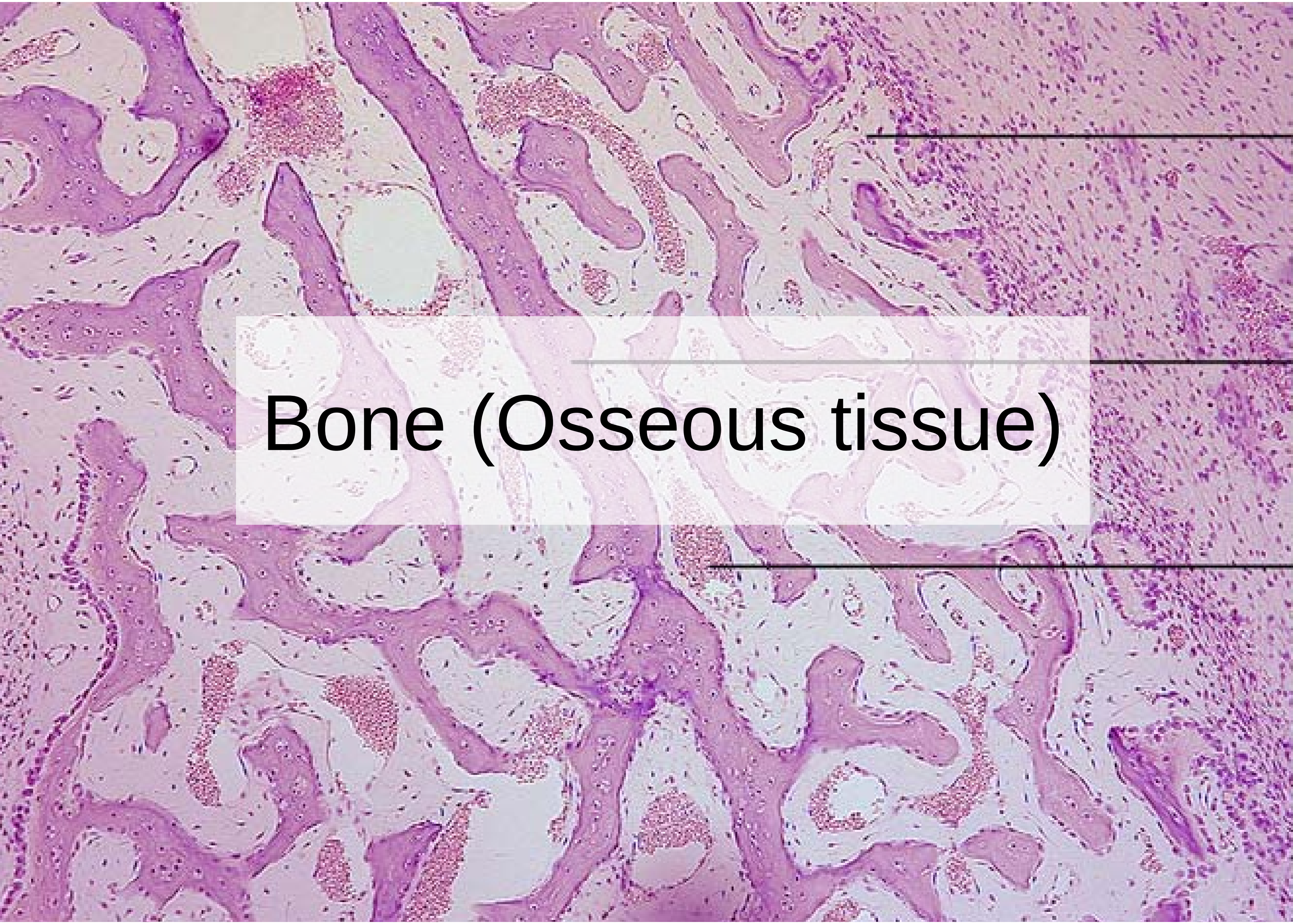
Bone (Osseous tissue)



Functions of the skeletal system

- Structural support
- Mineral storage & lipids (yellow marrow)
- Blood cell formation (red marrow)
- Protection of organs
- Leverage for muscles

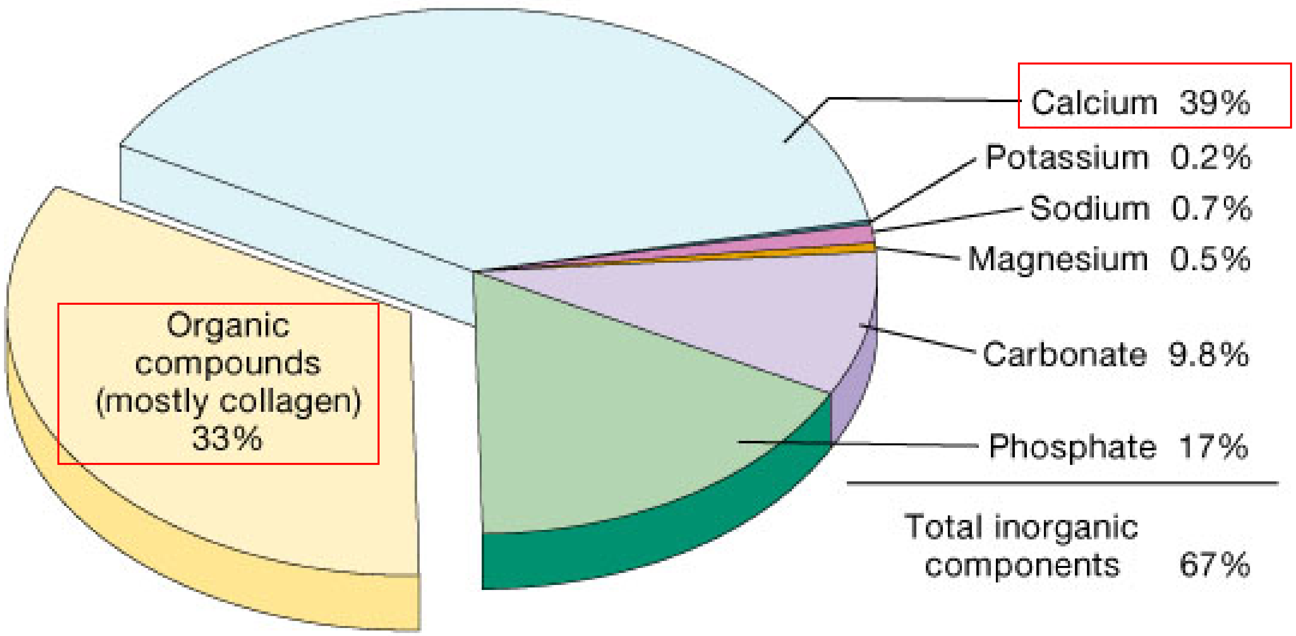
Composition of bone

- Calcium (Ca) accounts for much of the bone mass.
- The Ca crystals give bone its strength
  - Hydroxyapatite, $Ca_{10}(PO_4)_6(OH)_2$

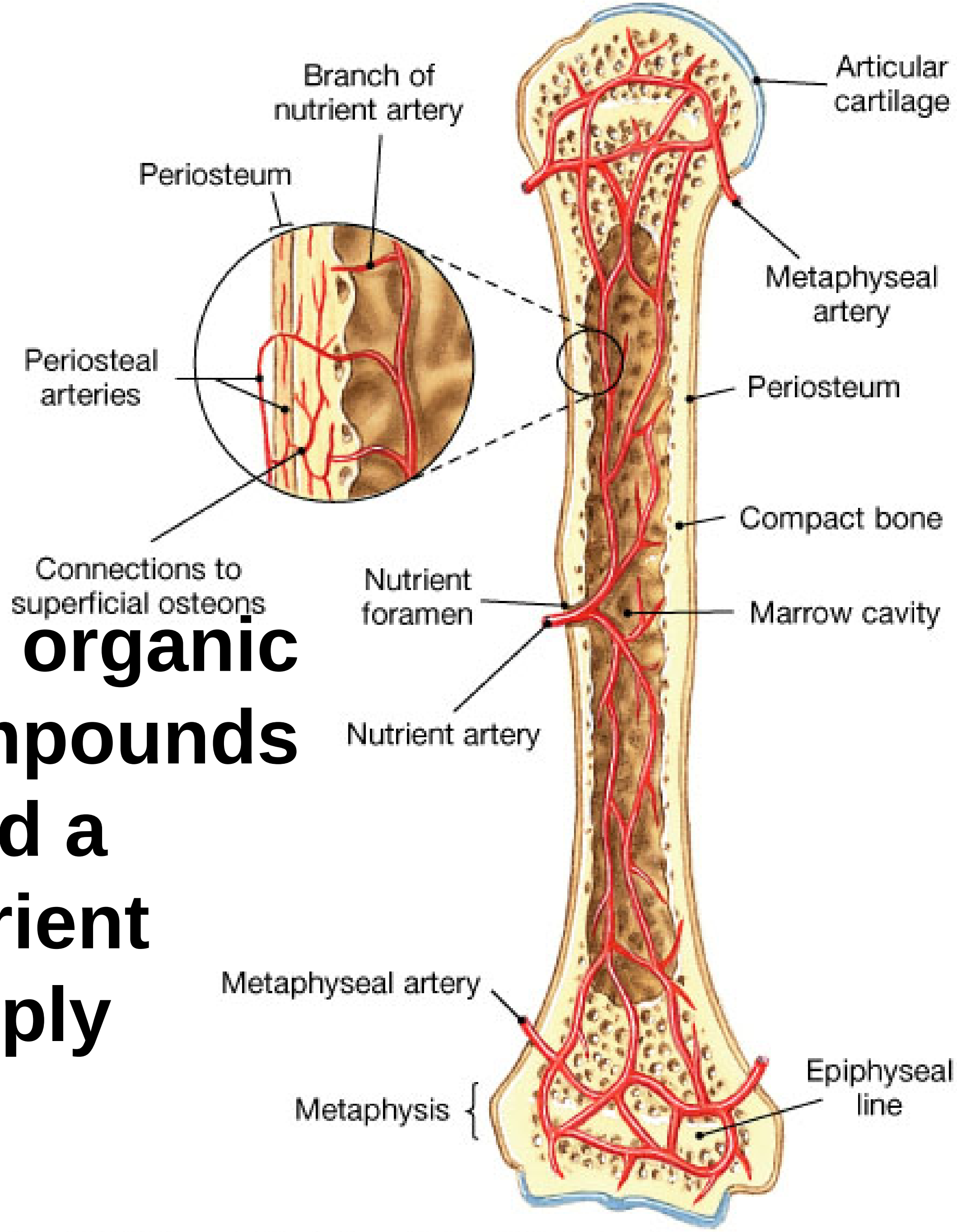
Collegen fibers give bones its flexibility

These two give bone its unique properties

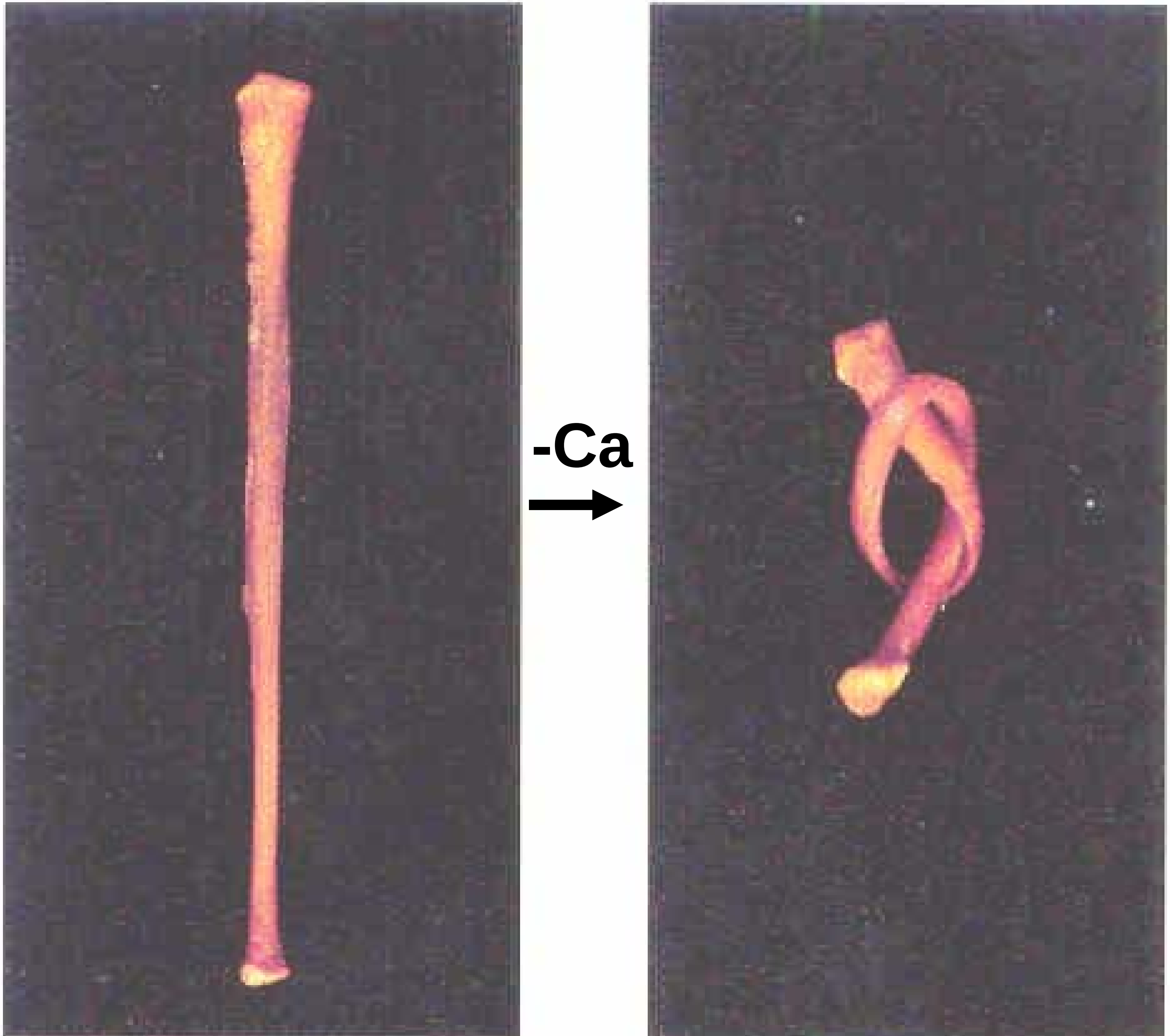
Composition of Bone



Amount in bone as percentage of the total amount in the body
Calcium 99%
Potassium 4%
Sodium 35%
Magnesium 50%
Carbonate 80%
Phosphate 88%



The organic compounds need a nutrient supply


-Ca

Cells of bone

- Osteoprogenitor cells-mesenchymal cells

↓

- Osteoblasts- (secretes bone matrix)

↓

- Osteocytes (former osteoblasts that are trapped in the matrix they secreted)

- Osteoclast- cells that release acids to degrade bone (mechanism to release Ca into the blood)

- Osteoblasts & osteoclasts –regulate Ca levels in the blood.

Two types of bone

- Compact bone-dense and solid
- Spongy bone-open framework

- Both types found in most bones of the body
- same chemical composition
- Spongy bone is deep to the compact bone

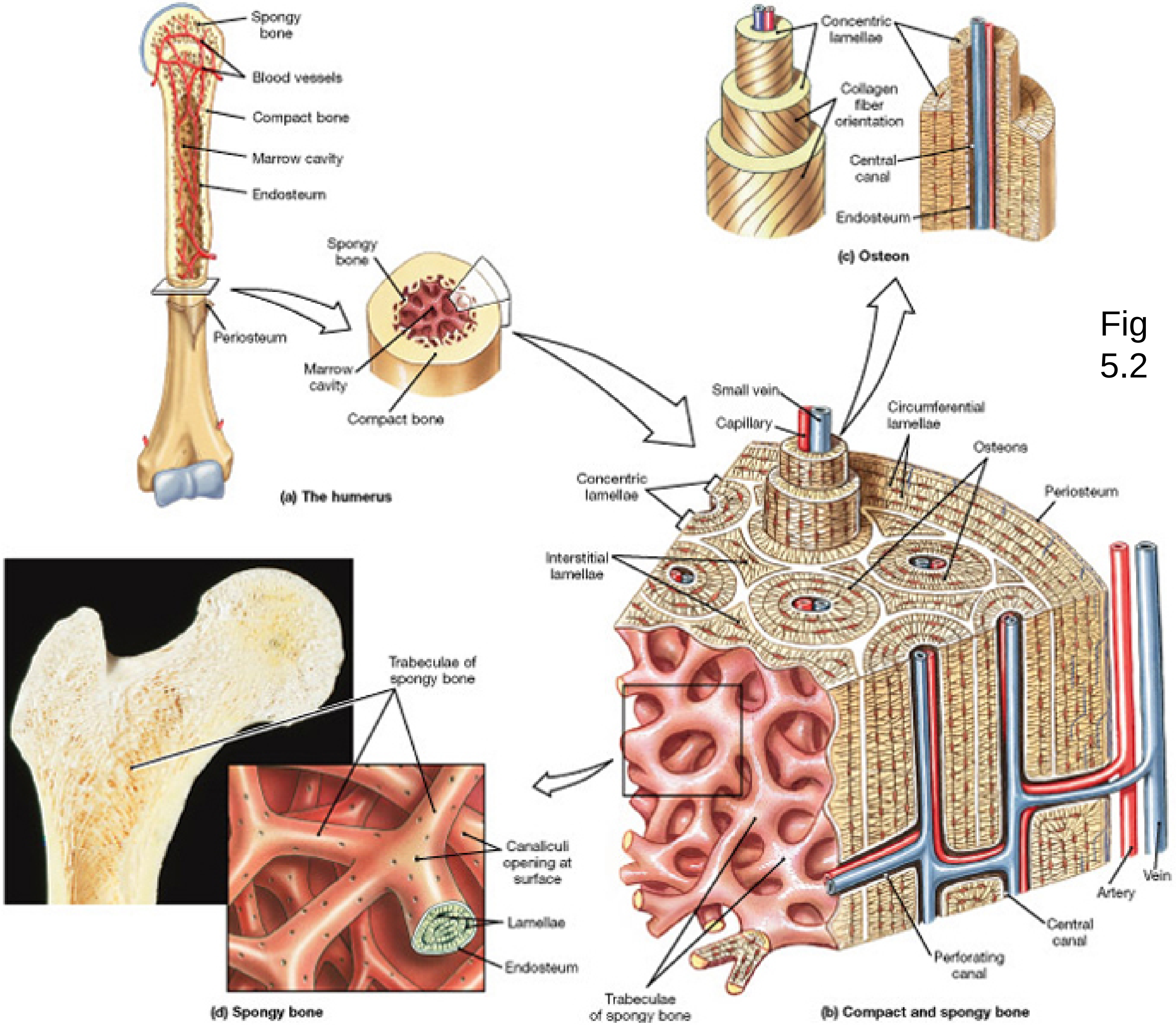

Spongy bone
Blood vessels
Compact bone
Marrow cavity
Endosteum
Periosteum
(a) The humerus
Spongy bone
Marrow cavity
Compact bone
Concentric lamellae
Collagen fiber orientation
Central canal
Endosteum
(c) Osteon
Small vein
Capillary
Circumferential lamellae
Osteons
Periosteum
Concentric lamellae
Interstitial lamellae
Trabeculae of spongy bone
Canaliculi opening at surface
Lamellae
Endosteum
(d) Spongy bone
Trabeculae of spongy bone
Perforating canal
Central canal
Artery
Vein
(b) Compact and spongy bone

Fig 5.2

Compact bone

- **Osteon**-structural unit of compact bone
- **Three types of lamelle:**
  - **Interstitial-between osteons**
  - **Concentric-rings**
  - **Circumferential-outter edge**

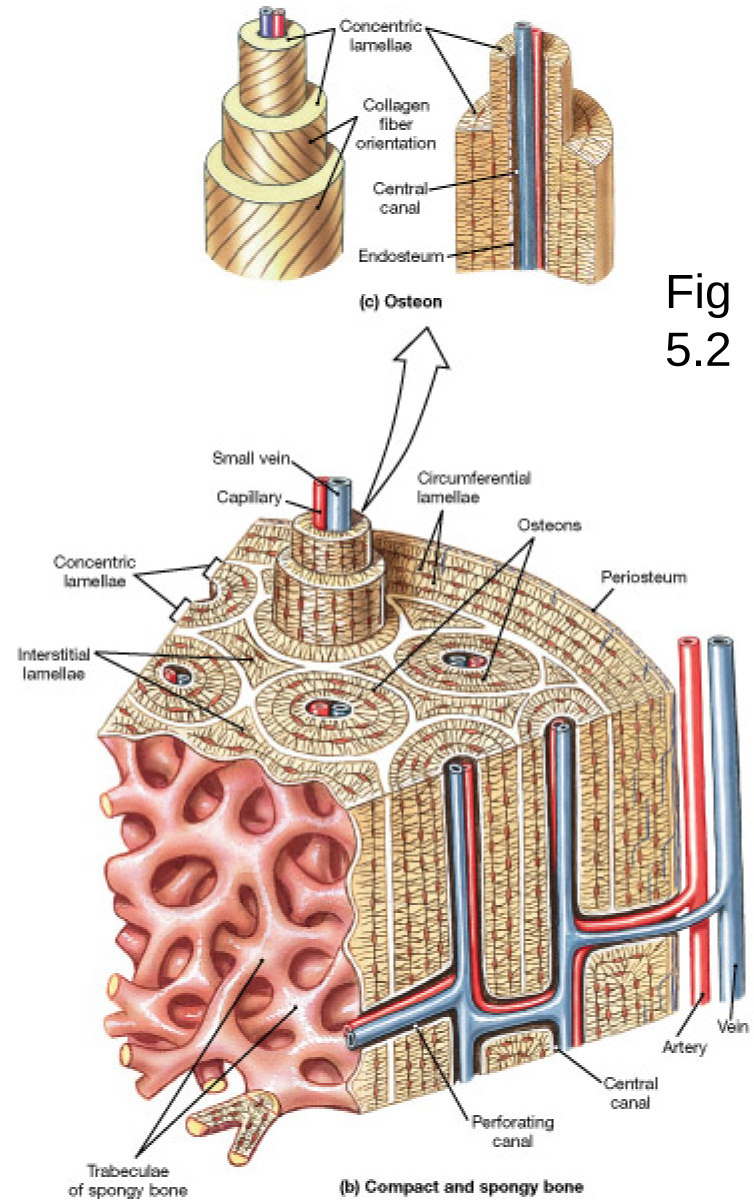
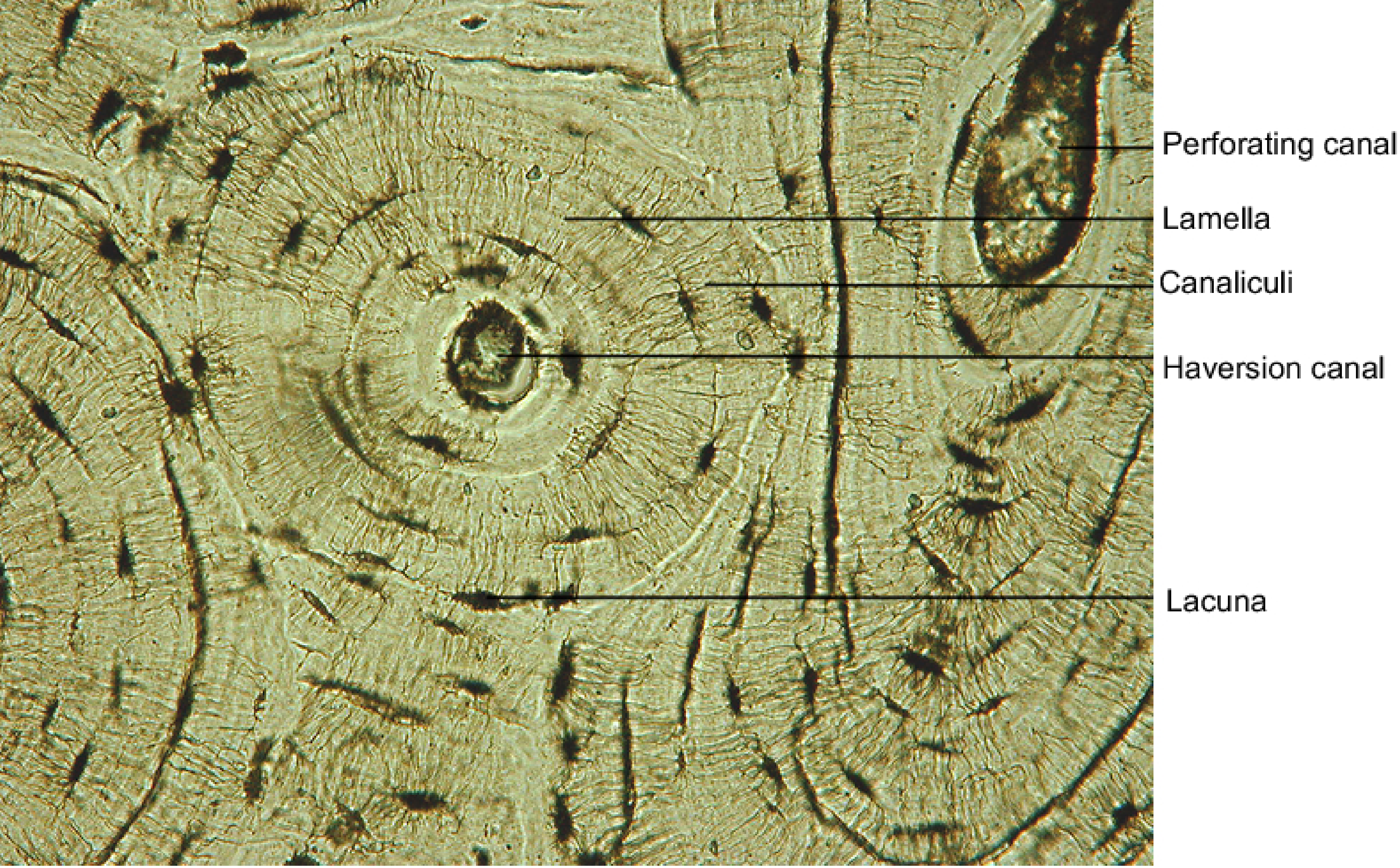


Fig 5.2



Compact Bone (100x)

Spongy bone

- **Trabeculae-**pieces that form the framework of spongy bone
- Light weight but still strong

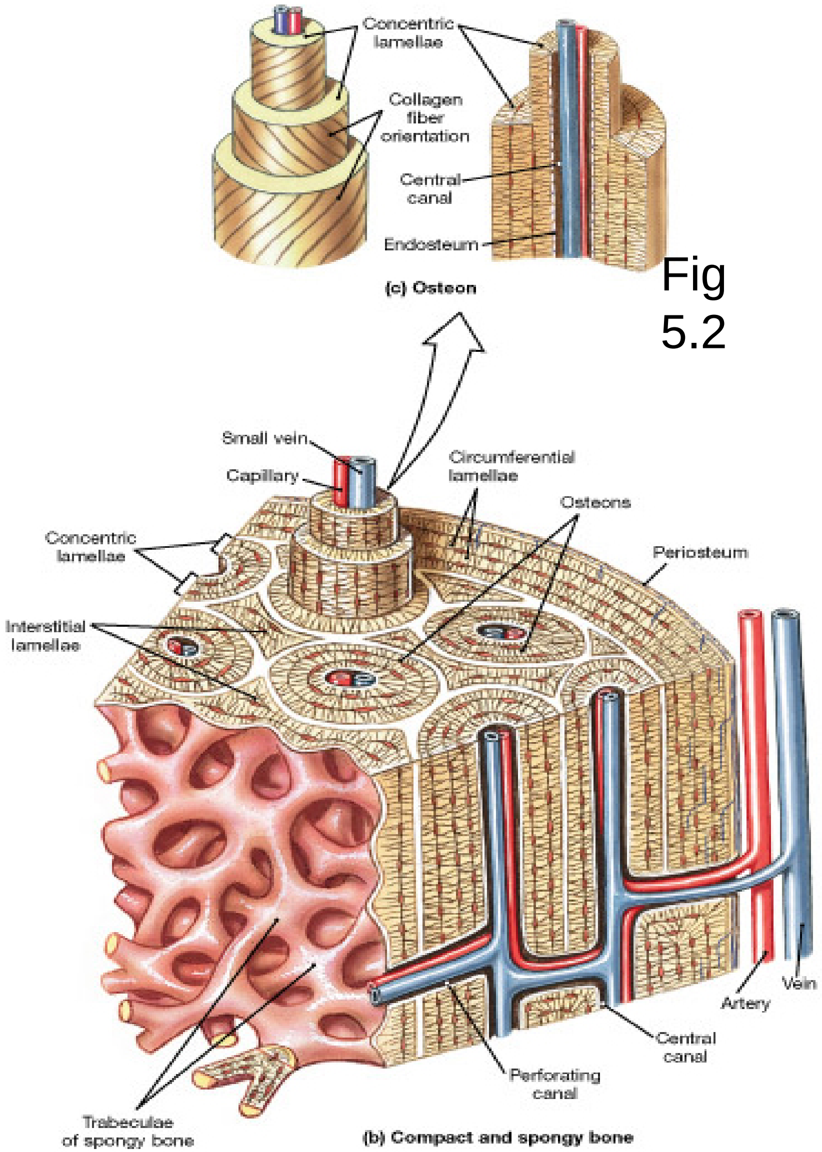
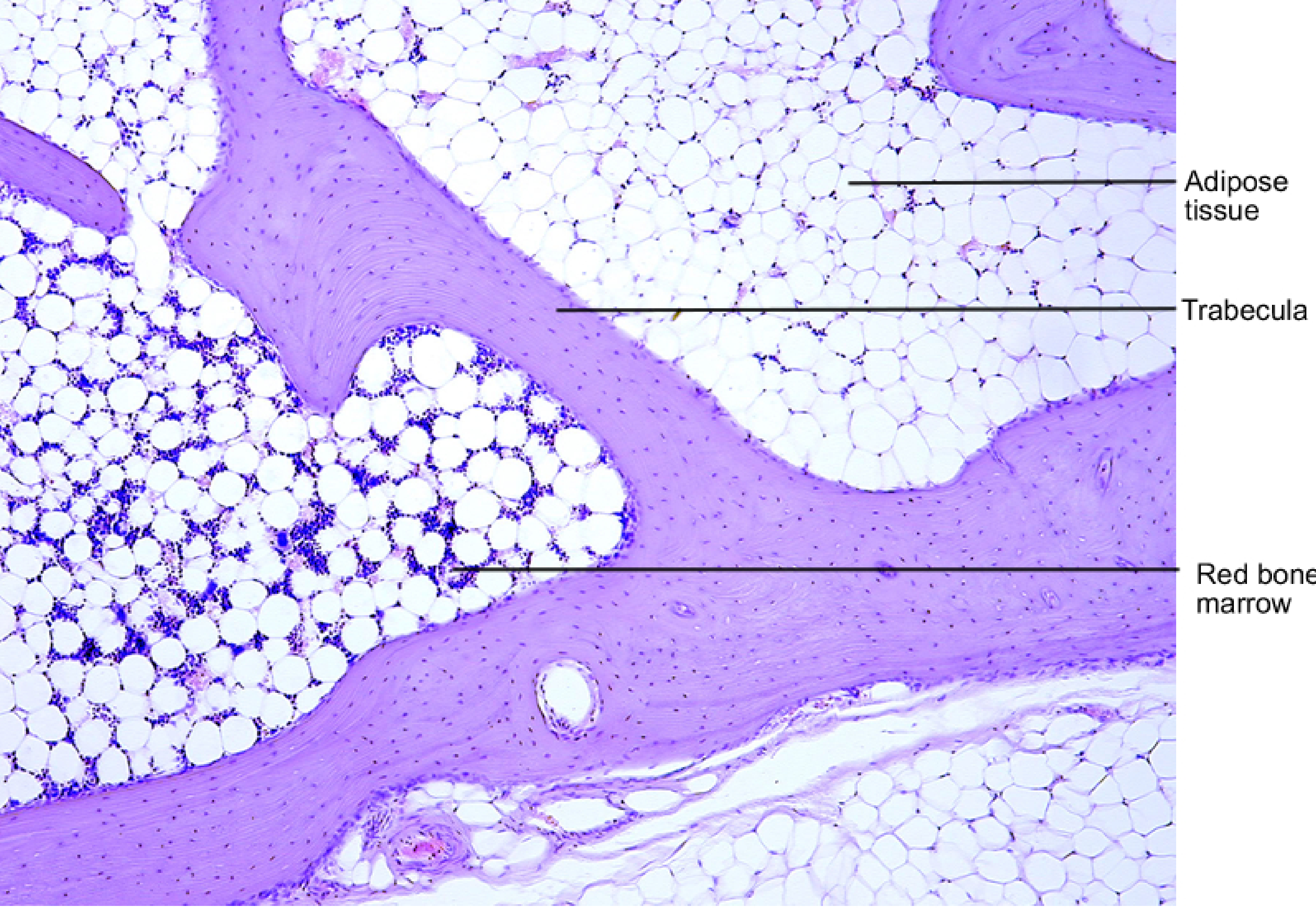
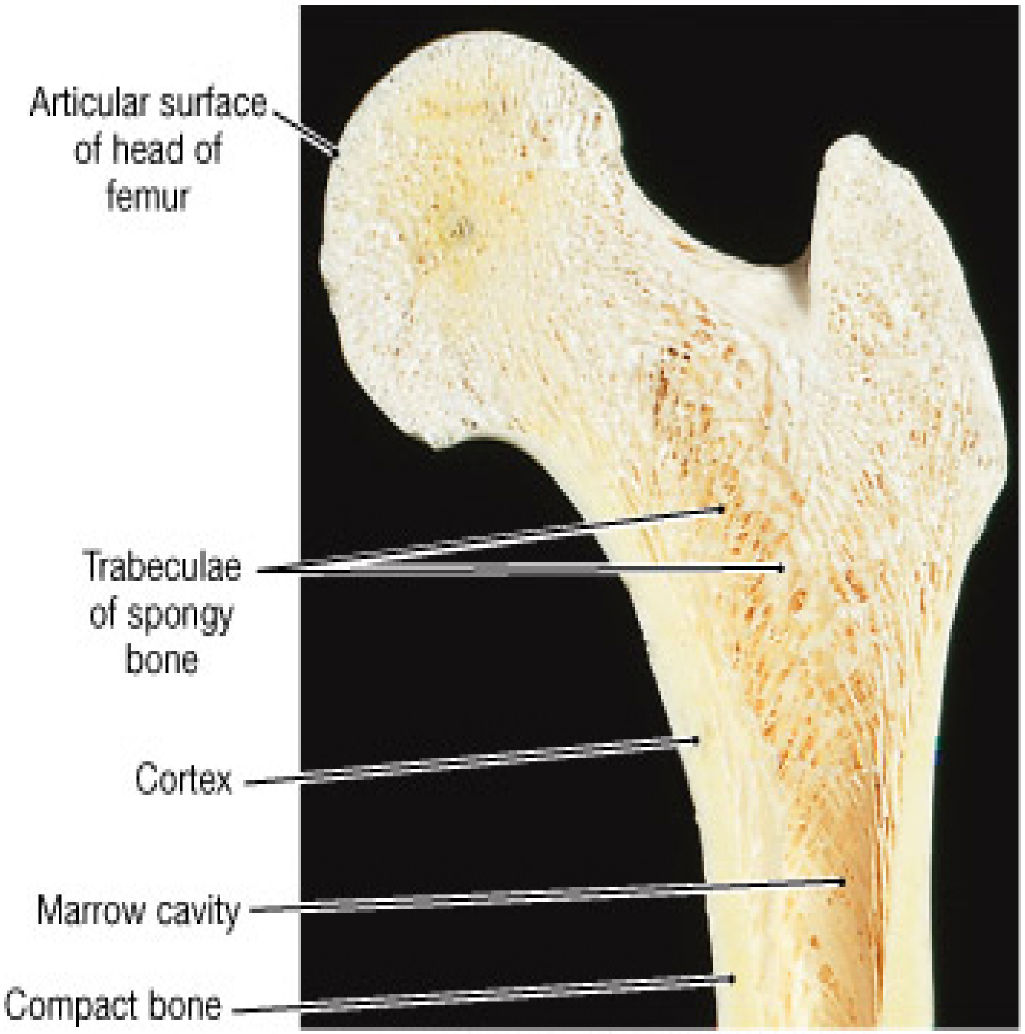


Fig 5.2

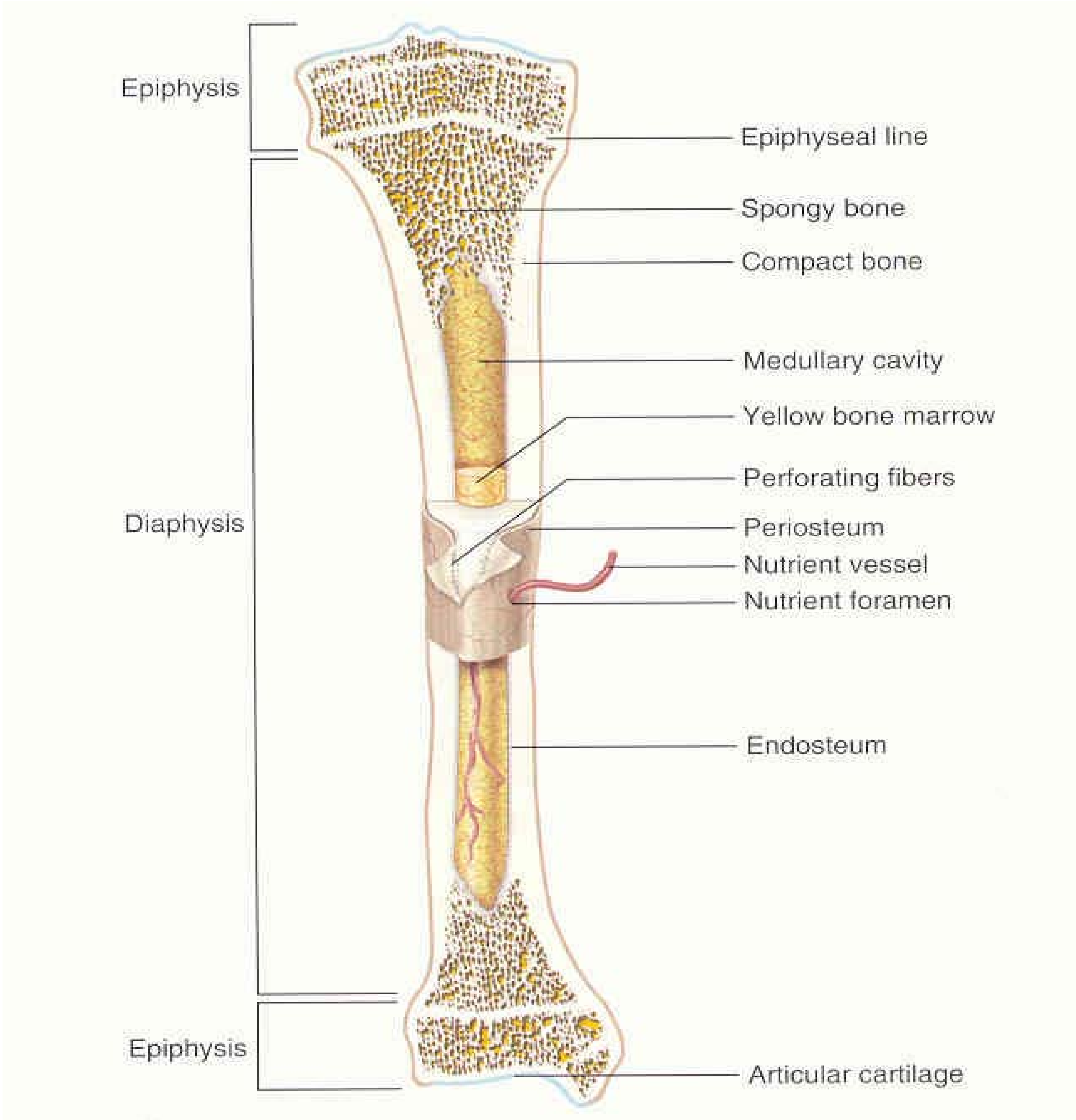


Cancellous (Spongy) Bone (100x)



(c) Epiphysis, sectional view

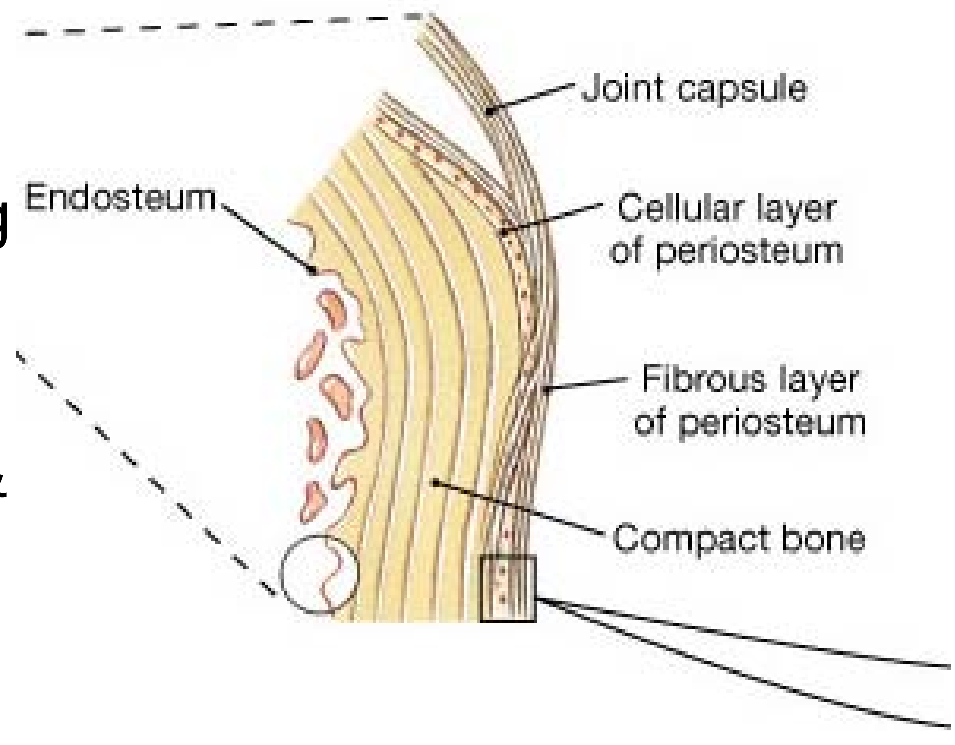
Fig 5.3


Epiphysis
Epiphyseal line
Spongy bone
Compact bone
Medullary cavity
Yellow bone marrow
Perforating fibers
Diaphysis
Periosteum
Nutrient vessel
Nutrient foramen
Endosteum
Epiphysis
Articular cartilage

Periosteum & endosteum

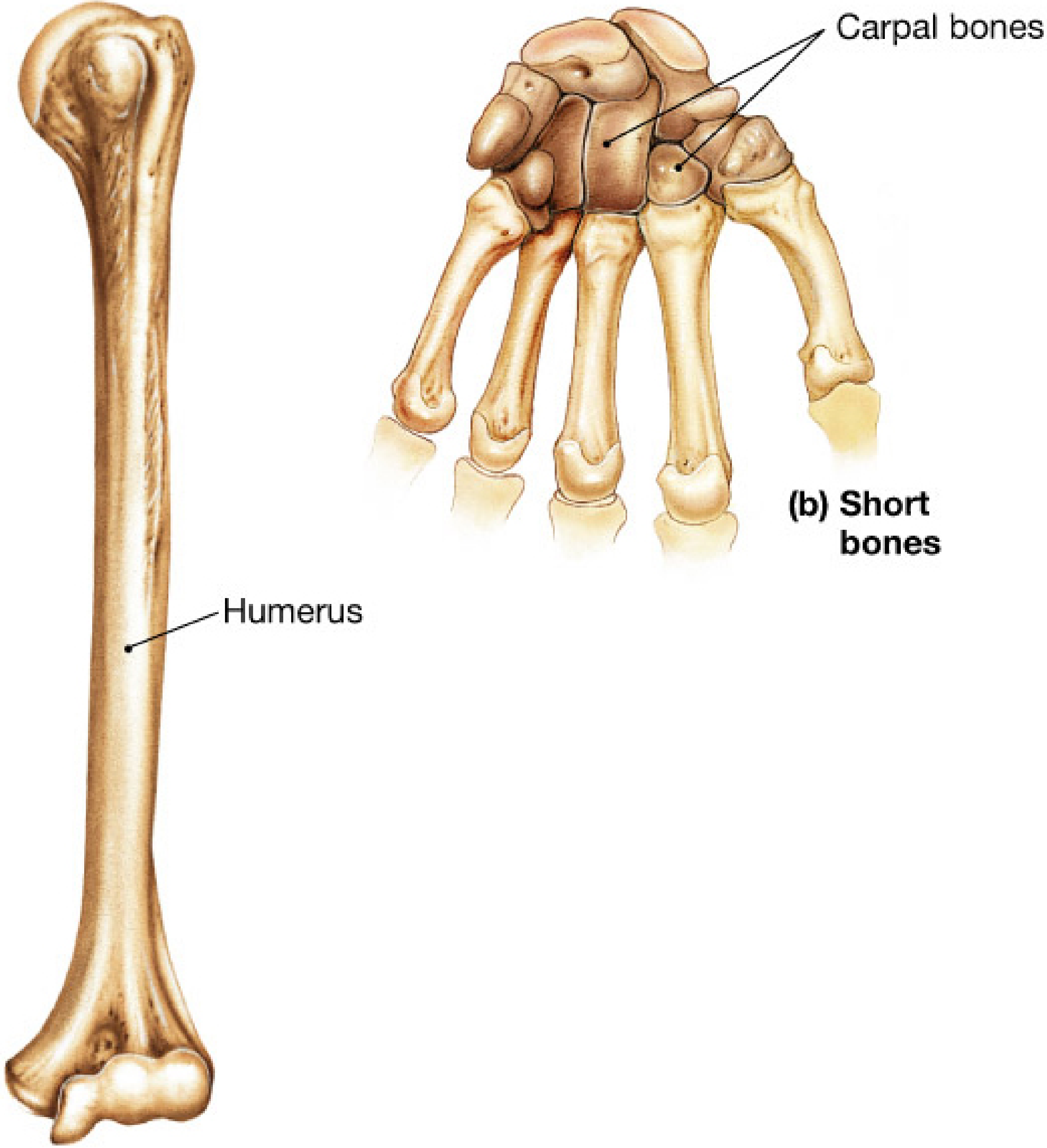
- **Periosteum-**a thick connective tissue membrane on the surface of bone
- Not on the articular (joint) surface
- Like pantyhoes over a leg

- **Endosteum**-membrane covering the trabeculae & medullary cavity of bone



Six classes of bone based on shape

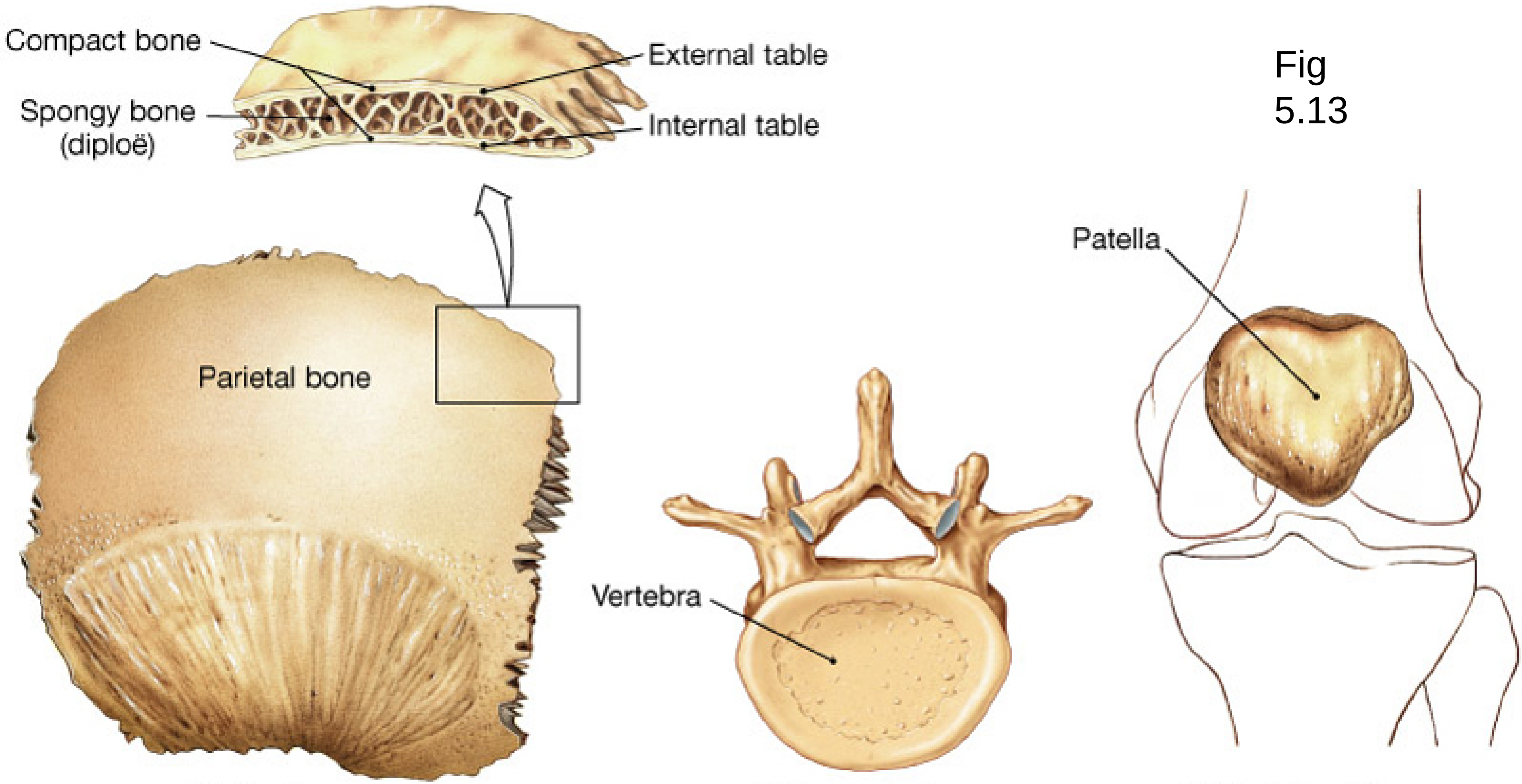
- **Long**-humerus, radius, tibia
- **Short**-cube shaped bones, carpal & tarsal
- **Flat**-sternum, ribs,parietal
- **Irregular**-odd shapes, bones of the face and vertebrae
- **Suture**-small bones filling in the space between skull bones
- **Sesamoid**-patella



(a) Long bone

Fig 5.13

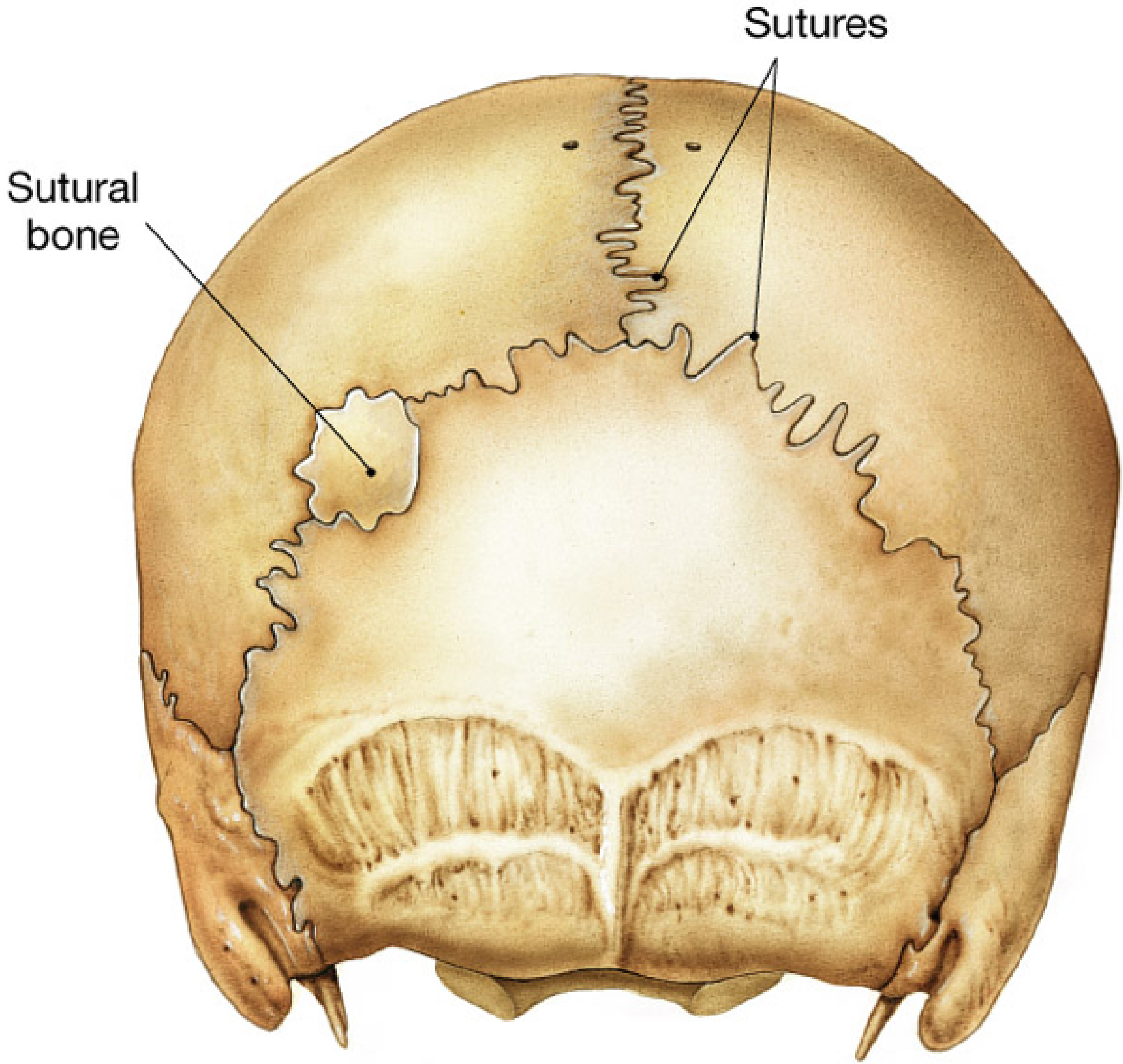
Fig
5.13



(c) Flat bone

(d) Irregular bone

(e) Sesamoid bone



(f) Sutural bones

Fig 5.13

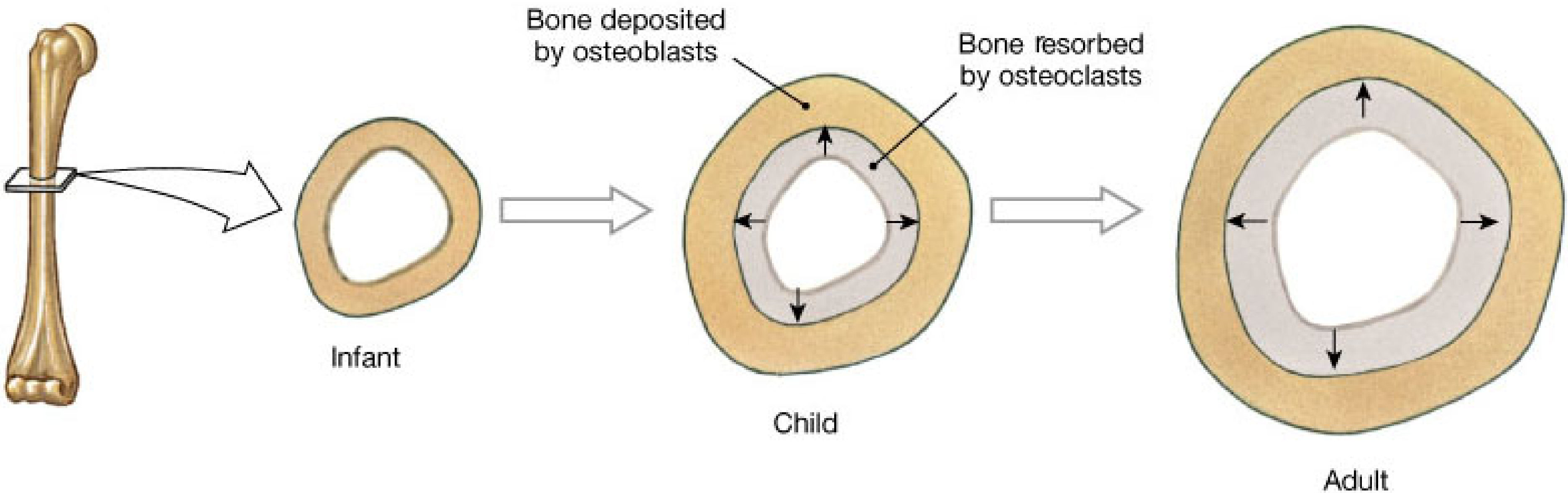
- Average person 206 bones
- extra sesamoid bones + suture bones= ??

Bone development

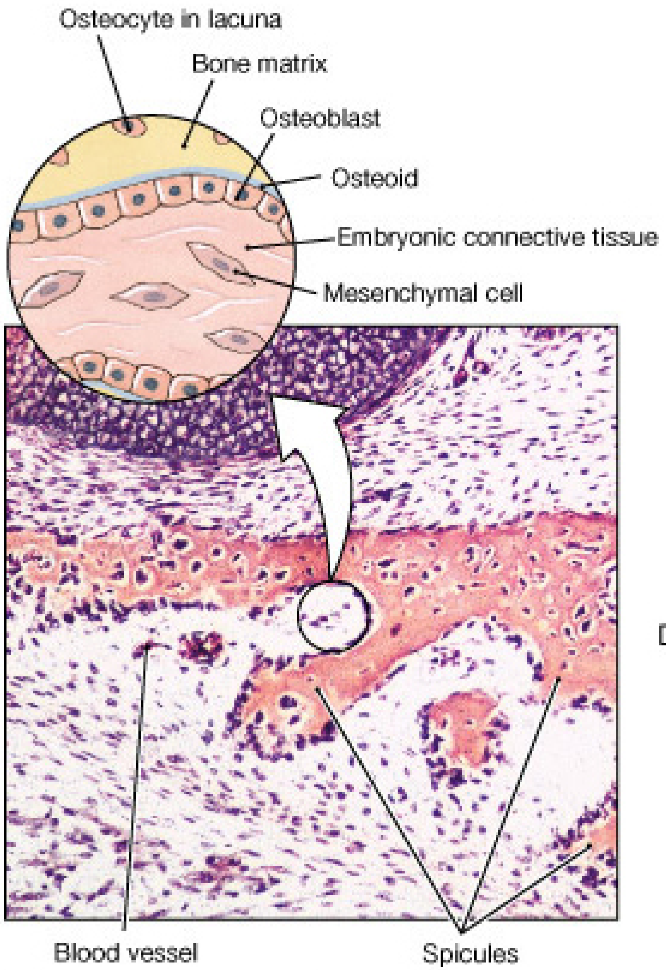
- Two mechanisms of bone development (ossification):
- Intramembranous ossification
- Endochondral ossification

Intramembranous ossification

- During growth bone tissue replaces connective tissue proper (dermis)
- Flat & sesamoid bones develop this way
- Causes appositional growth-increase in the width of a bone

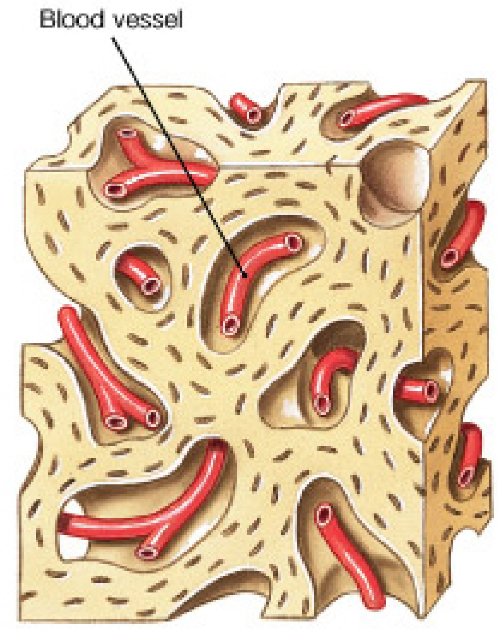


(b) Appositional growth and remodeling



Step 1: Mesenchymal cells aggregate, differentiate into osteoblasts, and begin the ossification process. The bone expands as a series of spicules that spread into surrounding tissues. (LM × 32)

Step 2: As the spicules interconnect, they trap blood vessels within the bone. (LM × 32)

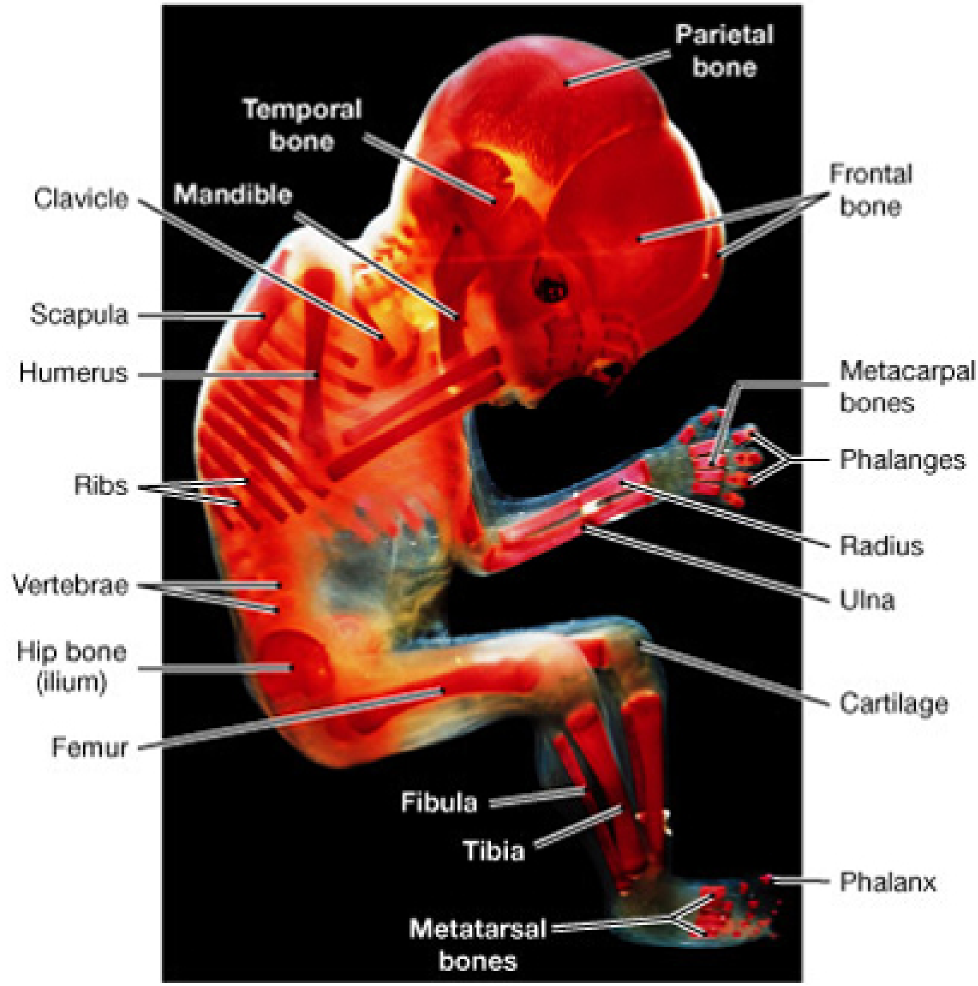


Step 3: Over time, the bone assumes the structure of spongy bone. Areas of spongy bone may later be removed, creating marrow cavities. Through remodeling, spongy bone formed in this way can be converted to compact bone.

Fig 5.5


Endochondral ossification replaces cartilages of embryonic skull
Intramembranous ossification produces the roofing bones of the skull
Primary ossification centers of the diaphyses (bones of the lower limb)
Future hip bone

(a)


Parietal bone
Temporal bone
Frontal bone
Clavicle
Mandible
Scapula
Humerus
Metacarpal bones
Phalanges
Ribs
Radius
Ulna
Vertebrae
Hip bone (ilium)
Cartilage
Femur
Fibula
Tibia
Phalanx
Metatarsal bones

(b)

Endochondral ossification

- During growth bone tissue replaces hyaline cartilage
- Long bones develop this way
- Causes appositional growth &
- **interstitial growth-**increase in bone length

basic outline

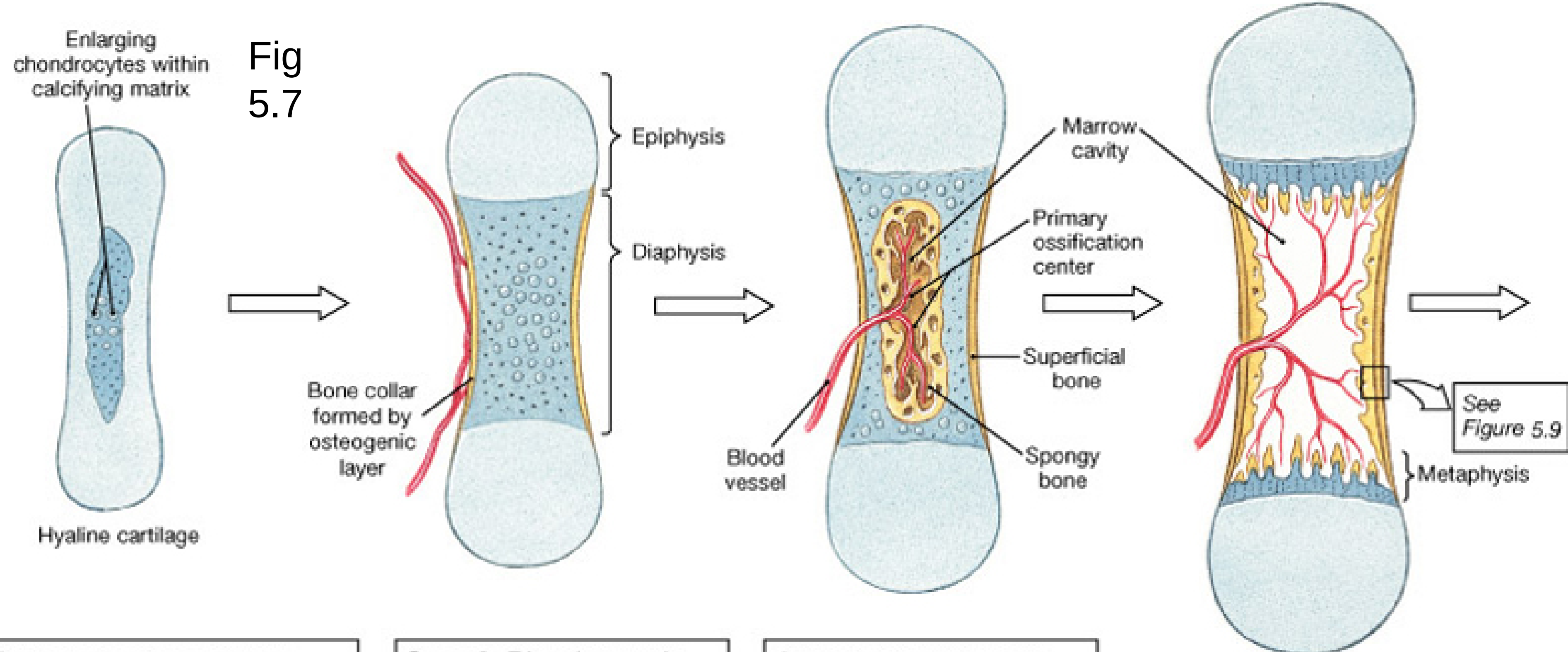
step 1

- Mesenchyme>chondroblasts>chondrocytes>cartilage

step 2

- Swelling of chondrocytes>chondrocytes die>blood vessels grow into the lacunae> osteoblasts>bone

Fig 5.7



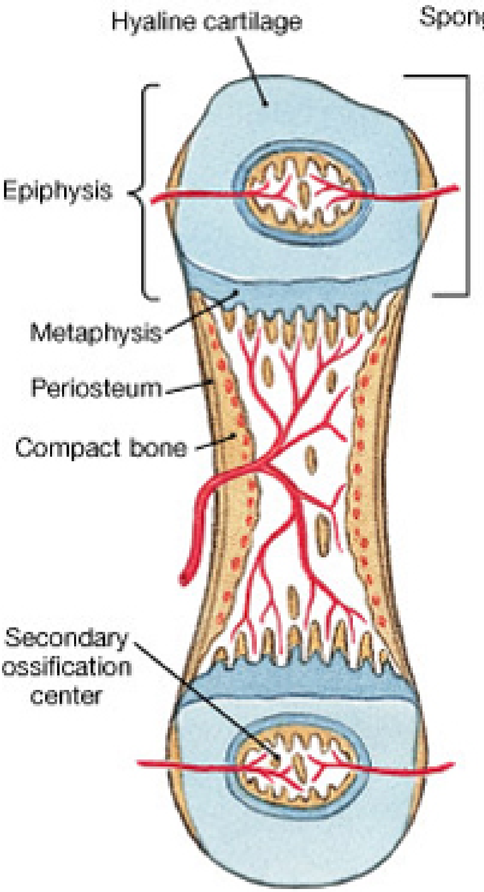
Step 1: As the cartilage enlarges through appositional and interstitial growth, chondrocytes near the center of the shaft increase greatly in size. The matrix is reduced to a series of small struts that soon begin to calcify. The enlarged chondrocytes then die and disintegrate, leaving cavities within the cartilage.

Step 2: Blood vessels grow around the edges of the cartilage, and the cells of the perichondrium convert to osteoblasts. The shaft of the cartilage then becomes ensheathed in a superficial layer of bone.

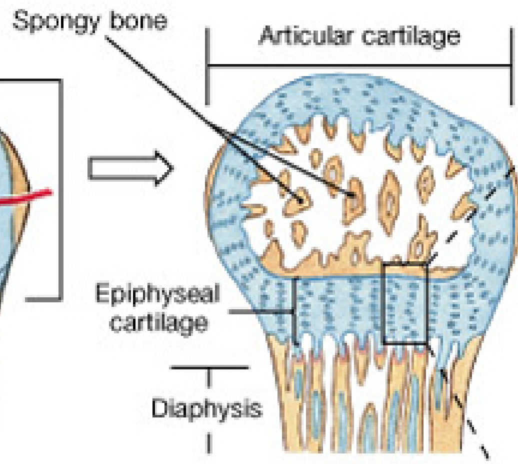
Step 3: Blood vessels penetrate the cartilage and invade the central region. Fibroblasts migrating with the blood vessels differentiate into osteoblasts and begin producing spongy bone at a primary ossification center. Bone formation then spreads along the shaft toward both ends.

Step 4: Remodeling occurs as growth continues, creating a marrow cavity. The bone of the shaft becomes thicker, and the cartilage near each epiphysis is replaced by shafts of bone. Further growth involves increases in both length (Steps 5-6) and diameter (Fig.5.9).

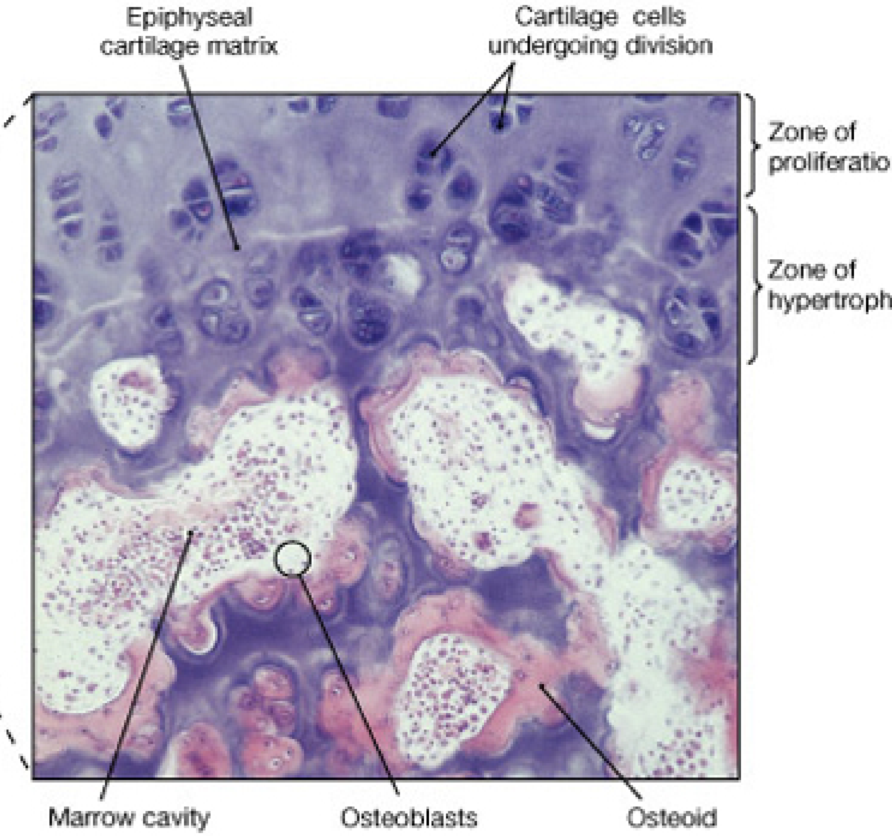
(a) Steps in endochondral ossification



Step 5: Capillaries and osteoblasts migrate into the epiphyses to create secondary ossification centers.



Step 6: Soon each epiphysisis filled with spongy bone. An articular cartilage remains exposed to the joint cavity; over time it will be reduced to a thin superficial layer. At each metaphysis, an epiphyseal cartilage separates the epiphysis from the diaphysis.

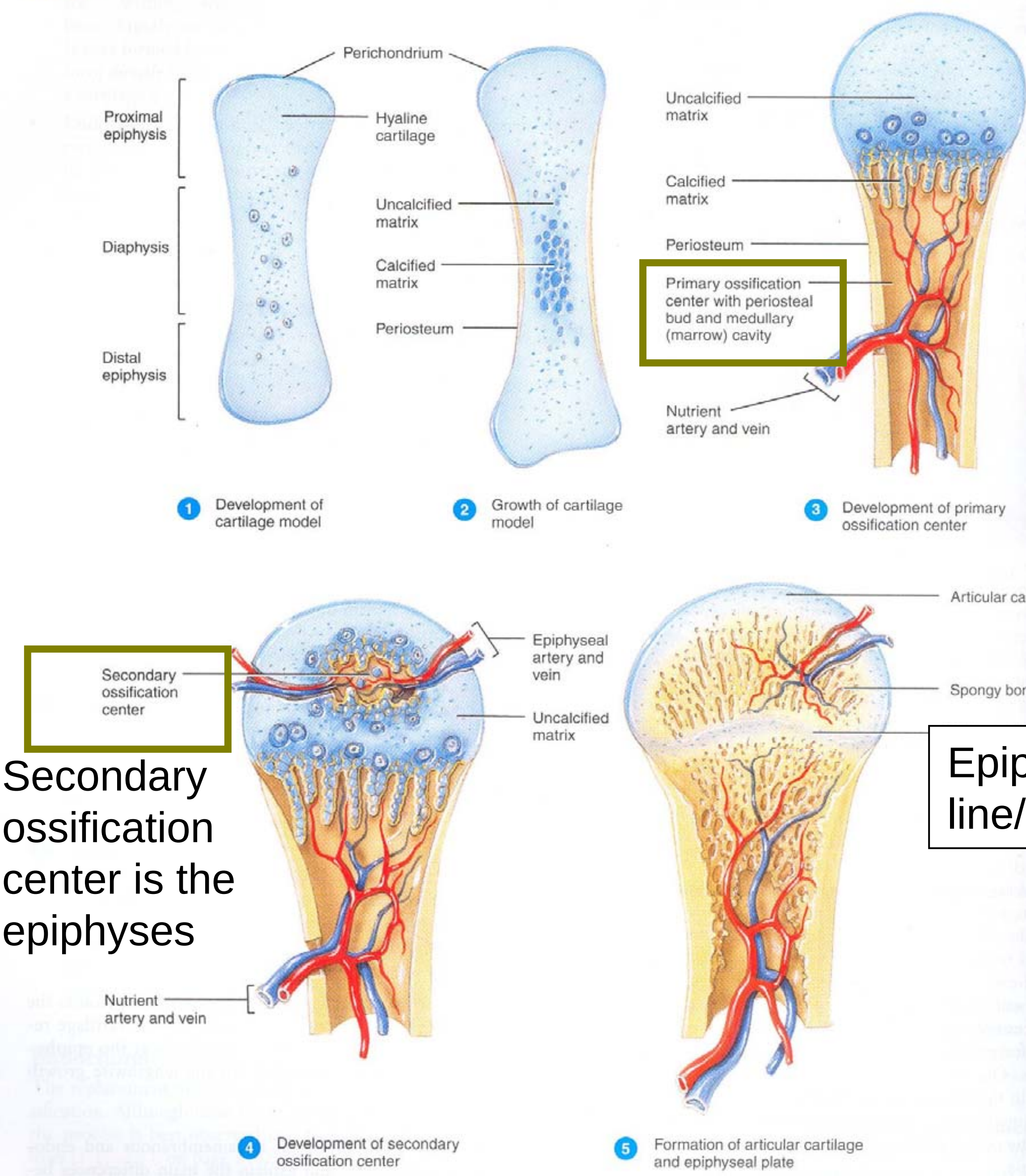


(b) Light micrograph of an epiphyseal cartilage

Fig 5.7

Figure 5.6 / Endochondral ossification.

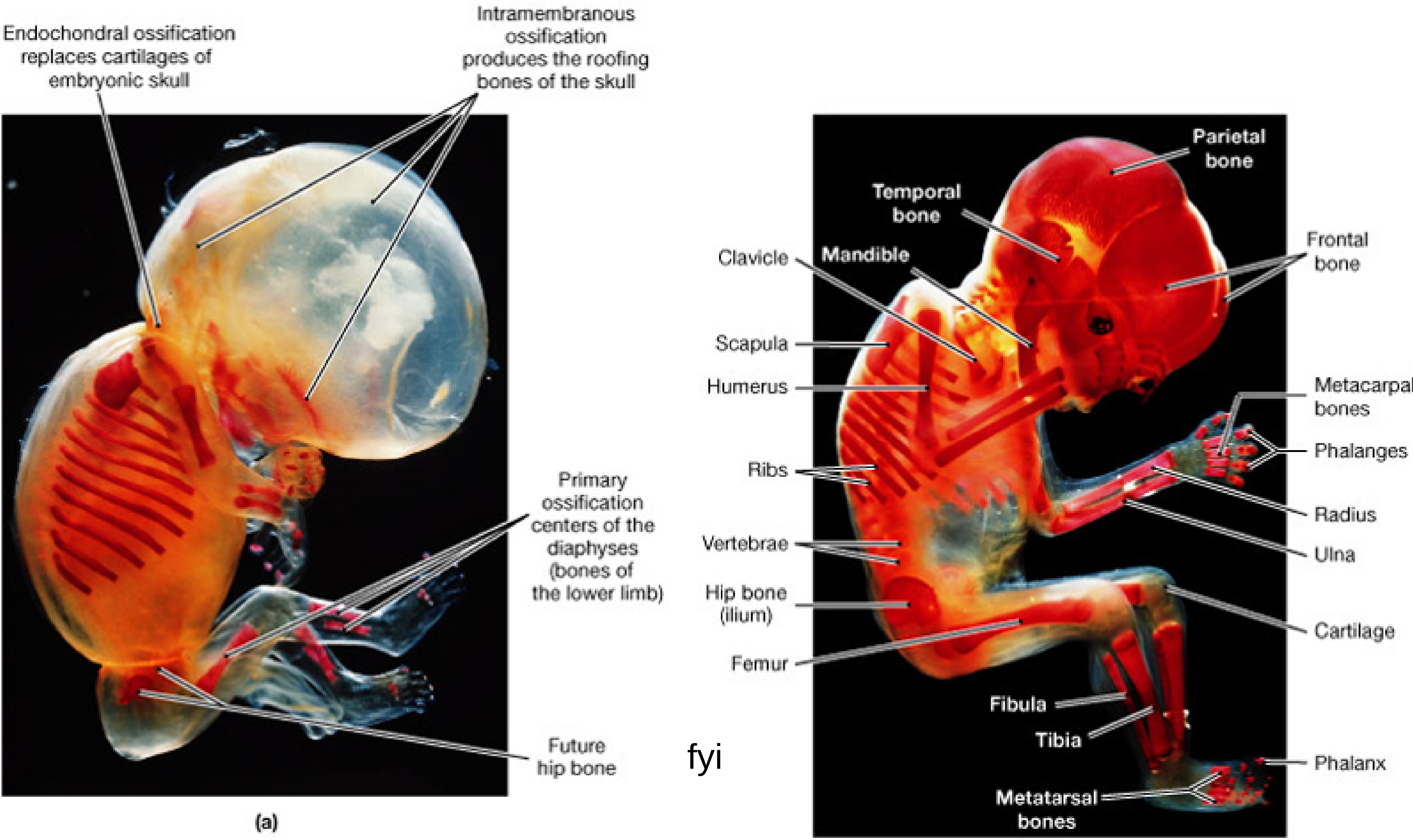
During endochondral ossification, bone gradually replaces a cartilage model.



Primary ossification center is the diaphasis

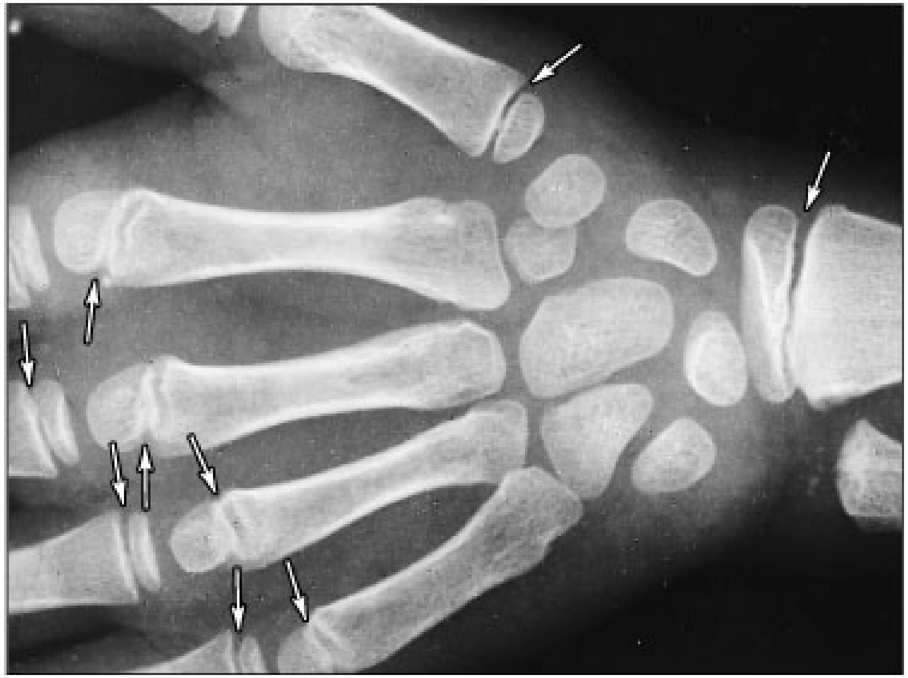
Secondary ossification center is the epiphyses

Epiphyseal line/plate


Endochondral ossification replaces cartilages of embryonic skull
Intramembranous ossification produces the roofing bones of the skull
Primary ossification centers of the diaphyses (bones of the lower limb)
Future hip bone
Parietal bone
Temporal bone
Frontal bone
Clavicle
Mandible
Scapula
Humerus
Metacarpal bones
Phalanges
Ribs
Radius
Vertebrae
Ulna
Hip bone (ilium)
Cartilage
Femur
Fibula
Tibia
Phalanx
Metatarsal bones

(a) (b)

fyi



(a) Epiphyseal cartilages

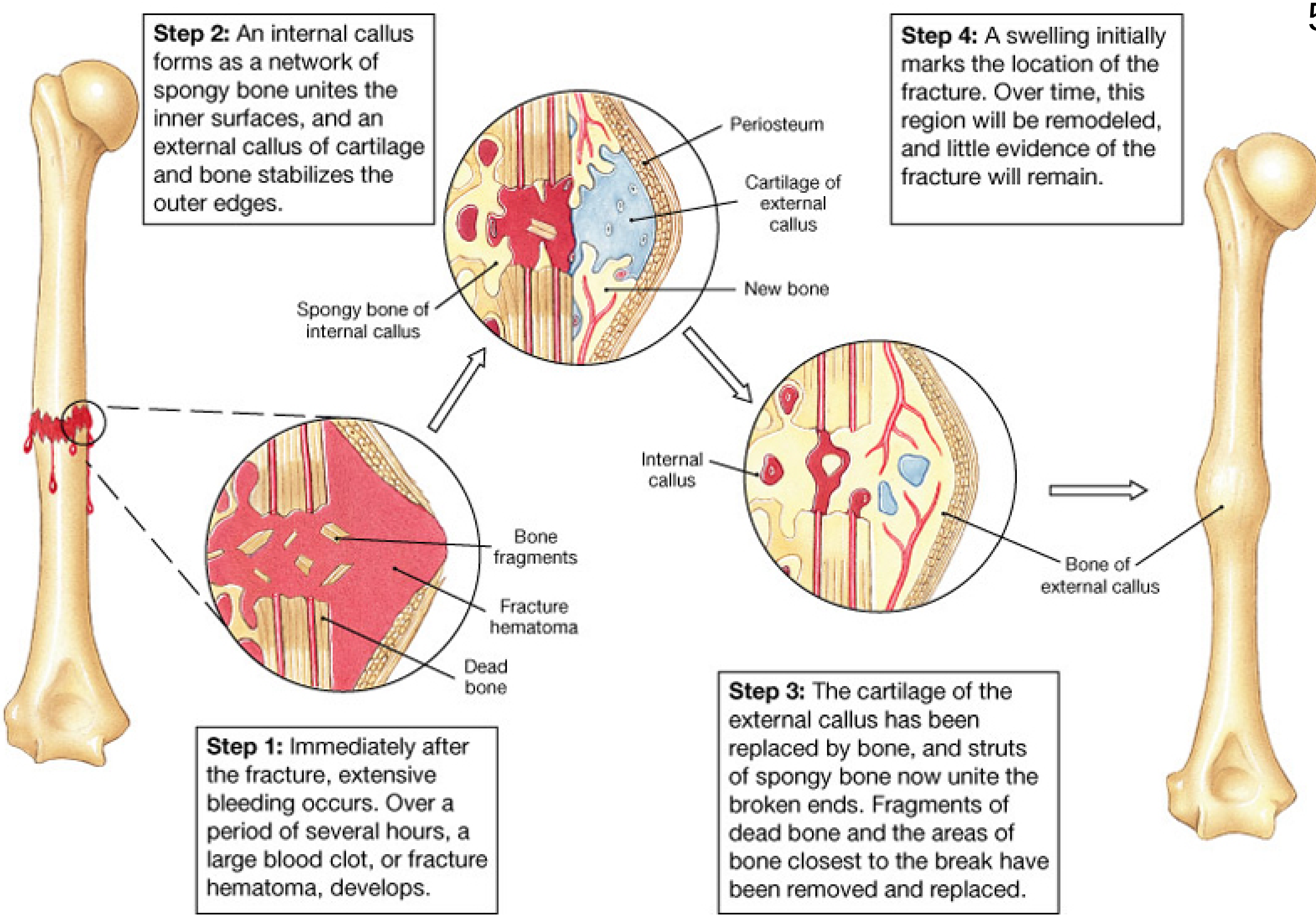
(b) Epiphyseal lines

Bone growth regulation

- Dietary source of Ca & vitamins A, C, & D
- Hormones (endocrine system):
  – Parathyroid hormone-increase Ca uptake
  – Calcitonin-increase Ca loss in urine
  – Growth hormone & Thyroxine-stimulate bone growth

Fracture

Fig 5.11



Compound fracture- breaks the skin

Simple fracture- internal bone injury

A **Pott's fracture** occurs at the ankle and affects both bones of the leg.

Comminuted fractures, such as this fracture of the femur, shatter the affected area into a multitude of bony fragments.

Transverse fractures, such as this fracture of the ulna, break a shaft bone across its long axis.

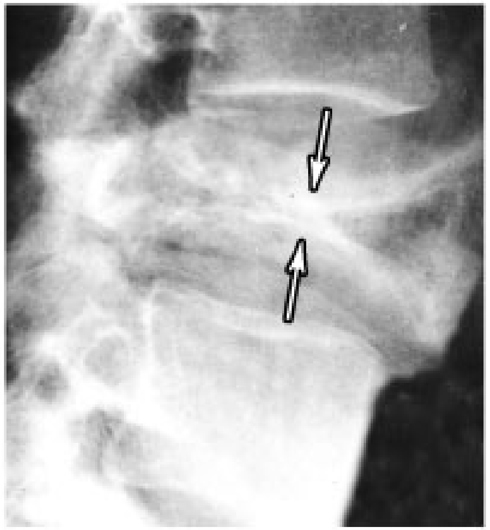
Spiral fractures, such as this fracture of the tibia, are produced by twisting stresses that spread along the length of the bone.

Displaced fractures produce new and abnormal bone arrangements; **nondisplaced fractures** retain the normal alignment of the bones or fragments.

A **Colles' fracture**, a break in the distal portion of the radius, is typically the result of reaching out to cushion a fall.

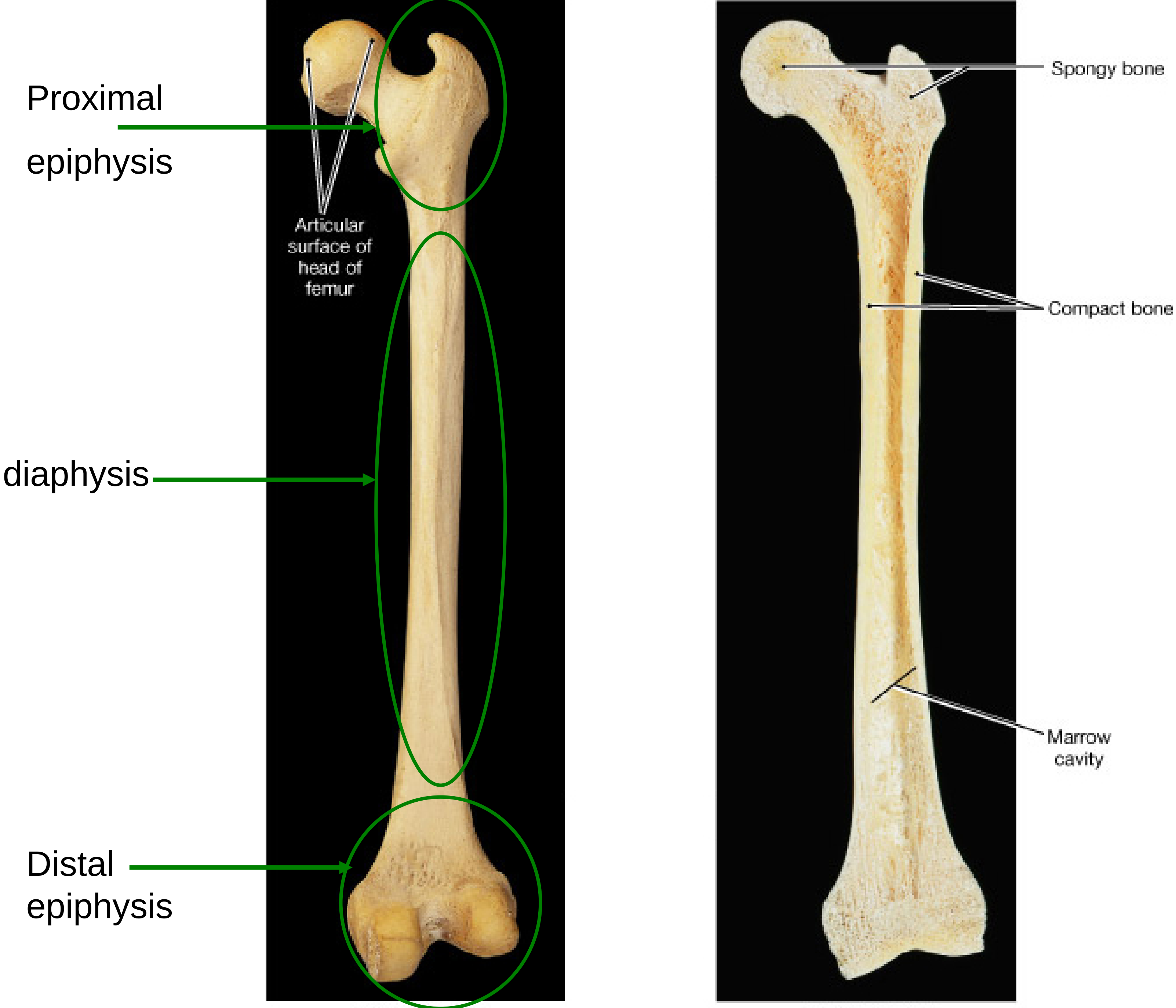
In a **greenstick fracture**, such as this fracture of the radius, only one side of the shaft is broken, and the other is bent. This type of fracture generally occurs in children, whose long bones have yet to ossify fully.

Epiphyseal fractures, such as this fracture of the femur, tend to occur where the bone matrix is undergoing calcification and chondrocytes are dying. A clean transverse fracture along this line generally heals well. Unless carefully treated, fractures between the epiphysis and the epiphyseal cartilage can permanently stop growth at this site.



Compression fractures occur in vertebrae subjected to extreme stresses, such as those produced by the forces that arise when you land on your seat in a fall.

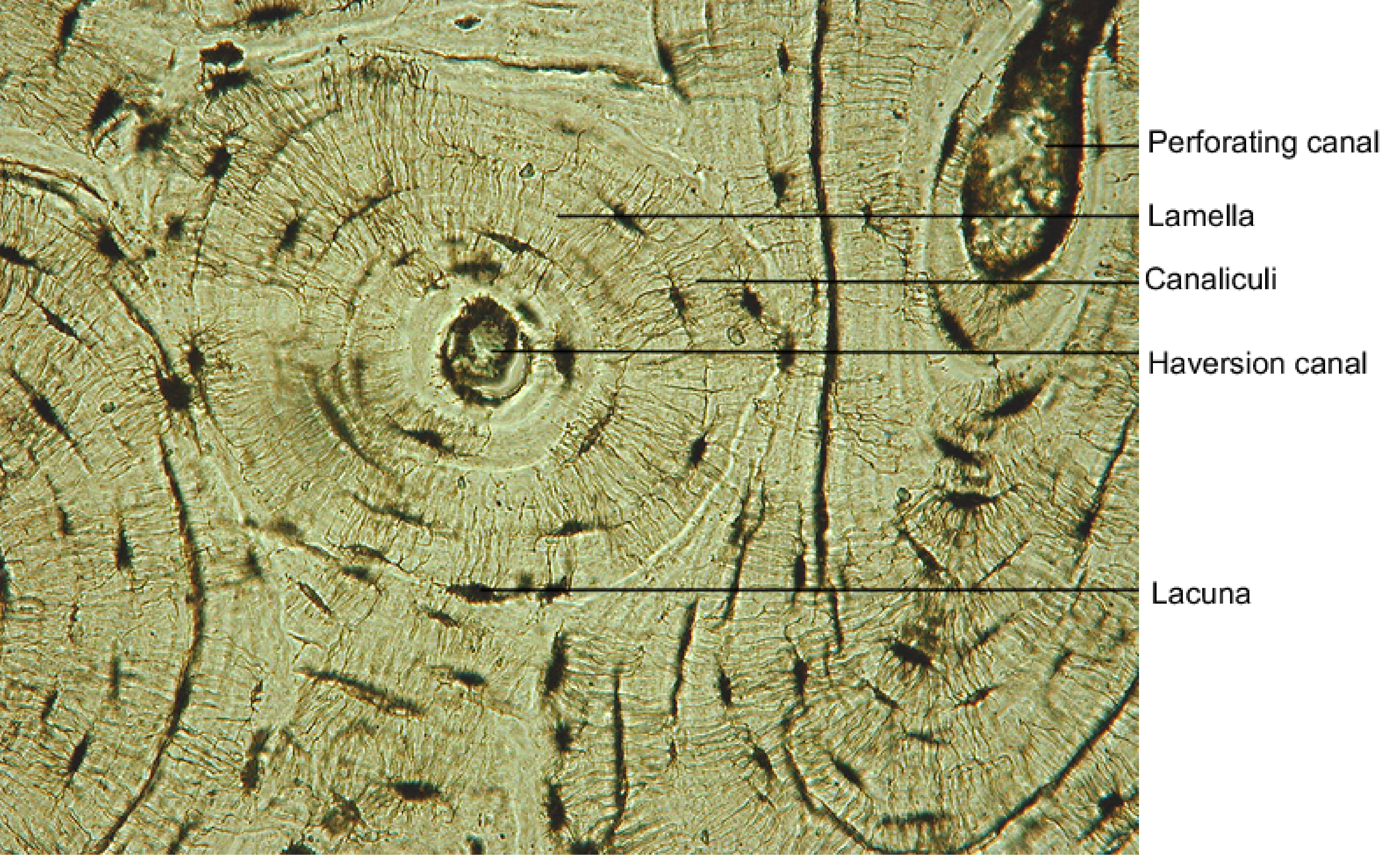
Lab 6



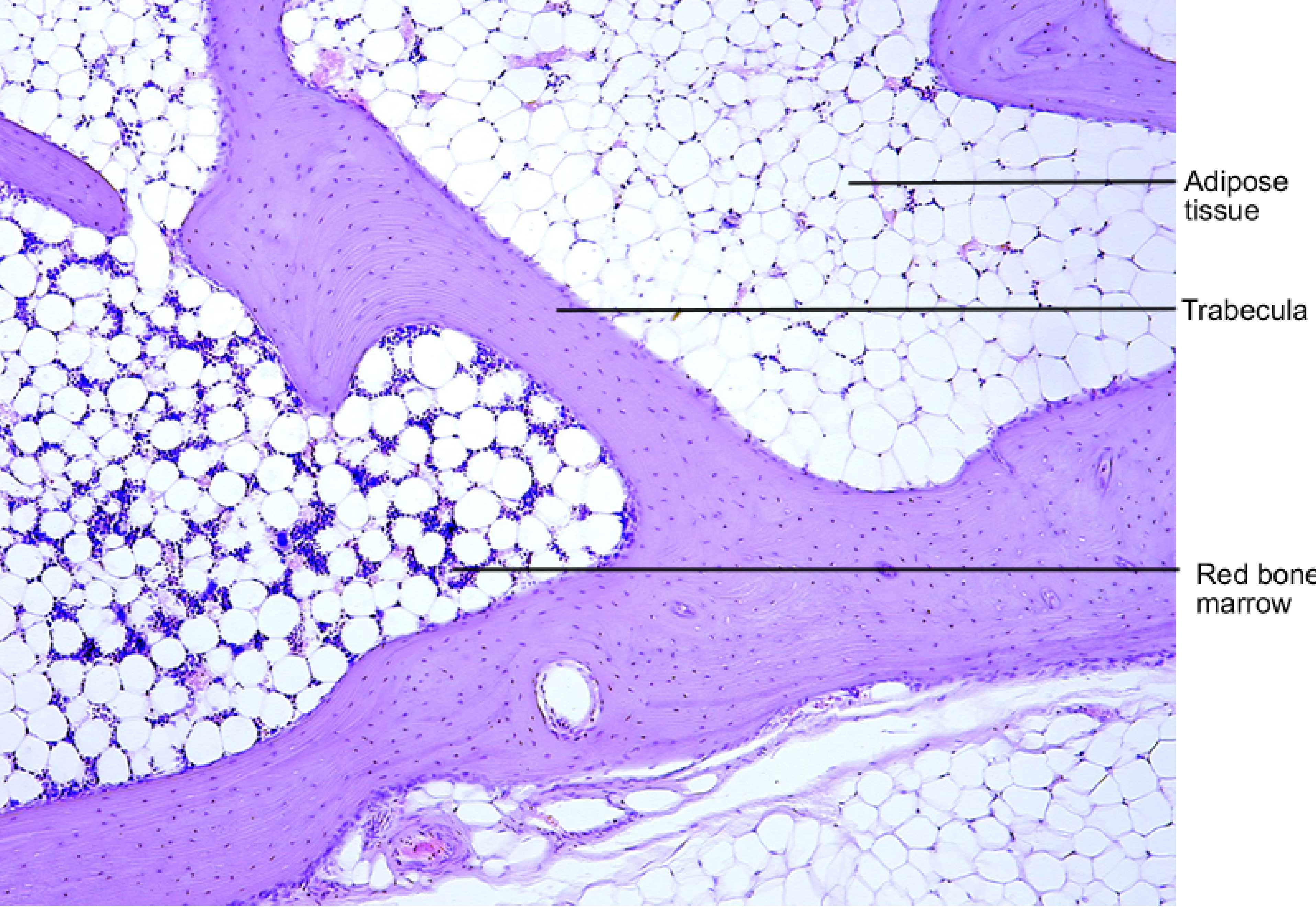
Posterior view

Sectional view

(a) Femur

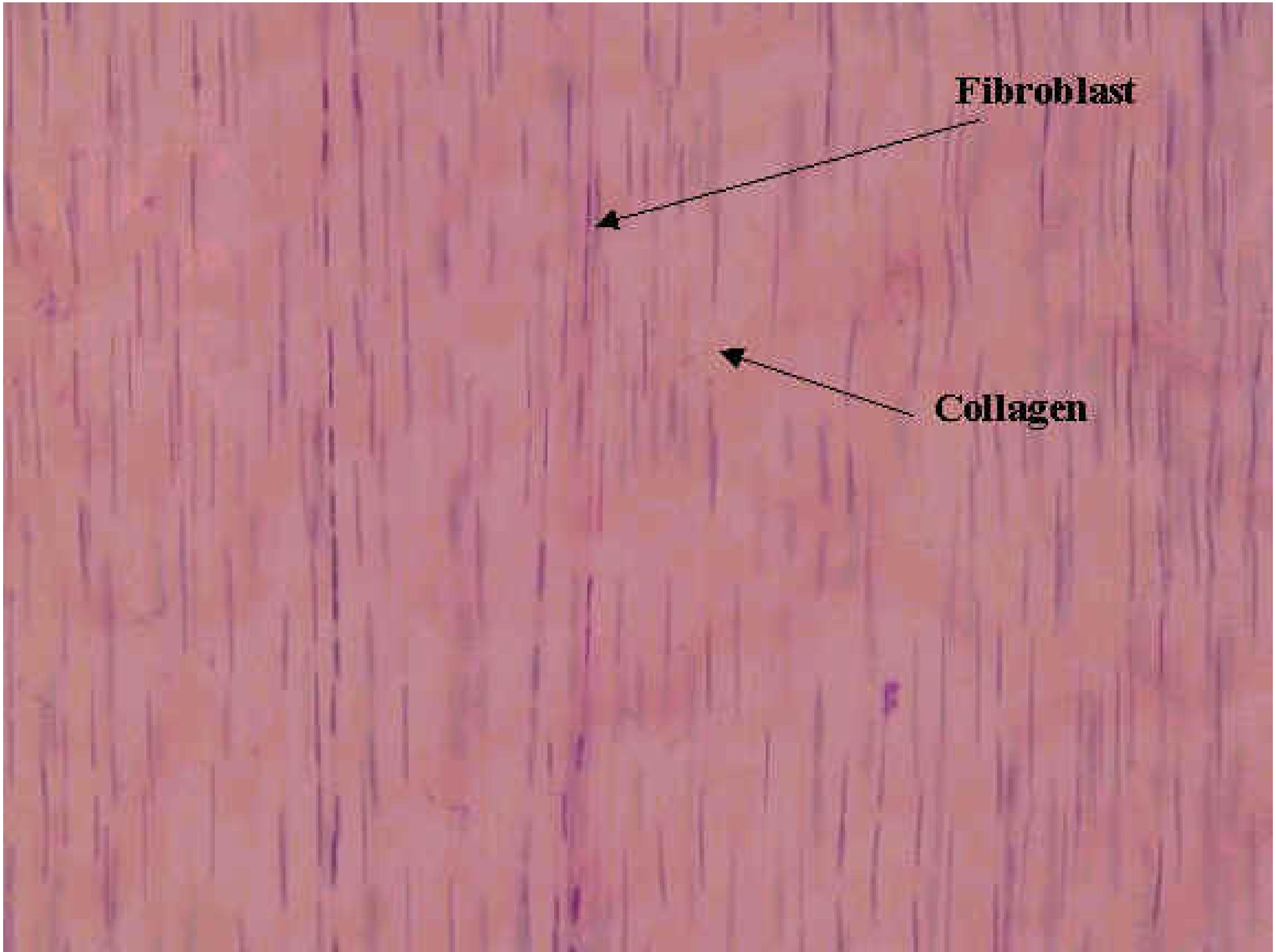


Compact Bone (100x)

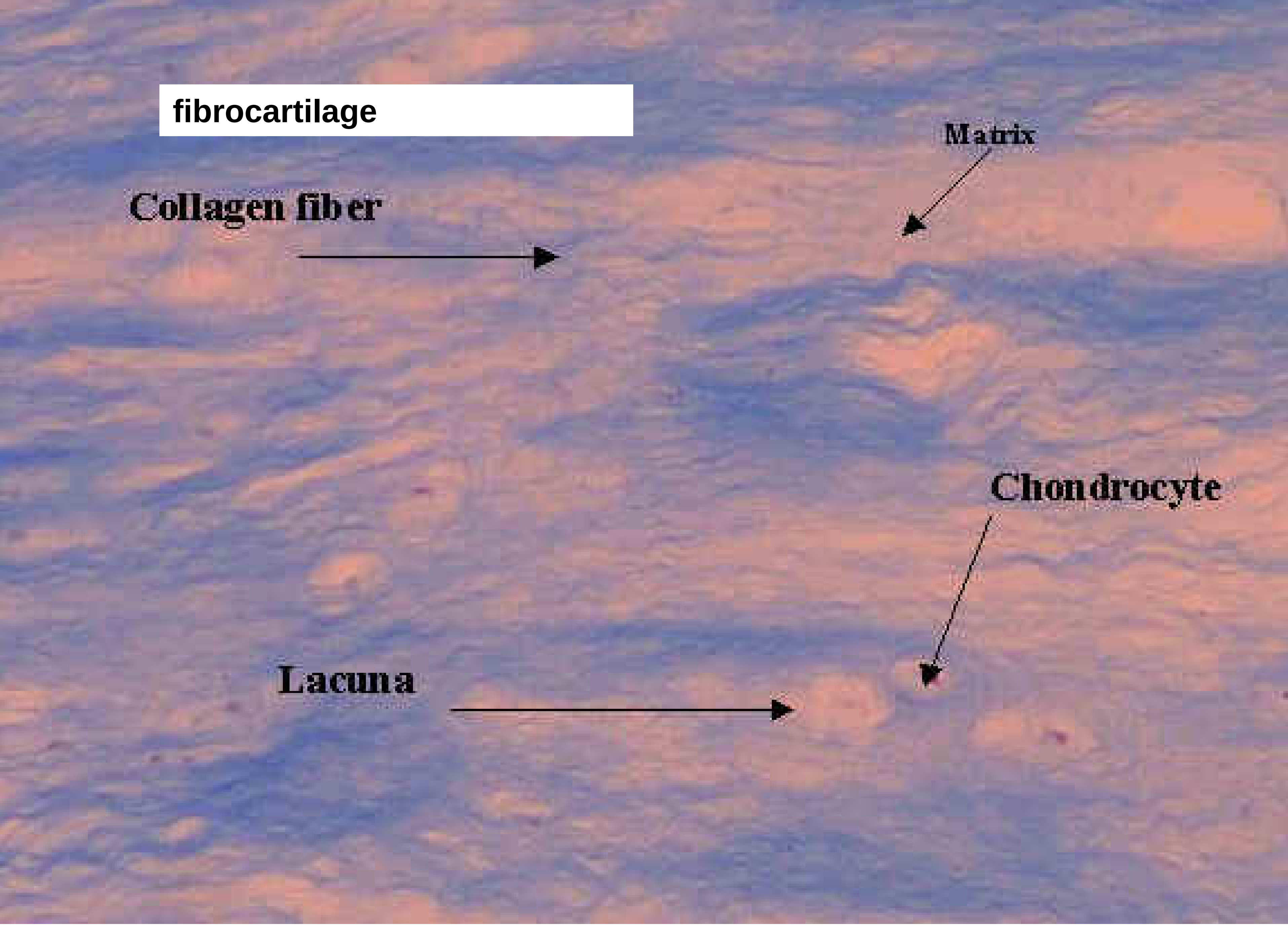


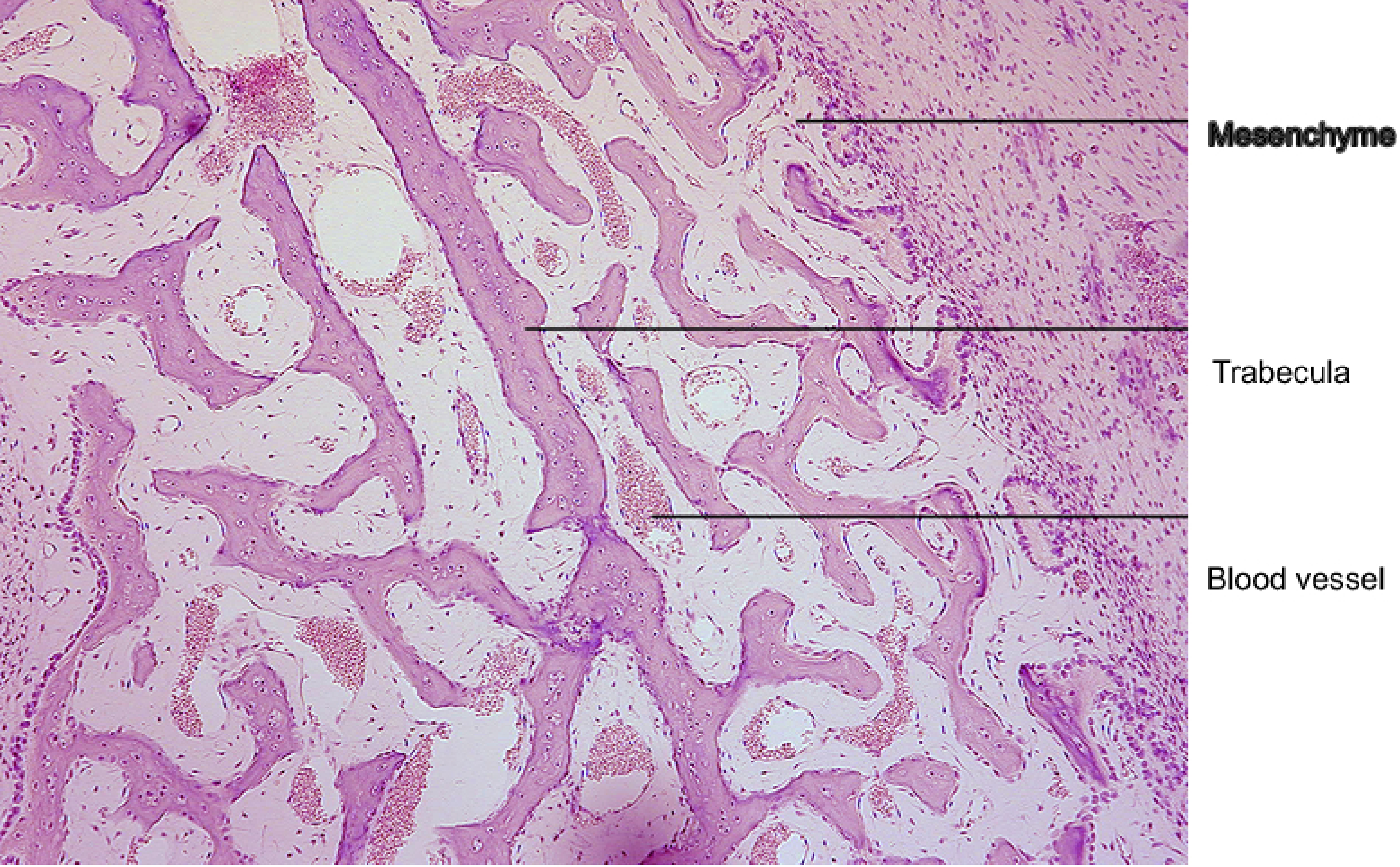
Cancellous (Spongy) Bone (100x)

Dense regular CT



fibrocartilage





Intramembranous Ossification (100x)

Intramembranous ossification produces flat bones of the skull. This ossification process begins with mesenchyme forming a sheet of tissue with a large supply of blood vessels. Eventually osteogenic cells give rise to osteoblasts which form spongy bone first and eventually both spongy bone and compact bone.


Endochondral ossification