Bio& 241
Unit 2 Lecture 2

Bone Tissue: Supportive Connective Tissue

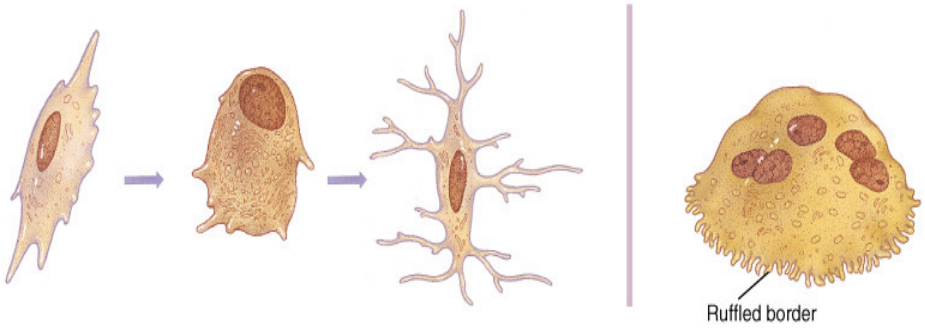
CONSISTS OF FOUR TYPES OF CONNECTIVE TISSUE (CT):

1. Cartilage 2. Bone 3. Bone Marrow 4. Periosteum

[*Osseous (bone) tissue makes up MOST of the skeleton.*]

Remember "CT" is composed of:
Cells
Extracellular Matrix

Cells of Bone Tissue



Osteogenic cell (develops into an osteoblast)

Osteoblast (forms bone tissue)

Osteocyte (maintains bone tissue)

Osteoclast (functions in resorption, the destruction of bone matrix)

Bone Tissue: Supportive Connective Tissue

Extracellular Matrix

25% Water

25% Protein or organic matrix

- 95% Collagen Fibers
- 5% Chondroitin Sulfate

50% Crystalized Mineral Salts

- Hydroxyapatite (Calcium Phosphate crystals)
- Other substances: Lead, Gold, Strontium, Plutonium, can be incorporated in etc.

RATIO OF ORGANIC TO NON ORGANIC MATRIX:

Youth = 1:1, 50%:50%

Adult = 1:2, 33%:66%

Elderly = 1:3, 25%:75%

(bones become more brittle as we age).

Two Kinds of Bone

Compact Bone:

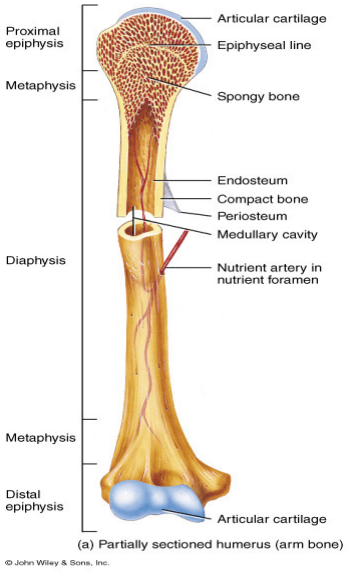
1. *Consists of osteons with very little space between them.*
2. *Composes bone tissue of the diaphysis.*

FX = Protect and support

Spongy Bone:

1. *Does NOT contain osteons.*
2. *Consist of trabeculae*
3. *Found in short, flat and irregular bones and in the epiphyses of long bones.*

FX = store RED marrow.

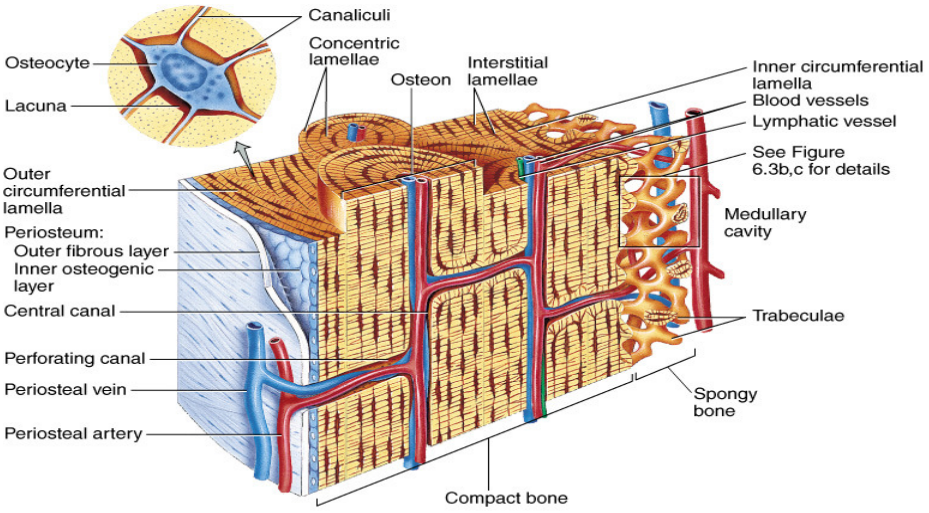


(a) Partially sectioned humerus (arm bone)

Compact Bone

- ***Compact bone* is arranged in units called *osteons* or *Haversian systems*.**
- **Osteons (Haversian canal) contain blood vessels, lymphatic vessels, nerves**
- **Surrounding this canal are concentric rings of osteocytes along with the calcified matrix.**
- **Osteons are aligned in the same direction along lines of stress. These lines can slowly change as the stresses on the bone changes.**

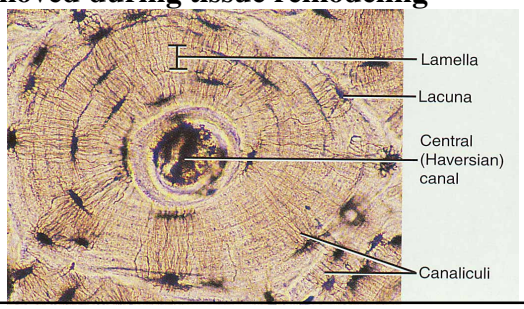
Histology of Bone Tissue



(a) Osteons (Haversian systems) in compact bone and trabeculae in spongy bone

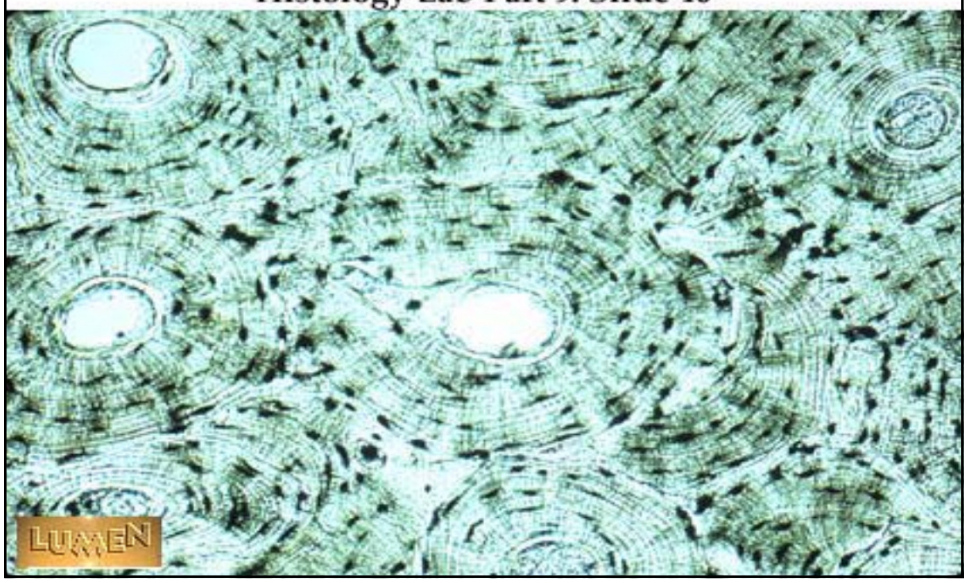
Histology of Compact Bone

- **Osteon is concentric rings (lamellae) of calcified matrix surrounding a vertically oriented blood vessel**
- **Osteocytes are found in spaces called lacunae**
- **Osteocytes communicate through canaliculi filled with extracellular fluid that connect one cell to the next cell**
- **Interstitial lamellae represent older osteons that have been partially removed during tissue remodeling**

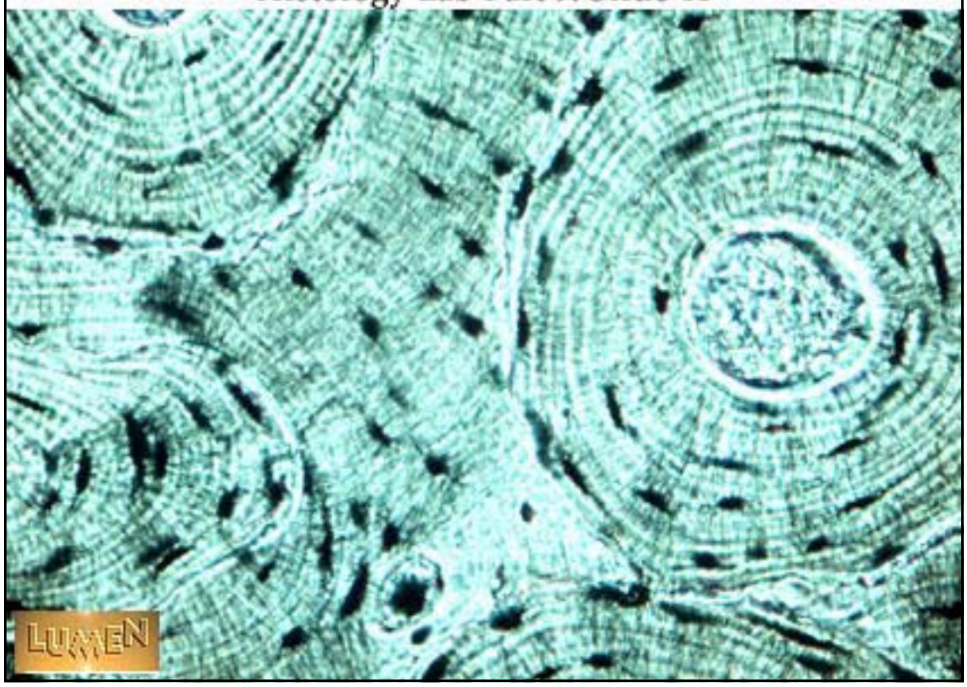


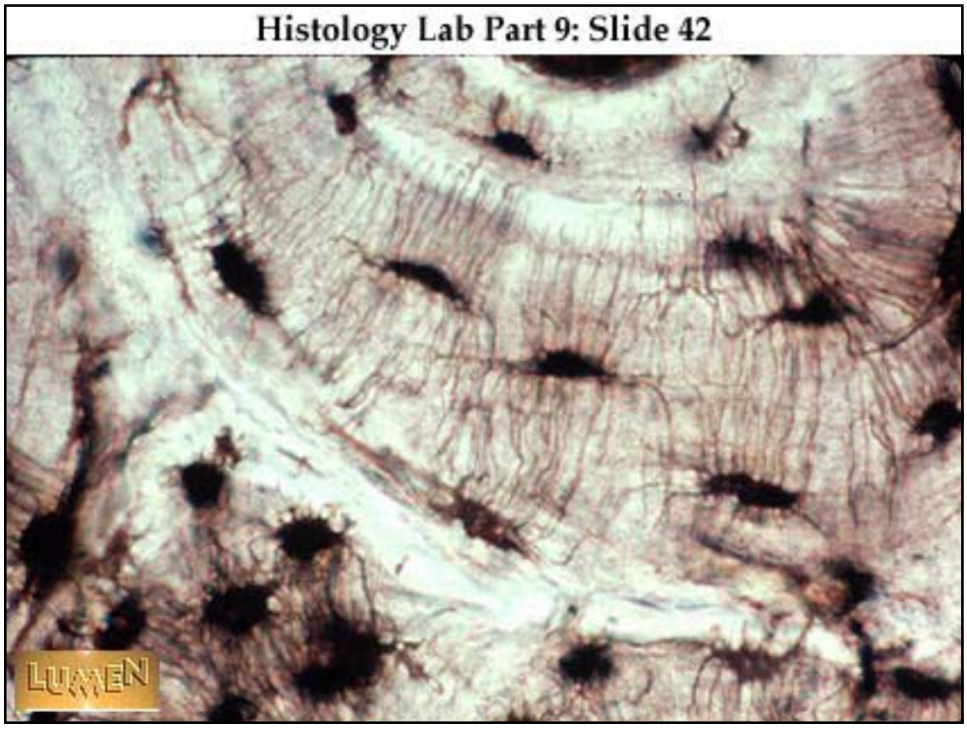
Compact Bone

Histology Lab Part 9: Slide 40



Histology Lab Part 9: Slide 41

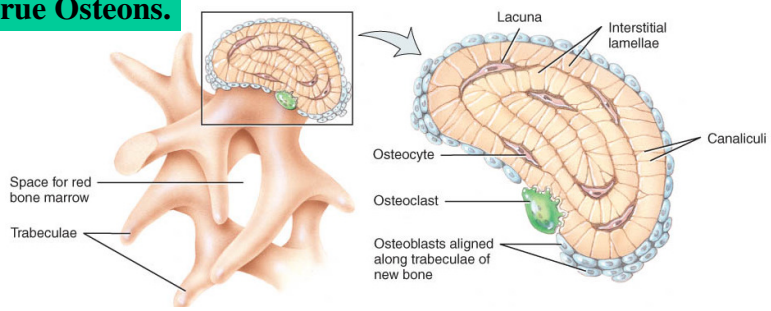




The Trabeculae of Spongy Bone

- **Latticework of thin plates of bone called trabeculae oriented along lines of stress**
- **Spaces in between these struts are filled with red marrow where blood cells develop**
- **Found in ends of long bones and inside flat bones such as the hipbones, sternum, sides of skull, and ribs.**

No true Osteons.



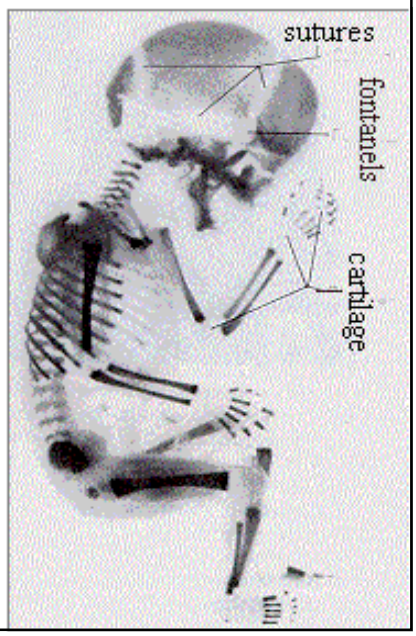
BONE FORMATION

- **All embryonic connective tissue begins as mesenchyme.**
- **Bone formation is termed *osteogenesis* or *ossification* and begins when mesenchymal cells provide the template for subsequent ossification.**
- **Two types of ossification occur.**
  - ***Intramembranous ossification* is the formation of bone directly from or within fibrous connective tissue membranes.**
  - ***Endochondrial ossification* is the formation of bone from hyaline cartilage models.**

Two Kinds of Ossification

1. Intramembranous Ossification

2. Endochondral Ossification

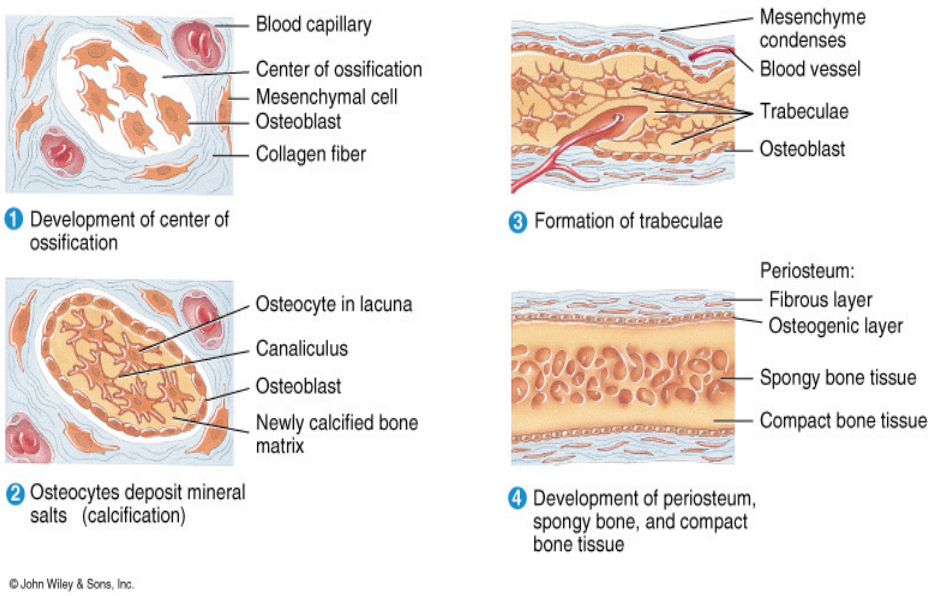


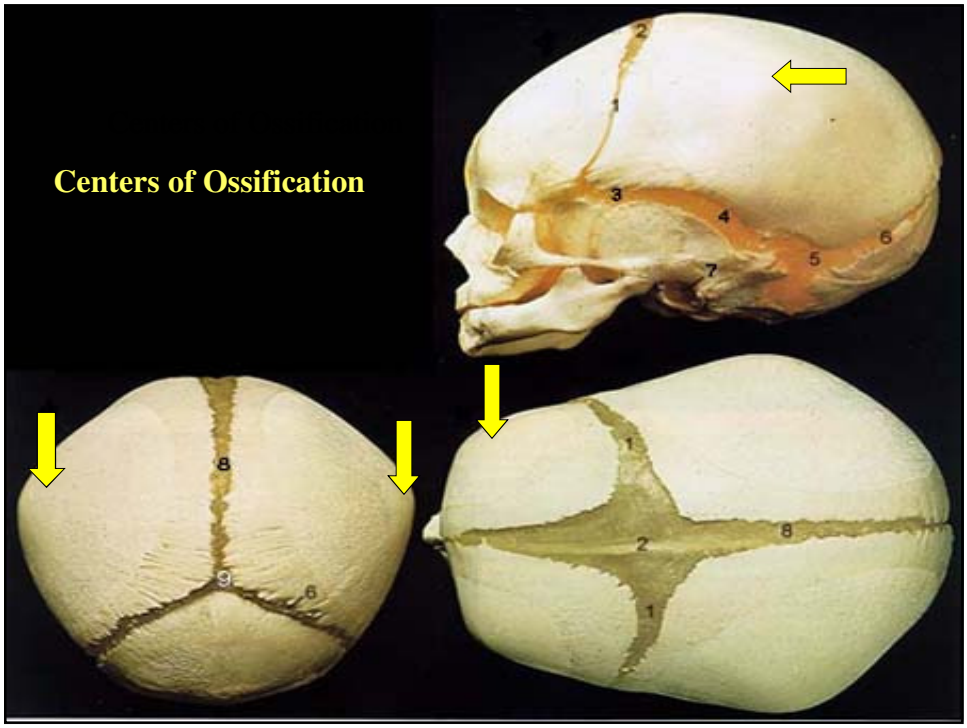
Intramembranous Ossification

Also called dermal ossification because it normally occurs in the deeper layers of connective tissue of the dermis of the skin.

- *All roofing bones of the Skull*
  - *Frontal bone*
  - *Parietal bones*
  - *Occipital bone*
  - *Temporal bones*
- *Mandible*
- *Clavicle*

Intramembranous Ossification





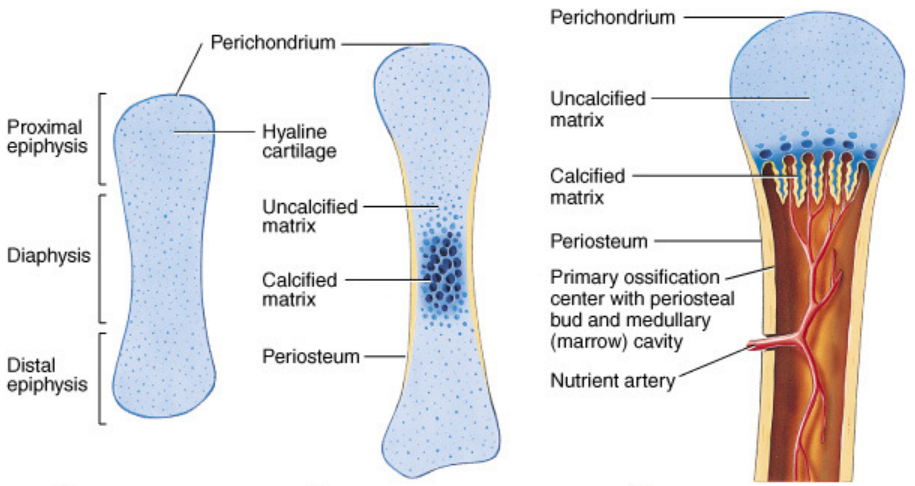
Endochondral Ossification

Developing bones are deposited as a hyaline cartilage model and then this cartilage is replaced by bone tissue.

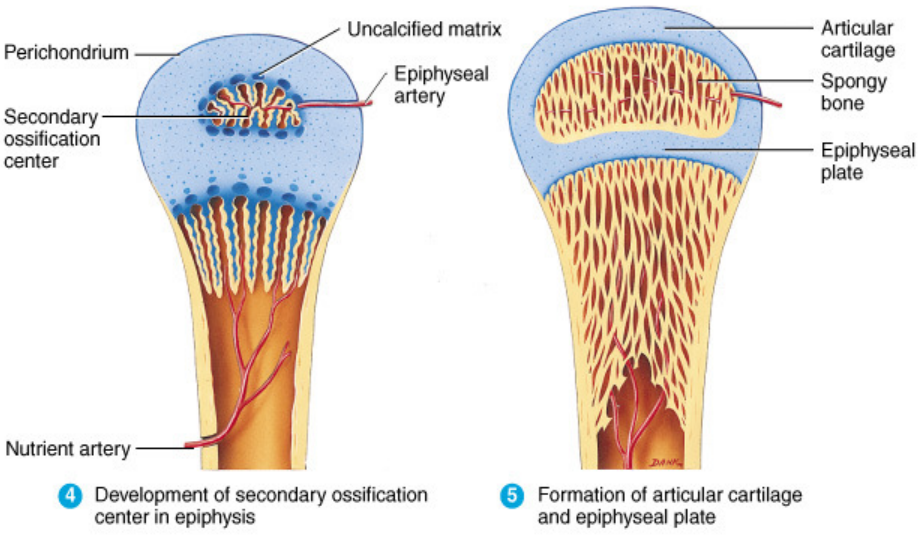
All bones of the body except:

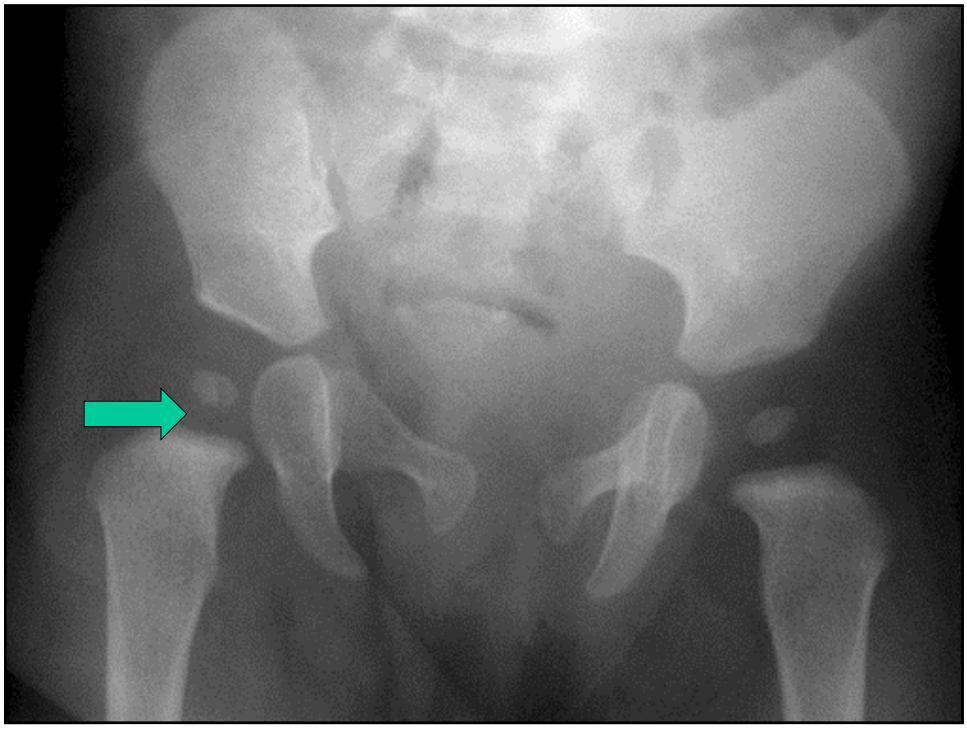
- *All roofing bones of the Skull*
- *Mandible*
- *Clavicle*

Endochondral Ossification



Endochondral Ossification

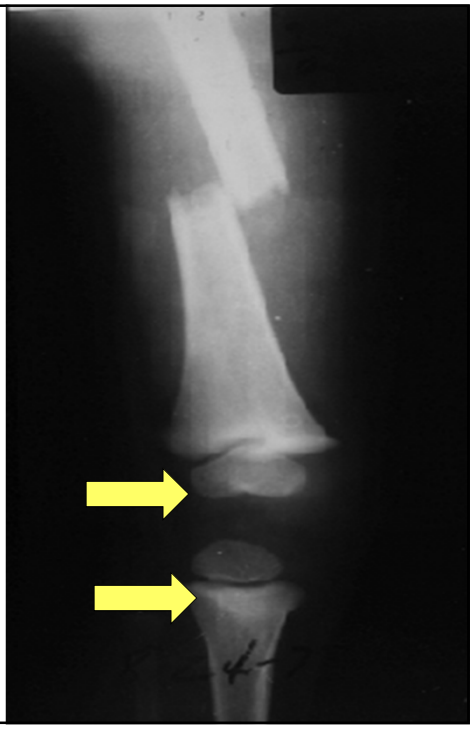




Growth at epiphyseal plates

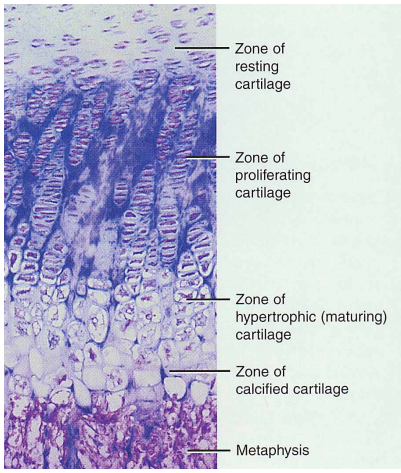
Zones of epiphyseal plates

Zone of Resting Cartilage
Zone of Proliferating Cartilage
Zone of Hypertrophic Cartilage
Zone of Calcified Cartilage



Zones of Growth in Epiphyseal Plate

- Zone of resting cartilage
  - anchors growth plate to bone
- Zone of proliferating cartilage
  - rapid cell division (stacked coins)
- Zone of hypertrophic cartilage
  - cells enlarged & remain in columns
- Zone of calcified cartilage
  - thin zone, cells mostly dead since matrix calcified
  - osteoclasts removing matrix
  - osteoblasts & capillaries move in to create bone over calcified cartilage



Growth at epiphyseal plates

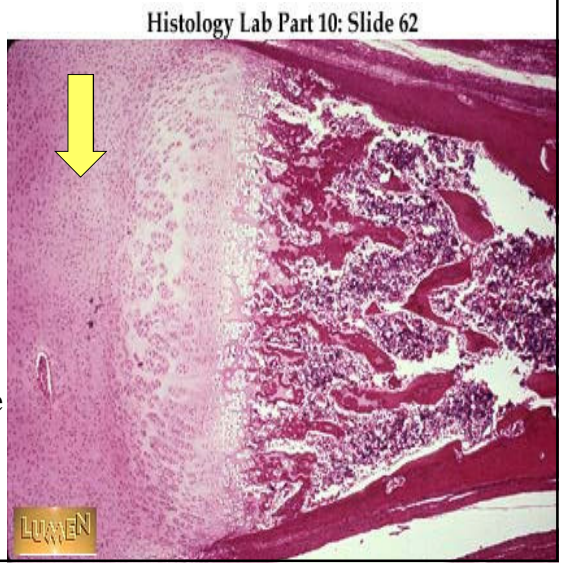
Zones of epiphyseal plates

Zone of Resting Cartilage

Zone of Proliferating Cartilage

Zone of Hypertrophic Cartilage

Zone of Calcified Cartilage



Growth at epiphyseal plates

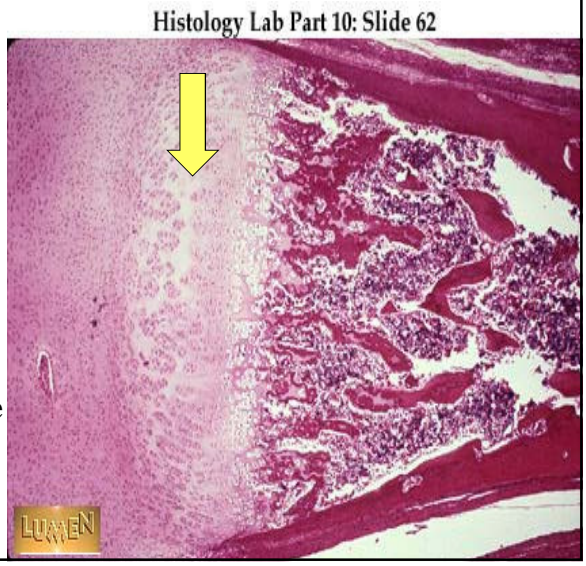
Zones of epiphyseal plates

Zone of Resting Cartilage

Zone of Proliferating Cartilage

Zone of Hypertrophic Cartilage

Zone of Calcified Cartilage



Growth at epiphyseal plates

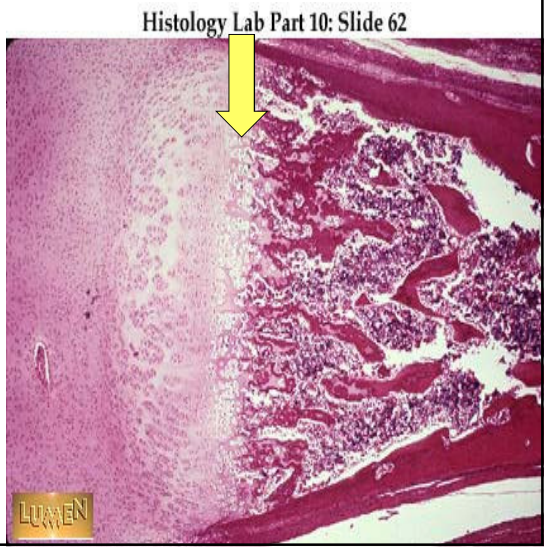
Zones of epiphyseal plates

Zone of Resting Cartilage

Zone of Proliferating Cartilage

Zone of Hypertrophic Cartilage

Zone of Calcified Cartilage



Growth at epiphyseal plates

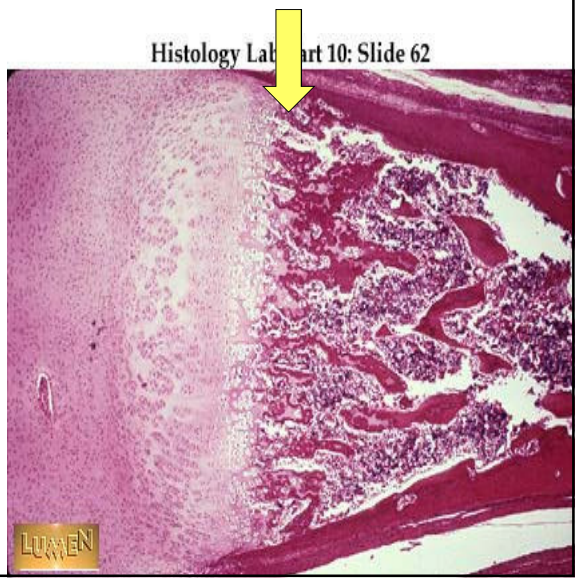
Zones of epiphyseal plates

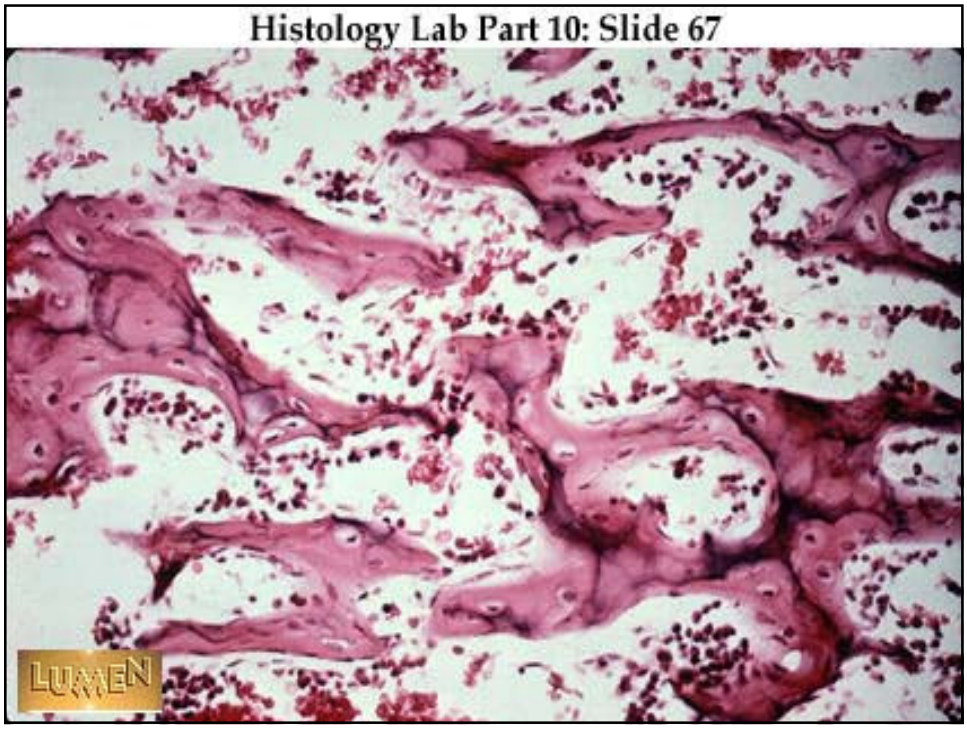
Zone of Resting Cartilage

Zone of Proliferating Cartilage

Zone of Hypertrophic Cartilage

Zone of Calcified Cartilage

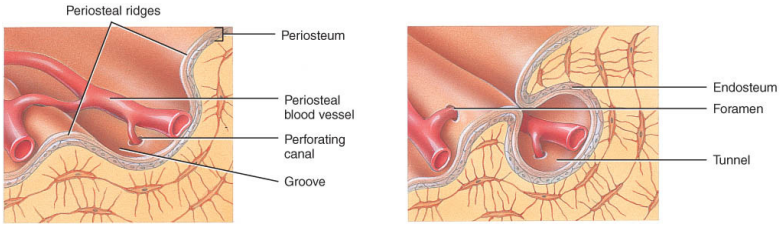




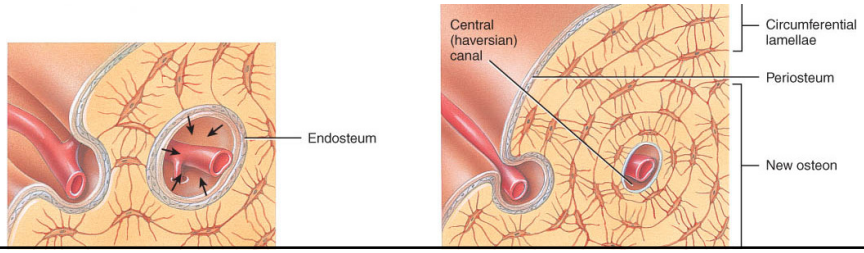
Growth in Thickness

- **Bone can grow in thickness or diameter only by *appositional growth*.**
- **The steps in these process are:**
  - **Periosteal cells differentiate into osteoblasts which secrete collagen fibers and organic molecules to form the matrix.**
  - **Ridges fuse and the periosteum becomes the endosteum.**
  - **New concentric lamellae are formed.**
  - **Osetoblasts under the peritsteum form new circumferential lamellae.**

Bone Growth in Width



- **Only by appositional growth at the bone's surface**
- **Periosteal cells differentiate into osteoblasts and form bony ridges and then a tunnel around periosteal blood vessel.**
- **Concentric lamellae fill in the tunnel to form an osteon.**



Factors That Affect Bone Growth

1. **Minerals**
2. **Vitamins**
3. **Hormones**
4. **Exercise**

Factors That Affect Bone Growth

Minerals

Calcium — **Makes bone matrix hard**

Hypocalcemia: low blood calcium levels.

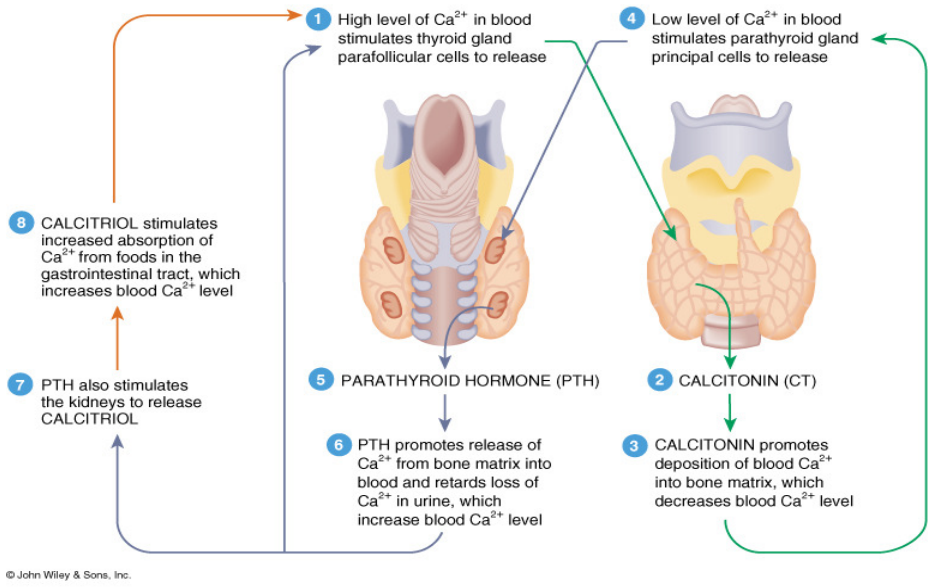
Hypercalcemia: high blood calcium levels.

Dietary Source	Serving size	Amount in (mg)
Yogurt (fat free/low fat)	8oz	487/447
Sardines	3.75oz	351
Ricotta cheese	½ cup	337
Skim milk	8oz	302
Orange juice (fortified)	8oz	300
Low fat Milk (1%)	8oz	300
Dried figs	10	270

Age	Amount of Calcium
Infants	
Birth - 6 months	210 mg
6 months - 1 year	270 mg
Children/Young Adults	
1 - 3 years	500 mg
4 - 8 years	800 mg
9 - 18 years	1,300 mg
Adult Women & Men	
19 - 50 years	1,000 mg
50 +	1,200 mg
Pregnant or Lactating	
18 years or younger	1,300 mg
19 - 50 years	1,000 mg

Source: National Academy of Sciences 1997.

Calcium Homeostasis



Nutrient	Effect on Bone Development	Dietary Source
Boron	Enhances calcium absorption and estrogen metabolism	avocado, nuts, peanuts, and prune juice
Fluoride	Stimulates bone and tooth development	fluoridated water, marine fish, teas, dental products
Magnesium	Enhances bone quality and improves bone density	green leafy vegetables, potatoes, nuts, seeds, whole grains, bananas
Phosphorus	Combines with calcium to form Hydroxyapatite	milk, yogurt, ice cream, peas, eggs, meat, breads
Manganese	Acts a coenzyme to form optimal bone matrix	Nuts, legumes, tea, whole grains

Factors That Affect Bone Growth

Vitamins

Vitamin A	**Controls activity, distribution, and coordination of osteoblasts/osteoclasts**
Vitamin B12	**May inhibit osteoblast activity**
Vitamin C	**Helps maintain bone matrix, deficiency leads to decreased collagen production which inhibits bone growth and repair**
	(scury) disorder due to a lack of Vitamin C
Vitamin D	**(Calcitriol) Helps build bone by increasing calcium absorption.**
	Deficiencies result in "Rickets" in children

Factors That Affect Bone Growth

Hormones

Human Growth Hormone	**Promotes general growth of all body tissue and normal growth in children**
Insulin-like Growth Factor	**Stimulates uptake of amino acids and protein synthesis**
Insulin	**Promotes normal bone growth and maturity**
Thyroid Hormones	**Promotes normal bone growth and maturity**
Estrogen and Testosterone	**Increases osteogenesis at puberty and is responsible for gender differences of skeletons**

Bone Fractures

Closed fracture: one that does not produce an open wound in the skin

Open fracture: one in which a wound through the adjacent or overlying soft tissues communicates with the site of the break.

Compound fracture: A fracture in which the bone is sticking through the skin. Also has been called an open fracture.

Simple fracture : an uncomplicated fracture in which the broken bones to not pierce the skin. Also has been called a closed fracture.

Comminuted fracture: The bone is splintered or crushed, Can be viewed as a "closed compound fracture"

Bone Fractures

Colles' fracture: fracture of the lower end of the radius, the lower fragment being displaced backward

Greenstick fracture: one side of a bone is broken, the other being bent. Most common in children.

Impacted fracture one bone fragment is firmly driven into the other. Common with vertebra.

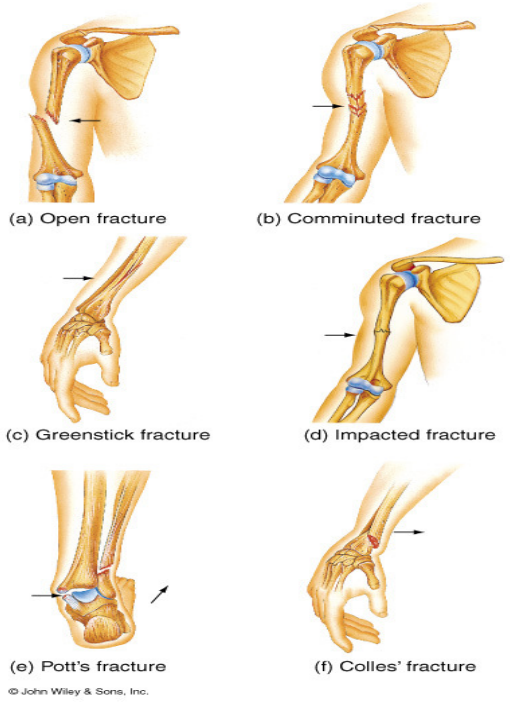
Pathologic fracture: due to weakening of the bone structure by pathologic processes, such as neoplasia, osteomalacia, or osteomyelitis

Pott's fracture: fracture of the lower part of the fibula, with serious injury of the lower tibial articulation, usually a chipping off of a portion of the medial malleolus, or rupture of the medial ligament

Bone Fractures

Terms:
Partial/Complete
Displaced/Non-displaced

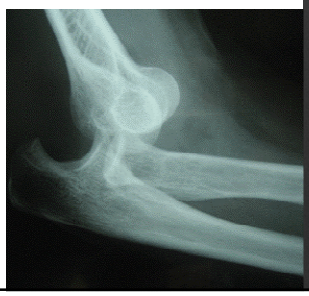
Other Fractures:
Spiral
Transverse
Longitudinal
Pathologic



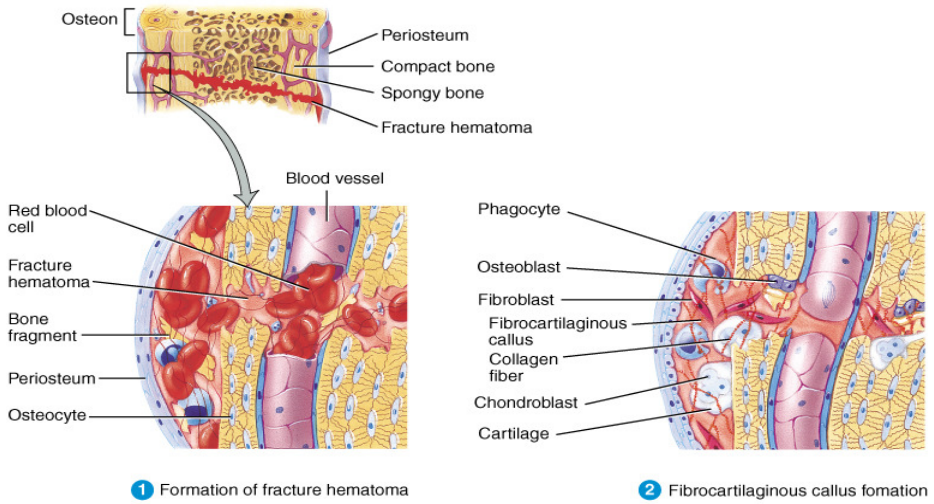
Dislocations

Subluxation : an incomplete or partial dislocation of a joint or organ.

Luxation: a complete dislocation of A joint or organ.



Bone Fracture Repair



From Priscilla LeMone and Karen M. Burke, *Medical-Surgical Nursing*, p. 1560 (Menlo Park, CA: Benjamin/Cummings, 1996). ©1996 The Benjamin/Cummings Publishing Company.

Steps in Fracture Repair

1. **Formation of a fracture hematoma**

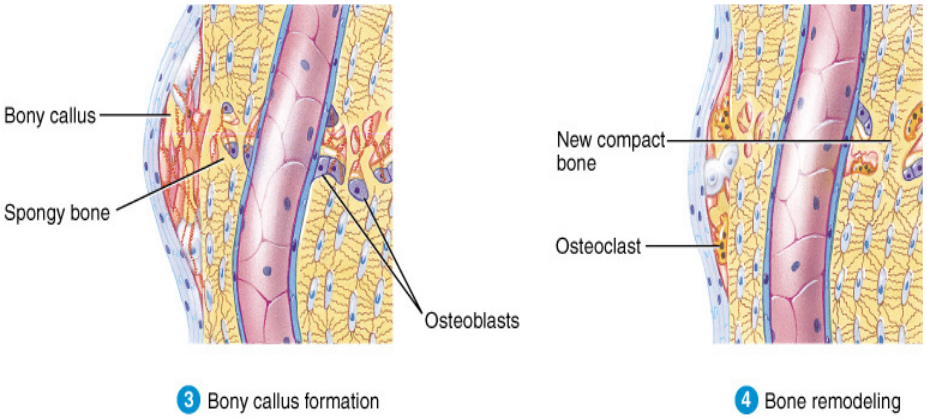
Immediately after the fracture, there is a sharp fracture line with associated soft tissue swelling. At the fracture Site, there is abundant hematoma with beginning fibroblastic penetration.

Steps in Fracture Repair

2. **Fibrocartilaginous Callus Formation**

At 2 weeks there is much visible callus. There is also bone resorption and osteoporosis, both difficult to see in this case because of the overlying callus. There has been migration of chondroblasts into the area and cartilage is beginning to cover the ends of the fracture. New osteous tissue is produced enchondrally.

Bone Fracture Repair

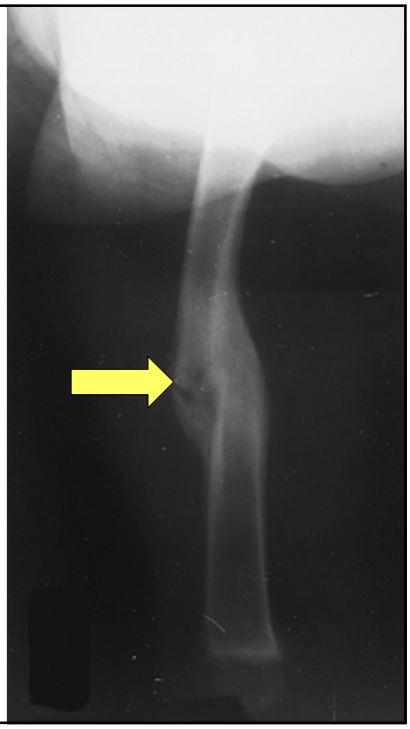


From Priscilla LeMone and Karen M. Burke, *Medical-Surgical Nursing*, p. 1560 (Menlo Park, CA: Benjamin/Cummings, 1996). ©1996 The Benjamin/Cummings Publishing Company.

Steps in Fracture Repair

3. Bony Callus Formation

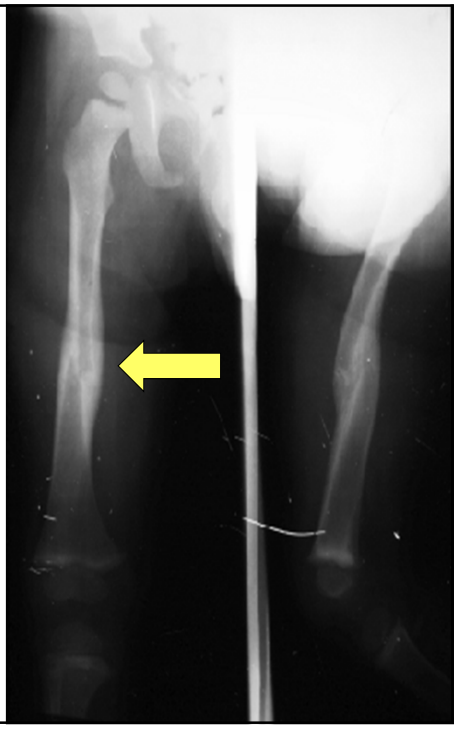
At 2 months, bony callus with sharp margins bridges the fracture and the fracture line itself begins to disappear.



Steps in Fracture Repair

4. Bone Remodeling

At 5-6 months, the marrow cavity is continuous and the compact bone of the diaphysis has been reformed.



Congenital Skeletal Birth Defects

Congenital Talipes Equinovarus (CTEV),[1]

1. occurs in about one in every 1,000 live births.
2. Approximately 50% of cases of clubfoot are bilateral
3. Occurs in males more often than in females by a ratio of 2:1.

BEFORE AFTER

CLUB FOOT DEFORMITY CORRECTION

compression of the median nerve as it passes through the carpal tunnel in the wrist. Signs and symptoms include pain in the hand and wrist associated with tingling and numbness,
distributed along the median nerve (palm side of thumb, index and middle fingers an possibly ½ of the ring finger

Bone Disorders

Osteopenia: *Refers to bone mineral density (BMD) that is lower than normal peak BMD but not low enough to be classified as osteoporosis*

Osteoporosis: *Loss of both bone salts and collagen fibers. Increased osteoclast activity and decreased osteoblast activity*

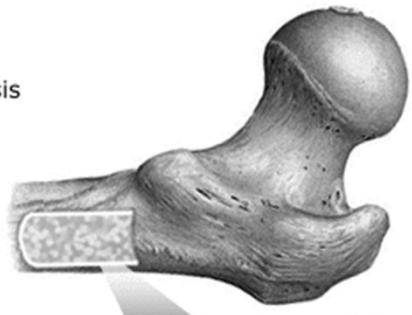
Risk Factors:

European/Asian ancestry	*Family history*	*Small body build*
Inactive lifestyle	*Cigarette smoking*	*early menopause*
excessive use of alcohol	*a diet low in calcium*	*advanced age*

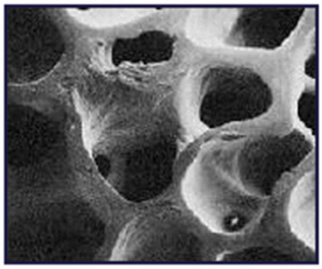
(African American and Hispanic women are at lower but significant risk)

prolonged use of certain medications, such as those used to treat lupus, asthma, thyroid deficiencies, and seizures.

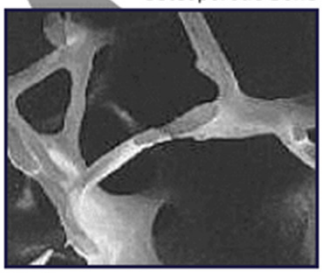
Section of bone showing osteoporosis



Normal Bone



Osteoporotic Bone



Reproduced from *J Bone Miner Res* 1986;1:16-21 with permission of the American Society for Bone and Mineral Research

Bone Disorders

Osteomalacia: *Loss of bone salts but not collagen (demineralization) due to poor diet, decreased absorption of calcium, and vitamin D deficiency. Basically a demineralization of bone*

Example: *Rickets in young children*

Bone Disorders

Paget's Disease: *Abnormal bone remodeling resulting in irregular thickening and thinning of bone through remodeling*

Osteomyelitis: Infection of bone most commonly by *Staphylococcus aureus*

Osteogenic sarcoma: *Bone cancer that affects osteoblasts at the metaphyses of long bones. Most common in teenagers*

Bone Disorders

Arthritis:

Osteoarthritis: *"DJD" degenerative joint disease*

Inflammatory Joint Disease:

- Rheumatoid arthritis: *Initially may be caused by transient infection that results in autoimmune attacks against collagen in the bones at joints.*
- Gouty Arthritis: *Build-up of uric acid in the joints due to metabolic problems with handling the amino acid cystine.*

Rheumatoid Arthritis

- Rheumatoid arthritis is a chronic inflammatory disorder that most typically affects the small joints in your hands and feet. Unlike the wear-and-tear damage of osteoarthritis, rheumatoid arthritis affects the lining of your joints, causing a painful swelling that can eventually result in bone erosion and joint deformity.
- Risk factors
- **Sex.** Women are more likely to develop rheumatoid arthritis than men are.
- **Age.** Rheumatoid arthritis can occur at any age, but it most commonly begins between the ages of 40 and 60.
- **Family history.** If a member of your family has rheumatoid arthritis, you may have an increased risk of the disease..
- **Smoking.** Smoking cigarettes increases your risk of rheumatoid arthritis. Quitting can reduce your risk.

Bone Disorders

Infectious arthritis: Lyme's disease

Lyme disease is the most common tick-borne disease in the Northern Hemisphere. It is caused by at least three species of bacteria belonging to the genus *Borrelia, Borrelia burgdorferi* is the predominant cause of Lyme disease in the United States, whereas *Borrelia afzelii* and *Borrelia garinii* are implicated in most European cases.

Borrelia is transmitted to humans by the bite of infected hard ticks belonging to several species of the genus *Ixodes*. Early manifestations of infection may include fever, headache, fatigue, depression, and a characteristic skin rash called erythema migrans. Left untreated, late manifestations involving the joints, heart, and nervous system can occur. In a majority of cases, symptoms can be eliminated with antibiotics, especially if diagnosis and treatment occur early in the course of illness. Late, delayed, or inadequate treatment can lead to late manifestations of Lyme disease which can be disabling and difficult to treat.

The disease only became apparent in 1975 when mothers of a group of children who lived near each other in Lyme, Connecticut, made researchers aware that their children all were diagnosed with **rheumatoid arthritis**.

Total Knee Replacement.

Hip Replacement