Chapter 08
Lecture Outline

See separate PowerPoint slides for all figures and tables pre-inserted into PowerPoint without notes.
Introduction

- Many organs are named for their relationships to nearby bones
- Understanding muscle movements also depends on knowledge of skeletal anatomy
- Positions, shapes, and processes of bones can serve as landmarks for clinicians
Overview of the Skeleton

- **Axial skeleton** is colored **beige**
  - Forms central supporting axis of body
  - Skull, vertebrae, sternum, ribs, sacrum, and hyoid

- **Appendicular skeleton** is colored **green**
  - Pectoral girdle
  - Upper extremity
  - Pelvic girdle
  - Lower extremity

Figure 8.1
Bones of the Skeletal System

• **Number of bones**
  – **206** in typical adult skeleton
    • Varies with development of **sesamoid bones**
      – Bones that form within tendons (e.g., patella)
    • Varies with presence of **sutural (wormian) bones** in skull
      – Extra bones that develop in skull suture lines
  – **270** bones at birth, but number decreases with fusion
Anatomical Features of Bones

• **Bone markings**—ridges, spines, bumps, depressions, canals, pores, slits, cavities, and articular surfaces

• **Ways to study bones**
  – Articulated skeleton: held together by wire and rods, shows spatial relationships between bones
  – Disarticulated bones: taken apart so their surface features can be studied in detail
# Anatomical Features of Bones

**TABLE 8.2 Anatomical Features (Markings) of Bones**

<table>
<thead>
<tr>
<th>Term</th>
<th>Description and Example</th>
<th>Depression</th>
<th>Passages and cavities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Articulations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condyle</td>
<td>A rounded knob that articulates with another bone (occipital condyles of the skull)</td>
<td>Alveolus</td>
<td>Canal</td>
</tr>
<tr>
<td>Facet</td>
<td>A smooth, flat, slightly concave or convex articular surface (articular facets of the vertebrae)</td>
<td>Fossa</td>
<td>Fissure</td>
</tr>
<tr>
<td>Head</td>
<td>The prominent expanded end of a bone, sometimes rounded (head of the femur)</td>
<td>Fovea</td>
<td>Foramen</td>
</tr>
<tr>
<td>Extensions and projections</td>
<td></td>
<td>Sulcus</td>
<td>Meatus</td>
</tr>
<tr>
<td>Crest</td>
<td>A narrow ridge (iliac crest of the pelvis)</td>
<td>Depression</td>
<td>Sinus</td>
</tr>
<tr>
<td>Epicondyle</td>
<td>An expanded region superior to a condyle (medial epicondyle of the femur)</td>
<td>A hole through a bone, usually round (foramen magnum of the skull)</td>
<td>An air-filled space in a bone (frontal sinus of the forehead)</td>
</tr>
<tr>
<td>Line</td>
<td>A slightly raised, elongated ridge (nuchal lines of the skull)</td>
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</tr>
<tr>
<td>Process</td>
<td>Any bony prominence (mastoid process of the skull)</td>
<td></td>
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</tr>
<tr>
<td>Protuberance</td>
<td>A bony outgrowth or protruding part (mental protuberance of the chin)</td>
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<td></td>
</tr>
<tr>
<td>Spine</td>
<td>A sharp, slender, or narrow process (mental spines of the mandible)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trochanter</td>
<td>Two massive processes unique to the femur</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tubercle</td>
<td>A small, rounded process (greater tubercle of the humerus)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tuberosity</td>
<td>A rough elevated surface (tibial tuberosity)</td>
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<td></td>
</tr>
</tbody>
</table>
Figure 8.2

(a) Skull (lateral view)
(b) Scapula (posterior view)
(c) Femur (posterior view)
(d) Humerus (anterior view)
The Skull

• Expected Learning Outcomes
  – Distinguish between cranial and facial bones.
  – Name the bones of the skull and the anatomical features.
  – Identify the cavities in the skull and in some of its individual bones.
  – Name the principal sutures that join the bones of the skull.
  – Describe some bones that are closely associated with the skull.
  – Describe the development of the skull from infancy through childhood.
The Skull

- **Skull**—most complex part of skeleton
- **22 bones** joined together by **sutures** (immovable joints)
- **Several cavities**—cranial cavity (brain case), orbits (eye sockets), nasal cavity, oral (buccal) cavity, middle- and inner-ear cavities, and paranasal sinuses
The Skull

- **Foramina**—holes that allow passage for nerves and blood vessels
- **Paranasal sinuses**—frontal, sphenoid, ethmoid, maxillary
  - Lined by mucous membrane and are air-filled
  - Act as chambers that add resonance to the voice; lighten the skull
Cranial Bones

- Cranium (braincase)
  - Meninges (membranes) separate brain from bones
    - Dura mater is thickest membrane
  - Consists of two parts: calvaria (skullcap) and cranial base

Figure 8.9
Cranial Bones

- **Base** is divided into three basins that comprise the cranial floor
  - **Anterior cranial fossa** holds the frontal lobe of the brain
  - **Middle cranial fossa** holds the temporal lobes of the brain
  - **Posterior cranial fossa** contains the cerebellum
- **8 cranial bones:** 1 frontal, 2 parietal, 2 temporal, 1 occipital, 1 sphenoid, 1 ethmoid
The Frontal Bone

- **Forms forehead** and part of the roof of the cranium
- **Coronal suture**—posterior boundary of frontal bone
- **Supraorbital margin**—ridge of bone deep to eyebrow
- **Supraorbital foramen** provides passage for nerve, artery, and vein
- **Glabella**—smooth area above root of the nose
- **Contains frontal sinus**
The Parietal Bones

- Form most of cranial roof and part of its lateral walls
- Bordered by four sutures
  - Sagittal: between parietal bones
  - Coronal: at anterior margin
  - Lambdoid: at posterior margin
  - Squamous: at lateral border
- Two temporal lines for attachment of the temporalis muscle

Figure 8.4a

Figure 8.6
The Temporal Bones

- Temporal bone: lateral wall and part of floor of cranial cavity
- Four parts: squamous, tympanic, mastoid, and petrous
- Squamous part
  - Encircled by squamous suture
  - Zygomatic process
  - Mandibular fossa
- Tympanic part
  - External auditory meatus
  - Styloid process
- Mastoid part
  - Mastoid process
  - Mastoid notch
  - Mastoid foramen
  - Stylomastoid foramen
The Temporal Bones (Continued)

- **Petrosus part**
  - Part of cranial floor
  - Separates middle from posterior cranial fossa
  - Houses middle- and inner-ear cavities
  - Receptors for hearing and balance
  - Internal auditory meatus—opening for CN VIII (vestibulocochlear nerve)
  - Carotid canal
  - Jugular foramen
The Temporal Bones

Figure 8.10
The Occipital Bone

- Rear and base of skull
- **Foramen magnum** opening for spinal cord
- **Basilar part**—thick median plate
- **Occipital condyles**—knobs resting on spinal column
  - **Condylar canal**, posterior to occipital condyle (only present in some people)
- **Hypoglossal canal** transmits hypoglossal nerve (CN XII)
- **External occipital protuberance** for nuchal ligament
- **Superior and inferior nuchal lines** for neck muscle attachment

Figure 8.5a
The Sphenoid Bone

- Body
- Greater wing
- Lesser wing
- Optic canal
- Anterior clinoid processes
- Superior orbital fissure
- Sella turcica
The Sphenoid Bone

- Foramen rotundum
- Foramen ovale
- Foramen lacerum
- Posterior nasal apertures or choanae
- Medial and lateral pterygoid plates
- Sphenoid sinus
The Sphenoid Bone

Figure 8.4b
The Sphenoid Bone

Figure 8.5a
The Ethmoid Bone

- Located between eyes
- Contributes to medial wall of orbit, walls and roof of nasal cavity, and nasal septum
- **Perpendicular plate** forms superior two-thirds of nasal septum
- **Cribriform plate** forms roof of nasal cavity
- Crista galli: blade, attachment for dura
- **Cribriform (olfactory) foramina**
- **Labyrinth** forms lateral masses
  - Ethmoidal cells
  - Orbital plate

Figure 8.12
The Ethmoid Bone

Figure 8.14
The Ethmoid Bone

Superior and middle nasal conchae—scroll-like plates that project into the nasal fossa

Along with an inferior concha (a separate bone), these plates occupy most of the nasal cavity, create turbulence of airflow, and help humidify air
The Ethmoid Bone

Figure 8.13
Facial Bones

- **Facial bones (14)**—skull bones anterior to the cranial cavity (do not enclose brain)
  - Support teeth
  - Give shape to face
  - Form part of orbital and nasal cavities
  - Provide attachments for muscles of facial expression and mastication

  2 maxillae
  2 palatine bones
  2 zygomatic bones
  2 lacrimal bones

  2 nasal bones
  2 inferior nasal conchae

  1 vomer
  1 mandible
The Maxillae

- Largest facial bones
- Forms upper jaw and meets at median **intermaxillary suture**
  - **Alveolar processes**: bony points between teeth
  - **Alveolus**: sockets that hold teeth
  - Cleft palate and cleft lip occur when the two maxillae fail to join at the suture

Figure 8.3
The Maxillae

Figure 8.5a
The Maxillae

(Continued)

- Forms inferomedial wall of orbit
  - Infraorbital foramen
  - Inferior orbital fissure

- Forms most of the **hard palate**
  - Forms roof of mouth and floor of nasal cavity
  - Palate allows us to chew while breathing
  - Palatine process
  - Incisive foramen
The Maxillae

- **Maxillary sinus** fills maxillae bone
- Larger in volume than frontal, sphenoid, and ethmoid sinuses
The Palatine Bones

- L-shaped bones
- Form posterior portion of the hard palate
- Part of lateral nasal cavity wall
- Part of the orbital floor
- Greater palatine foramina

Figure 8.13
Figure 8.5a
The Zygomatic Bones

- Form angles of cheekbones and part of each lateral orbital wall
- Zygomaticofacial foramen
- Zygomatic arch is formed from temporal process of zygomatic bone and zygomatic process of temporal bone
The Lacrimal Bones

- Form part of medial wall of each orbit
- Smallest bone of skull
- Lacrimal fossa houses lacrimal sac
  - Tears collect in sac and drain into nasal cavity
The Nasal Bones

- Form bridge of nose
- Support cartilages that shape lower portion of the nose
- Often fractured
The Inferior Nasal Conchae

- Inferior nasal concha is largest of three conchae in the nasal cavity
  - It is separate from the other conchae that are parts of the ethmoid bone
The Vomer

Inferior half of the nasal septum
– Inferior to perpendicular plate of ethmoid

Supports cartilage that forms anterior part of nasal septum

Figure 8.4b
The Mandible

- **Strongest bone of skull**
  - Only one to noticeably move

- **Supports lower teeth**
  - **Alveolar processes** between teeth

- **Provides attachments for muscles of expression and mastication**

- **Mental symphysis**—joint at midline
  - Ossifies in early childhood
  - **Mental protuberance**—point of chin

- **Mental foramen** on anterolateral surface
  - For nerves and vessels of chin

- **Mandibular foramen** on medial surface
  - For nerves and vessels of lower teeth
The Mandible

- **Major parts**
  - **Body**: supports teeth
  - **Ramus**: articulates with cranium
  - **Angle**—where body meets ramus

- **Features of ramus**
  - **Condylar process** with mandibular condyle that articulates with temporal bone forming **TMJ** (temporomandibular joint)
  - **Coronoid process** for temporalis muscle
  - **Mandibular notch** between processes
Bones Associated with the Skull

• **Auditory ossicles**
  – Three in each middle-ear cavity
  – **Malleus, incus, and stapes**

• **Hyoid bone**
  – Slender U-shaped bone between chin and larynx
  – Does not articulate with any other bone
  – Suspended from styloid process of skull
  – **Body and greater and lesser horns (cornua)**
  – Fractured hyoid bone is evidence of strangulation
The Skull in Infancy and Childhood

- **Fontanels**—spaces between unfused cranial bones
  - Contain fibrous membrane
  - Allow shifting of bones during birth and growth of brain
  - Anterior, posterior, **sphenoid** (anterolateral), and **mastoid** (posterolateral) fontanels

- Two frontal bones fuse by age 6 (**metopic suture**)

- Skull approaches adult size by 8 or 9 years of age
The Vertebral Column and Thoracic Cage

• Expected Learning Outcomes
  – Describe the general features of the vertebral column and those of a typical vertebra.
  – Describe the structure of the intervertebral discs and their relationship to the vertebrae.
  – Describe the special features of vertebrae in different regions of the vertebral column, and discuss the functional significance of the regional differences.
  – Describe the anatomy of the sternum and ribs and how the ribs articulate with the thoracic vertebrae.
General Features of the Vertebral Column

- **Functions of spine**
  - Supports skull and trunk and allows for their movement
  - Protects spinal cord
  - Absorbs stresses of movements
  - Provides attachments for limbs, thoracic cage, and postural muscles

- **33 vertebrae with intervertebral discs** between most of them
  - Discs account for about one-quarter of spine’s 71 cm length (on average)
  - Discs compress a bit during the day due to pressure of body weight

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<table>
<thead>
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<th>Anterior view</th>
<th>Posterior view</th>
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<td><strong>Cervical vertebrae</strong></td>
<td></td>
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<tr>
<td>Atlas (C1)</td>
<td>Axis (C2)</td>
</tr>
<tr>
<td>T1</td>
<td></td>
</tr>
<tr>
<td>T12</td>
<td></td>
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<tr>
<td>L1</td>
<td></td>
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<td>L5</td>
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<tr>
<td>S1</td>
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<tr>
<td>S5</td>
<td></td>
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<tr>
<td>Coccyx</td>
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<table>
<thead>
<tr>
<th><strong>Thoracic vertebrae</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>C7</td>
</tr>
<tr>
<td>T1</td>
</tr>
<tr>
<td>T12</td>
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<tr>
<td>L1</td>
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<td>L5</td>
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<tr>
<td>S1</td>
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<tr>
<td>S5</td>
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<tr>
<td>Coccyx</td>
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<table>
<thead>
<tr>
<th><strong>Lumbar vertebrae</strong></th>
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<tr>
<td>S1</td>
</tr>
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<td>S5</td>
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<tr>
<td>Coccyx</td>
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<tr>
<th><strong>Sacrum</strong></th>
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<tbody>
<tr>
<td>S1</td>
</tr>
<tr>
<td>S5</td>
</tr>
<tr>
<td>Coccyx</td>
</tr>
</tbody>
</table>

Figure 8.18
General Features of the Vertebral Column

- **Five vertebral groups**
  - 7 cervical in the neck
  - 12 thoracic in the chest
  - 5 lumbar in lower back
  - 5 fused sacral at base of spine
  - 4 fused coccygeal

- **Variations in number of vertebrae occur in 1 in 20 people**
  - Generally in the number of fused vertebrae in inferior part of spine

Figure 8.18
General Features of the Vertebral Column

- **Primary curvature**: spine exhibits one continuous C-shaped curve at birth (convex)
  - This persists as the curvature of the thoracic and pelvic spine
- **With crawling and walking, secondary curvatures** develop in cervical and lumbar areas (concave)
  - Vertebral column is S-shaped beyond the age of 3 years

Figure 8.20
General Features of the Vertebral Column

- S-shaped vertebral column with four normal curvatures
  - Cervical
  - Thoracic
  - Lumbar
  - Pelvic

Figure 8.19
Abnormal Spinal Curvatures

- Abnormalities result from disease, paralysis of trunk muscles, poor posture, pregnancy, or congenital defects

- **Scoliosis**—abnormal lateral curvature
  - Most common
  - Usually in thoracic region
  - Particularly of adolescent girls
  - Developmental abnormality in which the body and arch fail to develop on one side of the vertebrae

Figure 8.21
Abnormal Spinal Curvatures

- **Kyphosis** (hunchback)—exaggerated thoracic curvature
  - Usually from osteoporosis, also osteomalacia or spinal tuberculosis, wrestling or weight lifting in young boys

- **Lordosis** (swayback)—exaggerated lumbar curvature
  - From pregnancy or obesity
General Structure of Vertebra

- **Body (centrum)**
  - Spongy bone (with red marrow) covered with a shell of compact bone
  - Weight-bearing portion
  - Rough surfaces enhance attachment of intervertebral discs

- **Vertebral foramina**
  - Collectively form **vertebral canal** for spinal cord

- **Vertebral arch**
  - **Pedicle**: pillar-like
  - **Lamina**: plate-like

- **Spinous process**
  - Projects from arch
  - Bump that is visible under skin

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Figure 8.22a

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General Structure of Vertebra

- **Transverse process**
  - Extends laterally from point where pedicel and lamina meet

- **Superior articular processes**
  - Project upward from one vertebra and meets **inferior articular processes** from the vertebra above

- **Facets**
  - Flat articular surfaces covered with hyaline cartilage
General Structure of Vertebra

- **Intervertebral foramen**
  - Opening between pedicles of two adjoining vertebrae
  - Passageway for spinal nerves
  - **Inferior vertebral notch** in the pedicle of the upper vertebra
  - **Superior vertebral notch** in the pedicle of the lower vertebra

Figure 8.23b
Intervertebral Discs

- **Intervertebral discs (23)**
  - Pad consisting of:
    - **Nucleus pulposus**—inner gelatinous mass
    - **Anulus fibrosus**—outer ring of fibrocartilage
  - Bind vertebrae together
  - Support weight of the body
  - Absorb shock
  - **Herniated disc** ("ruptured" or "slipped" disc) puts painful pressure on spinal nerve or spinal cord
Regional Characteristics of Vertebrae

- **Cervical vertebrae** (C1-C7) are small and light
- **Bifid** or forked spinous processes in C2 to C6
- **Small body and large vertebral foramen**
- **Transverse foramen** in each short transverse process
  - Provides passage for vertebral artery and vertebral vein
- **C1 = atlas; C2 = axis**
- **C7 = vertebra prominens**—prominent spinous process

Figure 8.25a
Cervical Vertebrae

- **Atlas (C1)**
  - Supports the head
  - Has no body; consists of delicate ring around large vertebral foramen
  - **Lateral masses**
    - **Superior articular facets** articulate with occipital condyles forming *atlanto–occipital joint*; allows nodding “yes”
    - **Inferior articular facets** articulate with C2
  - **Anterior and posterior arches**
    - **Anterior and posterior tubercles**

Figure 8.24a
Cervical Vertebrae

- **Axis (C2)**
  - Allows head rotation gesturing “no”
  - **Dens** or **odontoid process**—prominent knob on its anterosuperior side
    - Fuses with axis by age 3 to 6 years
    - Projects into **vertebral foramen** of the atlas
    - Held in place by a **transverse ligament**
  - **Atlantoaxial joint:** between atlas and axis

Figure 8.24b
Atlas and Axis Articulation

Axis of rotation
Dens
Transverse ligament
Atlas
Axis

(c) Atlantoaxial joint

Figure 8.24c
The Thoracic Vertebrae

- 12 thoracic vertebrae (T1–T12)
  - Correspond to the 12 pairs of ribs attached to them
- **Spinous processes** pointed and angled sharply downward
- **Have larger body than cervical, but smaller than lumbar**
- **Superior and inferior costal facets** for attachment of ribs
  - On body as small, smooth, slightly concave spots
- **Transverse costal facets** at end of each transverse process T1–T10
  - Provide second point of articulation for ribs 1–10
The Lumbar Vertebrae

- Five lumbar vertebrae (L1–L5)
- Thick, stout body
- Blunt, squarish spinous process
- Superior articular processes face medially
  - Lumbar region resistant to twisting movements
The Sacrum

- **Sacrum**—bony plate that forms posterior wall of pelvic cavity

- **Five separate sacral vertebrae** (S1–S5) begin fusing around age 16 and complete fusion by age 26

- **Anterior surface**
  - Smooth and concave
  - Four transverse lines indicate regions of fusion
  - Four pairs of large anterior sacral (pelvic) foramina
    - Allow passage of nerves and arteries to pelvic organs
  - **Sacral promontory**—ridge jutting from front of S1

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Figure 8.26a

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The Sacrum

(Continued)

- **Posterior surface very rough**
  - Median sacral crest—fusion of spinous processes
  - Lateral sacral crests—fusion of transverse processes
  - Posterior sacral foramina—four pairs of openings for nerves to gluteal region and lower limbs

**Sacral canal** runs vertically through sacrum and ends as **sacral hiatus**
- Contains spinal nerve roots

- **Auricular surface** is part of **sacroiliac (SI) joint** formed with hip bone

- **Superior articular processes** on S1; articulates with L5

- **Alae**—pair of large, wing-like extensions lateral to the superior articular processes

Figure 8.26b
The Coccyx

- **Coccyx**—usually consists of four small vertebrae (Co1–Co4); sometimes five
- **Fuse into single, triangular bone by age 20 to 30**
- **Horns (cornua) on Co1**
  - Serve as attachment points for ligaments that bind coccyx to sacrum
- **Fractured during difficult childbirth or by hard fall**
- **Provides attachment for muscles of the pelvic floor**

![Figure 8.26b](image_url)
The Thoracic Cage

- Thoracic cage consists of thoracic vertebrae, sternum, and ribs
- Encloses lungs and heart
  - Also provides some protection of spleen, liver, kidneys
- Provides attachment for pectoral girdle and upper limbs
- Broad base, narrower apex
- Rhythmically expanded by respiratory muscles to draw air into lungs
- Costal margin—inferior border of thoracic cage formed by arc of lower ribs

Figure 8.27
The Sternum

- **Sternum** (breastbone)—bony plate anterior to the heart
- **Divided into three regions**
  - **Manubrium**
    - Broad superior portion
    - **Suprasternal (jugular) notch**
    - **Clavicular notches**—articulate with clavicle
  - **Body (gladiolus)**
    - Longest part of sternum
    - **Sternal angle**—point where body joins manubrium
    - Ribs attach along scalloped lateral margins
  - **Xiphoid**
    - Inferior point of sternum
    - Attachment for some abdominal muscles
    - CPR (cardiopulmonary resuscitation) should avoid pressure against the xiphoid to avoid internal bleeding
The Ribs

- **12 pairs** of ribs
  - Posterior (proximal) ends attached to vertebral column
  - Most ribs’ anterior (distal) ends attached to sternum
- Costal cartilages (made of hyaline cartilage) attach rib to sternum

Figure 8.27
The Ribs

- **Head**—portion of rib that articulates with bodies of thoracic vertebrae
  - Superior and inferior articular facets
- **Neck**—narrow portion distal to the head
- **Tubercle**—wider, rough area distal to the neck
  - Articulates with transverse costal facet of vertebra

Figure 8.28b

Figure 8.29b
The Ribs

- **Angle**—lateral curve of rib
- **Shaft**—long, gentle sloping, blade-like portion of rib
  - Costal groove on inferior margin of shaft

Figure 8.28b
The Ribs

Figure 8.29

(a) Anterior view

Vertebral body T5
Vertebral body T6

Rib 6

Inferior costal facet of T5
Superior articular facet of rib 6
Inferior articular facet of rib 6
Superior costal facet of T6

(b) Superior view

Superior articular facet
Transverse costal facet for rib 6
Tubercle
T6
Rib 6
Superior costal facet for rib 6
Neck
Head

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The Ribs

- **True ribs (ribs 1–7)**
  - Each is directly connected to sternum

- **False ribs (ribs 8–12)**
  - Lack independent connections to sternum
  - **Floating ribs (ribs 11–12)**
    - Do not have cartilaginous connection to sternum or higher costal cartilages
    - Do not have tubercles or attachments to transverse processes of vertebra
The Pectoral Girdle and Upper Limb

• Expected Learning Outcome
  – Identify and describe the features of the clavicle, scapula, humerus, radius, ulna, and bones of the wrist and hand.
The Pectoral Girdle

- **Pectoral girdle** (shoulder girdle) supports the arm
  - Consists of two bones on each side of the body
    - Clavicle (collarbone) and scapula (shoulder blade)
  - Clavicle articulates medially to the sternum and laterally to the scapula
    - Sternoclavicular joint
    - Acromioclavicular joint
  - Scapula articulates with the clavicle and the humerus
    - Glenohumeral joint: shoulder joint
    - Easily dislocated due to loose attachment
The Clavicle

- **Clavicle**—S-shaped, somewhat flattened bone
- **Sternal end**—hammer-like head
- **Acromial end**—flattened
- **Conoid tubercle**—rough bump near acromial end
- **Braces shoulder, keeps arm away from midline**
- **Frequently fractured**
The Scapula

- Scapula—named for resemblance to a shovel
- Triangular plate that posteriorly overlies ribs 2 to 7
  - Three sides: superior, medial, and lateral borders
  - Three angles: superior, inferior, and lateral angles
- Suprascapular notch—conspicuous notch on superior border
  - Provides passage for a nerve
- Spine—transverse ridge on posterior surface
  - Supraspinous fossa: indentation superior to the spine
  - Infraspinous fossa: broad surface inferior to the spine
The Scapula

• **Subscapular fossa**—concave, anterior surface of scapula

• **Lateral angle of scapula** has three main features
  – **Acromion**: plate-like extension of the spine
    • Forms apex of the shoulder
    • **Articulates with clavicle**—sole point of attachment of scapula and upper limb to the rest of the skeleton
  – **Coracoid process**: shaped like a bent finger
    • Provides attachment for tendons of biceps brachii and other arm muscles
  – **Glenoid cavity**: shallow socket that articulates with the head of the humerus
    • Helps form **glenohumeral joint**
The Scapula

Figure 8.31

- Superior border
- Acromion
- Coracoid process
- Glenoid cavity
- Supraspinous fossa
- Spine
- Infraspinous fossa
- Superior angle
- Lateral angle
- Subscapular fossa
- Lateral border
- Medial border
- Inferior angle

(a) Anterior view
(b) Posterior view
The Upper Limb

• Upper limb is divided into four regions containing a total of 30 bones per limb
  – Brachium (arm proper): extends from shoulder to elbow
    • Contains only 1 bone—humerus
  – Antebrachium (forearm): extends from elbow to wrist
    • Contains 2 bones—radius and ulna
  – Carpus (wrist)
    • Contains 8 small bones arranged in two rows
  – Manus (hand)
    • 19 bones in two groups
      – 5 metacarpals in palm
      – 14 phalanges in fingers
The Humerus

- **Proximal end**
  - Hemispherical head that articulates with the **glenoid cavity** of scapula
  - Anatomical neck
  - Greater and lesser tubercles and deltoid tuberosity
  - Intertubercular sulcus holds biceps tendon
  - Surgical neck

Figure 8.32
The Humerus

- **Distal end**
  - Rounded capitulum articulates with head of radius
  - **Trochlea** articulates with ulna
  - Lateral and medial epicondyles
  - Lateral and medial supracondylar ridges
  - Olecranon fossa holds olecranon process of ulna
  - Coronoid fossa
  - Radial fossa

Figure 8.32
The Radius

- **Radius**
  - **Head**: disc-shaped, allows for rotation during pronation and supination
    - Superior surface articulates with capitulum on humerus
    - Side of disc spins on radial notch on ulna
  - **Neck**
  - **Radial tuberosity** for biceps muscle
  - **Styloid process** can be palpated near thumb
  - **Ulnar notch** accommodates head of ulna

Figure 8.33
The Ulna

- **Ulna**
  - **Trochlear notch** articulates with trochlea of humerus
  - **Olecranon**: bony point at back of elbow
  - **Coronoid process**
  - **Radial notch** holds head of radius
  - **Styloid process**

- **Interosseous membrane**
  - Ligament attaches radius to ulna along interosseous margin of each bone

Figure 8.33
The Carpal Bones

• Eight bones form wrist
  – Allow movements of flexion, extension, abduction, and adduction

• Two rows (four bones each)
  – Proximal row: scaphoid, lunate, triquetrum, and pisiform
    • Pisiform is a sesamoid developed by age 9 to 12 in tendon of flexor carpi ulnaris muscle
  – Distal row: trapezium, trapezoid, capitate, and hamate
Figure 8.34a

- Distal phalanx II
- Middle phalanx II
- Proximal phalanx II
- Distal phalanx I
- Proximal phalanx I

Key to carpal bones:
- Distal row
- Proximal row

Phalanges
- Head
- Body
- Base

Metacarpal bones
- Head
- Body
- Base
- Hamulus of hamate
- Hamate
- Pisiform
- Triquetrum
- Lunate

Carpal bones
- Trapezoid
- Trapezium
- Capitate
- Scaphoid
The Metacarpal Bones and the Phalanges

- **Metacarpals**—bones of the palm
  - Metacarpal I proximal to base of thumb
  - Metacarpal V proximal to base of little finger
  - Proximal base, body, and distal head

- **Phalanges**—bones of the fingers
  - Thumb or pollex has two phalanges
    - Proximal, distal phalanx
  - Fingers have three phalanges
    - Proximal, middle, distal phalanx
The Right Wrist and Hand

Figure 8.34a
The Pelvic Girdle and Lower Limb

• Expected Learning Outcomes
  – Identify and describe the features of the pelvic girdle, femur, patella, tibia, fibula, and bones of the foot.
  – Compare the anatomy of the male and female pelvic girdles and explain the functional significance of the differences.
The Pelvic Girdle

- **Pelvic girdle**—a ring composed of three bones
  - Two **hip (coxal) bones**, also called **ossa coxae** or **innominate bones**
  - One **sacrum** (also part of vertebral column)

- **Pelvis**—the pelvic girdle plus ligaments and muscles that line the pelvic cavity and form its floor

Figure 8.35a
The Pelvic Girdle

- **Sacroiliac joint**—joins coxal bone to vertebral column
  - **Auricular surface of ileum** to **auricular surface** of sacrum

- **Pubic symphysis**—the interpubic disc (of fibrocartilage) joins pubic bones anteriorly
The Pelvic Girdle

- **Greater (false) pelvis**—between flare of the hips
- **Lesser (true) pelvis**—narrower and below
- **Pelvic brim**—round margin that separates the two
- **Pelvic inlet**—opening circumscribed by brim that infant’s head must pass during birth
- **Pelvic outlet**—lower margin of the lesser pelvis
The Pelvic Girdle

• Three distinct features of hip bone
  – Iliac crest: superior crest of hip
  – Acetabulum: hip socket
  – Obturator foramen: large hole below acetabulum

• Each adult hip bone is formed by the fusion of three childhood bones: ilium, ischium, pubis

(a) Lateral view

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The Pelvic Girdle

- **Ilium**
  - Largest bone in hip
  - Extends from iliac crest to center of the acetabulum
  - Anterior and posterior superior spine
  - Anterior and posterior inferior spines
  - Greater sciatic notch and iliac fossa

- **Ischium**
  - Inferioposterior portion of hip
  - Heavy body with prominent spine
  - Lesser sciatic notch
  - Ischial tuberosity
  - Ramus

- **Pubis (pubic bone)**
  - Most anterior portion of the hip bone
  - Body, superior, and inferior ramus
The Pelvic Girdle

- **Male**—heavier and thicker
- **Female**—wider and shallower, and adapted to the needs of pregnancy and childbirth, larger pelvic inlet and outlet for passage of infant’s head
# The Pelvic Girdle

<table>
<thead>
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<tr>
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<tr>
<td>Coccyx</td>
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</tbody>
</table>
The Lower Limb

- Lower limb divided into **four regions** containing **30 bones** per limb
  - **Femoral region (thigh):** extends from hip to knee region
    - Contains *femur* and *patella*
  - **Crural region (leg proper):** extends from knee to ankle
    - Contains medial *tibia* and lateral *fibula*
  - **Tarsal region (tarsus):** ankle—the union of the crural region with the foot
    - Tarsal bones are considered part of the foot
  - **Pedal region (pes):** foot
    - Composed of 7 tarsal bones, 5 metatarsals, and 14 phalanges in the toes
The Femur

- **Longest and strongest bone of the body**

- Hemispherical **head** articulates with acetabulum of pelvis
  - **Fovea capitis**: pit in head of femur for attachment of a ligament

- **Greater and lesser trochanters** for muscle attachment

- **Intertrochanteric crest**—thick ridge on posterior surface that connects the trochanters

- **Intertrochanteric line**—more delicate ridge on anterior surface that connects trochanters
The Femur

- **Linea aspera**—ridge on posterior of the shaft

- **Spiral (pectineal) line** and gluteal tuberosity

- **Medial and lateral condyles** and epicondyles found distally

- **Intercondylar fossa**

- **Patellar** and popliteal surface

Figure 8.38
The Patella

- **Patella**—triangular, sesamoid bone embedded in tendon of knee
- **Cartilaginous at birth**
  - Ossifies at age 3 to 6 years
- **Base**—broad, superior portion
- **Apex**—pointed, inferior portion
- **Articular facets**—shallow, posterior portion
- **Quadriceps tendon** extends from front of thigh to patella
  - Continues as the patellar ligament from patella to tibia

Figure 8.38
Tibia

- **Tibia**—thick, medial, leg bone
  - Only weight-bearing bone of the crural region
  - **Medial and lateral condyles**
    - Flat surfaces that articulate with condyles of femur
  - **Intercondylar eminence**—ridge separating condyles
  - **Tibial tuberosity**—attachment of patellar ligament, a continuation of quadriceps tendon
  - **Anterior border**—sharp, angular
  - **Medial malleolus**—bony knob on inside of ankle

Figure 8.39
The Fibula

- **Fibula**—slender, lateral strut that helps stabilize ankle
- **Does not bear any body weight**
- **Head**—proximal end
  - **Apex**—point of the head
- **Lateral malleolus**—distal expansion, bony knob on lateral side of ankle
- **Joined to tibia by interosseous membrane**

Figure 8.39
The Ankle and Foot

- **Tarsal bones**—in ankle
  - Differ from carpal bones due to load-bearing role of the ankle
- **Calcaneus**—largest tarsal bone
  - Forms heel
  - Distal portion is point of attachment for *calcaneal (Achilles)* tendon
- **Talus** is most superior tarsal bone
  - Forms ankle joint with tibia and fibula
  - Sits upon calcaneus and articulates with navicular
- **Proximal row** of tarsal bones
  - Talus, calcaneus, navicular
- **Distal row** of tarsal bones
  - Medial, intermediate, lateral cuneiforms and cuboid

Figure 8.40a
The Ankle and Foot

- The rest of the foot bones resemble the hand bones in name and arrangement

- **Metatarsals**
  - Metatarsal I is proximal to the great toe (hallux)
  - Metatarsal V is proximal to the little toe
  - Proximal base, intermediate shaft, and distal head

- **Phalanges**
  - Two in great toe
    - Proximal and distal phalanx
  - Three in all other toes
    - Proximal, middle, distal phalanx
The Ankle and Foot

- Rotation of upper and lower limbs in opposite directions
  - Starts seventh week of embryonic development
  - Largest digit medial in foot and lateral in hand
  - Each limb rotates about 90° in opposite directions
  - Rotation also explains why elbow flexes posteriorly and knee flexes anteriorly
The Ankle and Foot

- Sole of foot is not flat on ground
- Three springy arches absorb stress
  - Medial longitudinal arch
    - From heel to hallux
    - Formed from the calcaneus, talus, navicular, cuneiforms, and metatarsals I and III
  - Lateral longitudinal arch
    - From heel to little toe
    - Includes calcaneus, cuboid, and metatarsals IV and V

Figure 8.42a

(a) Inferior (plantar) view
The Ankle and Foot

- **Transverse arch**
  - Across middle of foot
  - Includes the cuboid, cuneiforms, and proximal heads of metatarsals
  - Arches held together by short, strong ligaments

- **Pes planus** (flat feet)—excessive weight, repetitious stress, or congenital weakness

Figure 8.42a (a) Inferior (plantar) view
Skeletal Adaptations for Bipedalism

• Humans are only animals habitually **bipedal**
  – 3.6-million-year-old human footprints indicate upright walking

• **Adaptations**
  – Strong, springy foot arches
  – Great toe not opposable
  – Femurs angle inward so knees are closer together—erect posture requires less muscular effort
  – Viscera supported in bowl-shaped pelvis
  – Insertions of gluteal muscles differ from other primates
Skeletal Adaptations for Bipedalism

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(a) Foot
(b) Knee

Chimpanzee
Human

Figure 8.43a,b
Skeletal Adaptations for Bipedalism

Figure 8.43c,d,e
Skeletal Adaptations for Bipedalism

(f) Skull

Chimpanzee

Human

Figure 8.43f

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