# Fascia and Bone Tissues

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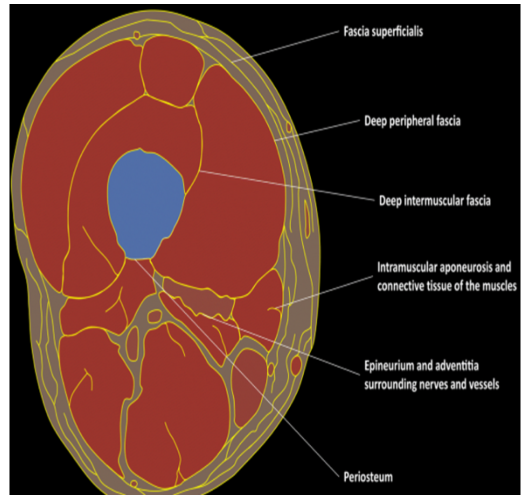
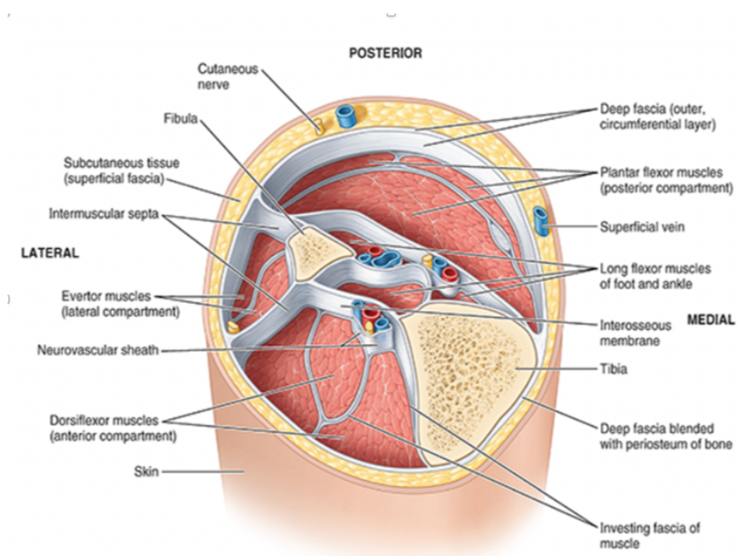
## Fascia




- Fascia constitute the wrapping, packing, and insulating materials of the deep structures of the body.
- Underlying the subcutaneous tissue (superficial fascia) almost everywhere is the deep fascia.
- The deep fascia is a dense, organized connective tissue layer, devoid of fat, that covers most of the body parallel to (deep to) the skin and subcutaneous tissue.
- Extensions from its internal surface invest deeper structures, such as individual muscles and neurovascular bundles, as investing fascia.
- Its thickness varies widely. For example, in most of the face, distinct layers of deep fascia are absent.

## Compartments

- In the limbs, groups of muscles with similar functions, usually sharing the same nerve supply, are located in fascial compartments.
- These compartments are separated by thick sheets of deep fascia, called intermuscular septa, that extend centrally from the surrounding fascial sleeve to attach to bones.

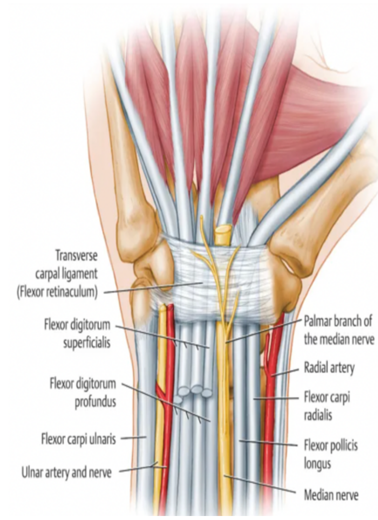



- These compartments may contain or direct the spread of an infection or a tumor.
- In a few places, the deep fascia gives attachment (origin) to the underlying muscles (although it is not usually included in lists or tables of origins and insertions)
- In most places, the muscles are free to contract and glide deep to it.
- However, the deep fascia itself never passes freely over bone; where deep fascia contacts bone, it blends firmly with the periosteum (bone covering).
- Blood is pushed out as the veins of the muscles and compartments are compressed.
- Valves within the veins allow the blood to flow only in one direction (toward the heart), preventing the backflow that might occur as the muscles relax.

**Compartments**

- The deep fascia, contracting muscles, and venous valves work together as a venous pump to return blood to the heart, especially in the lower limbs where blood must move against the pull of gravity.
- There are three ways that blood is returned back to the heart.

**Retinaculum**



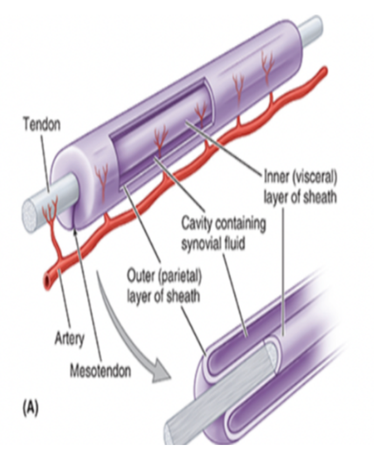

- Near the wrist, ankle and knee, the deep fascia becomes markedly thickened, forming a retinaculum to hold tendons in place where they cross the joint during flexion and extension, preventing them from taking a shortcut, or bow stringing, across the angle created.
- There are 2 in the wrist
    - Flexor and Extensor Retinaculum
- There are 5 in the ankle
    - Flexor and Superior and Inferior Extensors
    - Superior and inferior fibular retinaculum
- There are 2 in the knee
    - Lateral retinaculum
    - Medial patellar retinaculum

**Bursa**

- A bursa is a closed, fluid-filled sac that works as a cushion and gliding surface to reduce friction between tissues of the body.
- The major bursae (this is the plural of bursa) are located next to the tendons near the large joints, such as in the shoulders, elbows, hips, and knees.
- Bursae are closed sacs or envelopes of serous membrane (a delicate connective tissue membrane capable of secreting fluid to lubricate a smooth internal surface).
- Bursae are normally collapsed.

**Bursal Sacs Protect Viscera**

- Collapsed bursal sacs surround many important organs (e.g., the heart, lungs, and abdominal viscera) and structures (e.g., portions of tendons).
- This configuration is much like wrapping a large but empty balloon around a structure, such as a fist.
- The object is surrounded by the two layers of the empty balloon but is not inside the balloon; the balloon itself remains empty.
- For an even more exact comparison, the balloon should first be filled with water and then emptied, leaving the empty balloon wet inside.




**Synovial Tendon Sheaths**

- Synovial tendon sheaths are a specialized type of elongated bursae that wrap around tendons, usually enclosing them as they create tunnels that anchor the tendons in place.

**Big takeaway of fascia and bursa**

- Divide muscles into groups (intermuscular septa)
- Invest individual muscles and neurovascular bundles (investing fascia)
- Lie between musculoskeletal walls and the serous membranes lining body cavities (subserous fascia)
- Hold tendons in place during joint movements (retinacula)
- Bursae are closed sacs formed of serous membrane that occur in locations subject to friction
- Bursa enable one structure to move freely over another.

**Cartilage**

- Location and basic structure of cartilages
    - Found throughout adult body
        - Cartilage in the external ear
        - Cartilage of the nose
        - Articular cartilages and costal cartilage
        - Cartilages in the larynx and trachea
        - Intervertebral discs, pubic symphysis, and articular discs
- Perichondrium
    - Surrounds cartilages
    - Resists outward pressure
    - Functions in growth and repair of cartilage
- Consists primarily of water
- Is a resilient tissue
    - Springs back to original shape

**Types of Cartilage**

- All cartilages share some similarities
    - Cell type is the chondrocyte
    - Chondrocytes are located within lacunae
    - Matrix contains
        - *Fibers*
        - Jellylike ground substance

**Hyaline cartilage**

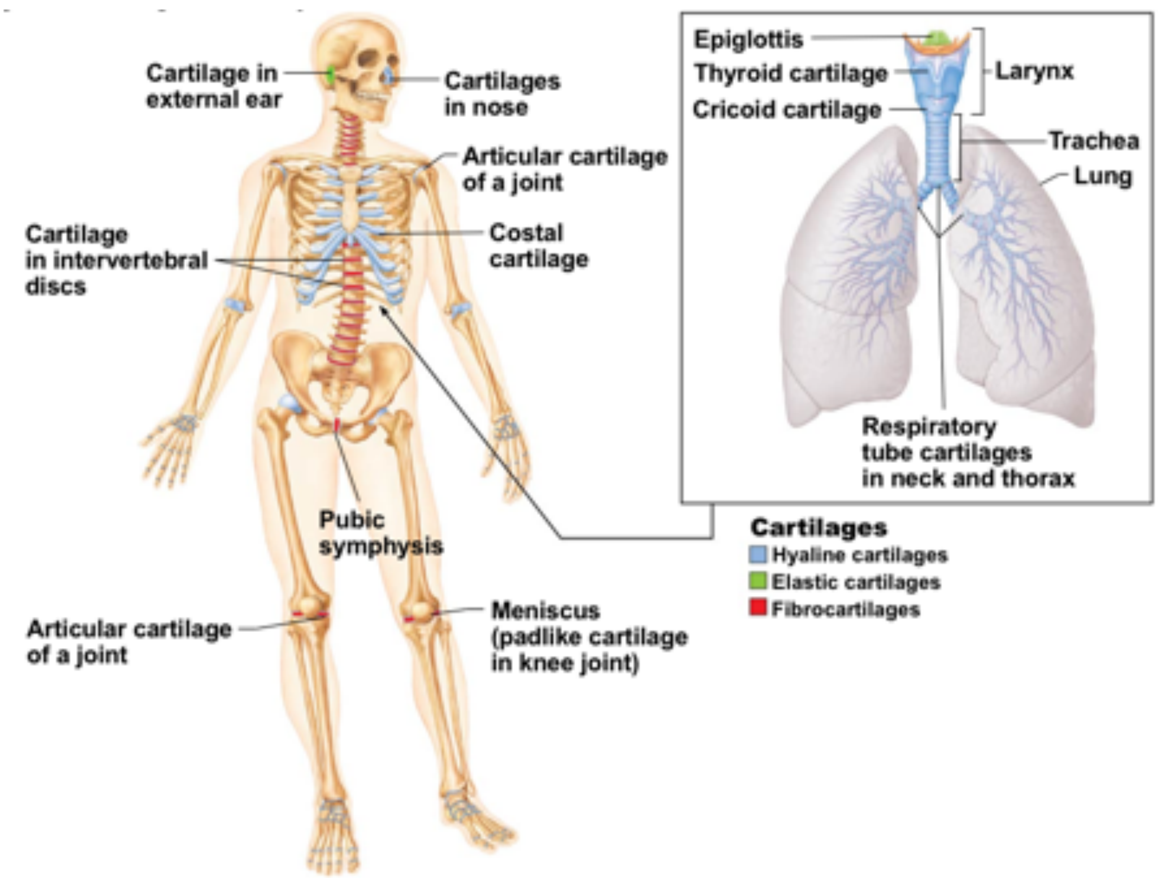
- Most abundant cartilage
- Chondrocytes appear spherical
- Collagen unit fibril is the only type of fiber in the matrix
- Ground substance holds a large amount of water
- Provides support through flexibility

**Elastic cartilage**

- Contains many elastic fibers
- Able to tolerate repeated bending
- Locations—epiglottis and cartilage of external ear

**Fibrocartilage**

- Resists strong compression and strong tension
- An intermediate between hyaline and elastic cartilage
- Locations—pubic symphysis, menisci of knee, anulus fibrosus




**Tissues in Bone**

- Bones contain several types of tissues
    - Dominated by bone connective tissue
    - Contain nervous tissue and blood connective tissue
    - Contain cartilage in articular cartilages
    - Contain epithelial tissue lining blood vessels

**Function of Bones**

- Support – form the framework that supports the body and cradles soft organs
- Protection – provide a protective case for the brain, spinal cord, and vital organs
- Movement – provide levers for muscles
- Mineral storage – reservoir for minerals, especially calcium and phosphorus
- Blood cell formation – hematopoiesis occurs within the marrow cavities of bones

**Bone Tissue**

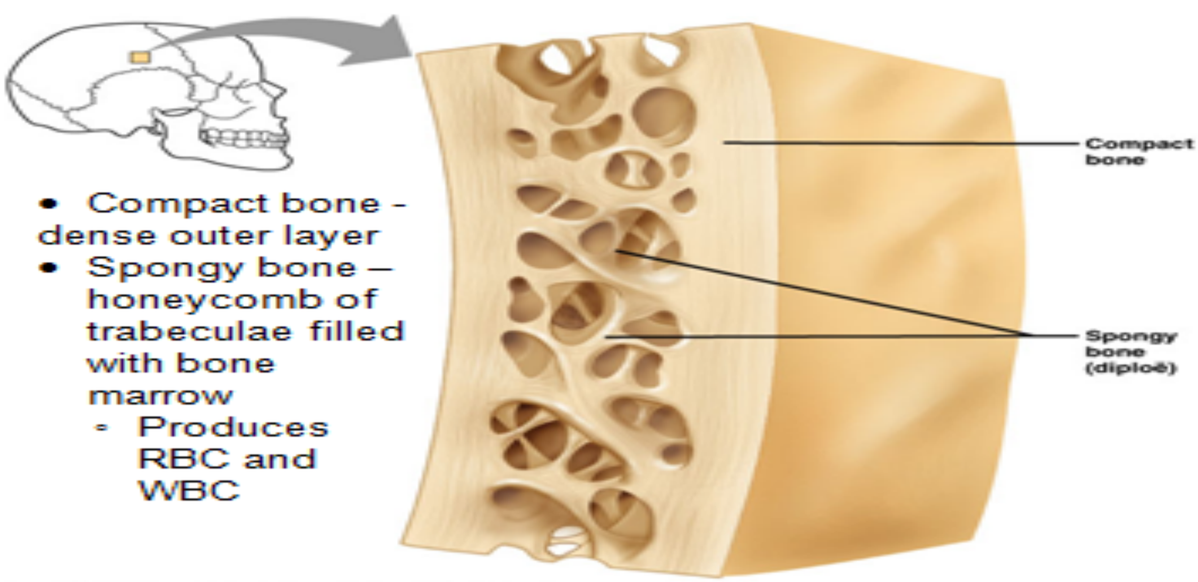
- Bone tissue
  - Organic components
- Cells, fibers, and ground substance
  - Inorganic components
- Mineral salts that invade bony matrix

**Extracellular Matrix**

- Unique composition of matrix
  - Gives bone exceptional properties
  - 35%—organic components
- Contribute to flexibility and tensile strength
  - 65%—inorganic components
- Provide exceptional hardness, resist compression

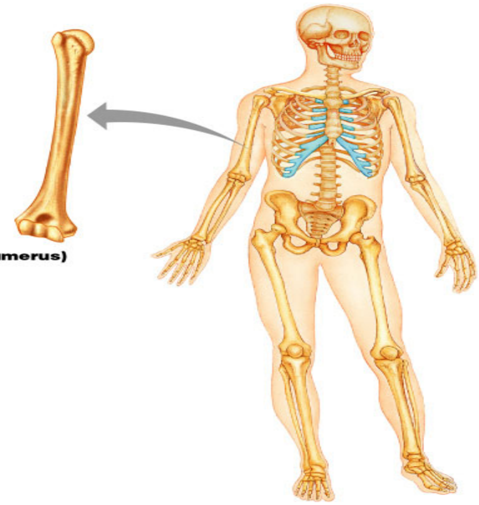
**Cells**

- Three types of cells in bone produce or maintain bone
  - Osteogenic cells—stem cells that differentiate into osteoblasts
  - Osteoblasts—actively produce and secrete bone matrix
- Bone matrix is osteoid
  - Osteocytes—keep bone matrix healthy
  - Osteoclasts
    - Found within bone tissue
    - Responsible for resorption of bone
    - Are derived from a line of white blood cells
    - Secrete hydrochloric acid and lysosomal enzymes



**Shape of Bones**

- Long bones
- Short bones
- Flat bones
- Irregular bones

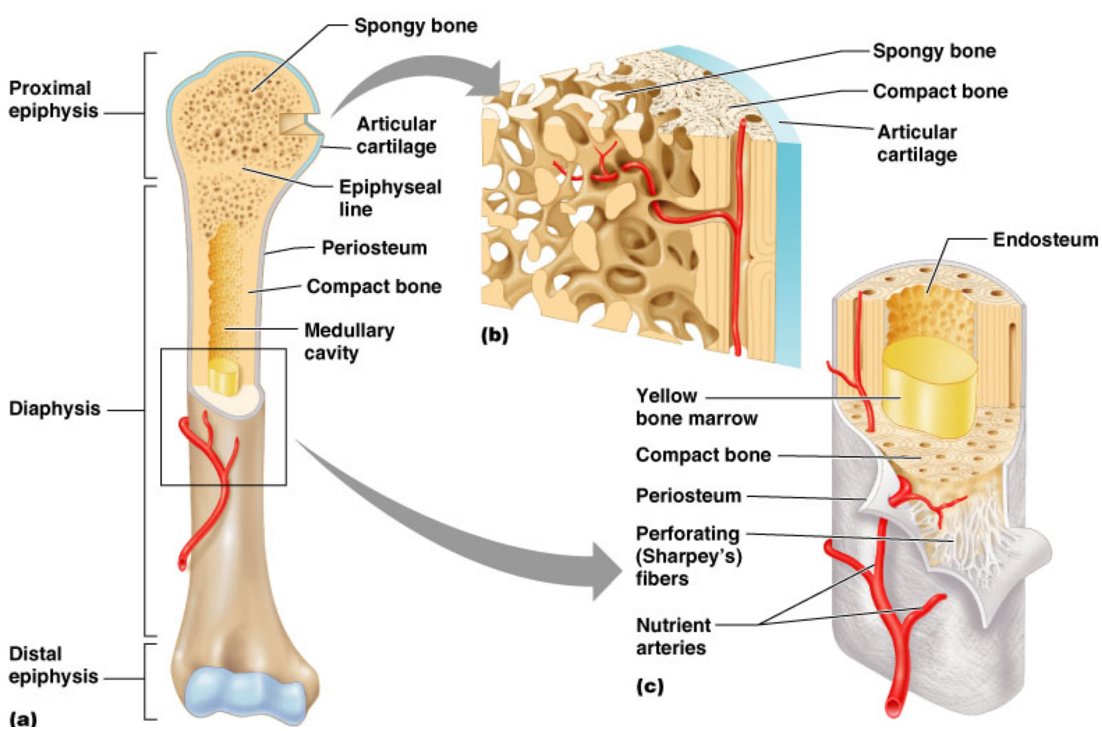



**Long Bones**

- Long bones – longer than they are wide
- Humerus, radius, ulna
- Femur, tibia, fibula

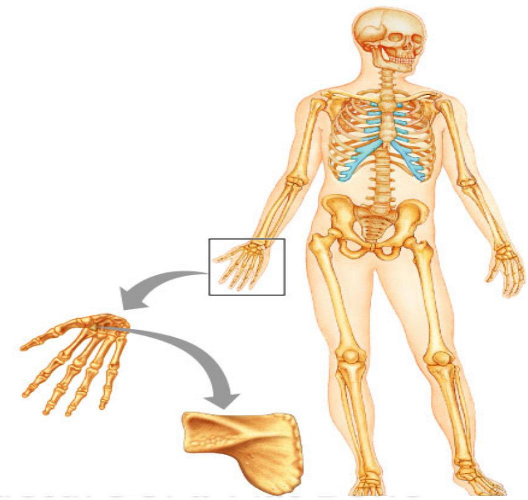
**Structure of Long Bones**

- Diaphysis
  - Tubular shaft that forms the axis of long bones
- Epiphyses
  - Expanded ends of long bones
  - Joint surface is covered with articular (hyaline) cartilage
  - Epiphyseal line separates the diaphysis from the epiphyses
- Blood vessels—well vascularized
- Medullary cavity—hollow cavity filled with yellow marrow
- Membranes
  - Periosteum, perforating collagen fiber bundles (Sharpey's fibers), and endosteum



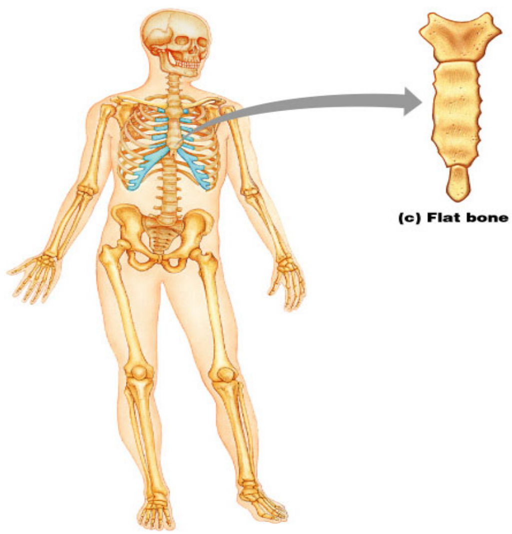
**Short Bones**

- Short bones
    - Bones of the wrist and ankle
    - Bones that form within tendons (e.g., patella)

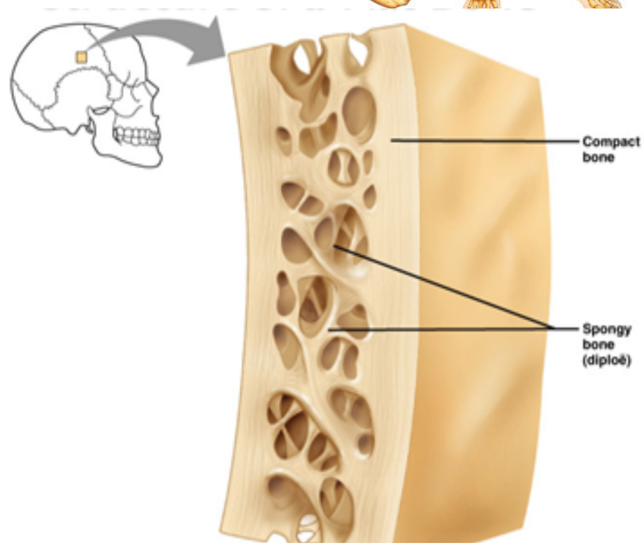


**Flat Bones**

- Flat bones – thin, flattened, and a bit curved (e.g., sternum, and most skull bones)

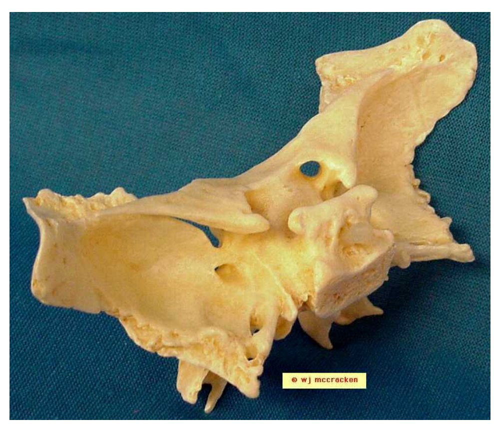


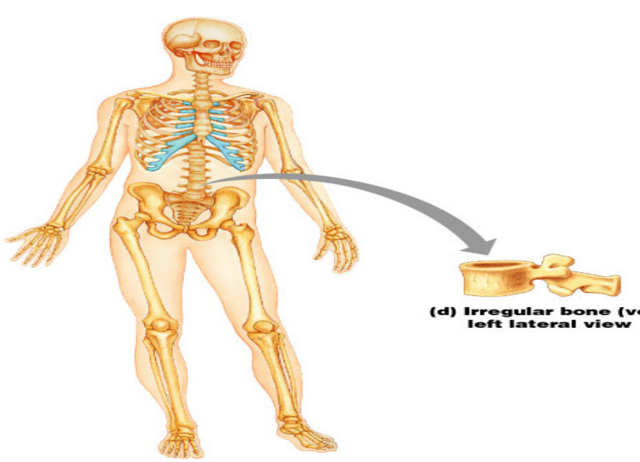
(c) Flat bone (sternum




**Irregular Bones**

- Irregular bones – bones with complicated shapes (e.g., vertebrae and hip bones)

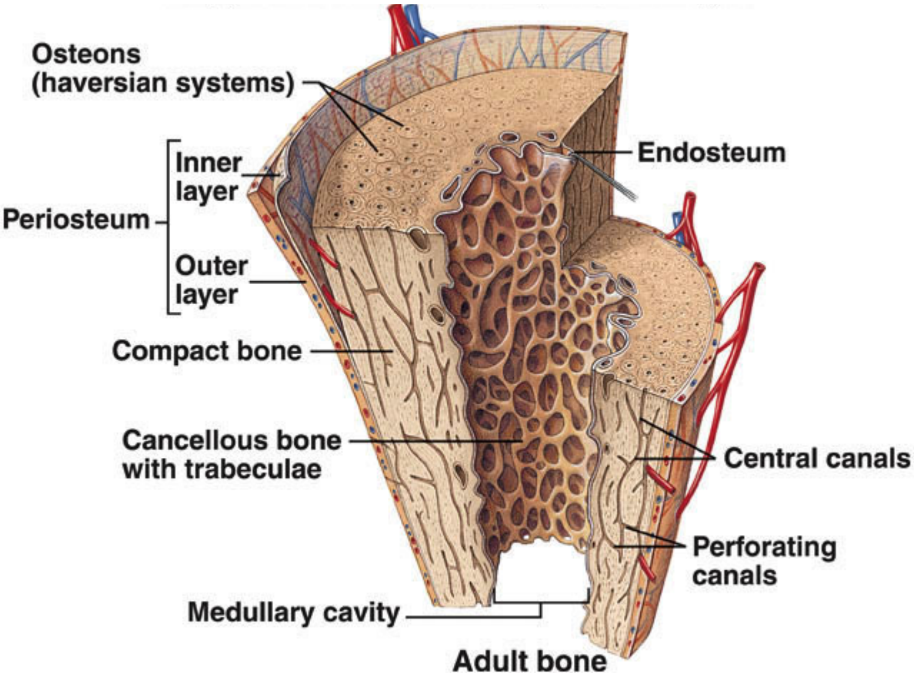


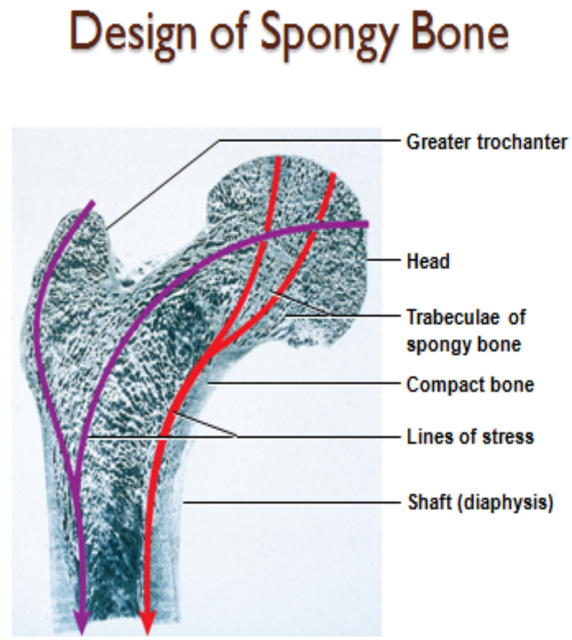



(d) Irregular bone (vertebra), left lateral view

**Bone Membranes**

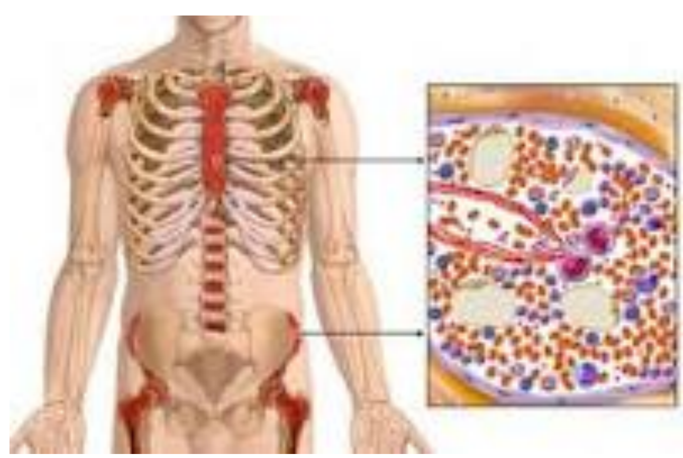
- Periosteum – double-layered protective membrane
  - Outer fibrous layer is dense regular connective tissue
  - Richly supplied with nerve fibers, blood, and lymphatic vessels, which enter the bone via nutrient foramina
- Endosteum – delicate membrane covering internal surfaces of bone



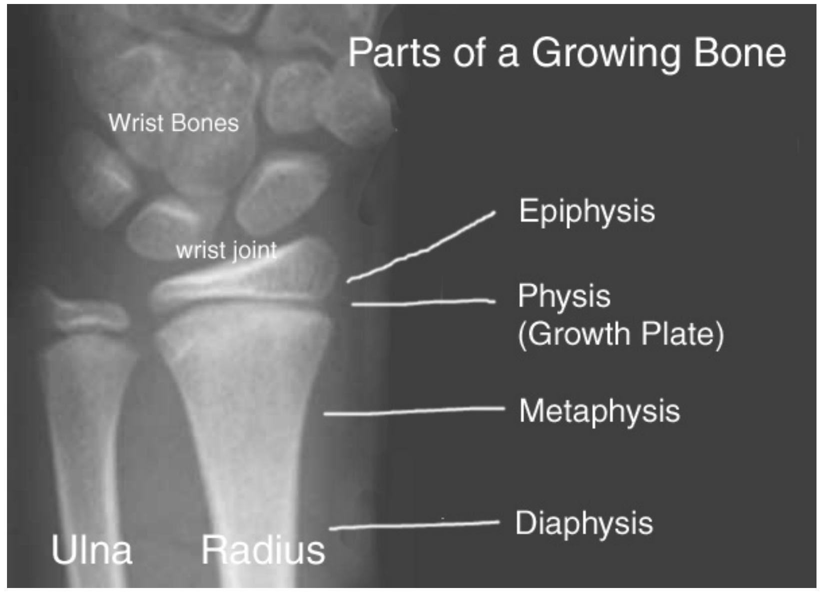

**Bone Marrow**

- Bone marrow – general term for soft tissue that occupies the marrow cavity of a long bone and small spaces amid the trabeculae of spongy bone
- Red marrow
  - in nearly every bone in a child
  - hemopoietic tissue - produces blood cells
  - in adults, found in skull, vertebrae, ribs, sternum, part of pelvic girdle, and proximal heads of humerus and femur
- Yellow marrow found in adults
  - most red marrow turns into fatty yellow marrow
  - no longer produces blood



**Bone Development**

- Ossification or osteogenesis – the formation of bone
- in the human fetus and infant, bone develops by two methods:
    - intramembranous ossification
    - endochondral ossification




**Bone Growth**

- The process of bone development and growth is carefully regulated, and a breakdown in regulation affects all body systems.
- From fertilization to about eight weeks of age, an embryo's skeletal elements are composed of either mesenchyme or hyaline cartilage.
- The bony skeleton begins to form at eight weeks. During subsequent development, the bones increase tremendously in size.
- Bone growth continues through adolescence, and portions of the skeleton usually do not stop growing until age 25.
- The growth of the skeleton determines the size and proportions of the body.
- The growth of the skeleton determines the size and proportions of the body.
- During embryonic development, bone replaces both mesenchyme and cartilage.
- This process of replacing other tissues with bone is Ossification.
- Calcification refers to the deposition of calcium salts within a tissue. Any tissue can be calcified, but only ossification forms bone.
- **Calcification is almost always pathology**

**Ossification**

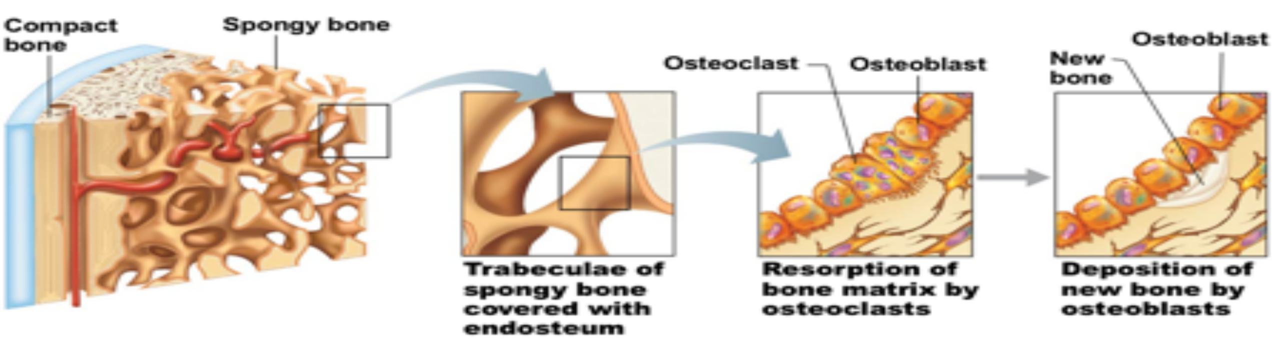
- Ossification continues throughout life with the growth and remodeling of bones
- bones grow in two directions: length and width
- bone elongation
    - Epiphyseal plate – a region of transition from cartilage to bone
        - functions as growth zone where the bones elongate
        - consists of typical hyaline cartilage in the middle
        - with a transition zone on each side where cartilage is being replaced by bone

**Increasing the Diameter of a Developing Bone**

- The diameter of a bone enlarges through growth at the outer surface of the bone.
- In this process of appositional growth, stem cells of the inner layer of the periosteum differentiate into osteoblasts and add bone matrix to the surface.
- This adds layers of circumferential lamellae to the superficial surface of the bone.
- Over time, the deeper lamellae are recycled and replaced with the osteons typical of compact bone.
- Blood vessels and collagen fibers of the periosteum can and do become enclosed within the matrix.
- Where this occurs, the process of appositional bone growth is somewhat more complex.
- While osteoblasts add bone to the outer surface, osteoclasts reabsorb (remove) bone matrix at the inner surface.
- As a result, the medullary cavity gradually enlarges as the bone increases in diameter.

**Bone Remodeling**

- Bone is a dynamic living tissue
    - 500 mg of calcium may enter or leave the adult skeleton each day
    - Bone matrix and osteocytes are continually removed and replaced
    - Cancellous bone of the skeleton is replaced every 3–4 years
    - Compact bone is replaced every 10 years
- Bone deposit and removal
    - Occurs at periosteal and endosteal surfaces
- Bone remodeling
    - Bone deposition—accomplished by osteoblasts
    - Bone reabsorption—accomplished by osteoclasts




**Postnatal Growth of Endochondral Bones**

- During childhood and adolescence:
    - Bones lengthen entirely by growth of the epiphyseal plates
    - Cartilage is replaced with bone connective tissue as quickly as it grows
    - Epiphyseal plate maintains constant thickness
    - Whole bone lengthens

**Postnatal Growth of Endochondral Bones**

- As adolescence draws to an end:
    - Chondroblasts divide less often
    - Epiphyseal plates become thinner
    - *Cartilage stops growing*
    - *Replaced by bone tissue*
- Long bones stop lengthening when diaphysis and epiphysis fuse

**Postnatal Growth of Endochondral Bones**

- Growing bones widen as they lengthen
    - Osteoblasts—add bone tissue to the external surface of the diaphysis
    - Osteoclasts—remove bone from the internal surface of the diaphysis
- Appositional growth—growth of a bone by addition of bone tissue to its surface

**Factors Affecting Bone Growth**

- Heredity
- Nutrition
    - Calcium, phosphorus, protein, Vitamin D, A, C
- Hormones
- Exercise or "stress"

    Without bones becoming weight bearing, they lose calcium

**Hormonal Regulation of Bone Growth During Youth**

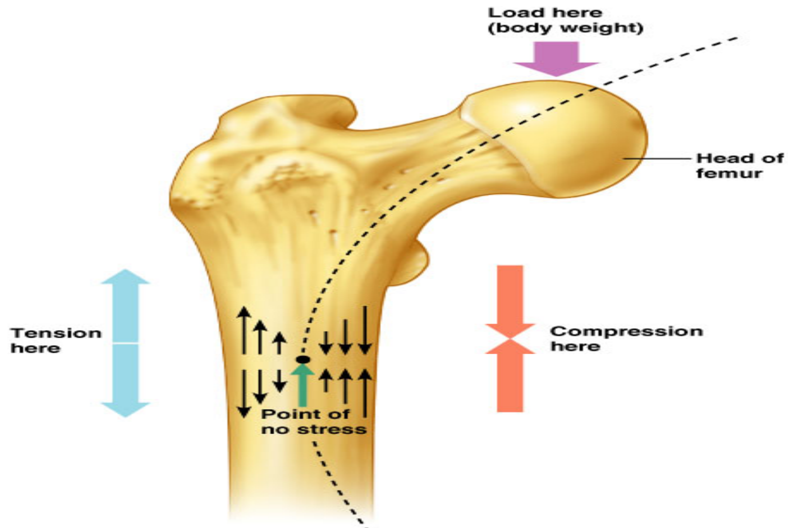
- During infancy and childhood, epiphyseal plate activity is stimulated by growth hormone
- During puberty, testosterone and estrogens:
    - Initially promote adolescent growth spurts
    - Cause masculinization and feminization of specific parts of the skeleton
    - Later induce epiphyseal plate closure, ending longitudinal bone growth

**Importance of Ionic Calcium in the Body**

- Calcium is necessary for:
    - Transmission of nerve impulses
    - Muscle contraction
    - Blood coagulation
    - Secretion by glands and nerve cells
    - Cell division

**Response to Mechanical Stress**

- Wolff's law – a bone grows or remodels in response to the forces or demands placed upon it
- Observations supporting Wolff's law include
    - Long bones are thickest midway along the shaft (where bending stress is greatest)
    - Curved bones are thickest where they are most likely to buckle

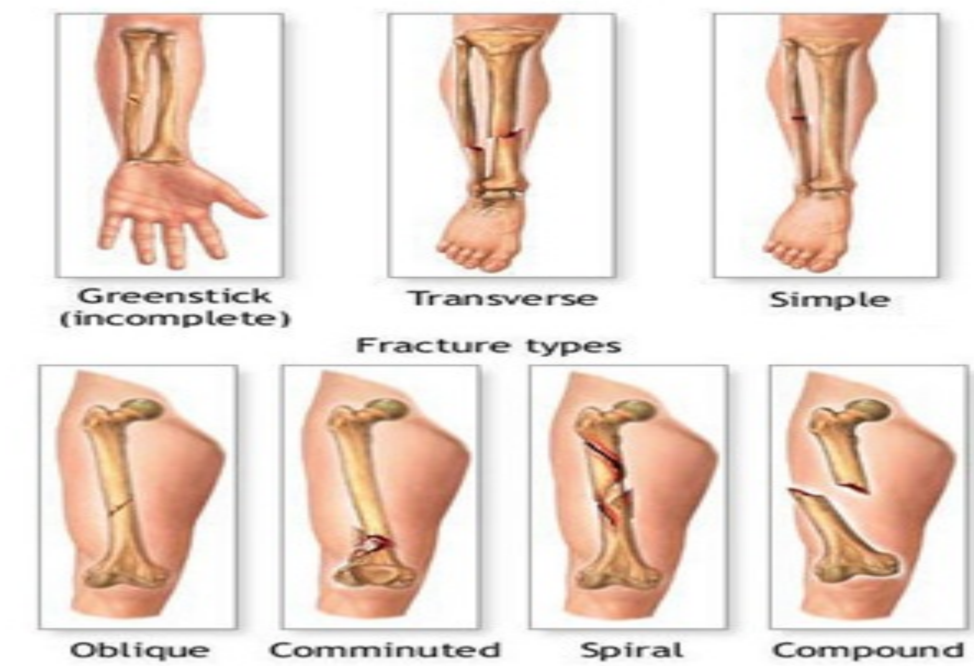



**Bone Markings**

- Superficial surfaces of bones reflect stresses on them
- There are three broad categories of bone markings:
    - Projections for muscle attachment
    - Surfaces that form joints
    - Depressions and openings

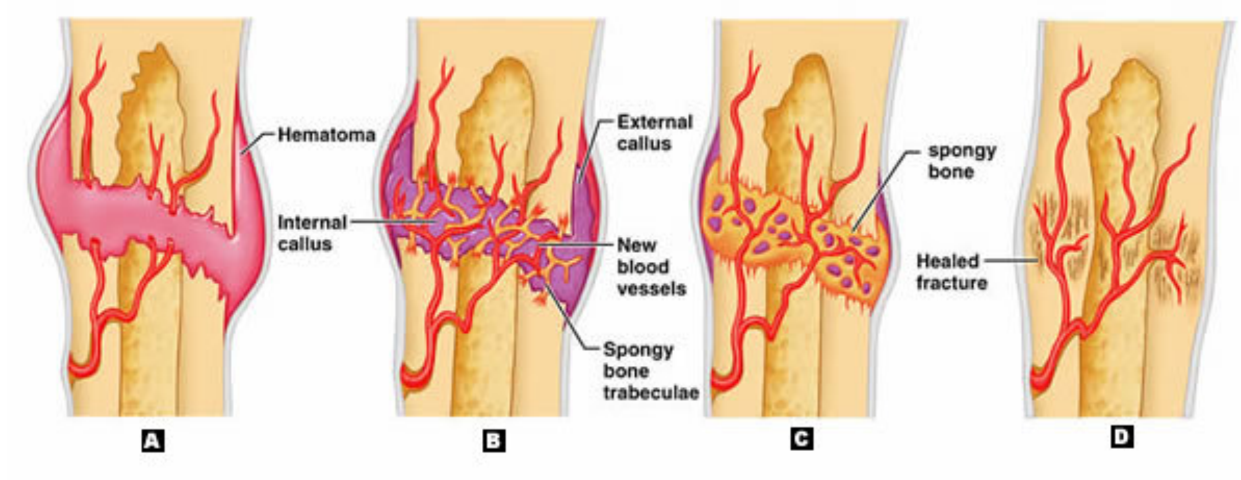
**Bone Fractures (Breaks)**

- Bone fractures are classified by:
    - The position of the bone ends after fracture
    - The completeness of the break
    - The orientation of the bone to the long axis
    - Whether or not the bones ends penetrate the skin
- Types of Bone Fractures
    - Compound (open) – bone ends penetrate the skin
    - Simple (closed) – bone ends do not penetrate the skin
    - Greenstick – incomplete fracture where one side of the bone breaks and the other side bends; common in children
    - Comminuted – bone fragments into three or more pieces; common in the elderly
    - Compression – bone is crushed; common in porous bones




**Stages in the Healing of a Bone Fracture**

- Hematoma formation — A
  - Torn blood vessels hemorrhage
  - A mass of clotted blood (hematoma) forms at the fracture site
  - Site becomes swollen, painful, and inflamed
- Fibrocartilaginous callus forms — B
- Bony callus formation — C
  - Bone callus begins 3-4 weeks after injury, and continues until firm union is formed 2-3 months later
- Bone remodeling — D
  - Excess material on the bone shaft exterior and in the medullary canal is removed
  - Compact bone is laid down to reconstruct shaft walls




**The Skeleton Throughout Life**

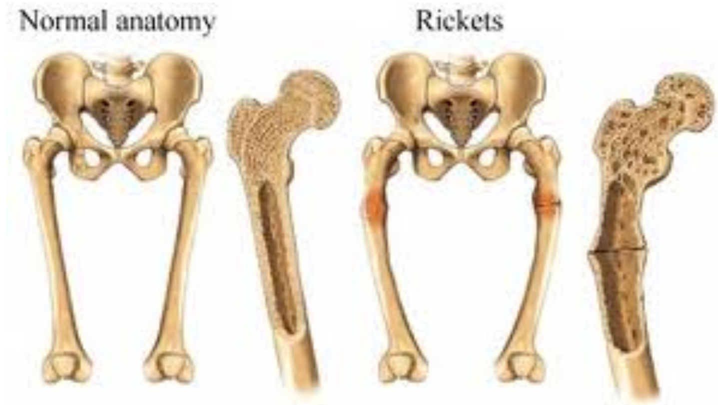
- Cartilage grows quickly in youth
- Skeleton shows fewer chondrocytes in the elderly
- Bones are a timetable
  - Mesoderm - Gives rise to embryonic mesenchyme cells
  - Mesenchyme - Produces membranes and cartilage
  - Membranes and cartilage ossify

**The Skeleton Throughout Life**

- Skeleton grows until the age of 18–21 years
- In children and adolescents, bone formation exceeds rate of bone reabsorption
- In young adults, bone formation and bone reabsorption are in balance
- In old age, reabsorption predominates
- Bone mass declines with age

**Homeostatic Imbalances**

- Osteomalacia
  - Bones are inadequately mineralized causing softened, weakened bones
  - Main symptom is pain when weight is put on the affected bone
  - Caused by insufficient calcium in the diet, or by vitamin D deficiency
- Rickets
  - Bones of children are inadequately mineralized causing softened, weakened bones
  - Bowed legs and deformities of the pelvis, skull, and rib cage are common
  - Caused by insufficient calcium in the diet, or by vitamin D deficiency





- Osteopenia
  - Normal bone demineralization seen after 35-40 years old
- Osteoporosis
  - Spongy bone of the spine is most vulnerable
  - Occurs most often in postmenopausal women
  - Bones become so fragile that sneezing or stepping off a curb can cause fractures
  - Osteoporosis Treatment
    - Calcium and vitamin D supplements
      - 1200 mg. of calcium per day
      - Increased weight-bearing exercise
      - Hormone (estrogen) replacement therapy (HRT) slows bone loss
      - Natural progesterone cream prompts new bone growth