Chapter 5 - The Skeletal System

I. BONES: AN OVERVIEW

- skeleton includes bone and articulations (joints). Each has bone tissue, cartilage, fibrous tissue in tendons and ligaments, and others.

- ossification: bones start off as fibrous membranes and cartilage. These tissues are replaced by bone by osteoblasts.

- also, bone is dynamic (always being broken down and rebuilt) and can be remodeled (change shape due to body’s needs). Osteoclasts break down bone, osteoblast build it up.

A. Functions of the Bones

1. Support

2. Protection


4. Storage of minerals: (especially Ca, P, Mg), fat. Osteoclasts break down bone, returning nutrients to bloodstream. Fastest rate = proximal ends of femur, totally replaced every 6 months.

- Axial skeleton houses & protects CNS within dorsal cavity, facial bones & gives limbs something to attach to.

  *skull: cranium surrounds brain
  Facial bones

  *vertebral column: surrounds spinal cord & muscular attachment

- Appendicular skeleton: limbs + associated girdles.

  * pectoral girdle: arms attach

  *pelvic girdle: legs attach

B. Classification of Bones:

1. Shape-level: long, short, flat and irregular.

2. Tissue-level:

   i. Compact Bone: smooth, homogeneous, made of osteons, good for weight-bearing, but doesn't handle horizontal pressure very well.

   Osteons (Haversian systems), made up of lamella (bony rings) surrounding a central canal with blood vessels and nerves.

   Osteocytes are dormant in lacunae; when active, osteoblasts secrete osteoid (matrix), made up of calcium salts, laid down on collagen fibers.

   Osteitis imperfecta: do not make collagen correctly
   Rickets - need vitamin D to make collagen

   Canaliculi = channels between cells, let nutrient & wastes pass.

   ii. Spongy Bone: trabeculae, good for compaction stress.
3. Organ-level:
   
i. Long bones. Limbs.

   Gross Anatomy Structure of a Long Bone:

   **see bone markings/features, table 5.1

   1. Diaphysis: shaft. Compact bone outside, spongy bone center. Center has medullary cavity with red marrow (Hematopoetic tissue, especially in children) or yellow marrow (fat storage in adults).

   2. 2 epiphyses: accommodate articulations. Spongy bone with compact shell, covered with articular cartilages (hyaline).

   3. metaphyses: between the 2. Contain growth plates (epiphyseal plates)

ii. Short, flat & irregular bones. Also has periosteum and endosteum. Growth in width, and remodeling.

C. Bone Formation, Growth, Remodeling and Repair

-these 4 happen continually and use the same cells and basic processes

1. Formation

-2 types of formation: **endochondral** and **intramembranous**. Bones start off as hyaline (long bones) or fibrous membranes (flat, short, irregular).

   A. Endochondral: start off as hyaline. This tissue is ossified by osteoblasts. Articular cartilage is retained. Long bones and most flat bones of appendicular skeleton.

      -also an important process during growth and repair.

   B. Intramembranous: precursor is not cartilage, but rather fibrous membrane model. Bones of the skull and clavicle.

      -also important process during remodeling and repair.
2. Growth & Remodeling - continually happening.

- Growth:
  * endochondral ossification - growth in length at epiphyseal plate
  * intramembraneous ossification - growth in width

- Remodeling: breaking down and building bone, adjusting it to the needs of the body.
  Chondroblast - build cartilage
  Fibroblasts - build fibrous membranes
  Osteoblasts - lay down bone on one of the two structures above
  Osteoclasts - break down bone. Release Calcium.

  * But, body has to meet 2 sometimes contradictory needs:

a. Growth & remodeling (reacting to the needs of the muscles)
b. Seral Ca++ levels (Calcium Blood levels): important for correct functioning of muscular contraction, nerve impulses and blood clotting

(i). Growth in length (long bones only): Problematic due to articulations at the ends.

- **Endochondral growth** (growth within the cartilage).
  Make bone inside cartilage pad.

- Metaphyses with epiphyseal plate (in youth) = cartilaginous pads. Bones grow outward, pushing epiphyses away from shaft.

(ii). Growth in width & remodeling: We always talk about growth in width AND remodeling together, because you have to remodel it if you grow in width.

- Other remodeling (in response to stress) occurs in the same manner.

- periosteum = covering containing osteoblasts. Growth in width, & respond to stresses by building ridges, etc. Endosteum contains osteoclasts, breaking down bone, enlarging cavity, and making sure the bone doesn’t change in shape.

- Growth and remodeling of flat, short and irregular bones occurs in same manner.
- But...growth must STOP! Hormones control when growth starts and stops.

*recall contradiction between skeletal needs and blood Ca++ homeostasis needs. Different hormones control these 2 processes:


ii. sex hormones: estrogen increases osteoblast activity, but doesn’t affect osteoclasts.

Increase at puberty begins closure of epiphyseal plate. sex hormones (estrogen & testosterone) increase activity of osteoblasts, cause these plates to ossify (epiphyseal line).

iii. PTH: hormone that controls (increases) blood Ca++ levels by increasing osteoclast activity and Ca++ absorption at gut. Increases osteoclast activity.

iv. calcitonin increases calcium deposition on bones. Needs vitamin D.
- **Overview:**

2 needs by body:
- skeleton as support
  - bone growth & maintenance
- skeleton as mineral storage
  - blood calcium levels

<table>
<thead>
<tr>
<th>blood stream</th>
<th>bone</th>
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<tbody>
<tr>
<td>Ca++</td>
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- hormones turn on and off cells that cause this
- *chondroblast, osteoblast, osteoclast

- GH, sex steroids (testosterone, estrogen)
- PTH, Calcitonin

Rule of thumb: if there is a conflict between these 2 needs, homeostasis of blood Ca++ levels prevails, and we see bone mass problems

- **Pathologies:**

  * too little GH: dwarfism
  * too much GH: gigantism (childhood) or acromegaly (adulthood)
  * early/high levels of sex hormones: premature closing of plates.
  * too much or too little PTH or Calcitonin results in too much or too little blood Ca++. Recall the importance to muscles, nerves and blood clotting. Shakes, twitching, sweating, spasms, blood clotting problems.
  * Low dietary vitamin D or calcium (especially as children): rickets
D. Bone Fractures

- see table 5.2
- simple: doesn’t break skin, compound: breaks the skin
- Comminuted: fragments.
- Impacted: ends forced into each other
- Spiral: twisted around bone
- Greenstick: transverse beginning, but then runs down length of bone.
More common in children = more collagen, less ossification. Breaks like a “green stick”.

II. AXIAL SKELETON

A. Skull

1. Cranium - surrounds brain
   - Frontal Bone
   - Parietal Bones
   - Temporal Bones
   - Occipital Bone
   - Sphenoid Bone
   - Ethmoid Bone

2. Facial Bones

   - Maxillae
   - Palatine Bones
   - Zygomatic Bones
   - Lacrimal Bones
   - Nasal Bones
   - Vomer Bone
   - Mandible
   - The Hyoid Bone

3. Fetal Skull
   - Anterior & Posterior Fontanel
B. Vertebral Column (Spine)
- intervertebral disks and foramen
  *herniated disks
- regions and curvatures
  S-shaped: resiliency
    *cervical: C1-C7
    *thoracic: T1-T12
    *lumbar: L1-L5
    *sacrum: 5 fused
    *coccyx: 4 fused
*primary curvatures: thoracic & sacral, present as infant.
*secondary: all 5 together. Raising head and walking.
*scoliosis - lateral curvature, lordosis,= exaggerated lumbar curvature (pregnancy and other weight gain), and kyphosis (hunch bck, exaggerated curve of thoracic and cervical vertebrae)

C. Bony Thorax
- Sternum
- Ribs
  *True Ribs
  *False Ribs
  *Floating Ribs

III. APPENDICULAR SKELETON

A. Bones of the Shoulder Girdle
- Clavicle (Collarbones)
- Scapulae (Shoulder Blades)

B. Bones of the Upper Limbs
- Arm
  *Humerus
- Forearm
  *Radius
  *Ulna
- Hand
  *Carpals
  *Metacarpals
  *Phalanges
C. Bones of the Pelvic Girdle
- Coxa Bones (Hip Bones)
  *Ilium
  *Ischium
  *Pubis

D. Bones of the Lower Limbs
- Thigh
  *Femur
- Leg
  *Tibia
  *Fibula
- Foot
  *Tarsals
  *Metatarsals
  *Phalanges

IV. JOINTS

A. Fibrous Joints
  *Fibrous membrane connect the 2 bones. Not much movement. Sutures are an example.

B. Cartilaginous Joints
  *Cartilage pad connects the 2 bones. Not much movement. Ribs attaching to sternum, pubic symphysis.

C. Synovial Joints
  **“diarthrotic” = freely moveable
  *Synovium with articular capsule, synovial joint filled with fluid, ligaments between the bones (often). Sometimes bursae and tendon sheaths.
  *Types:
    2. Ball-and-Socket Joint - lots of movement along several planes. Expanded head & deep fossa.
    5. Plane Joint - wrist bones
    6. Saddle Joint - base of thumb allows opposition of thumb and fingers
D. Inflammatory Disorders of Joints

* sprains: torn/ripped ligament.
* bursitis and tendonitis: swellings of bursae and tendon sheath
* arthritis: many kinds. Osteoarthritis most common, where bony deposits cause spurs, rough edges, pain. Rheumatoid = rarer, autoimmune disorder (immune system attacks and destroys joints). Gout = crystallizations of uric acid in tissues, gravity usually brings them down to foot, swelling of joint.