The SKELETAL System

The framework of bones and cartilage which protect organs, and provides a lever system that allows locomotion.
Functions of the Skeletal System

- Support
- Protection
- Movement Facilitation
- Mineral Storage and Homeostasis
- Hematopoiesis
- Storage of Energy
Types of Bone Cells

- Osteoblasts deposit mineral salts and collagen fibers
- Osteocytes maintain bone tissue
- Osteoclasts break down bone tissue
Bone Cells

- Osteogenic cell (develops into an osteoblast)
- Osteoblast (forms bone matrix)
- Osteocyte (maintains bone tissue)
- Osteoclast (functions in resorption, the breakdown of bone matrix)
Ossification

• the process by which bones form in the body (Osteogenesis)
• the replacement of pre-existing connective tissue with bone
• Intramembranous Ossification
  - Membranes ----> Bone
  - (Periosteum - Width-wise Growth)
• Endochondral Ossification
  - Cartilage ----> Bone
  - (Epiphyseal Plate - Length-wise Growth)
Intramembranous Ossification

1. Development of center of ossification
2. Calcification
3. Formation of trabeculae
4. Development of the periosteum
Endochondral Ossification
Homeostasis and Bone Remodeling

- Bones are constantly undergoing ossification and remodeling
- Replacing old bone matrix with new bone matrix
  - bone reabsorption (osteoclasts)
  - bone deposition (osteoblasts)
- Allows injured or worn out bone to be replaced
- Compact bone tissue is formed by the reorganization of spongy bone tissue
Types of Bones

- Long Bones
- Short Bones
- Flat Bones
- Irregular Bones
- Sesamoid Bones (not a classification used by all anatomists)
Types of Bones

- Long bone (humerus)
- Short bone (trapezoid, wrist bone)
- Flat bone (sternum)
- Irregular bone (vertebra)
- Sesamoid bone (patella)
Long Bones

- Greater length than width
- Have a distinct diaphysis and a variable number of epiphysis
- Slightly curved for strength
- Examples: humerus, ulna, radius, femur, tibia, fibula, metacarpals, metatarsals, phalanges
**Short Bones**

- Cube-shaped bones
- Nearly equal in length and width
- Spongy texture on inside of the bone
- Examples: carpal and tarsal bones
Flat Bones

- Generally thin and flat
- Compact bone on anterior and posterior surfaces with spongy bone in the middle
- Provides protection to organs
- Large surface area for muscle attachment
- Examples: cranial bones, sternum, scapula, ribs
**Irregular Bones**

- Complex shaped bones
- Cannot be classified into other categories
- Vary in the amount of spongy and compact bone
- Examples: vertebrae, facial bones, patella
Long Bone Structure

- Periosteum – the outer covering
- Diaphysis - shaft of a long bone
- Epiphysis - ends of a long bone
- Medullary Cavity – contains marrow
- Red Marrow – where blood cells are produced.
- Yellow Marrow – where fat is stored
• Articular Cartilage – hyaline cartilage found at the ends of long bones to reduce friction during movement.
• Endosteum – the lining of the medullary cavity.
• Compact Bone – densely packed osteocytes to provide strength to the bone.
• Spongy bone – loosely packed osteocytes which help to reduce the weight of the bone and form the red marrow.
Long Bone Structure

- Articular cartilage
- Epiphyseal line
- Red bone marrow
- Spongy bone
- Endosteum
- Compact bone
- Periosteum
- Medullary cavity
- Nutrient arteries in nutrient foramen
- Metaphysis
- Epiphysis
- Cranial epiphysis
- Femur
- Partially sectioned humerus (arm bone)
- Pelvic bone
- Metaphysis
- Concretion
- Medullary cavity in diaphysis
- Compact bone
- Endosteum
- Sesamoid bone
Proximal End of a Long Bone

- Articular cartilage
- Epiphyseal vein
- Epiphyseal artery
- Epiphyseal line
- Metaphyseal vein
- Metaphyseal artery
- Periosteum
- Periosteal artery
- Periosteal vein
- Medullary cavity
- Compact bone
- Nutrient foramen
- Nutrient vein
- Nutrient artery
Epiphyseal Plate

(a) Radiograph showing the epiphyseal plate of the femur of a 3-year-old

(b) Histology of the epiphyseal plate

- Zone of calcified cartilage
- Zone of hypertrophic cartilage
- Zone of proliferating cartilage
- Zone of resting cartilage
Classification of Bones

- **Compact Bone (Dense Bone)**
  - little space between the solid components of bone

- **Spongy Bone (Trabecular Bone)**
  - made up of an irregular network of thin plates of bone with many intercellular spaces called trabeculae (spicules)
    - spaces between trabeculae filled with red bone marrow
    - responsible for hematopoiesis
Spongy Bone Structure

(a) Enlarged aspect of spongy bone trabeculae
(b) Details of a section of a trabecula
Compact Bone

[Diagram of compact bone structure with labels for various components such as osteocytes, osteoclastic, osteoblastic, and osteoclastic.]
Bone Markings

- Foramen - an opening or hole in a bone
- Meatus - a tube-like passageway within a bone
- Sinus - a space within a bone lined with mucus membrane that reduces the weight of a bone
- Fossa - a depression or groove on a bone
Bone Markings

- Condyle - “Knuckle” - a large rounded prominence on a bone
- Tuberosity - an elevated, rounded, usually roughened area of a bone
- Trochanter - a large blunt process found only on the femur
- Tubercle - a small rounded process
Bone Markings

- Process - any projection from the surface of a bone
Suture and Fontanel

- Sutures are the joints between the skull bones. They fuse together between the ages of 18 months old and 3 years.
- Fontanels are the soft, membranous spots of a baby’s skull that allows for brain growth and the delivery of the fetus through the birth canal.
Skull – Lateral View
Divisions of the Skeleton

- Axial Skeleton - bones that lie along the long axis of the body. Includes the skull, hyoid bone, sternum, ribs, and vertebrae.
- Appendicular Skeleton - bones of the extremities.
Bones of the Skeletal System
The Axial Skeleton
Axial Skeleton
80 Bones

- Skull
- Hyoid Bone
- Vertebral Column
- Sternum
- Ribs
Axial Skeleton
Location of Basic Skull Bones

- Mandible
- Maxilla
- Zygomatic
- Frontal
- Parietal
- Occipital
- Sphenoid
Location of Basic Skull Bones

- Ethmoid
- Hyoid
- Temporal
- Mastoid Process
Cranial Bones (8)

- Frontal Bone
- Parietal Bones (2)
- Temporal Bones (2)
- Occipital Bone
- Sphenoid Bone
- Ethmoid Bone
Skull – Anterior View
Skull – Lateral View
Skull – Inferior View
Skull - Transverse Section
Frontal Bone

- Forms the forehead
- Forms the roof of the orbits (eye sockets)
- Forms most of the anterior portion of the cranial floor
**Parietal Bones (2)**

- Form the greater portion of the sides and roof of the cranial cavity
Temporal Bones (2)

- Form the inferior sides of the cranium and part of the cranial floor
- Temporal bone landmarks:
  - Zygomatic Process
  - Mandibular Fossa
  - External Auditory Meatus
  - Mastoid Process
  - Styloid Process
Occipital Bone

- The posterior part and prominent portion of the base of the cranium
- Occipital bone landmarks:
  - Foramen Magnum
  - Occipital Condyles
  - External Occipital Protuberance
Sphenoid Bone

• Bone situated in the middle part of the base of the skull
• Shaped like a bat
• Only bone that connects to all other cranial bones
• Sphenoid bone landmarks:
  – Body
  – Greater Wings
  – Sella Turcica
  – Sphenoid Sinuses
Sphenoid Bone

Optic foramen
Sphenoidal sinus
Foramen rotundum
Greater wings
Lesser wings
Superior orbital fissure
Body
Pterygoid processes

(b) Anterior view of sphenoid bone

Frontal plane View

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Ethmoid Bone

- Light, spongy bone located in the anterior floor of the cranium between the orbits
- Makes up much of the structure of the nasal cavity
- Ethmoid bone landmarks:
  - Lateral Masses (Labyrinths)
  - Ethmoid Sinuses - Crista Galli
  - Perpendicular Plate - Cribriform Plate
  - Superior Nasal Conchae
  - Middle Nasal Conchae
Ethmoid Bone
Facial Bones (14)

- Nasal Bones (2)
- Maxillae (2)
- Zygomatic Bones (2)
- Lacrimal Bones (2)
- Palatine Bones (2)
- Inferior Nasal Conchae (2)
- Vomer
- Mandible
Facial Bones

Anterior view showing the bones of the right orbit.
Zygomatic Bones (2)

• cheek bones
• form the prominences of the cheeks and the floor and outer walls of the orbits
• Zygomatic bone landmarks:
  – temporal processes
  – zygomatic arches
Maxillary Bones (2)

• Pair of bones that unite to form the upper jaw
• Articulate with every bone of the face except the mandible
• Maxillary bone landmarks:
  – Alveolar Processes
  – Alveoli
  – Palatine Processes - horizontal projection from the maxillae that forms the anterior three fourths of the hard palate
  – Cleft Palate
  – Cleft Lip
Facial Bones
Sagittal Section

- Crista galli
- Frontal bone
- Nasal bone
- Nasal cartilage
- Palatine process of maxilla

Sagittal section

Nasal septum:
- Perpendicular plate of ethmoid bone
- Septal cartilage
- Vomer
- Horizontal plate of palatine bone
Mandible (Lower Jaw) Bone

- Largest and strongest bone in the face
- The only moveable skull bone
- Articulates with the temporal bone to form the Temporal Mandibular Joint (TMJ)
Mandibular Landmarks

- Body - front and sides of the bone
- Rami - perpendicular portions of bone
- Angle
- Condylar Processes - joint
- Coronoid Processes - muscles
- Mandibular Notch
- Alveolar Processes and Alveoli
- Mental Foramen - front/body
- Mandibular Foramen - posterior ramus
- Mandibular Canal
Hyoid Bone

- U-shaped bone suspended from the styloid processes by ligaments
- Only bone in the body that doesn’t directly articulate with another bone
- Located between mandible and larynx
- Supports the tongue and provides point of attachment for some tongue and neck muscles
Hyoid Bone

(a) Anterior view  (b) Right lateral view

Greater horn
Lesser horn
Body

07.15
The Vertebral Column (Spine)

- Together with ribs and sternum provide about two-fifths (40%) of the height of the body
- Composed of 33 (26) different bones
- Encloses and protects the spinal cord
- Supports the head
- Lower vertebrae supports the weight of the entire upper body
Vertebrae

- Bones of the vertebral column
- Cervical vertebrae (7) - neck
- Thoracic vertebrae (12) - ribs
- Lumbar vertebrae (5) - lower back
- Sacral vertebrae (5) - pelvic bones
- Coccygeal vertebrae (4) - tail bone
- Intervertebral Foramina - openings between the vertebrae for nerve exit
Vertebral Column
Intervertebral Discs

- Discs of fibrocartilage found between the vertebrae from C1 to the sacrum
- Functions to absorb shock
- Allows for the multi-directional motion between each vertebrae
  - Annulus Fibrosis - outer fibrous ring
  - Nucleus Pulposus - inner, soft pulpy portion of the intervertebral discs
Herniated Discs
(Slipped Discs)

• Rupture of the fibrocartilage discs
• Usually caused by compression forces
• Usually occurs between L4 and L5 or L5 and the 1st Sacral Vertebrae
• Disc protrudes and exerts pressure on spinal nerves
• To decrease risk of herniated discs:
  – 1. maintain optimal body weight
  – 2. strengthen abdominal muscles
  – 3. increase lower back flexibility
Spina Bifida

- congenital defect where the neural arch fails to unite
- usually involves the lumbar vertebrae
- symptoms may be mild to severe
  - usually results in paralysis
  - partial or complete loss of bladder control
  - absence of reflexes
- can be diagnosed during pregnancy by sonography, amniocentesis, blood tests
Curvature of the Spine

- Increases strength of the spine
- Helps maintain balance
- Dissipates vertical shock
- Protects spinal column from fracture

- Anterior Curves (Secondary Curves)
  - Cervical Vertebrae
  - Lumbar Vertebrae

- Posterior Curves (Primary Curves)
  - Thoracic Vertebrae
  - Sacral Vertebrae
Curvature of the Spine
Abnormal Curvatures of the Spine

• Scoliosis - lateral curvature of the spine
  – usually in thoracic and lumbar region
• Kyphosis - hunchback/humpback
  – exaggeration of thoracic curvature
• Lordosis - swayback (sprinters butt)
  – exaggeration of lumbar curvature
Abnormal Curvatures

Scoliosis  Kyphosis  Lordosis
The Appendicular Skeleton
Appendicular Skeleton
126 Bones

- clavicle
- scapula
- humerus
- ulna
- radius
- carpals
- metacarpals
- phalanges
- pelvis
- femur
- patella
- tibia
- fibula
- tarsals
- metatarsals
- phalanges
Appendicular Skeleton
Joints (Articulations)

The points of contact between bones, between bones and cartilage, or between teeth and bones.
Structural Classification of Joints

• Classification of joints based upon how they are held together

• Fibrous Joints
  – held together by fibrous connective tissue

• Cartilaginous Joints
  – held together by cartilage

• Synovial Joints
  – joint enclosed within a synovial or joint capsule
Synovial Joints

• Enclosed within a joint or synovial capsule
  – fibrous capsule - outer layer
    • attaches to periosteum of bone
  – synovial membrane - inner layer
    • secretes synovial fluid
• Space between the ends of articulating bones called a synovial space
• End of articulating bones are covered with hyaline (articular) cartilage
Typical Synovial Joint
Menisci

- Pads of fibrocartilagenous discs found between bony surfaces in some joints
- Allows the bones to fit together better
- Maintains the stability of the joint
- Absorbs shock
- Directs the flow of synovial fluid to areas of greatest friction
Bursae

- Sac-like structures that resemble joint capsules situated within body tissues
- Function like ball-bearings
- Reduces friction between bones and soft tissues
- Reduces friction between bones and skin
Knee Joint
Shoulder Joint
Shoulder Joint

- Acromion of scapula
- Subacromial bursa
- Tendon of biceps brachii muscle (long head)
- Tendon of infraspinatus muscle
- Glenoid cavity
- Articular capsule
- Tendon of teres minor muscle
- Posterior

SUPERIOR
- Coracocromial ligament
- Tendon of supraspinatus muscle
- Coracoacromial ligament
- Conoid process of scapula
- Tendon of subscapularis muscle

ARTICULAR
CAPSULE
- Glenohumeral ligaments
- Glenoid labrum

ANTERIOR

(B) Lateral view (opened)

(Q3.11b)
Tendons and Ligaments

- **Tendons** - connect muscle to bone
  - A band or cord of dense fibrous connective tissue extending from a muscle to a bone for attachment

- **Ligaments** - connect bone to bone
  - A band or cord of dense fibrous connective tissue extending from one bone to another bone to provide a joint with structural stability
Osteoarthritis

- Degenerative joint disease associated with aging
- Usually preceded by traumatic joint injury
- Characteristics:
  - degeneration of articular cartilage
  - development of bone spurs
  - usually effects large joints (knees, hips, etc)
- Treatment:
  - rest
  - removal of bone spurs
  - joint replacement
Osteoporosis

Decrease in bone mass and increased susceptibility to fractures.


Osteoporosis
Contributing Factors

- Decreased estrogen production
- Poor nutritional status
- Low activity levels
- Weight
- Smoking
- Drugs and alcohol consumption
- Gender/race/hereditary factors
Osteoporosis - Treatment

- Calcium supplementation
- Estrogen Replacement Therapy
- Weight-bearing exercise
- Steroid treatment therapy