Chapter 7: The Skeleton

Objectives:
1. Name the major parts of the axial and appendicular skeletons and describe their relative functions.
2. Name, describe and identify the skull bones. Identify their important markings.
3. Compare and contrast the major functions of the cranium and the facial skeleton.
4. Define the bony boundaries of the orbits, nasal cavity and paranasal sinuses.
5. Describe the structure of the vertebral column, list its components, and describe its curvatures.
6. Indicate a common function of the spinal curvatures and the intervertebral discs.
7. Discuss the structure of a typical vertebra and describe regional features of cervical, thoracic, and lumbar vertebrae.
8. Name and describe the bones of the thoracic cage (bony thorax).
9. Differentiate true from false ribs.
10. Identify bones forming the pectoral girdle and relate their structure and arrangement to the function of this girdle.
11. Identify important bone markings on the pectoral girdle.
12. Identify or name the bones of the upper limb and their important markings.
13. Name the bones contributing to the os sacrum and relate the pelvic girdle’s strength to its function.
14. Describe differences in the male and female pelves and relate these to functional differences.
15. Identify the lower limb bones and their important markings.
16. Name the arches of the foot and explain their importance.
17. Define fontanels and indicate their significance.
18. Describe how skeletal proportions change through life.
19. Discuss how age-related skeletal changes may affect health.

Part I: The Axial Skeleton

I. The Skull
   A. body’s most complex bony structure
   B. formed by the cranium and facial bones
      1. Cranium
a. protects the brain  
b. site of attachment for head and neck muscles

2. Facial bones
   a. Supply the framework of the face, the sense organs, and the teeth  
   b. Provide openings for the passage of air and food  
   c. Anchor the facial muscles of expression

C. Anatomy of the Cranium
   1. Eight cranial bones
      a. two parietal  
      b. two temporal  
      c. frontal  
      d. occipital  
      e. sphenoid  
      f. ethmoid
   2. Cranial bones are thin and remarkably strong for their weight

D. Frontal Bone
   1. Forms the anterior portion of the cranium
   2. Articulates posteriorly with the parietal bones via the coronal suture
   3. Major markings  
      a. supraorbital margins  
      b. the anterior cranial fossa  
      c. frontal sinuses (internal and lateral to the glabella)

E. Parietal Bones and Major Associated Sutures
   1. Four sutures mark the articulations of the parietal bones
      a. Coronal suture – articulation between parietal bones and frontal bone anteriorly
      b. Sagittal suture – where right and left parietal bones meet superiorly
      c. Lambdoid suture – where parietal bones meet the occipital bone posteriorly
      d. Squamosal or squamous suture – where parietal and temporal bones meet

F. Occipital Bone and Its Major Markings
   1. Forms most of skull’s posterior wall and base
   2. Major markings  
      a. posterior cranial fossa  
      b. foramen magnum  
      c. occipital condyles
d. hypoglossal canal

G. Temporal Bones
1. Form the inferolateral aspects of the skull and parts of the cranial floor
2. Divided into four major regions
   a. squamous
   b. tympanic
   c. mastoid
   d. petrous
3. Major markings
   a. zygomatic process
   b. styloid process
   c. mastoid process
   d. mandibular fossae
   e. middle cranial fossae
4. Major openings
   a. stylomastoid foramina
   b. jugular foramina
   c. external and internal auditory meatuses
   d. carotid canal

H. Sphenoid Bone
1. Butterfly-shaped bone that spans the width of the middle cranial fossa
2. Forms the central wedge that articulates with all other cranial bones
3. Consists of
   a. central body
   b. greater wings
   c. lesser wings
   d. pterygoid processes
4. Major markings
   a. sella turcica
   b. hypophyseal fossa
   c. pterygoid processes
5. Major openings
   a. foramina rotundum, ovale, and spinosum
   b. the optic canals
   c. superior orbital fissure

I. Ethmoid Bone
1. Most deep of the skull bones; lies between the sphenoid and nasal bones
2. Forms most of the bony area between the nasal cavity and the orbits
3. Major markings
   a. cribriform plate
   b. crista galli
   c. perpendicular plate
   d. nasal conchae
   e. ethmoid sinuses
J. Wormian Bones
   1. Tiny irregularly shaped bones that appear within sutures
K. Facial Bones
   1. Fourteen bones
      a. Unpaired
         1. mandible
         2. vomer
      b. Paired
         1. maxillae
         2. zygomatic
         3. nasal
         4. lacrimal
         5. palatines
         6. inferior nasal conchae
L. Mandible and Its Markings
   1. largest, strongest bone of the face
   2. major markings
      a. coronoid process
      b. mandibular condyle
      c. alveolar margin
      d. mandibular and mental foramina
M. Maxillary Bones
   1. Medially fused bones that make up the upper jaw and the central portion of the facial skeleton
   2. Facial keystone bones that articulate with all other facial bones except the mandible
   3. major markings
      a. palatine, frontal, and zygomatic processes
      b. alveolar margin
      c. inferior orbital fissure
d. maxillary sinuses

**N. Zygomatic Bones**
1. Irregularly shaped bones (cheekbones) that form the prominences of the cheeks and the inferolateral margins of the orbits

**O. Other Facial Bones**
1. Nasal bones – thin medially fused bones that form the bridge of the nose
2. Lacrimal bones – contribute to the medial walls of the orbit and contain a deep groove called the lacrimal fossa that houses the lacrimal sac
3. Palatine bones – two bone plates that form portions of the hard palate, the posterolateral walls of the nasal cavity, and a small part of the orbits
4. Vomer – plow-shaped bone that forms part of the nasal septum
5. Inferior nasal conchae – paired, curved bones in the nasal cavity that form part of the lateral walls of the nasal cavity

**P. Orbits**
1. Bony cavities in which the eyes are firmly encased and cushioned by fatty tissue
2. Formed by parts of seven bones
   a. frontal
   b. sphenoid
   c. zygomatic
   d. maxilla
   e. palatine
   f. lacrimal
   g. ethmoid

**Q. Nasal Cavity**
1. Constructed of bone and hyaline cartilage

**R. Paranasal Sinuses**
1. Mucosa-lined, air-filled sacs found in five skull bones
   a. frontal
   b. sphenoid
   c. ethmoid
   d. paired maxillary bones
2. Air enters the paranasal sinuses from the nasal cavity and mucus drains into the nasal cavity from the sinuses
3. Lighten the skull and enhance the resonance of the voice

**S. Hyoid Bone**
1. Not actually part of the skull, but lies just inferior to the mandible in the anterior neck
2. Only bone of the body that does not articulate directly with another bone
3. Attachment point for neck muscles that raise and lower the larynx during swallowing and speech

II. The Vertebral Column
   A. Formed from 26 irregular bones (vertebrae) connected in such a way that a flexible curved structure results
      1. Cervical vertebrae – 7 bones of the neck
      2. Thoracic vertebrae – 12 bones of the torso
      3. Lumbar vertebrae – 5 bones of the lower back
      4. Sacrum – bone inferior to the lumbar vertebrae that articulates with the hip bones
   B. Vertebral Column: Curvatures
      1. Posteriorly concave curvatures – cervical and lumbar
      2. Posteriorly convex curvatures – thoracic and sacral
      3. Abnormal spine curvatures
         a. scoliosis (abnormal lateral curve)
         b. kyphosis (hunchback)
         c. lordosis (swayback)
   C. Vertebral Column: Ligaments
      1. Anterior and posterior longitudinal ligaments – continuous bands down the front and back of the spine from the neck to the sacrum
      2. Short ligaments connect adjoining vertebrae together
   D. Vertebral Column: Intervertebral Discs
      1. Cushion-like pad
   E. General Structure of Vertebrae
      1. Body – disc-shaped, weight-bearing region
      2. Vertebral arch – composed of pedicles and laminae that, along with the body, enclose the vertebral foramen
      3. Vertebral foramina – make up the vertebral canal through which the spinal cord passes
      4. Spinous processes project posteriorly
      5. Transverse processes project laterally
      6. Intervertebral foramina – lateral openings formed from notched areas on the superior and inferior borders of adjacent pedicles
F. Cervical Vertebrae
1. Seven vertebrae (C₁-C₇) are the smallest, lightest vertebrae
2. C₃-C₇ are distinguished with an oval body, short spinous
   processes, and large, triangular vertebral foramina
3. Each transverse process contains a transverse foramen

G. Cervical Vertebrae: The Atlas (C₁)
1. The atlas has no body and no spinous process
2. It consists of anterior and posterior arches, and two lateral
   masses
3. The superior surfaces of lateral masses articulate with the
   occipital condyles

H. Cervical Vertebrae: The Axis (C₂)
1. The axis has a body, spine, and vertebral arches as do other
   cervical vertebrae
2. Unique to the axis is the dens, or odontoid process, which
   projects superiorly from the body and is cradled in the anterior
   arch of the atlas
3. The dens is a pivot for the rotation of the atlas

I. Thoracic Vertebrae
1. There are twelve vertebrae (T₁-T₁₂) all of which articulate with
   ribs
2. Major markings
   a. two facets
   b. two demifacets on the heart-shaped body
   c. circular vertebral foramen
   d. transverse processes
   e. long spinous process
3. The location of the articulate facets prevents flexion and
   extension, but allows rotation of this area of the spine

J. Lumbar Vertebrae
1. The five lumbar vertebrae (L₁-L₅) are located in the small of the
   back and have an enhanced weight-bearing function
2. They have short, thick pedicles and laminae, flat hatchet-shaped
   spinous processes, and a triangular-shaped vertebral foramen
3. Orientation of articular facets locks the lumbar vertebrae
   together to provide stability

K. Sacrum
1. Consists of five fused vertebrae (S₁-S₅), which shape the
   posterior wall of the pelvis
2. It articulates with L₅ superiorly, and with the auricular surfaces of the hip bones
3. Major markings
   a. sacral promontory
   b. transverse lines
   c. alae
e. dorsal sacral foramin
   f. acral canal
   e. sacral canal

L. Coccyx (Tailbone)
   1. The coccyx is made up of four (in some cases three to five) fused vertebrae that articulate superiorly with the sacrum

J. Bony Thorax (Thoracic Cage)
   1. The thoracic cage is composed of the thoracic vertebrae dorsally, the ribs laterally, and the sternum and costal cartilages anteriorly
   2. Functions
      a. Forms a protective cage around the heart, lungs, and great blood vessels
      b. Supports the shoulder girdles and upper limbs
      c. Provides attachment for many neck, back, chest, and shoulder muscles
e. Uses intercostal muscles to lift and depress the thorax during breathing

K. Sternum (Breastbone)
   1. A dagger-shaped, flat bone that lies in the anterior midline of the thorax
   2. Results from the fusion of three bones
      a. manubrium
      b. body
      c. xiphoid process
   3. Anatomical landmarks
      a. jugular (suprasternal) notch
      b. the sternal angle
c. xiphisternal joint

L. Ribs
   1. There are twelve pair of ribs forming the flaring sides of the thoracic cage
   2. All ribs attach posteriorly to the thoracic vertebrae
a. The superior 7 pair (true ribs) attach directly to the sternum via costal cartilages
b. Ribs 8-10 (false ribs) attach indirectly to the sternum via costal cartilage
c. Ribs 11-12 (floating ribs) have no anterior attachment

Part 2: The Appendicular Skeleton

I. Pectoral Girdles (Shoulder Girdles)
   A. Consist of the anterior clavicles and the posterior scapulae
   B. Attach the upper limbs to the axial skeleton in a manner that allows for maximum movement
   C. Provide attachment points for muscles that move the upper limbs
   D. Clavicles (Collarbones)
      1. Slender, doubly curved long bones lying across the superior thorax
      2. The acromial (lateral) end articulates with the scapula, and the sternal (medial) end articulates with the sternum
      3. Provide attachment points for numerous muscles
      4. Act as braces to hold the scapulae and arms out laterally away from the body
   E. Scapulae (Shoulder Blades)
      1. Triangular, flat bones lying on the dorsal surface of the rib cage, between the second and seventh ribs
      2. Scapulae have three borders and three angles
      3. Major markings
         a. suprascapular notch
         b. supraspinous and infraspinous fossae
         c. spine
         d. acromion
         e. coracoid process

II. The Upper Limb
   A. Consists of
      1. arm (brachium)
      2. forearm (antebrachium)
      3. hand (manus)
   B. Thirty-seven bones form the skeletal framework of each upper limb
   C. The humerus is the sole bone of the arm
D. It articulates with the scapula at the shoulder, and the radius and ulna at the elbow

E. Major markings
   1. Proximal humerus includes
      a. head
      b. anatomical and surgical necks
      c. greater and lesser tubercles
      d. intertubercular groove
   2. Distal humerus includes
      a. capitulum
      b. trochlea
      c. medial and lateral epicondyles
      d. coronoid and olecranon fossae
   3. Medial portion includes
      a. radial groove
      b. deltoid process

F. Forearm
   1. Bones of the forearm
      a. radius
      b. ulna
   2. They articulate proximally with the humerus and distally with the wrist bones
   3. They also articulate with each other proximally and distally at small radioulnar joints

G. Ulna
   1. The ulna lies medially in the forearm and is slightly longer than the radius
   2. Forms the major portion of the elbow joint with the humerus
   3. Major markings
      a. olecranon
      b. coronoid process
      c. trochlear notch
      d. radial notch
      e. styloid process

H. Radius
   1. The radius lies opposite (lateral to) the ulna and is thin at its proximal end, widened distally
   2. The superior surface of the head articulates with the capitulum of the humerus
   3. Medially, the head articulates with the radial notch of the ulna
4. Major markings
   a. radial tuberosity
   b. ulnar notch
   c. styloid process

I. Hand
   1. Skeleton of the hand contains
      a. wrist bones (carpals)
      b. bones of the palm (metacarpals)
      c. bones of the fingers (phalanges)

J. Carpus (Wrist)
   1. Consists of eight bones
      a. Proximally
         1. scaphoid
         2. lunate
         3. triquetral
         4. pisiform
      b. Distally
         1. Trapezium
         2. trapezoid
         3. capitate
         4. hamate

K. Metacarpus (Palm)
   1. Five numbered (1-5) metacarpal bones radiate from the wrist to form the palm
   2. Their bases articulate with the carpals proximally, and with each other medially and laterally
   3. Heads articulate with the phalanges

L. Phalanges (Fingers)
   1. Each hand contains 14 miniature long bones called phalanges
   2. Fingers (digits) are numbered 1-5, beginning with the thumb (pollex)
   3. Each finger (except the thumb) has three phalanges – distal, middle, and proximal
   4. The thumb has no middle phalanx

III. Pelvic Girdle (Hip)
   A. The hip is formed by a pair of hip bones (os coxae, or coxal)
   B. Together with the sacrum and the coccyx, these bones form the bony pelvis
   C. The pelvis
1.Attaches the lower limbs to the axial skeleton with the strongest ligaments of the body
2.Transmits weight of the upper body to the lower limbs
3.Supports the visceral organs of the pelvis

D. Ilium
1. The ilium is a large flaring bone that forms the superior region of the coxal bone
2. It consists of a body and a superior winglike portion called the ala
3. The broad posterolateral surface is called the gluteal surface
4. The auricular surface articulates with the sacrum (sacroiliac joint)
5. Major markings
   a. iliac crests
   b. four spines
   c. greater sciatic notch
   d. iliac fossa
   e. arcuate line
   f. pelvic brim

E. Ischium
1. The ischium forms the posteroinferior part of the hip bone
2. The thick body articulates with the ilium, and the thinner ramus articulates with the pubis
3. Major markings include
   a. ischial spine
   b. lesser sciatic notch
   c. ischial tuberosity

F. Pubis
1. The pubic bone forms the anterior portion of the hip bone
2. It articulates with the ischium and the ilium
3. Major markings
   a. superior and inferior rami
   b. the pubic crest
   c. pubic tubercle
   d. pubic arch
   e. pubic symphysis
   f. obturator foramen (along with ilium and ischium)
4. Comparison of Male and Female Pelvic Structure
   a. Female pelvis
      1) Tilted forward, adapted for childbearing
2) True pelvis defines birth canal
3) Cavity of the true pelvis is broad, shallow, and has greater capacity

b. Male pelvis
   1) Tilted less forward
   2) Adapted for support of heavier male build and stronger muscles
   3) Cavity of true pelvis is narrow and deep

IV. The Lower Limb
   A. The three segments of the lower limb
      1. thigh
      2. leg
      3. foot
   B. They carry the weight of the erect body, and are subjected to exceptional forces when one jumps or runs
   C. Femur
      1. The sole bone of the thigh is the femur, the largest and strongest bone in the body
      2. It articulates proximally with the hip and distally with the tibia and fibula
      3. Major markings
         a. head
         b. fovea capitis
         c. greater and lesser trochanters
         d. gluteal tuberosity
         e. lateral and medial condyles and epicondyles
         f. linea aspera
         g. patellar surface
         h. intercondylar notch
   D. Leg
      1. The tibia and fibula form the skeleton of the leg
      2. They are connected to each other by the interosseous membrane
      3. They articulate with the femur proximally and with the ankle bones distally
      4. They also articulate with each other via the immovable tibiofibular joints
   E. Tibia
1. Receives the weight of the body from the femur and transmits it to the foot
2. Major markings
   a. medial and lateral condyles
   b. intercondylar eminence
   c. tibial tuberosity
   d. anterior crest
   e. medial malleolus
   f. fibular notch

F. Fibula
   a. Sticklike bone with slightly expanded ends located laterally to the tibia
   b. Major markings
      a. head
      b. lateral malleolus

G. Foot
   1. The skeleton of the foot includes the tarsus, metatarsus, and the phalanges (toes)
   2. The foot supports body weight and acts as a lever to propel the body forward in walking and running

H. Tarsus
   1. Composed of seven bones that form the posterior half of the foot
   2. Body weight is carried primarily on the talus and calcaneus
   3. Talus articulates with the tibia and fibula superiorly, and the calcaneus inferiorly
   4. Other tarsus bones
      a. cuboid
      b. navicular
      c. medial cuneiform
      d. intermediate cuneiform
      e. lateral cuneiforms

I. Calcaneus
   1. Forms the heel of the foot
   2. Carries the talus on its superior surface
   3. Point of attachment for the calcaneal (Achilles) tendon of the calf muscles

J. Metatarsals
   1. Five (1-5) long bones that articulate with the proximal phalanges
   2. The enlarged head of metatarsal 1 forms the “ball of the foot”
K. Phalanges
1. The 14 bones of the toes
2. Each digit has three phalanges except the hallux, which has no middle phalanx

L. Arches of the Foot
1. The foot has three arches maintained by interlocking foot bones and strong ligaments
2. Arches allow the foot to hold up weight
3. The arches are:
   a. Lateral longitudinal – cuboid is keystone of this arch
   b. Medial longitudinal – talus is keystone of this arch
   c. Transverse – runs obliquely from one side of the foot to the other

V. Developmental Aspects
A. Fetal Skull
1. Infant skull has more bones than the adult skull
2. At birth, fetal skull bones are incomplete and connected by fontanels
3. Fontanels
   a. Unossified remnants of fibrous membranes between fetal skull bones
   b. The four fontanels
      1) anterior
      2) posterior
      3) mastoid
      4) sphenoid

B. Growth Rates
1. At birth, the cranium is huge relative to the face
2. Mandible and maxilla are foreshortened but lengthen with age
3. The arms and legs grow at a faster rate than the head and trunk, leading to adult proportions

C. Spinal Curvature
1. Only thoracic and sacral curvatures are present at birth
2. The primary curvatures are convex posteriorly, causing the infant spine to arch like a four-legged animal
3. Secondary curvatures – cervical and lumbar – are convex anteriorly and are associated with the child’s development

D. Old Age
1. Intervertebral discs become thin, less hydrated, and less elastic
2. Risk of disc herniation increases
3. Loss of stature by several centimeters is common after age 55
4. Costal cartilages ossify causing the thorax to become rigid
5. All bones lose mass