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
(form bone matrix)

Osteocyte
(maintains bone tissue)

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

06.02
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

1. Development of cartilage model
2. Growth of cartilage model
3. Development of primary ossification center
4. Development of secondary ossification center
5. Formation of articular cartilage and epiphyseal plate
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
  - Diaphysis—the shaft (or long, main portion of the long bone)
  - Epiphysis—the expanded ends of long bone
- 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
    - Found only in the vertebrae, hips, breastbone, ribs, and skull and at the ends of the long bones of the arm and leg (in adults)
  + Yellow Marrow – where fat is stored
    - Found in other spongy bones and the central cavities of the long bones
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

(a) Partially sectioned humerus (arm bone)
(b) Partially sectioned femur (thigh bone)
PROXIMAL END OF A LONG BONE
EPIPHYSEAL PLATE

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

Femur
EPIPHYSEAL PLATE
Tibia
Diaphyseal side

Diaphysis
Zone of calcified cartilage
Zone of hypertrophic cartilage
Zone of proliferating cartilage
Zone of resting cartilage

Epiphyseal side

(b) Histology of the epiphyseal plate

LM 60x
06.08
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

- Space for red bone marrow
- Trabeculae
- Lacuna
- Interstitial lamellae
- Canaliculi
- Osteocyte
- Osteoclast
- Osteoblasts aligned along trabeculae of new bone

06.04
COMPACT BONE

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

06.03
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

Coronal suture

PARIETAL BONE

Temporal squama

Squamous suture

TEMPORAL BONE

Zygomatic process

Lambdoid suture

Mastoid portion

OCCIPITAL BONE

External occipital protuberance

External auditory meatus

Mastoid process

Styloid process

Foramen magnum

Zygomatic arch

FRONTAL BONE

SPHENOID BONE

ZYGMOMATIC BONE

ETHMOID BONE

LACRIMAL BONE

Lacrimal fossa

NASAL BONE

Temporal process

Intraorbital foramen

MAXILLA

Mandibular fossa

Articular tubercle

MANDIBLE

HYOID BONE

Right lateral view

07.04
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.
THE AXIAL SKELETON
AXIAL SKELETON—80 BONES

- Skull
- Hyoid Bone
- Vertebral Column
- Sternum
- Ribs
LOCATIONS 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

FRONTAL BONE

PARIETAL BONE

Squamous suture

SPHENOID BONE

Orbit

ETHMOID BONE

LACRIMAL BONE

Zygomaticofacial foramen

Infraorbital foramen

Perpendicular plate

INFERIOR NASAL CONCHA

VOMER

Mental foramen

Sagittal suture

Coronal suture

Frontal squama

Supraorbital foramen

Supraorbital margin

Optic foramen

Superior orbital fissure

TEMPORAL BONE

NASAL BONE

Inferior orbital fissure

Middle nasal concha

ZYGOMATIC BONE

MAXILLA

MANDIBLE

Anterior view

07.03
SKULL – TRANSVERSE SECTION

(a) Superior view of sphenoid bone in floor of cranium

07.08a
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
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

Frontal plane

View

Greater wings
Lesser wings

Optic foramen
Sphenoidal sinus
Foramen rotundum

Superior orbital fissure
Body
Pterygoid processes

(b) Anterior view of sphenoid bone

07.08b
**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
  - Perpendicular Plate
  - Superior Nasal Conchae
  - Middle Nasal Conchae
  - Crista Galli
  - Cribiform Plate
ETHMOID BONE

(a) Medial view of sagittal section

(b) Superior view

(c) Anterior view

(d) Anterior view of position of ethmoid bone in skull
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

FRONTAL BONE
Supraorbital margin

SPHENOID BONE
Optic foramen
Superior orbital fissure

PALATINE BONE
Zygomaticofacial foramen

ZYGOMATIC BONE
Infraorbital foramen

Supraorbital foramen
NASAL BONE
LACRIMAL BONE
ETHMOID BONE
Lacrimal fossa
MAXILLA
Inferior orbital fissure

Anterior view showing the bones of the right orbit
07.12
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
CLEFT LIP AND PALATE
FACIAL BONES—SAGITTAL SECTION

- Sagittal plane
- View
- Sagittal section
- Nasal septum:
  - Perpendicular plate of ethmoid bone
  - Septal cartilage
  - Vomer
- Horizontal plate of palatine bone
- Sphenoid bone
- Crista galli
- Frontal bone
- Nasal bone
- Nasal cartilage
- Palatine process of maxilla

07.11
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
MANDIBLE

- Condylar process
- Coronoid process
- Mandibular notch
- Mandibular foramen
- Ramus
- Alveolar process
- Body
- Mental foramen
- Angle

Right lateral view

07.10
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

Skeleton in Action

(a) Anterior view
(b) Right lateral view

Greater horn
Lesser horn
Body

07.15

Skeleton in Action
**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
PARTS OF A VERTEBRA

Parts of a Vertebral Column:

- Spinal process
- Lamina
- Facet
- Foramen
- Transverse process
- Vertebral body

Cervical Vertebra:
- Transverse foramen
- Superior articular facet
- Inferior articular facet

Thoracic Vertebra:
- Facets for head of rib

Lumbar Vertebra:
- Spine
- Spinal foramen
- Superior articular facet
- Lamina
- Arch
- Pedicle
- Body
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
INTERVERTEBRAL DISCS

- Normal intervertebral disc
- Compressed intervertebral disc in a weight-bearing situation

Diagram showing:
- Intervertebral foramen
- Vertebral body
- Nucleus pulposus
- Annulus fibrosus

Meletis
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
SPINA BIFIDA

- Spina Bifida
- Normal Spine
- Vertebra
- Meninges
- Spinal Cord
- Spinal Fluid
- SPINE
SPINA BIFIDA

Normal

Occult Spinal Dysraphism

Meningocele

Myelomeningocele

Spinal cord

CSF

Meninges

Vertebra

Hair

Meletis
SPINA BIFIDA
SPINA BIFIDA
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

(a) Anterior view showing regions of the vertebral column
- Cervical vertebrae (7)
- Thoracic vertebrae (12)
- Lumbar vertebrae (5)
- Sacrum (1)
- Coccyx (1)

(b) Right lateral view showing four normal curves
- Cervical curve (formed by 7 cervical vertebrae)
- Thoracic curve (formed by 12 thoracic vertebrae)
- Lumbar curve (formed by 5 lumbar vertebrae)
- Sacral curve (formed by sacrum)

(c) Fetal and adult curves
- Single curve in fetus
- Four curves in adult

(d) Intervertebral disc
- Normal intervertebral disc
- Compressed intervertebral disc in a weight-bearing situation
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
ABNORMAL CURVATURES—SCOLIOSIS
ABNORMAL CURVATURES - KYPHOSIS
ABNORMAL CURVATURES-LORDOSIS

Figure 7-1: Postural changes during pregnancy. Note the increasing lordosis of the lumbosacral spine and the increasing curvature of the thoracic area.
THE APPENDICULAR SKELETON
APPENDICULAR SKELETON (126 BONES)

- clavicle
- scapula
- humerus
- ulna
- radius
- carpals
- metacarpals
- phalanges
- pelvis
- femur
- patella
- tibia
- fibula
- tarsals
- metatarsals
- phalanges

Written in Bone
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
FUNCTIONAL CLASSIFICATION OF JOINTS

- Classification of joints based upon their movement
- Synarthrosis
  - Immovable joint in which two bones are connected rigidly by fibrous tissue
- Amphiarthrosis
  - Slightly movable joint in which the surfaces of bones are connected by ligaments or cartilage
- Diarthrosis
  - Freely moveable in various planes
FUNCTIONAL CLASSIFICATION OF JOINTS

- Synarthrosis
  + Little or no movement
  + Correlates with Fibrous joints
  + Ex
    - Sutures
    - Gomphosis (where teeth attach to jaw bones)
    - Syndesmosis (membranous connection between radius and ulna)
FUNCTIONAL CLASSIFICATION OF JOINTS
FUNCTIONAL CLASSIFICATION OF JOINTS

- Amphiarthrosis
  + Slightly moveable
  + Correlates with cartilaginous joints
  + Ex
    - intervertebral discs
    - pubic symphysis
    - ligaments between the distal ends of the tibia and fibula
    - connection between the ribs and the sternum or
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

- Periosteum
- Articular capsule: Fibrous capsule
- Synovial membrane
- Articulating bone
- Synovial (joint) cavity (contains synovial fluid)
- Articular cartilage
- Articulating bone

Frontal section
09.03
TYPES OF SYNOVIAL JOINTS

× **Gliding joint**
  - Transitional joint in which the articular cartilage surfaces of the adjacent bones are planar (relatively flat) and where the joint capsule and ligaments allow only slight translational, sliding movements
  - Ex: the intercarpal and intertarsal joints

× **Hinge joint**
  - Uniaxial joint in which the articular cartilage surface of one bone is relatively cylindrical with a groove or depression to guide the movement of the articular cartilage surface of the other bone which is trough shaped with a ridge that fits the groove in the opposite bone
  - Allows uniaxial movements in only one plane
  - Ex: flexion and extension at the elbow, knee or interphalangeal joints

× **Pivot joint**
  - Uniaxial joint in which the articular cartilage surface of one bone is rounded and moves against a ring or sleeve-shaped articular cartilage surface on the other bone which may be additionally supported by ligaments
  - Allows uniaxial rotational movement of the first bone around its own long axis
  - Ex: rotation between the dens of the axis (C2) and the atlas (C1) or between head of the radius and the radial notch of the ulna at the elbow.
TYPES OF SYNOVIAL JOINTS

× **Condyloid joint (ellipsoid)**
  + the articular cartilage surface of one bone is rounded and convex and moves against rounded concave articular cartilage surface on the other bone
  + allows biaxial angular movements including flexion and extension, abduction and adduction, and combinations of these movements;
  + Ex: the metacarpophalangeal joints (knuckles), the radiocarpal joint (wrist), the joint between the occipital bone at the base of the skull and the atlas (C1), etc.

× **Saddle joint**
  + A type of (biaxial) synovial joint in which the articular cartilage surfaces of both bones are rounded with both convex and concave regions on each articular surface
  + allows greater freedom of movement than condyloid joints;
  + Ex: the carpometacarpal joints of the thumbs

× **Ball-and-socket joint**
  + Multiaxial joint in which the articular cartilage surface of one bone is convex and hemispherical and moves against a rounded concave cup-like articular cartilage surface on the other bone
  + allows multiaxial angular and rotational movements including flexion and extension, abduction and adduction, rotation around the long axis of the first bone and circumduction
  + Ex: the glenohumeral (shoulder) and femerocoxal (hip) joints
TYPES OF SYNOVIAL JOINTS

- **Plane joint**
- **Hinge joint**
- **Pivot joint**
- **Condyloid joint**
TYPES OF SYNOVIAL JOINTS

- Saddle joint
- Ball-and-socket 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

(c) Sagittal section

(d) Anterior deep view
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
Fractures or broken bones are caused by the stress on bones placed upon them by trauma or disease conditions.

Can occur in any bone of the body and are classified by the fracture -- either by specific names or locations of the bone break.
Dislocation

- Displacement of a bone from a joint with tearing of ligaments, tendon, and articular capsule
Any painful state of the supporting structures of the body.
Includes the bones, ligaments, joints, tendons, and muscles
Ex.
+ Rheumatoid arthritis
RICKETS

- A deficiency condition in children that results in inadequate deposition of lime salts in developing cartilage and newly formed bone causing abnormalities in shape and structure of bone.
Strain

- Trauma to a muscle or the musculo-tendinous units from violent contraction or excessive forcible stretch.
SPRAIN

- Trauma to the joint that causes pain and disability depending upon the degree of injury to ligaments.
SPRAIN VS. STRAIN

- Sprain involves the ligament or joint capsule
- Strain involves the muscle and connecting tendon