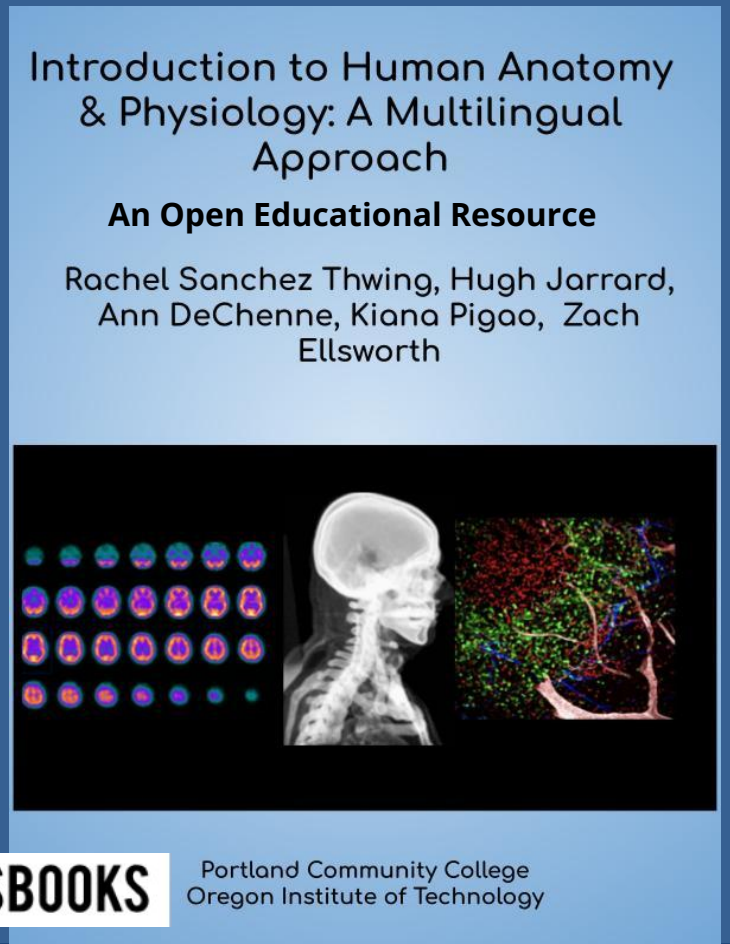
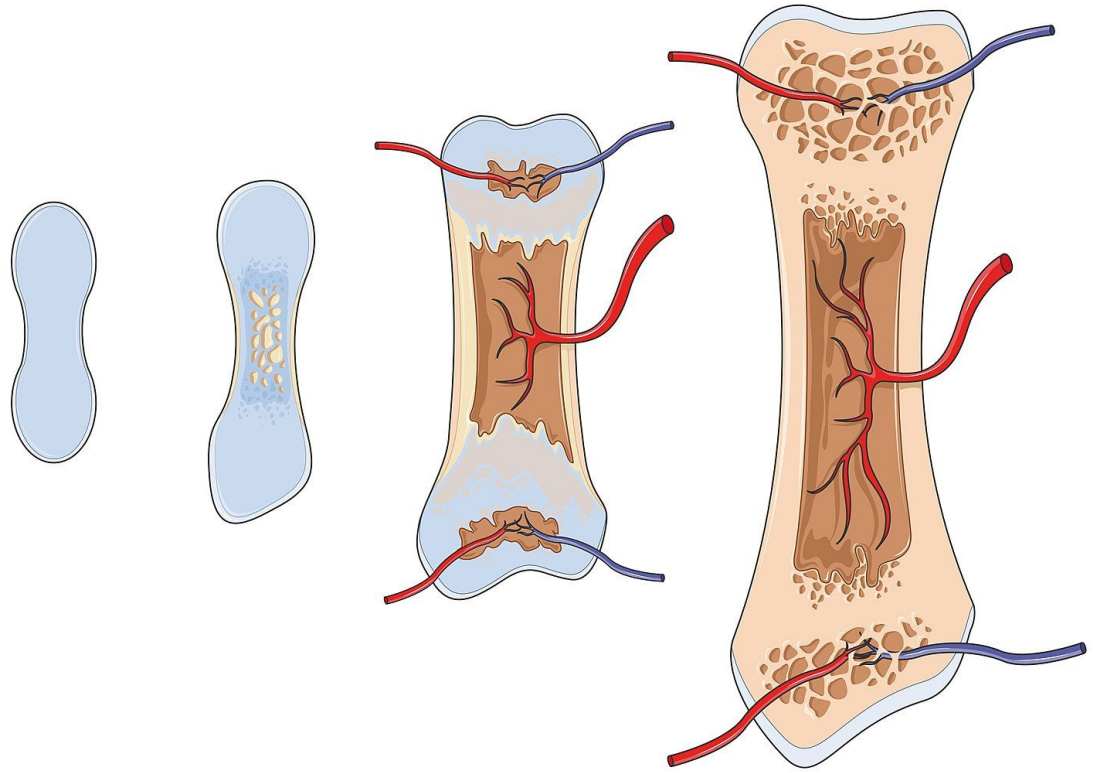
Skeletal System:
Bone Growth, Repair, and Remodeling





Bone Growth By Laboratoires Servier, CC BY-SA 3.0, via Wikimedia Commons

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Lesson 3: Bone Growth, Repair, and Remodeling

Learning Objectives:

- Describe the structure of bone matrix at the cellular level
- List the steps of intramembranous ossification
- List the steps of endochondral ossification
- Explain the growth through elongation and appositional growth
- Describe bone remodeling

See the Skeletal System Wordlist!

- Can be found in accompanying materials to this lecture
- Materials are available in English, Spanish, Russian, Vietnamese, Filipino, East African French, Kiswahili (Swahili) and Chinese.

Module 3 Skeletal System Word List

Microscopic Anatomy
Bone Matrix
Compact Bone
Lacunae (containing Osteocytes)
Lamellae
Osteon
Central canal
Spongy bone

Bone cells:
Osteoblasts
Osteocytes
Osteoclasts

Cranium (Skull):
Occipital Bone
Temporal Bone
Parietal Bone
Frontal Bone
Sphenoid Bone
Nasal Bone
Zygomatic Bone
Maxilla
Mandible
Ethmoid Bone
Vomer Bone
Palatine Bone
Paranasal Sinuses

Axial Skeleton:
Vertebral Column
Intervertebral disc
Atlas (C1)
Axis (C2)
Cervical Vertebrae (C1-C7)
Thoracic Vertebrae (T1-T12)
Lumbar Vertebrae (L1-L5)
Sacrum
Coccyx (3-5 fused vertebrae)

Thoracic Cage:
True Ribs (1-7)
False Ribs (8-12)
Sternum

Appendicular Skeleton:
Upper Appendages
Clavicle
Scapula
Humerus
Ulna
Radius
Carpals
Metacarpal (5)
Phalanges of Hand (Proximal, Middle, Distal)

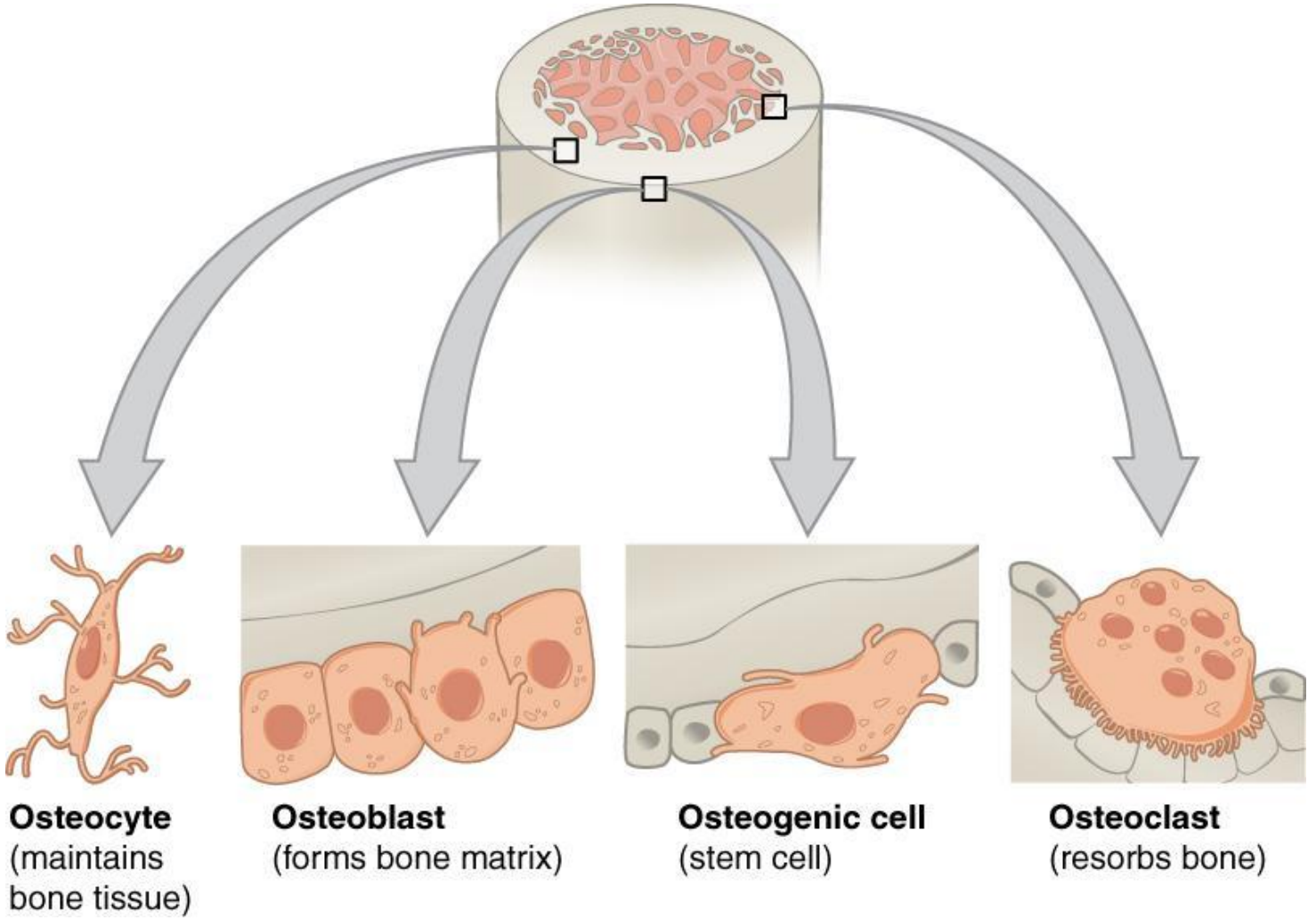
Lower Appendages
Pelvis
Ilium
Pubic bone
Ischium
Femur
Patella
Tibia
Fibula
Tarsals
Metatarsal (5)
Phalanges of Foot (Proximal, Middle, Distal)

Ossification:
Intramembranous
Endochondral

Homeostatic Imbalances
Osteoarthritis
Osteoporosis

Bone Cells and Their Development

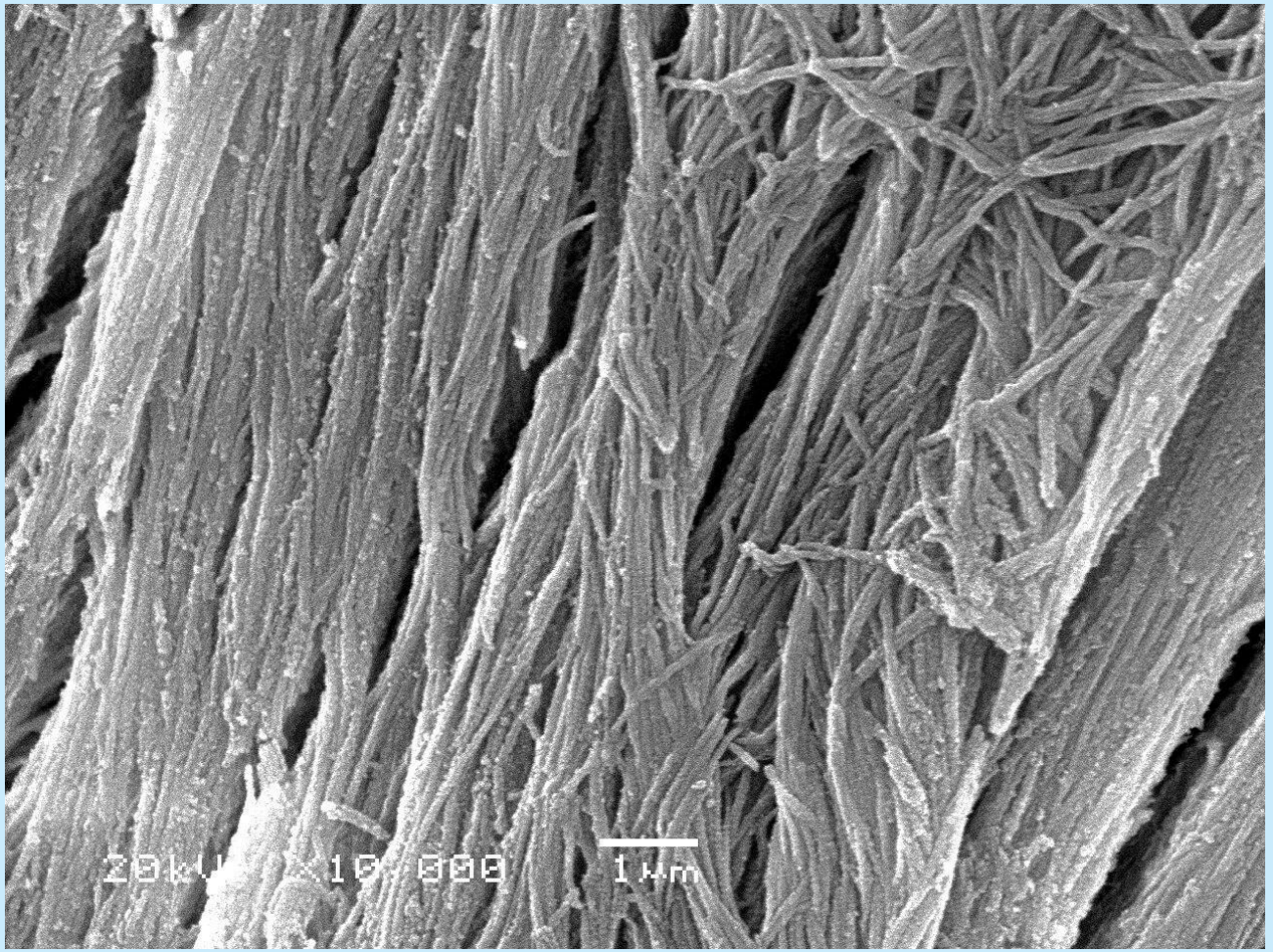
- **Osteogenic cells:**
  stem cells give rise to osteoblasts
- **Osteoblasts:**
  synthesize organic matter of bone
- **Osteocytes:**
  former osteoblasts, trapped in matrix
- **Osteoclasts:**
  bone-dissolving cells



Bone Cells by Openstax A&P, 2e

Bone Matrix Formation

- Matrix surrounds osteocytes
- 1/3 organic (collagen and other proteins)
  - Allows a bit of flexibility to resist tension
  - Formed by osteoblasts
- 2/3 minerals (mostly calcium phosphate)
  - Provides strength



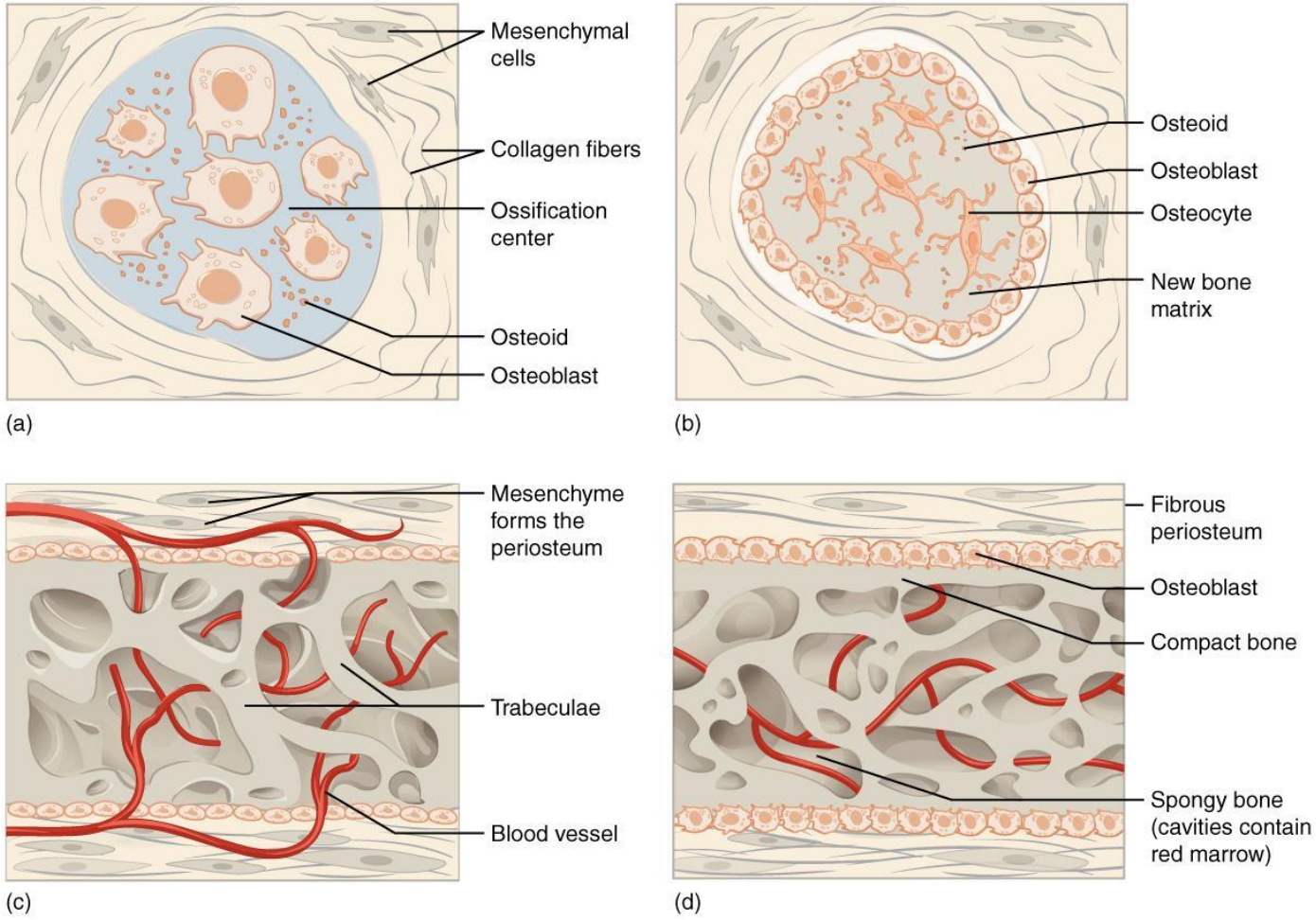
Electron micrograph (10,000 magnification) of mineralized Collagen fibers in Bone by Sbertazzo, CC BY-SA 3.0, via Wikimedia Commons

Ossification

Ossification:
the process of bone formation

Two types:

- **Intramembranous ossification:** produces the flat bones of the skull
- **Endochondral ossification:** produces most other bones of the body

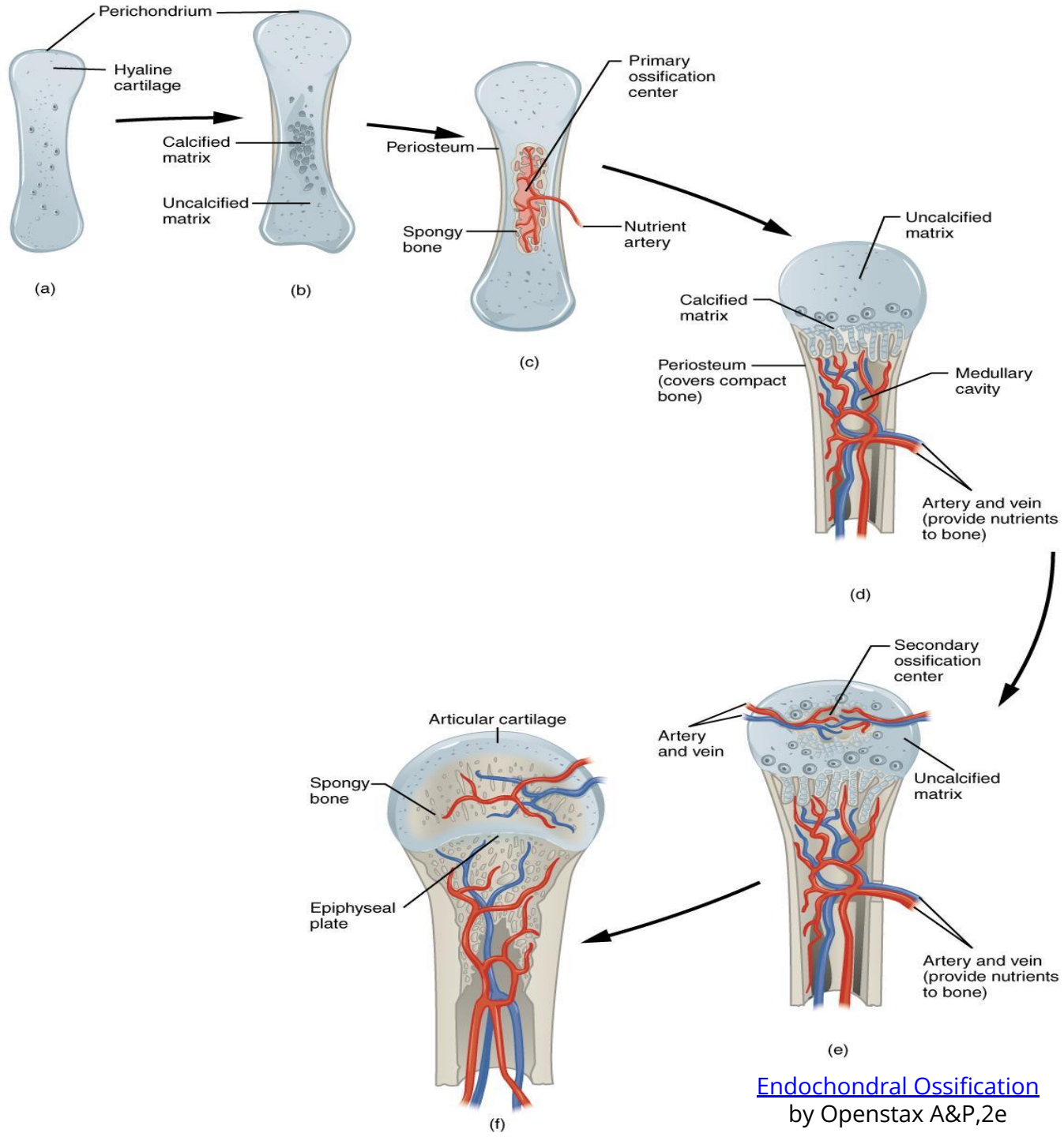


Intramembranous Ossification by Openstax A&P,2e

ENDOCHONDRAL OSSIFICATION

Bone develops by replacing cartilage

- Cartilage serves as a template to be completely replaced by new bone.
- Takes much longer than intramembranous ossification.



[Endochondral Ossification](#) by Openstax A&P,2e

BONE GROWTH AND REMODELING

Bone Elongation:

In children, limb bones elongate (growth in height) as epiphyseal plates thicken

On X-rays, plates appear as a transparent line across end of bone

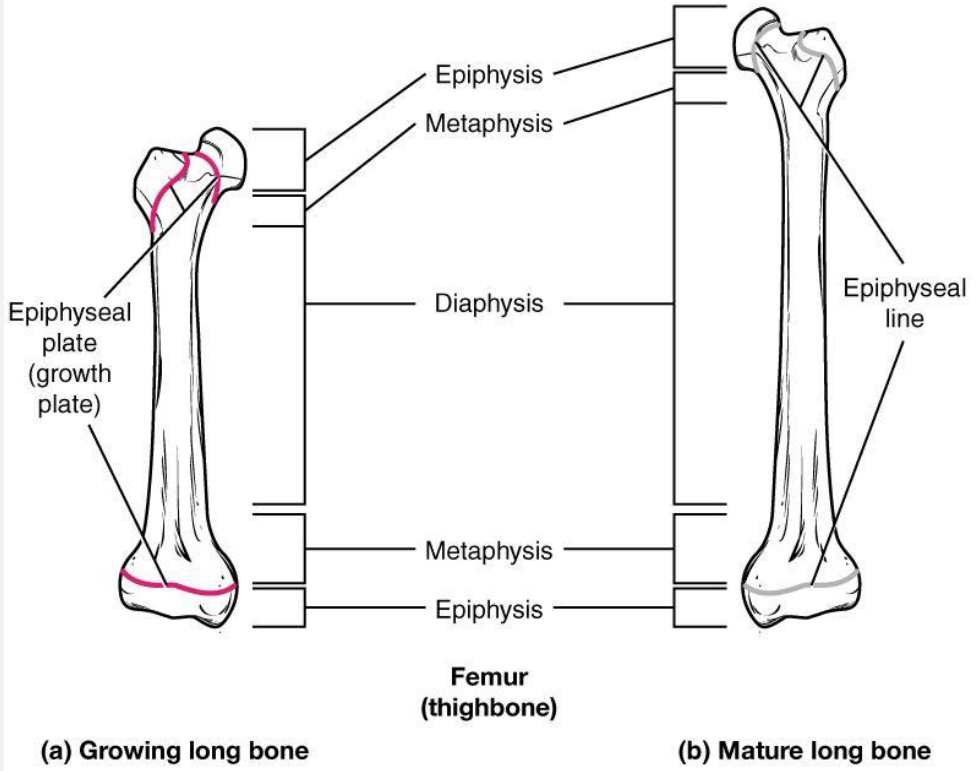
Plates “close” when cartilage is depleted, replaced by bone

Bone Thickening (appositional growth):

In adults, bones do not elongate

Thickening of Bones occurs throughout adulthood

With increased tension on bone, athletes will have greater bone mass than sedentary people

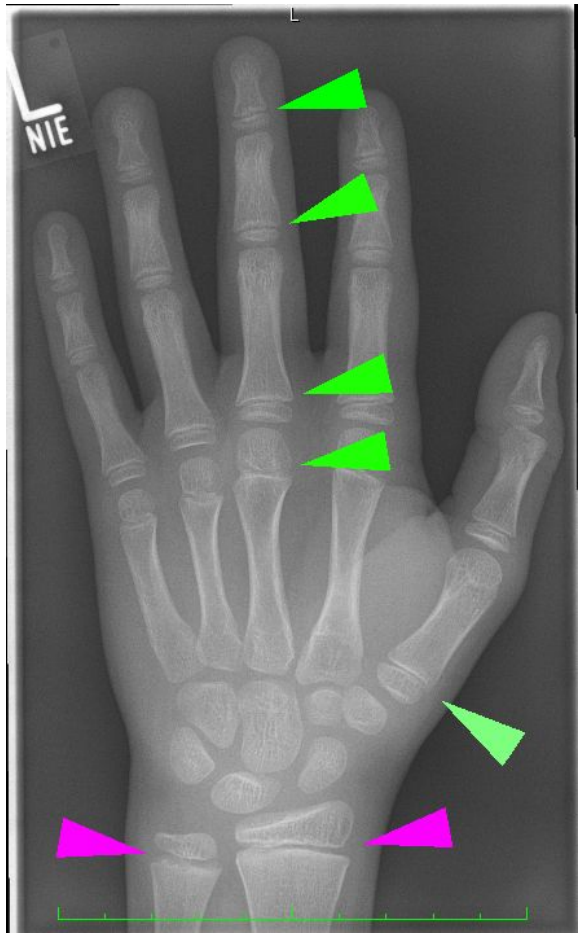


Progression from Epiphyseal Plate to Line by Openstax A&P, 2e

Adult versus Child Hand X-ray

Note that the epiphyseal plate cartilage is absent in the image of the adult hand on the left.

The child's hand on the right has pink and green arrows depicting epiphyseal plate cartilage.

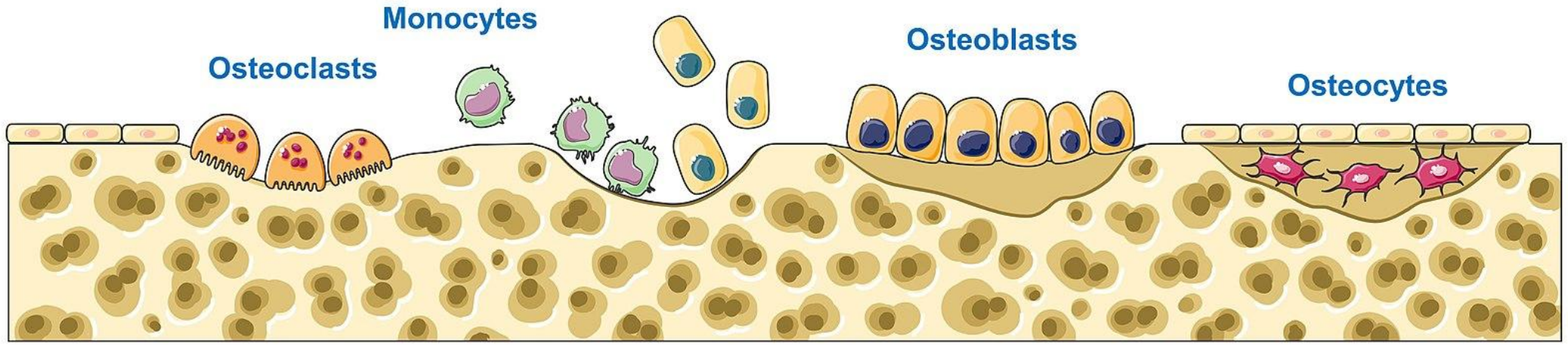


Left: X-Ray of Adult's Hand by Mikael Häggström M.D, CCO 1.0, via Wikimedia Commons
Right: X-Ray of Child's Hand by eigen, CC BY-SA 4.0, via Wikimedia Commons

Bone Growth: Remodeling

Bones are remodeled throughout life

- In old or damaged bone, osteoblasts lay new bone to replace that which is resorbed.
- Injury, exercise, and other activities lead to remodeling.
- ~ 5 - 10 percent of the skeleton is remodeled annually by remodeling



Bone Regeneration and Remodeling Cycle By Laboratoires Servier,CC BY-SA 3.0, via Wikimedia Commons

Lesson 3: Bone Growth, Repair, and Remodeling Wrap Up

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