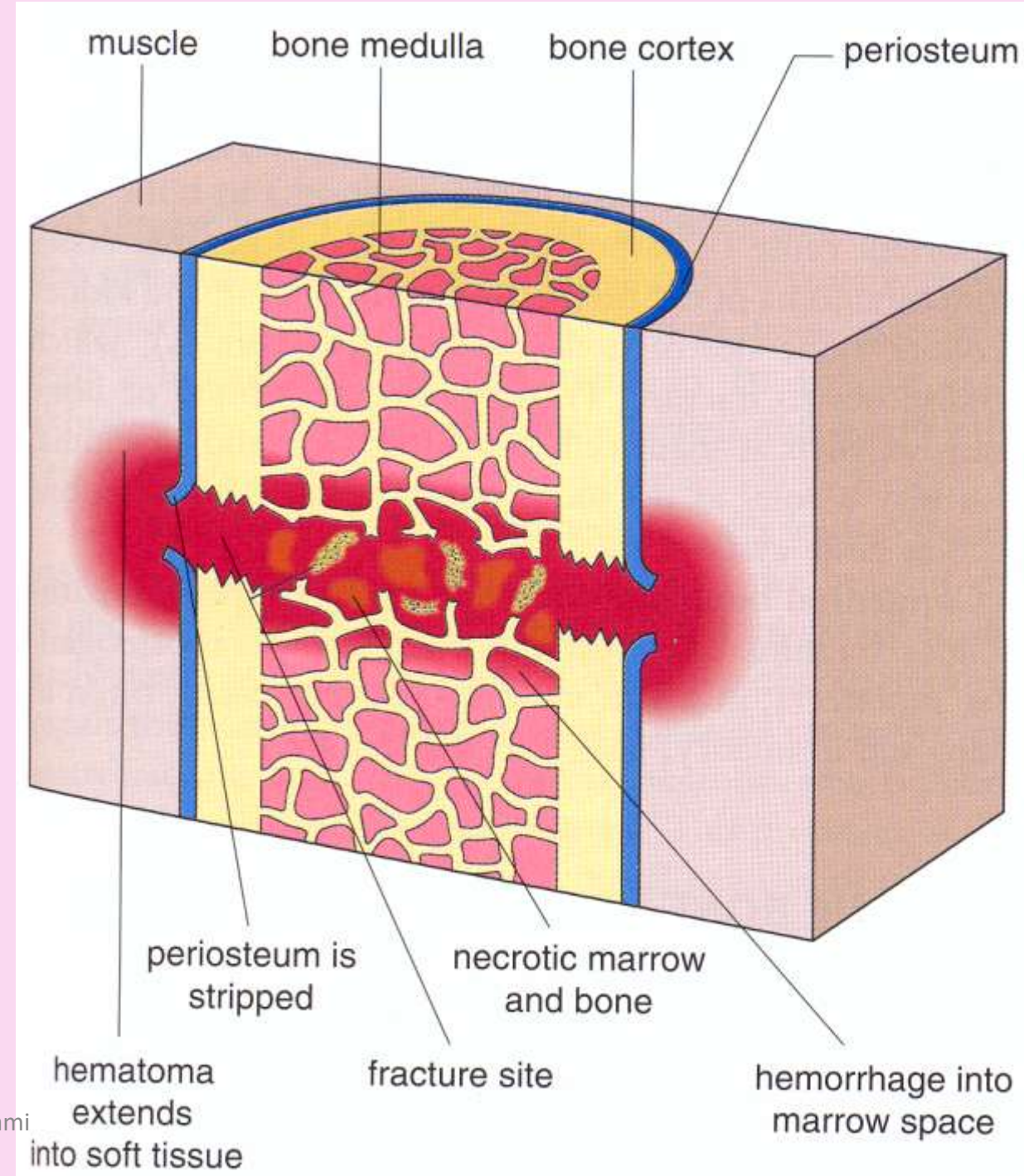


1- Reactive phase:

- Bleeding causes swelling due to inflammation induced by chemical mediators produced from macrophages and other inflammatory cells with granulation tissue formation.

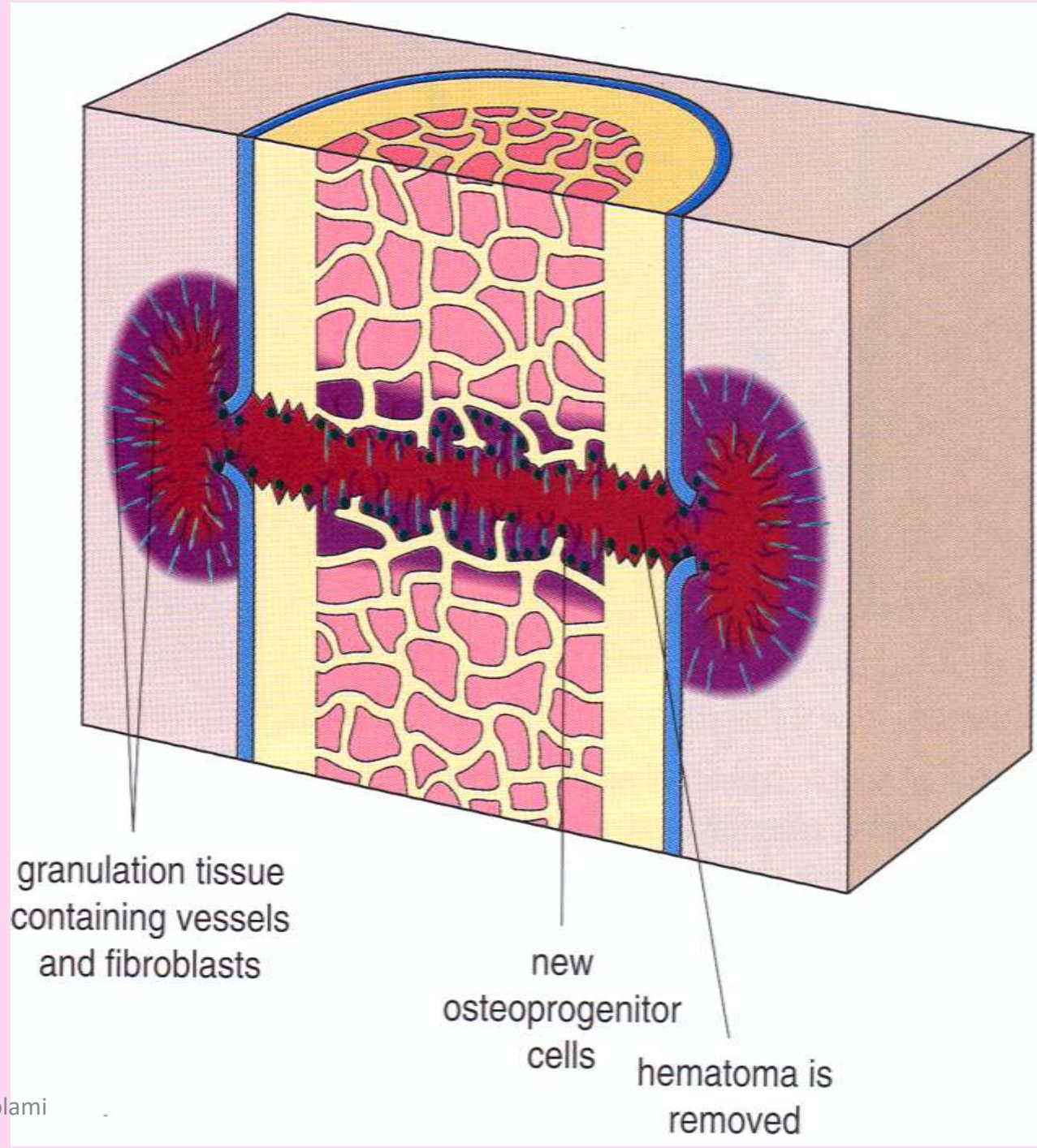
1- reactive phase

- A. Due to tearing of blood vessels in the medullary cavity, cortex and periosteum, a hematoma forms at the site of fracture. The periosteum is stripped from the surface.

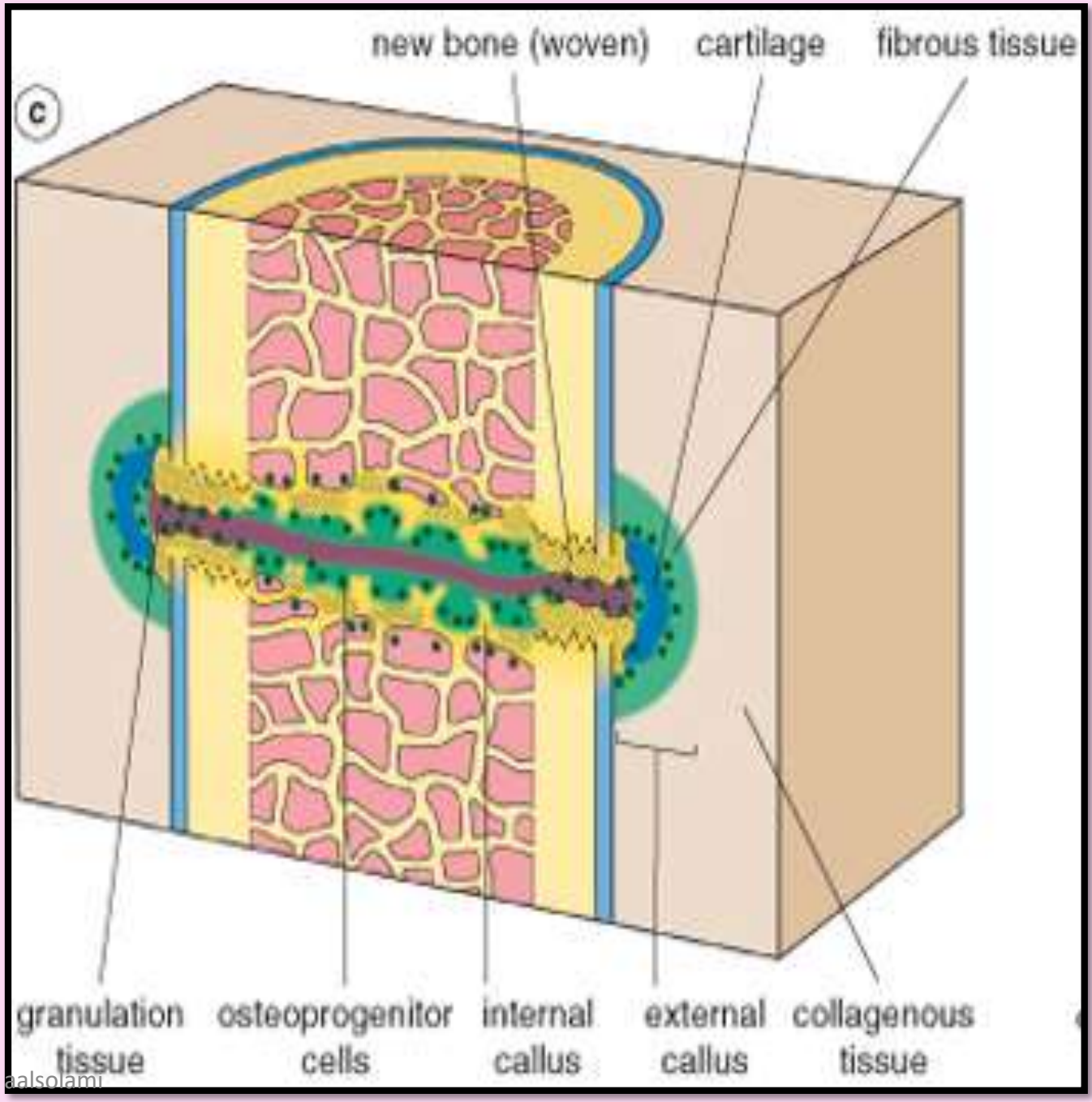


1- reactive phase

- B. Organization of the hematoma is associated with the migration of neutrophils and macrophages into the fracture hematoma; these cells phagocytose the hematoma and necrotic debris.



2- Raparative phase



2- Raparative phase:

- Degranulated platelets and marauding inflammatory cells subsequently release a host of cytokines (e.g., platelet-derived growth factor, fibroblast growth factor, TGF-B)
- PDGF, FGF, and TGF-B.. activate bone progenitor cells, and within a week, the involved tissue is primed for new matrix synthesis.
- This soft callus/procallus can hold the ends of the fractured bone in apposition but is noncalcified and cannot support weight bearing (end of first week).

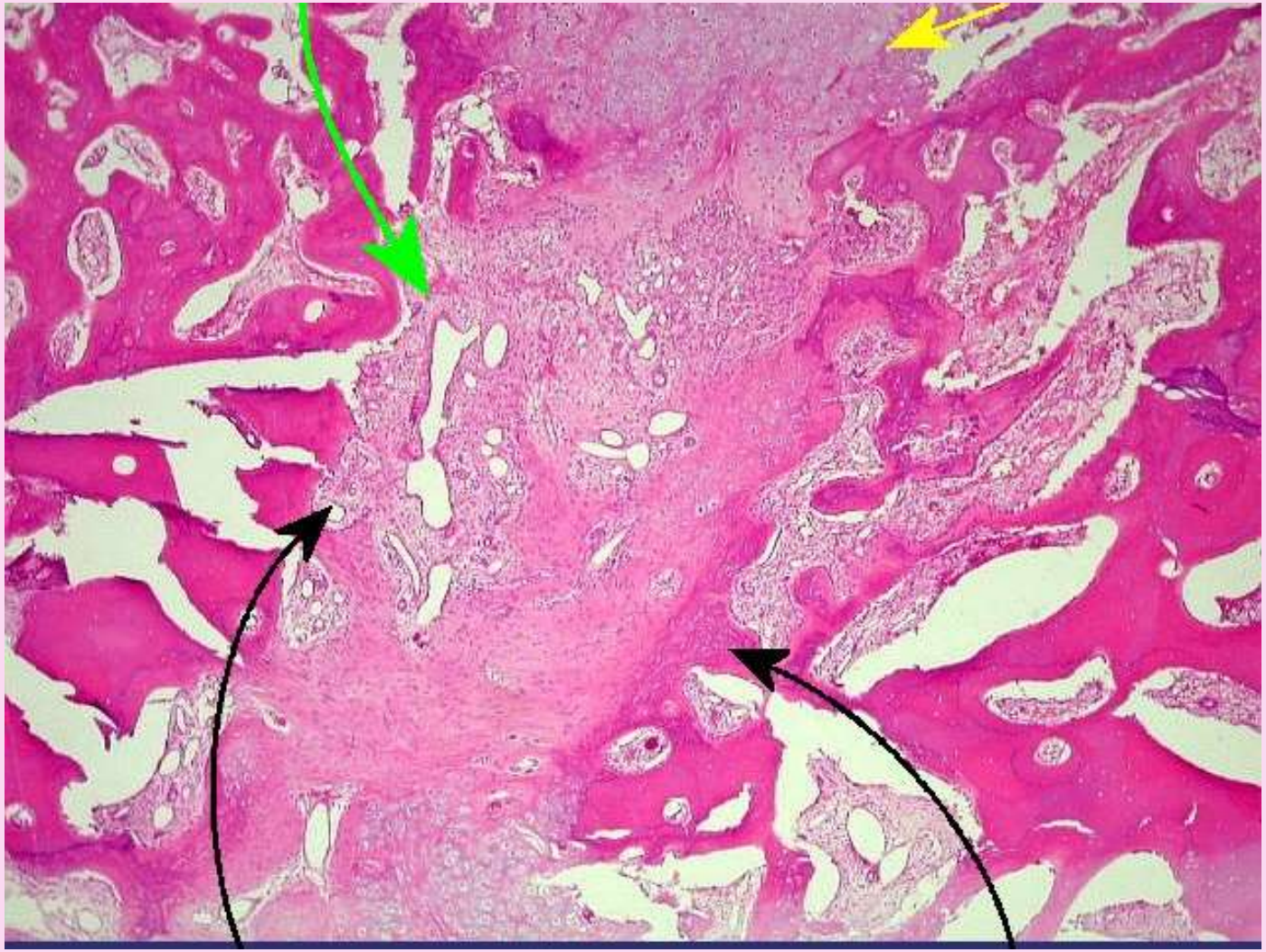
2- Reparative phase: after 2 weeks

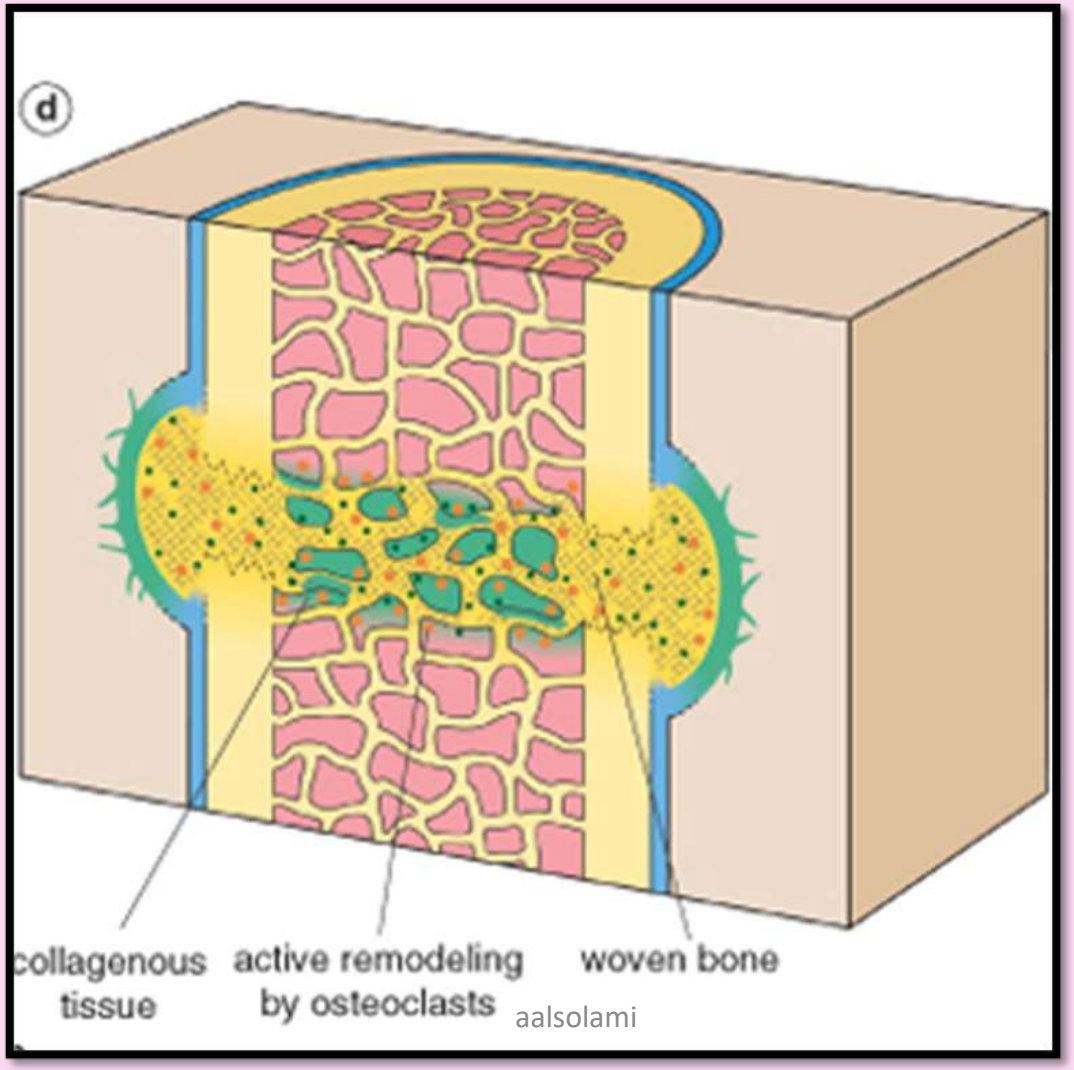
- HARD CALLUS:

- Activated osteoprogenitor cells deposit *woven bone.*
- In some cases, the activated mesenchymal cells in the soft tissues and bone surrounding the fracture line also differentiate into chondrocytes that make fibrocartilage and hyaline cartilage.
- In uncomplicated fractures, this early repair process peaks within 2 to 3 weeks.

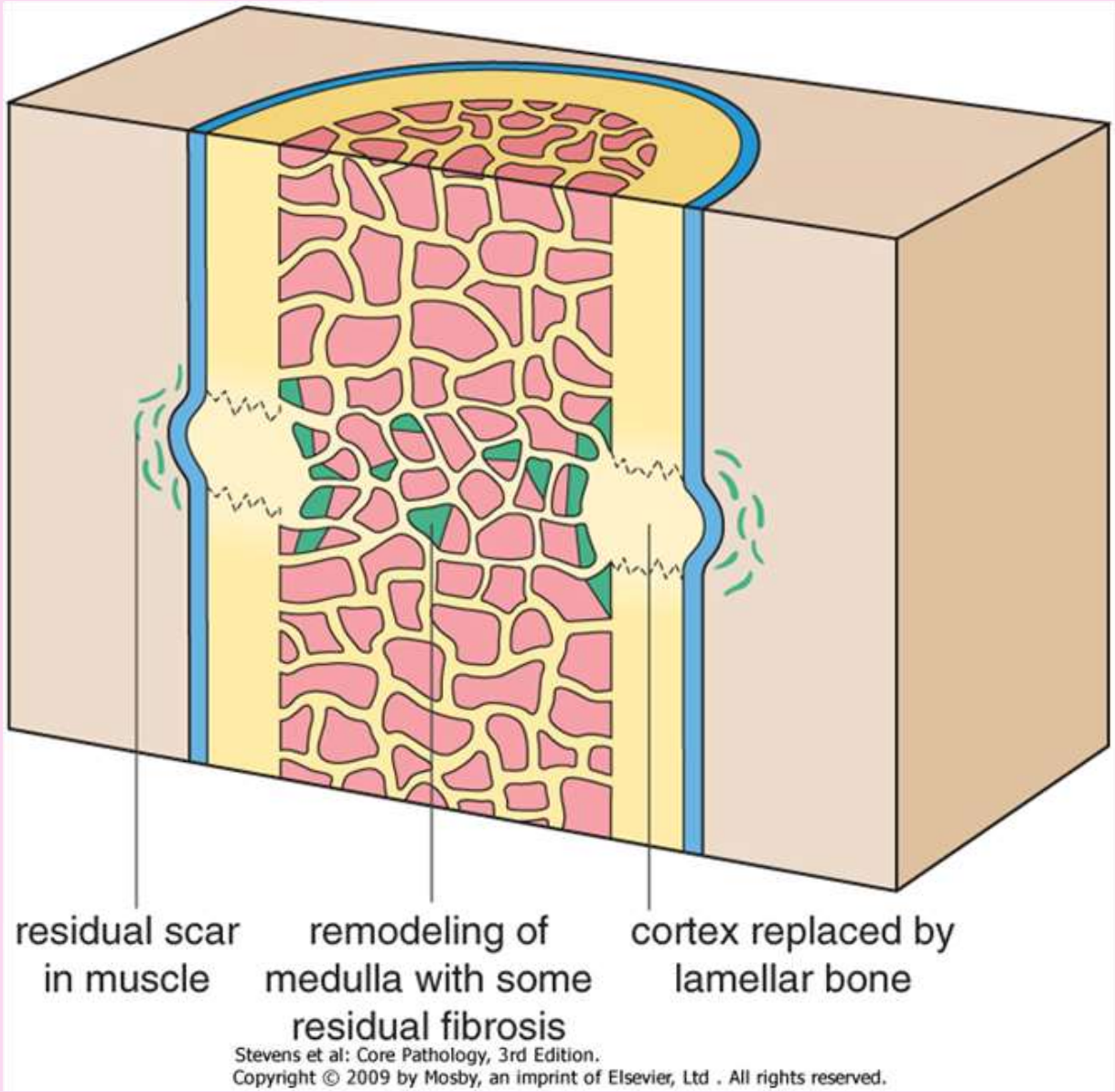
- The newly formed cartilage acts as a nidus for endochondral ossification, recapitulating the process of bone formation in epiphyseal growth plates. This connects the cortices and trabeculae in the juxtaposed bones.

- With ossification, the fractured ends are bridged by a bony callus.




d
collagenous tissue
active remodeling by osteoclasts
woven bone

3- Remodeling phase:

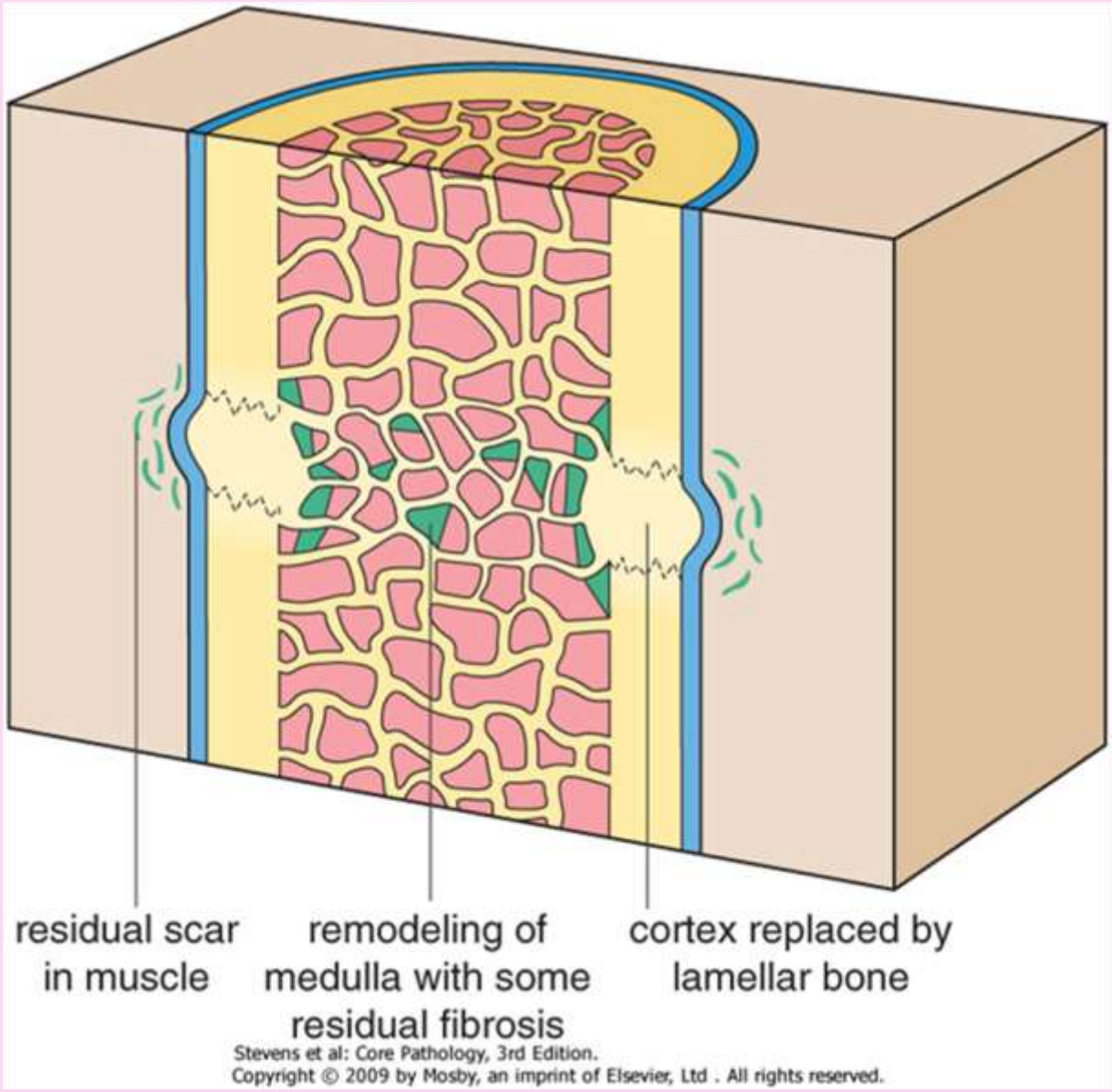


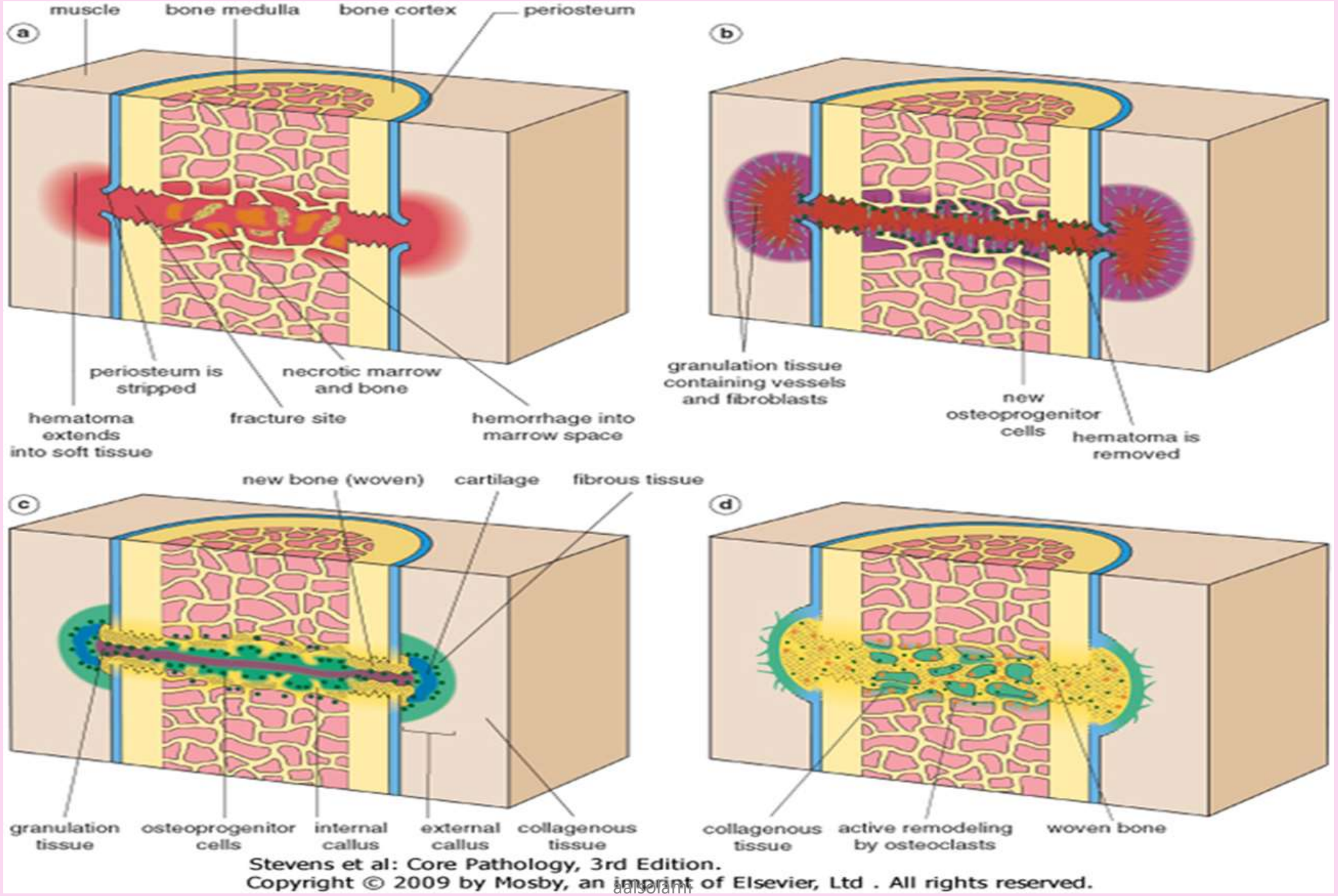
3- remodeling phase:

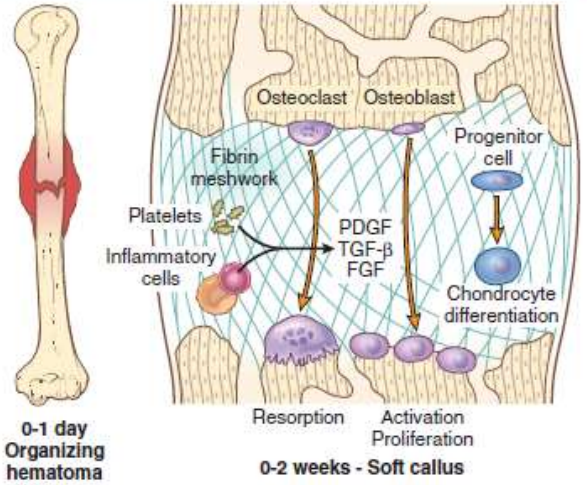
- Beginning about 8 to 1 2 weeks after the injury, the fracture site remodels itself, correcting any deformities that may remain as a result of the injury. This final stage of fracture healing can last up to several years.
- Although excess fibrous tissue, cartilage, and bone are produced in the early callus, subsequent weight bearing leads to remodeling of the callus… lamellar bone and restoration of medullary cavity.

3-remodeling phase

- The rate of healing and the ability to remodel a fractured bone vary tremendously for each person and depend on
  - age
  - health
  - the kind of fracture
  - the bone involved.

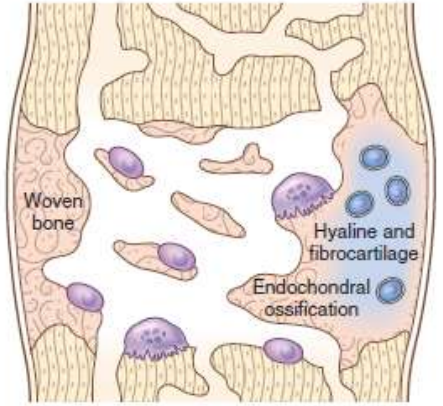




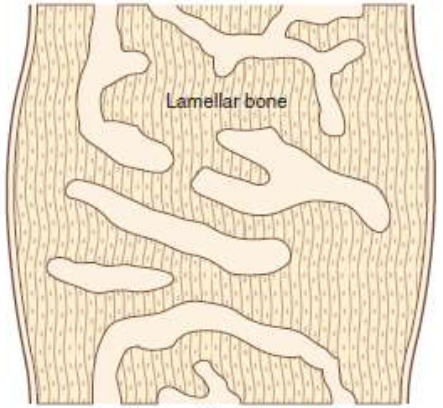


0-1 day
Organizing hematoma

0-2 weeks - Soft callus



2-3 weeks - Bony callus



3 weeks-months - Bony callus

Factors disrupting healing process:

1- Displaced and comminuted fractures

2- Infection

3- Vascular insufficiency:

This is particularly important in certain areas such as the scaphoid bone in the wrist and the neck of the femur, both of which can be associated with **avascular necrosis** of fracture fragments.

4- Inadequate minerals and vitamins

5- Inadequate immobilization (movement of the callus and prevents its normal maturation, resulting in *delayed union* or *Nonunion)*

Complications

1- Delayed union

2- Nonunion

3- Malunion

4- Neurovascular injury

5- Infection (Open fractures can become infected)

6- Post-traumatic arthritis (Fractures that extend into the joints (intra-articular fractures))

7- Growth abnormalities (A fracture in the open physis, or growth plate, in a child, can cause many problems)

….UNION

1- Delayed…:
A fracture that takes longer to heal than expected is a delayed union.

2- Non…:
A fracture that fails to heal in a reasonable amount of time is called a nonunion (pseudarthrosis)..

3- Mal…:
A fracture that does not heal in a normal alignment is called a malunion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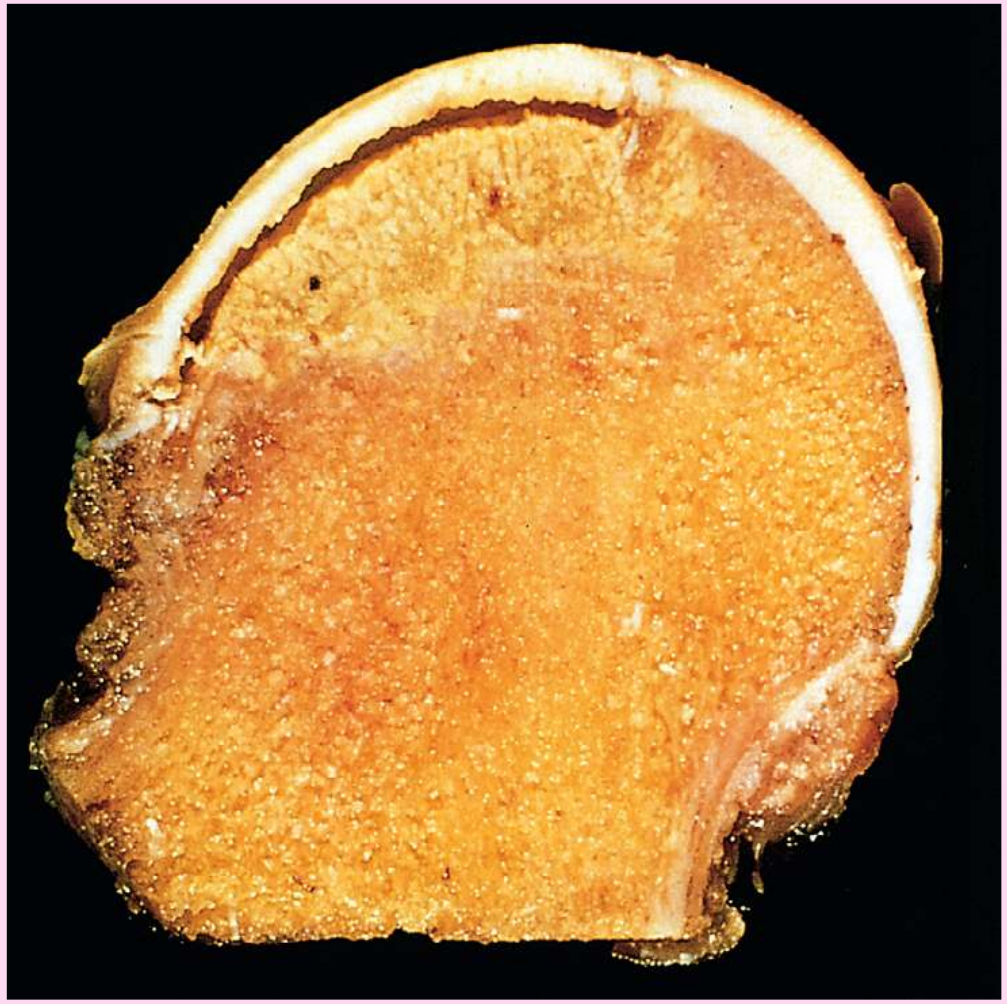
Osteonecrosis (avascular necrosis)

- Infarction (ischemic necrosis) of bone and marrow cells, peak 30-50, 10% hip replacement.
- Causes: 1) Vascular injury (trauma, vasculitis)
  2) Drugs (corticosteroids)
  3) Systemic disease (sickle cell disease)
  4) Radiation
  5) Unknown (25%)
- Mechanism: 1) Mechanical disruption of vessel
  2) Thrombotic occlusion
  3) Extravascular compression

- Cortex not affected .. Collateral blood flow.
- Overlying cartilage is viable.. Synovial fluid
- Dead bone.. Empty lacunae
- Can lead to secondary osteoarthritis



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