Bone Development, Growth, and Repair

Notes

**Bone Development**

The process of bone tissue formation is called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ or \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. It begins in the \_\_\_\_\_\_\_\_\_ month of development. By the last 6 months before birth, much of the cartilage/membrane has been replaced by bone. Ossification is completed by about age 21 in both sexes but growth of long bones occurs until approximately age 25.

Bones are capable of growing thicker throughout life. However, ossification in adults serves mainly for bone remodeling and repair.

Up until the \_\_\_\_\_\_ week of development, fibrous membranes and hyaline cartilage of the fetal skeleton are replaced with \_\_\_\_\_\_\_\_\_ tissue.

Hyaline cartilage is replaced by the process of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ ossification; forms most of the skeleton. “cartilage bones”

Fibrous membranes are replaced by the process of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ ossification; forms most all bones inferior to base of skull except clavicles. Begins in month \_\_\_\_\_ of development. “membrane bones”

**Prenatal Ossification – Watch video on my website entitled “Development of Bone” (6 minutes). It is under the Skeletal System tab.**

A. Endochondral Ossification: {Endo= within; Chondro= cartilage} Occurs in most bones, especially long bones; begins at 8 wks of development

Steps:

1. Cartilage cells become enlarged at ossification centers & secrete substance that calcifies matrix.

2. Cartilage cells die, disappear, & leave space

3. Stem cells divide & become osteoblasts that appear in the spaces; Bone collar forms around calcified cartilage shaft.

4. Periosteal bud w/blood vessels & osteoblasts invades core & becomes primary ossification center (by 12th wk of development).

5. Secondary ossification centers form at epiphyses (ends) replacing calcified cartilage with spongy bone.

6. Osteoclasts resorb bone & form hollow medullary cavity.

7. Ossification concludes with articular cartilage being formed at ends of bone; epiphyseal plate (growth plate) becomes epiphyseal line.

**In the space below, draw a long bone and indicate:**

1. **primary center of ossification (1\*)- color it blue**
2. **2 secondary centers of ossification (2\*)- color them red**

B. Intramembranous Ossification: {Intra= inside; Membran= membranes} Occurs in flat bones

Steps:

1. Osteoblasts form from mesenchymal stem cells at ossification centers

2. Matrix formation phase: Osteoblasts secrete osteoid; osteoblasts become osteocytes when trapped by matrix.

3. Osteoid calcifies & becomes spicules to form spongy bone (trabeculae)

4. Blood vessels condense & form periosteum around outside of bone.

5. Trabeculae thicken & form woven bone {weak}.

6. Woven bone becomes lamellar (compact) bone {strong}over spongy bone.

**Prenatal Bone Growth**

Long bones grow

a. in length \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (longitudinal) growth of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ plate.

* Near end of adolescence the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ divide less often
* Epiphyseal plate thins & is replaced with \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* Bone lengthening stops
  + Females= \_\_\_\_\_\_\_\_\_\_ of age
  + Males=\_\_\_\_\_\_\_\_\_\_\_\_\_\_of age
* Hormones that regulate bone growth include:
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_- stimulates epiphyseal plate activity in kids
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_- moderates activity of growth hormone for proper proportions
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (male) and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (female)- promote growth at puberty; end growth by inducing epiphyseal plate closure

b. in width/thickness \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ growth.

* Growing bones \_\_\_\_\_\_\_\_\_\_\_\_ as they lengthen
* Occurs throughout life
* Thicken in response to\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ or \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ secrete bone matrix on external bone while \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ remove bone on endosteal surface

**Bone Remodeling – Watch video on my website entitled “Bone Remodeling and Modeling” (4 minutes). It is under the Skeletal System tab.**

About \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_% of bone mass is recycled each week.

Spongy bone replaced every \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ years.

Compact bone replaced every \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ years

Bone remodeling includes both \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ on the surfaces of the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (on the outside) and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (on the inside).

New bone matrix is deposited by \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

Resorption is done by the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. It is triggered by \_\_\_\_\_\_\_\_\_ hormone & \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ proteins.

Bone remodeling occurs all the time but is regulated by genetic factors as well as 2 control loops:

1. Hormonal (negative feedback involving blood \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ levels

Explain the PTH/Calcitonin feedback loop here:

1. Response to mechanical stress

State Wolf’s Law:

Hormonal controls determine \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_\_\_\_\_ remodeling occurs in response to changing blood \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ levels, but mechanical stress determines \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ it occurs.

**Bone Repair – Watch video on my website entitled “Anatomy of a Fracture” (3 minutes). It is under the Skeletal System tab.**

Bone fractures are also called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. In the young, they most likely result from \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. In the old, from \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

Fractures are classified 3 ways:

1. Position of bone ends after fracture.

* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_- ends retain normal position
* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_- ends are out of normal alignment

2. Completeness of break

* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_- broken all the way through
* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_- not broken all the way through

3. Whether the skin is penetrated

* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_- skin is penetrated
* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_- skin is not penetrated

\* can also be described by \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of fracture, \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ appearance & \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of break. \*\* Look at common fracture types in ppt & your text p.191\*\*

Treatment of fractures involves \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and immobilization.

* closed= physical manipulation
* open= surgical pins/wires

Steps in repair of a fracture:

1. formation of a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_; mass of clotted blood formed 1st
2. formation of a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

* capillaries grow; phagocytes clear debris
* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ secrete collagen fibers to connect the broken ends
* reconstruction of bone begins by \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* mass of repair tissue is called a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. formation of a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_; occurs within 1 week

* new \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ appear
* callus converted to a hard callus made of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* continues for about \_\_\_\_\_\_\_\_\_\_\_\_\_ months

1. bone \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_; begins during step#3, continues several months

* excess material on \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ exterior and within \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ is removed
* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ bone is laid down to reconstruct shaft walls
* new bone resembles original bone

**Bone Disorders- most often due to imbalances between bone deposit and bone resorption**

1. Osteomalacia- due to poor mineralization; bones are \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. Rickets- also called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of children; bowed legs because bone ends are enlarged & too long; caused by \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ deficiency & lack of dietary \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. Osteoporosis- bone resorption exceeds deposit; normal matrix but bone \_\_\_\_\_\_\_\_\_ declines; most susceptible are the spongy bone of \_\_\_\_\_\_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ although many fractures of the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ & \_\_\_\_\_\_\_\_\_\_\_\_\_ are commonly seen. Most oftenly seen in \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ women due to decreased levels of estrogen. Men less prone because of the protection of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

* Treatments include:
  + calcium
  + Vit \_\_\_\_\_\_\_ supplements
  + weight-bearing \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ therapy
* Prevention by:
  + plenty of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ in early adulthood
  + reduction in \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ & alcohol
  + plenty of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_