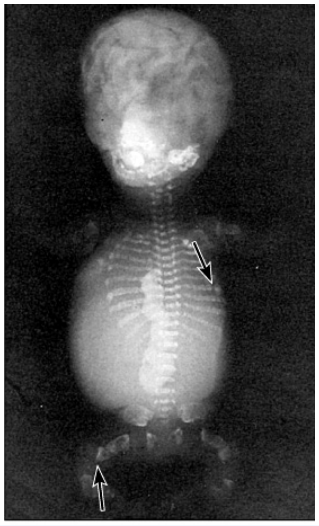
1

BIO 211:

ANATOMY & PHYSIOLOGY I



CHAPTER 07

SKELETAL SYSTEM

Dr. Lawrence G. Altman
www.lawrencegaltman.com
Some illustrations are courtesy of McGraw-Hill.

Naugatuck Valley Community College

2

Bone Function

Support and Protection

gives shape to head, etc.
supports body's weight
protects lungs, brain etc.

Body Movement

interacts with muscles
bones act as rigid bar
of a lever

Inorganic Salt Storage

calcium
phosphate
magnesium
sodium
potassium

Blood Cell Formation

hematopoiesis
red marrow

3

Bones of the Skeletal System

1. **There are 206 bones in the adult;**
   270 in a newborn.
   Many fuse during growth and development.

2. **The skeleton is divided into**
   axial and appendicular portions.

   Axial skeleton:

   the skull, middle-ear bones, the hyoid bone, rib cage, vertebral column, and sternum.

   Appendicular skeleton:

   the upper and lower extremities, and the pectoral and pelvic girdles.

4

Shapes of Bones

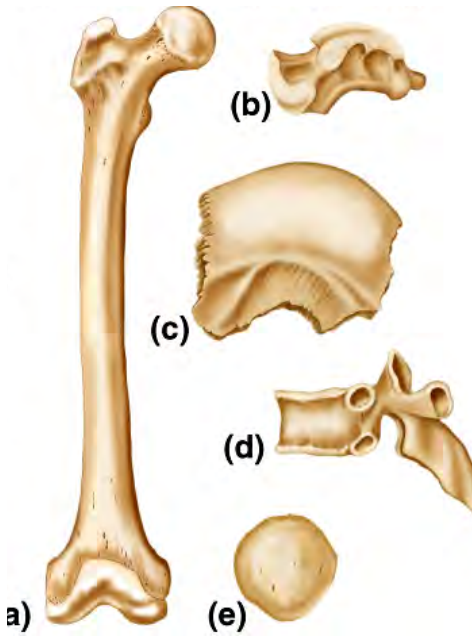
Long bones Example: Femur (a)
include those in the appendages that produce body movement.

Short bones Example: Tarsal (b)
are equal in length and width, such as those of the wrist and ankle.

Flat bones Example: Parietal (c)
such as in the skull, protect soft tissues.

Irregular Example: Vertebra (d)
include the vertebrae and others.

Sesamoid Example: Patella (e)
Round bone with tendons adjacent to joints



5

General Features of Bones

1. The features of a **long bone** include its outer layer of **compact bone,** bone marrow, and **spongy bone** at its ends.

2. The shaft of a long bone is referred to as the **diaphysis**; the expanded ends are the **epiphyses.**

3. The epiphyses are covered with **articular cartilage**, and the outer bone is covered by **periosteum**.
   The inside is lined with **endosteum.**

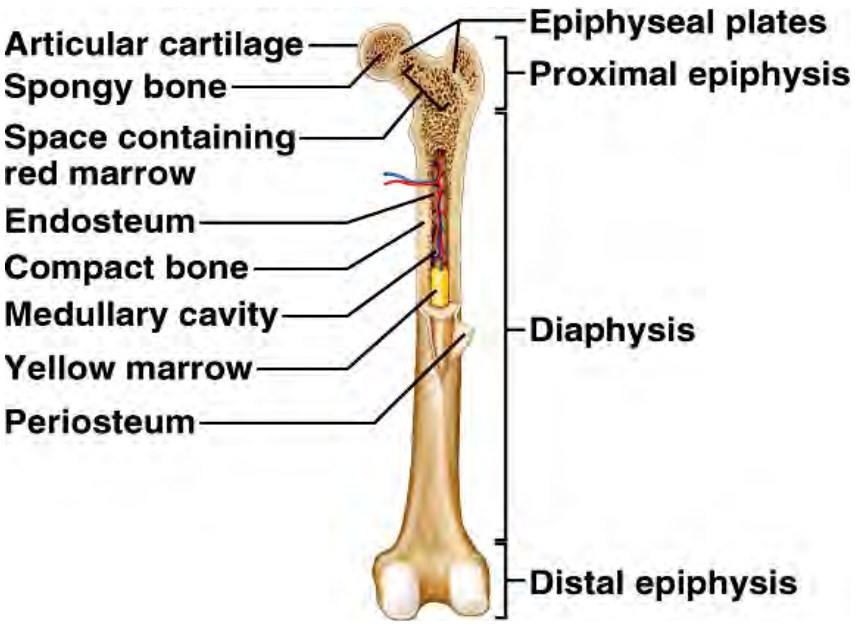
4. During growth, an **epiphyseal plate of hyaline cartilage** forms a model for bone to replace.

6

Parts of a Long Bone

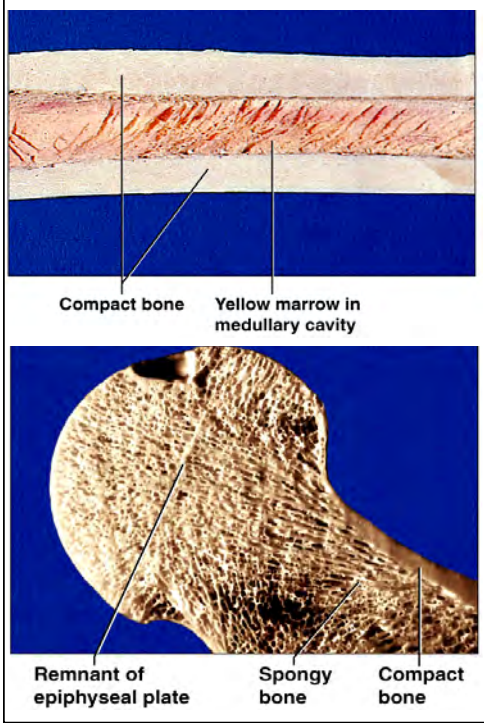
epiphysis
- **distal**
- **proximal**

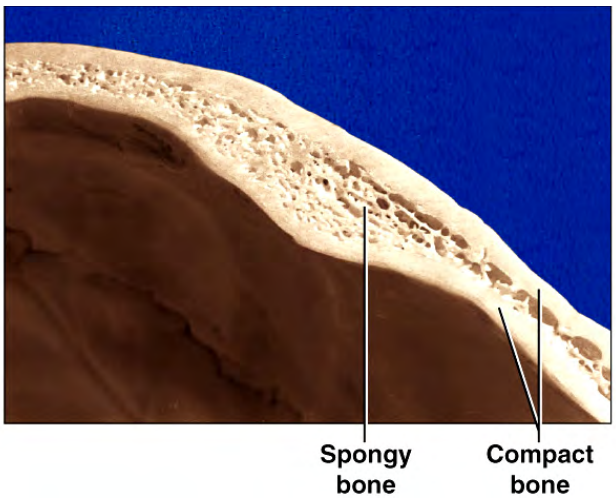
diaphysis
compact bone
spongy bone
articular cartilage
periosteum
endosteum
medullary cavity
trabeculae slender plates of **spongy bone**
marrow-
in the spongy bone:
red
yellow



Compact and Spongy Bone

7





Histology of Osseous Tissue Cells

8

OSTEO = bone

Osteogenic cells develop from mesenchyme and occur in the endosteum, the inner periosteum, and in the Haversian canals. They are the only source of new cells of osteoblasts and osteocytes.

Osteoblasts
are bone-forming cells, and build new bone matrix.

Osteocytes are osteoblasts trapped in bone matrix.
They remain active in maintenance of bone.

Osteoclasts
are bone-dissolving cells that form by fusion of monocytes.
They break down bone and release its minerals to the blood.

Histology of Osseous Tissue — Compact Bone

9

Organic matter in bone (one-third of the dry weight)
collagen, GAGs, proteoglycans and glycoproteins.

Mineral components in bone:
especially **hydroxyapatite** and **calcium carbonate**.
Other minerals are present in minute quantities.

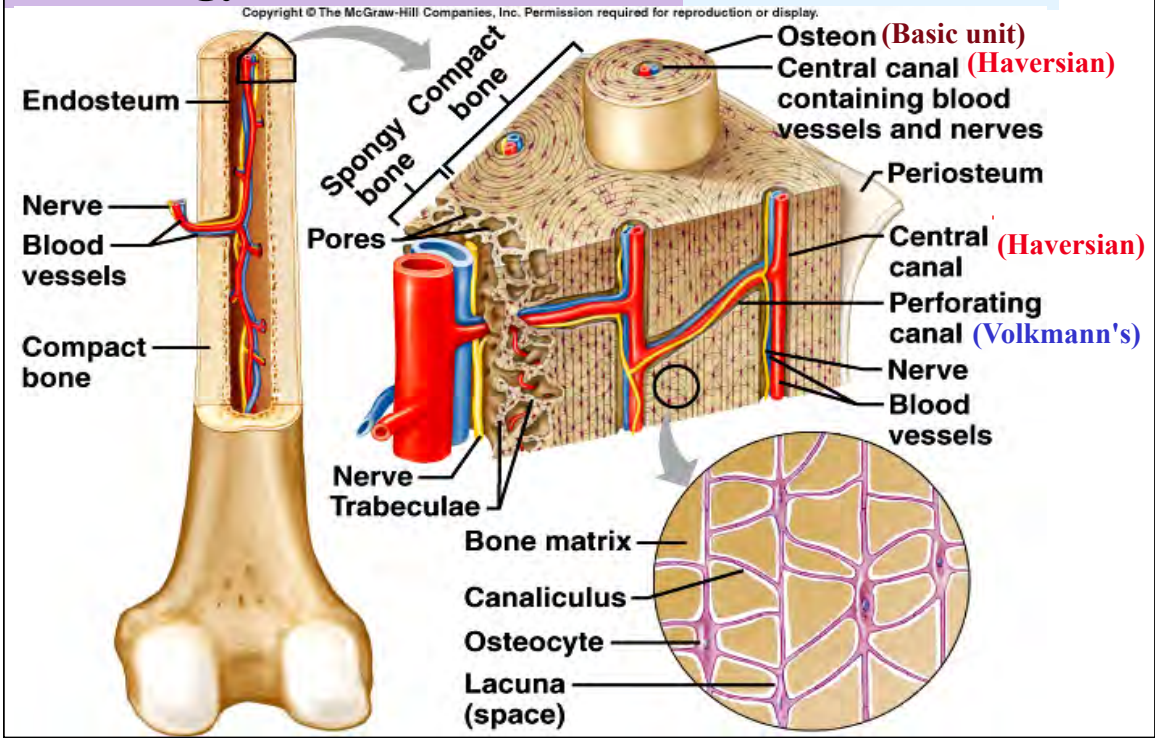
Lamellae are arranged mostly in *concentric circles* around Haversian canals.
This is the basic structural unit of compact bone: osteon.

Within the lamellae lie the lacunae with osteocytes.
Canaliculi extend between adjacent lamellae.

Perforating (Volkmann's) canals enter the bone from the outside and inside, and feed into the Haversian systems, carrying nerves and blood vessels.

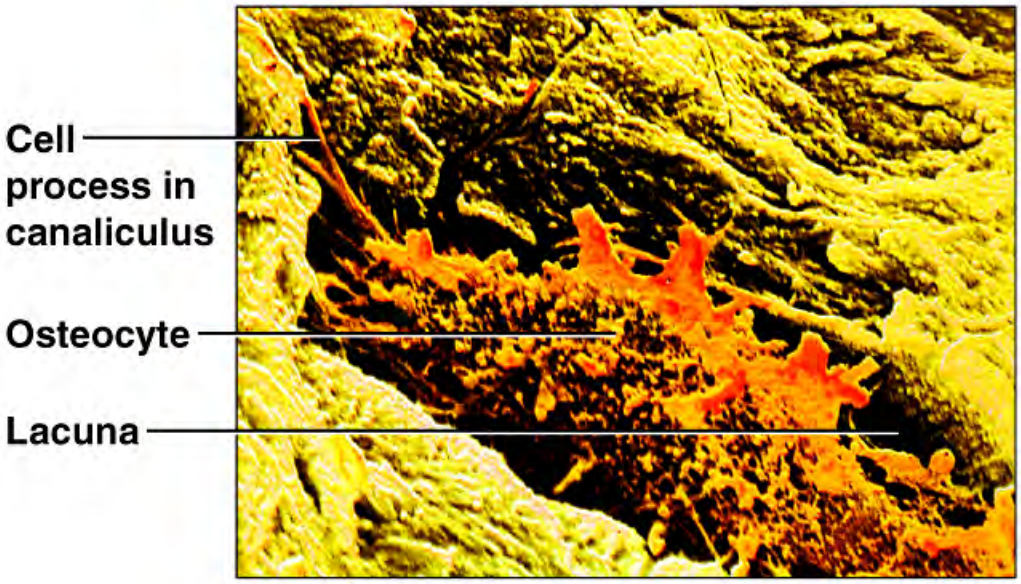
Histology of Osseous Tissue — Compact Bone

10



Histology of Osseous Tissue — Compact Bone

11



Histology of Osseous Tissue — Marrow

12

1. **In children, red marrow (myeloid tissue) is hemopoietic and fills the medullary cavity.**
   Myeloid = pertaining to the marrow.
   Hemopoietic:
   adj : pertaining to the formation of blood or blood cells; "hematopoietic stem cells in bone marrow" [syn: hematopoietic, haematopoietic, haemopoietic, hematotic, haematotic, hematogenetic, haematogenetic]

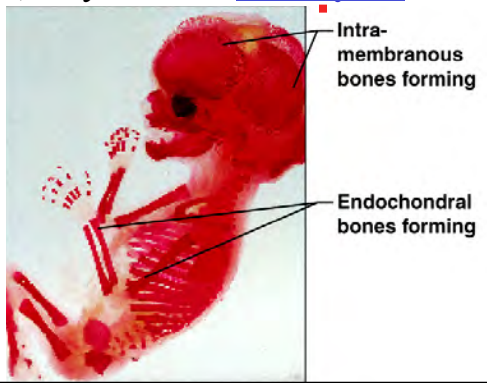
2. **In adults (age 30), most of the marrow in the medullary cavity is yellow marrow that stores fat.**

3. **In older adults (age 70), most of the yellow marrow is replaced by gelatinous marrow.**

13

Bone Formation *Intramembranous*

1. **Intramembranous ossification** occurs **within a membrane of soft tissue** that represents the location of a future flat bone. Its cells differentiate into **osteogenic cells** and **osteoblasts**, and **trabeculae** are formed.
2. **Osteoblasts** form on the **trabeculae** and lay down an **organic matrix** and deposit **calcium phosphate** within it. When trapped, they become **osteocytes.**



14

Bone Formation *Endochondral*

1. **Endochondral ossification** is bone formation using a **cartilage model**. In the center of the model is the ***primary ossification center*** where lacunae enlarge and minerals are deposited around them.

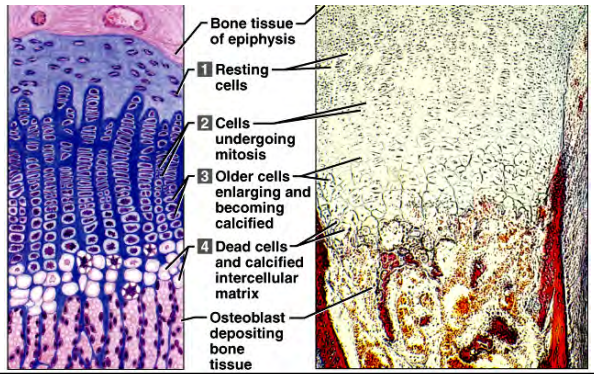
2. **The Primary Ossification Center:**
   a. Cells of the **perichondrium** develop into a **periosteum** where osteogenic cells and osteoblasts and produce bone on the ***outside*** of the model.
   b. In the center of the model, a primary marrow space is formed.

3. **The Metaphysis**
   a. The transition ***between the head of hyaline cartilage and the primary marrow*** space is the **metaphysis.**
   b. It exhibits five zones representing stages of ossification: the zone of reserve cartilage; the zone of cell proliferation; the zone of cell hypertrophy; the zone of calcification; and the zone of bone deposition.

15

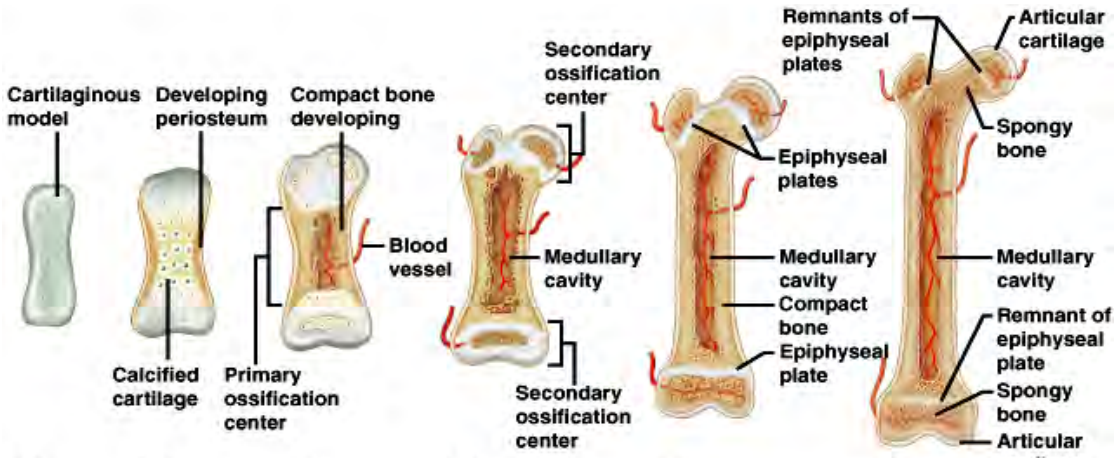
Bone Formation — *Endochondral*

4. **The Secondary Ossification Center**
   a. At birth, **secondary ossification centers** form in the **epiphyses** of long bones.
   The epiphysis is hollowed out from the center outward and is replaced by bone.
   b. Cartilage remains **until adulthood** at the ***epiphyseal plates***.



16

Bone Formation — *Endochondral*



17

Bone Formation *Intramembranous vs. Endochondral*

TABLE 7.1 Major Steps in Bone Development

Intramembranous Ossification	Endochondral Ossification
1. Sheets of primitive connective tissue appear at sites of future bones.	1. Masses of hyaline cartilage form models of future bones.
2. Primitive connective tissue cells collect around blood vessels in these layers.	2. Cartilage tissue breaks down. Periosteum develops.
3. Connective tissue cells differentiate into osteoblasts, which deposit spongy bone.	3. Blood vessels and differentiating osteoblasts from the periosteum invade the disintegrating tissue.
4. Osteoblasts become osteocytes when bony matrix completely surrounds them.	4. Osteoblasts form spongy bone in the space occupied by cartilage.
5. Connective tissue on the surface of each developing structure forms a periosteum.	5. Osteoblasts become osteocytes when bony matrix completely surrounds them.
6. Osteoblasts on the inside of the periosteum deposit compact bone over the spongy bone.	6. Osteoblasts beneath the periosteum deposit compact bone around spongy bone.

Bone Formation *Growth & Remodeling*

1. Each year, bone exchanges 18% of its calcium.
   About 5% of the adult skeleton undergoes remodeling at any one time.
2. Physical activity enlarges bony prominences.
3. **Cartilage** can grow two ways: by **interstitial growth** and by **appositional growth.**
4. In **achondroplastic dwarfism**, chondrocytes fail to multiply in long bones.

18

Factors Affecting Bone Development, Growth, and Repair

Deficiency of Vitamin A	**retards bone development**
Deficiency of Vitamin C	**results in fragile bones**
Deficiency of Vitamin D	***rickets:*** **Metabolic Disorder: phosphorous/calcium** ***osteomalacia:*** **bone softening**
Insufficient Growth Hormone	**dwarfism**
Excessive Growth Hormone	**gigantism**
Insufficient Thyroid Hormone	**delays bone growth**
Sex Hormones	**promote bone formation; stimulate ossification of epiphyseal plates**
Physical Stress	**stimulates bone growth**

19

Physiology — *Ossesous Tissue*

Mineral Resorption

Resorption is the process of dissolving bone to release its minerals ***to the bloodstream.***
Osteoclasts dissolve bone using **acid phosphatase.**

Calcium and Phosphorus Homeostasis

The skeleton serves as a **reservoir for calcium, phosphorus, and other minerals** that play important roles in physiology.

Excessively low calcium concentration is called **hypocalcemia**, causing the *nervous system* to become ***hyperexcitable***.
Muscle tetany can result.

Excessive calcium is **hypercalcemia**, which can cause ***nervous system depression*** and sometimes ***cardiac arrest.***

20

Physiology — *Osseous Tissue*

Calcium and Phosphorus Homeostasis *cont.*

The balance between **calcium storage** (into bone) and **calcium resorption** (into the blood) is controlled by two hormones:

calcitonin

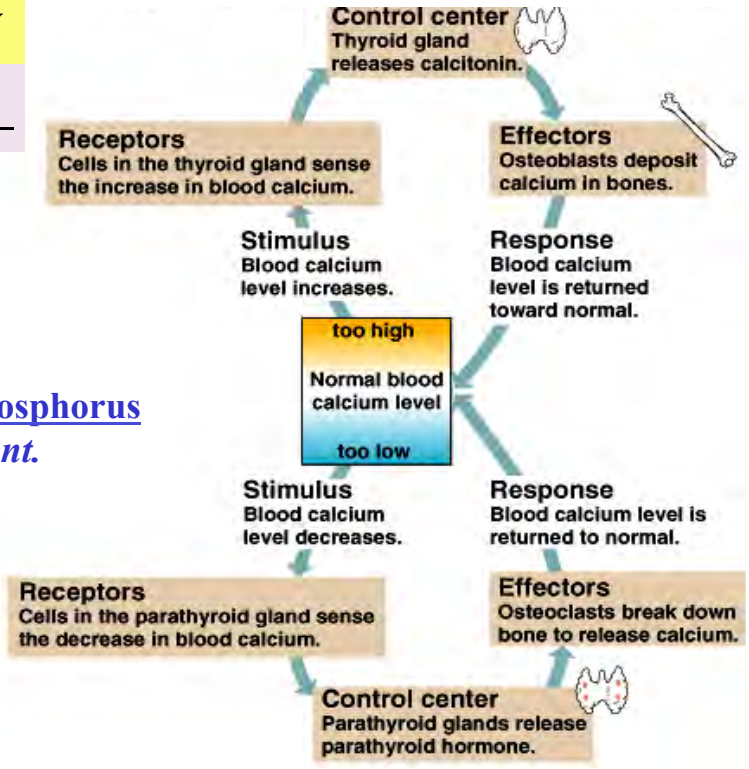
acts to ***lowers blood levels of calcium*** by **stimulating osteoblasts and inhibiting osteoclasts.**

parathyroid hormone (PTH)

raises blood calcium when it drops too low.
PTH stimulates osteoclasts, lessens urinary excretion of calcium, and stimulates the synthesis of vitamin D.

Physiology *Osseous Tissue* 21

Calcium and Phosphorus Homeostasis *cont.*



Physiology *Osseous Tissue* 22

Vitamin D

Vitamin D is a hormone that is produced in concert by the skin, liver, and kidney.

The most active form is **calcitrol**, produced together by the skin (with UV light), liver, and kidney.

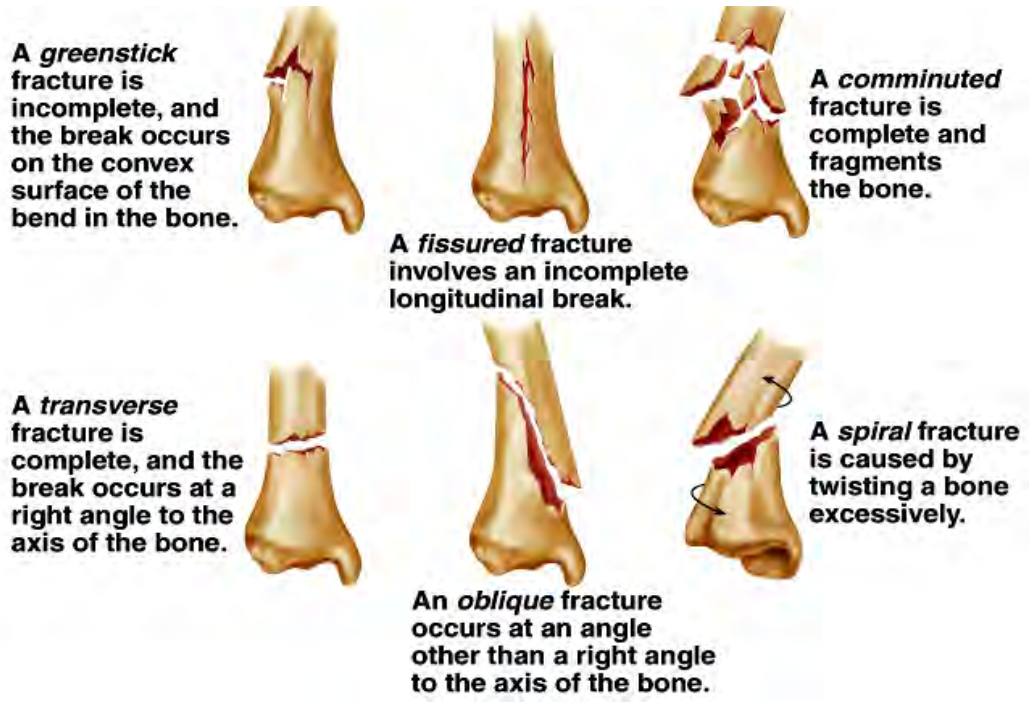
Calcitrol promotes **intestinal absorption of calcium and phosphate** while reducing urinary elimination of these minerals.

Insufficient vitamin D can cause **rickets** in children and **osteomalacia** in adults. (see previous chart)

23

Bone Disorders

Types of Fractures



24

Bone Disorders

Fractures and their Repair

The Healing of Fractures

A bone fracture results in a **hematoma** from torn blood vessels.

Next, **soft granulation tissue** forms as ***blood vessels grow*** into the hematoma.

Macrophages remove debris as osteoclasts, osteogenic cells; **fibroblasts** migrate to the area.

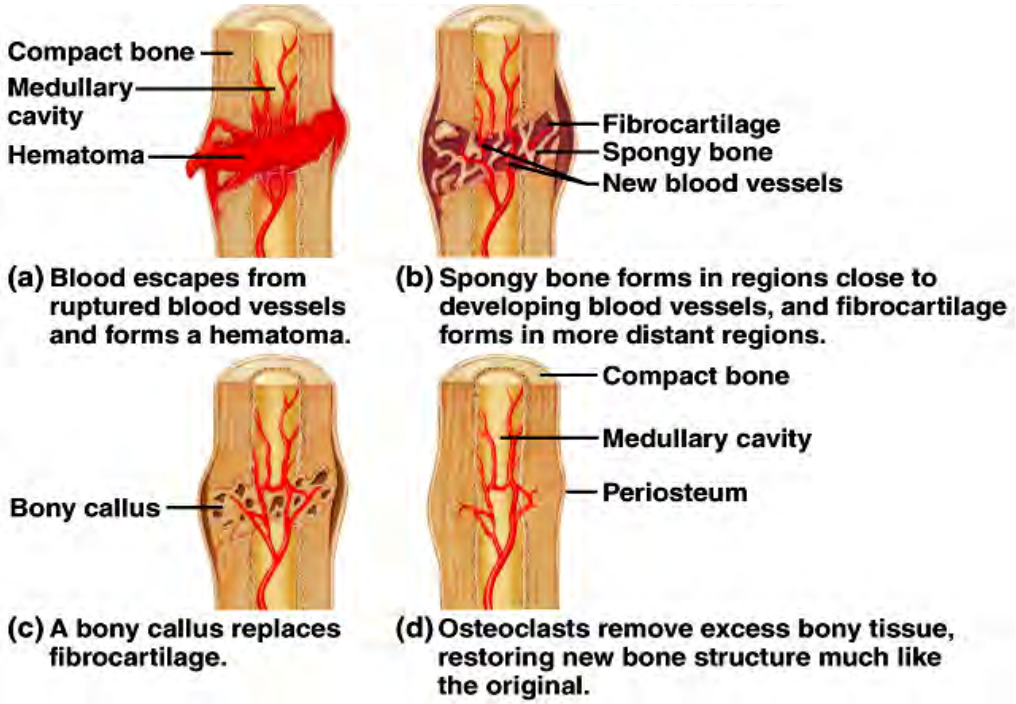
Fibroblasts deposit **collagen**, and a **fibrocartilage callus** is formed by chondroblasts.
The callus is first soft, then hard as it is replaced with bony tissue.

The area of the fracture is remodeled for 3-4 months until broken bone fragments are resorbed.

25

Bone Disorders

Fractures and their Repair



(a) Blood escapes from ruptured blood vessels and forms a hematoma.

(b) Spongy bone forms in regions close to developing blood vessels, and fibrocartilage forms in more distant regions.

(c) A bony callus replaces fibrocartilage.

(d) Osteoclasts remove excess bony tissue, restoring new bone structure much like the original.

26

Bone Disorders

Treatment of Fractures

Fractures may be set by:

closed reduction
no surgery

open reduction
surgical placement of bones, using pins and plates.

Orthopedics:
branch of medicine dealing with injuries/disorders of bones, joints, and muscles.

27

Bone Disorders — *Osteoporosis*

The most common bone disease is ***osteoporosis*** in which bones **lose mass and become brittle.**

The group most prone to this disease are elderly, postmenopausal white women; black women are rarely afflicted.

The **spine commonly becomes compressed**, a condition leading to **kyphosis.**

Disuse osteoporosis occurs at any age due to immobilization or inadequate weight-bearing exercise.

28

TABLE 7.13 Reasons for Falls Among the Elderly

- Overall frailty
- Decreased muscle strength
- Decreased coordination
- Side effects of medication
- Slowed reaction time due to stiffening joints
- Poor vision and/or hearing
- Disease (cancer, infection, arthritis)

LAST SLIDE