The Skeletal System

- overview of the skeleton
- the skull
- the vertebral column and thoracic cage
- the pectoral girdle and upper limb
- the pelvic girdle and lower limb

Figure 8.1a
Overview of the Skeleton

• **two regions** of the skeleton
  – **axial skeleton** – forms the central supporting axis of the body
    • skull, auditory ossicles, hyoid bone, vertebral column, and thoracic cage (ribs and sternum)
  – **appendicular skeleton** – includes the bones of the upper limb and pectoral girdle, and the bones of the lower limb and pelvic girdle
Anatomical Features of Bones

Figure 8.2

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

- **skull** – the most complex part of the skeleton
- **22 bones** joined together by **sutures** (immovable joints)
- **8 cranial bones** surround **cranial cavity** which encloses the **brain**
- **other cavities** – orbits, nasal cavity, oral (buccal) cavity, middle-, and inner ear cavities, and paranasal sinuses
- **paranasal sinuses** – frontal, sphenoid, ethmoid, and maxillary
  - lined by mucous membrane and air-filled
  - lighten the anterior portion of the skull
  - act as chambers that add resonance to the voice
- **foramina** – holes that allow passage for nerves and blood vessels
- **14 facial bones** support teeth, facial and jaw muscles
Major Skull Cavities

Figure 8.7

Cranial cavity

- Ethmoid air cells
- Zygomatic bone
- Maxilla
- Maxillary sinus
- Nasal cavity

Frontal bone

Ethmoid bone

Nasal conchae

Superior
Middle
Inferior

Vomer

Mandible

Oral cavity
Cranial Fossa

- **cranium (braincase)** – protects the brain and associated sense organs
  - swelling of the brain inside the rigid cranium may force tissue through foramen magnum resulting in death

- **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
Frontal Bone

- forms **forehead** and part of the roof of the cranium
- **coronal suture** – posterior boundary of frontal bone
- contains **frontal sinus**
Parietal Bone

- form most of cranial roof and part of its lateral walls
- bordered by 4 sutures
  - **sagittal** – between parietal bones
  - **coronal** – at anterior margin
  - **lambdoid** – at posterior margin
  - **squamous** – at lateral border

**Figure 8.4a**

**Figure 8.6**
Temporal Bone

- lateral wall and part of floor of cranial cavity
  - squamous part
    - encircled by squamous suture
    - zygomatic process
    - mandibular fossa
  - tympanic part
    - external auditory meatus
    - styloid process
  - mastoid part
    - mastoid process

Figure 8.4a
Temporal Bone

- part of cranial floor

- separates middle from posterior cranial fossa

- houses middle and inner ear cavities

- internal auditory meatus

Figure 8.5b
Occipital Bone

- rear and base of skull
- **foramen magnum** holds spinal cord
- skull rests on atlas at **occipital condyles**
Sphenoid Bone

- optic foramen

(b) Posterior view

(b) Superior view of cranial floor
Sphenoid Bone

Figure 8.11a

(a) Superior view

Figure 8.5b

(b) Superior view of cranial floor
Ethmoid Bone

- between the eyes
- contributes to medial wall of orbit
- lateral walls and roof of nasal cavity, and nasal septum
Ethmoid Bone

- Superior and middle concha
- Perpendicular plate of nasal septum
Facial Bones

- **facial bones** (14) – those that have no direct contact with the brain or meninges
  - support the teeth
  - give shape and individuality to the face
  - form part of the orbital and nasal cavities
  - provide attachments for muscles of facial expression and mastication

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</table>
Maxillary Bones

Figure 8.3

Frontal bone
Glabella
Coronal suture
Squamous suture
Sphenoid bone
Lacrimal bone
Nasal bone
Middle nasal concha
Infraorbital foramen
Vomer
Mandible
Sphenoid bone
Ethmoid bone
Nasal bone
Zygomatic bone
Maxilla
Mental foramen
Temporal bone
Supraorbital margin
Parietal bone
Ethmoid bone
Zygomatic bone
Inferior nasal concha
Maxilla
Mental protuberance

Figure 8.5a

Incisive foramen
Zygomatic bone
Zygomatic arch
Posterior nasal aperture
Vomer
Sphenoid bone
Mandibular fossa
Styloid process
External acoustic meatus
Occipital condyle
Mastoid process
Mastoid notch
Temporal bone
Condylar canal
Parietal bone
Inferior nuchal line
Superior nuchal line
Occipital bone
Palatine process of maxilla
Intermaxillary suture
Palatine bone
Greater palatine foramen
Medial pterygoid plate
Lateral pterygoid plate
Foramen ovale
Foramen spinosum
Foramen lacerum
Basilar part of occipital bone
Carotid canal
Stylohyoid foramen
Jugular foramen
Foramen magnum
Mastoid foramen
Lambdoid suture
External occipital protuberance

(a) Inferior view
Location of Maxillary Sinus

- **maxillary sinus** fills maxillae bone
- larger in volume than frontal, sphenoid and ethmoid sinuses
Palatine Bones

- form the posterior portion of the hard palate
Zygomatic Bones

- forms angles of the cheekbones and part of lateral orbital wall
- zygomatic arch is formed from temporal process of zygomatic bone and zygomatic process of temporal bone

Figure 8.4a
Lacrimal Bones

- form part of medial wall of each orbit
- smallest bone of skull
- **lacrimal fossa** houses lacrimal sac in life
  - tears collect in lacrimal sac and drain into nasal cavity

Figure 8.4a
Nasal Bones

- forms bridge of nose
- supports cartilages that shape lower portion of the nose
Vomer

- inferior half of the nasal septum
  - superior half formed by perpendicular plate of ethmoid

- supports cartilage that forms the anterior part of the nasal septum

Figure 8.4b
- strongest bone of the skull
- only bone of skull that moves noticeably
- supports lower teeth
- provides attachments for muscles of facial expression and mastication
Ramus, Angle and Body of Mandible

- **condylar process** bears the **mandibular condyle** – oval knob that articulates with the mandibular fossa of the temporal bone forming the hinge **temporomandibular joint (TMJ)**
- **coronoid process** – point of insertion of temporalis muscle

Figure 8.15

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Bones Associated With Skull

- auditory ossicles

- hyoid bone
  - slender u-shaped bone between the chin and larynx
  - does not articulate with any other bone
  - suspended from styloid process of skull by muscle and ligament

Figure 8.16

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Skull in Infancy and Childhood

- **fontanels** - spaces between unfused bones
  - filled with fibrous membrane
  - allow shifting of bones during birth and growth of brain
- two frontal bones fuse by age 6
- skull reaches adult size by 8 or 9 years of age

Figure 8.17
The Vertebral Column (Spine)

- **functions**
  - supports the skull and trunk
  - allows for their movement
  - protects the spinal cord
  - absorbs stress of walking, running, and lifting
  - provides attachments for limbs, thoracic cage, and postural muscles

- **33 vertebrae with intervertebral discs of fibrocartilage** between most of them
The Vertebral Column (Spine)

• 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

Figure 8.18
General Structure of Vertebra

- **body (centrum)**
  - weight bearing portion
  - rough superior and inferior surfaces provide firm attachment for intervertebral discs
- **vertebral foramina**
  - collectively form **vertebral canal** for spinal cord
- **spinous process**
  - projection extending from the apex of arch
  - extends posteriorly and downward
- **transverse process**
  - extends laterally
- **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

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**Figure 8.22**
Intervertebral Foramen and Discs

- **Intervertebral foramen**
  - passageway for spinal nerves

- **Intervertebral discs (23)**
  - first one between C2 and C3
  - last one between L5 and sacrum
  - 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

Figure 8.23b
Cervical Vertebra C1 + C2

† **atlas (C1)**
  † articulates with occipital condyles
  † allows nodding motion of skull gesturing ‘yes’

† **axis (C2)**
  † allows rotation of the head gesturing ‘no’
Cervical Vertebra C2 - Axis

• axis (C2)
  – allows rotation of the head gesturing ‘no’
Sacrum and Coccyx

**Sacrum** – bony plate that forms the posterior wall of the pelvic cavity in children, five separate sacral vertebrae

**Coccyx** – usually consists of four sometimes five, fuse into a single, triangular bone by age 20 – 30

Figure 8.26a
Thoracic Cage

- consists of thoracic vertebrae, sternum and ribs
- provides attachment for pectoral girdle and upper limbs

Figure 8.27
Sternum

- **sternum** (breastbone) – bony plate anterior to the heart
- divided into **three regions**:
  - Manubrium
  - body
  - xiphoid
Articulation of Rib 6 with Vertebrae T5 and T6

Figure 8.29
True and False Ribs

- **true ribs (ribs 1 to 7)**
  - each has its own costal cartilage connecting it to the sternum

- **false ribs (ribs 8-12)**
  - lack independent cartilaginous connection to the sternum
  - **floating ribs (ribs 11 – 12)**

Figure 8.27
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

• scapula articulates with the humerus
  – **glenohumeral joint** - shoulder joint
Clavicle

- **clavicle** - S-shaped, somewhat flattened bone
- **inferior** – grooves and ridges for muscle attachment
- **sternal end** - rounded head
- **acromial end** – flattened

- braces the shoulder keeping upper limb away from the midline of the body
Scapula

• scapula

• lateral angle of scapula has three main features:
  – acromion
    • forms apex of the shoulder
    • articulates with the clavicle
  – coracoid process
    • provides attachment for tendons of the biceps brachii and other arm muscles
  – glenoid cavity – shallow socket that articulates with the head of the humerus
    • forming glenohumeral joint
Scapula

Figure 8.31

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

• Humerus
• Radius and ulna
• Carpal bones (wrist)
• 5 metacarpals in palm
• 14 phalanges in fingers
**Humerus**

- **proximal end**
  - hemispherical **head** that articulates with the **glenoid cavity** of scapula
  - **greater** and **lesser tubercles** and deltoid tuberosity
  - **intertubercular sulcus** holds biceps tendon

- **distal end**
  - rounded **capitulum** articulates with head of radius
  - **trochlea** articulates with ulna
  - **lateral** and **medial epicondyles**
  - **olecranon fossa** holds olecranon process of ulna
Radius

- **radius**
  - **head** – disc-shape, allows for rotation around the longitudinal axis of the bone during pronation and supination of hand
    - superior surface articulates with **capitulum** on humerus
    - side of disc spins on **radial notch** on ulna
  - **radial tuberosity** for biceps muscle
  - **styloid process** can be palpated near thumb
  - **ulnar notch**
**Ulna and Interosseous Membrane**

- **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
  - enables the two elbow joints to share the load

*Figure 8.33*
Metacarpals and Phalanges

Figure 8.34a
• **pelvic girdle** – consists of a complete ring composed of three bones
  - two **hip (coxal) bones**
    - also called **ossa coxae** or **innominate bones**
  - **sacrum** that is also part of the vertebral column

• **pelvis** – bowl-shaped structure composed of the two coxal bones and sacrum as well as their ligaments and muscles that line the pelvic cavity and form its floor
  - supports trunk on the lower limbs and protects viscera, lower colon, urinary bladder, and internal reproductive organs

• **sacroiliac joint** - joins hipbone to the vertebral column
  - **auricular surface** of ileum to **auricular surface** of sacrum

• anteriorly, **interpubic disc** – pad of fibrocartilage joins pubic bones

• **pubic symphysis** – the interpubic disc and adjacent regions of the pubic bone on each side

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**Figure 8.35a**

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**Pelvic Girdle**
Pelvic Inlet and Outlet

- **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
• three distinct features of hip bone
  – iliac crest – superior crest of hip
  – acetabulum – the hip socket
  – obturator foramen – large hole below acetabulum

• each adult hip bone is formed by the fusion of three childhood bones
  – ileum
  – ischium
  – pubis (pubic bone)
Comparison of Male and Female

- Male - heavier and thicker due to forces exerted by stronger muscles
- Female - wider and shallower, and adapted to the needs of pregnancy and childbirth, larger pelvic inlet and outlet for passage of infant’s head

Figure 8.37

- Pelvic brim
- Pelvic inlet
- Obturator foramen
- Pubic arch

- Male: 90°
- Female: 120°
Lower Limb

- Femur (upper leg)
- Patella (knee cap)
- medial tibia and lateral fibula (lower leg)
- 7 tarsal bones, 5 metatarsals, and 14 phalanges in the toes (foot)
Femur

- **head** that articulates with the acetabulum of the pelvis
  - forms ball-and-socket joint
- **greater** and **lesser trochanters** for muscle attachment
- **medial** and **lateral condyles** and **epicondyles** found distally

Figure 8.38
Tibia

- **tibia** - thick, medial, weight-bearing bone
  - **medial** and **lateral condyles**
    - fairly flat articular surfaces
    - articulate with condyle of femur
  - **tibial tuberosity** – attachment of quadricep muscles
  - **medial malleolus** – bony knob on inside of ankle

Figure 8.39
Fibula

- **fibula** – slender, lateral strut that helps stabilizes ankle
- does not bear any body weight
- **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** – arranged in proximal and distal groups

- **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

Figure 8.40a
The Foot

- remaining bones of foot are similar in name and arrangement to the hand
- metatarsals
- phalanges