The Skeletal System: Axial Skeleton

The Big Idea

- The Axial Skeleton & Homeostasis
  - The bones of the axial skeleton contribute to homeostasis by protecting many of the body's organs such as the brain, spinal cord, heart, and lungs. They are also important in support and calcium storage and release

- Bones protect soft body parts and make movement possible
  - They also serve as landmarks for locating parts of other body systems
- The musculoskeletal system is composed of the bones, joints, and muscles working together

7.1 Divisions of the Skeletal System

- Objectives
  - Describe how the skeleton is organized into axial and appendicular divisions

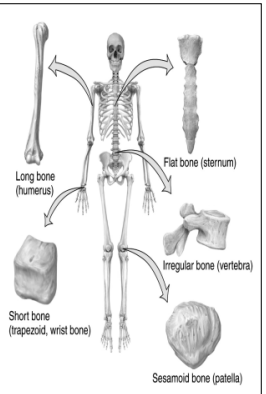
- The human skeleton consists of 206 named bones grouped into two principal divisions:
  - Axial skeleton
  - Appendicular skeleton
- In this graphic, the axial skeleton is highlighted in blue, while the appendicular skeleton constitutes the remainder

- The axial skeleton consists of the bones that lie around the longitudinal axis of the human body
  - Skull bones, auditory ossicles (ear bones), hyoid bone, ribs, sternum (breastbone), and bones of the vertebral column
- The appendicular skeleton consists of the bones of the upper and lower limbs (extremities) and the bones forming the girdles that connect the limbs to the axial skeleton
  - Pectoral girdles, bones of the upper limbs, pelvic girdles, and bones of the lower limbs

7.2 Types of Bones

- Objectives
  - Classify bones based o their shape or location

- Each of the 206 named bones of the axial and appendicular skeleton can be placed in one of 6 broad classifications based on their embryological origins and their anatomical characteristics



- Long bones are greater in length than in width and are often slightly curved for the purpose of weight bearing
  - Femur, tibia, fibula, humerus, ulna, radius, metacarpals, metatarsals, and phalanges
- Short bones (cube-shaped) include the carpals & tarsals
- Flat bones are thin and composed of two nearly parallel plates of compact bone enclosing a layer of spongy bone
  - Cranial bones, ribs, sternum, scapulae, and clavicles

- Irregular bones include complex shapes like the vertebrae and some facial bones
- Sesamoid bones vary in number and protect tendons and ligaments from excessive wear
  - The best example is the patella
  - Sesamoid bones can develop fractures due to friction, tension, and stress

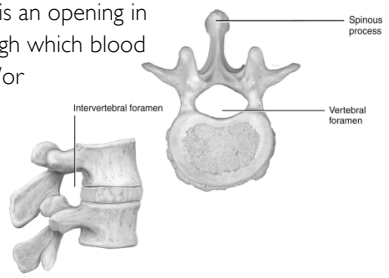
- Sutural bones, also known as Wormian bones, are small extra bone plates located within the sutures of cranial bones
  - These are found as isolated examples, and although unusual, they are not rare

7.3 Bone Surface Markings

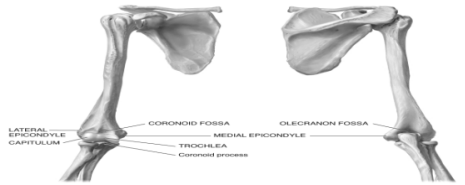
- Objectives
  - Describe the principal surface markings on bones and the functions of each

- Bones have characteristic surface markings, which are structural features adapted for specific functions
- There are two major types of surface markings
  - Depressions and openings
    - Allow the passage of blood vessels and nerves
    - Form joints
  - Processes
    - Projections or outgrowths that form joints
    - Serve as attachment points for ligaments and tendons

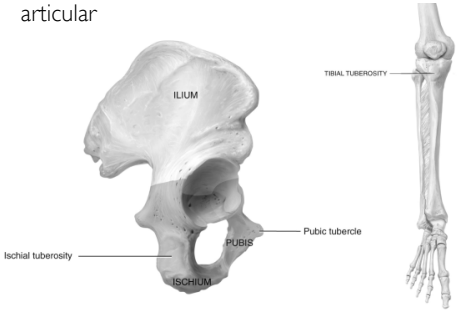
- While a process is any projection of bone (large or small), a spinous process is a slender projection from a vertebrae
- A foramen is an opening in bone through which blood vessels and/or nerves pass



- If a bony process is large, round, and articular, it might be called a condyle
  - The condyles of the humerus are the Trochlea and the Capitulum
- An epicondyle is a bony protuberance above a condyle
- A fossa is a shallow depression in bone



- A tubercle is a small rounded projection
- A tuberosity is a large bony prominence that is not articular



- A meatus is a tube-like canal
  - The external auditory meatus
- The trochanters are two very large bony projections on the femur

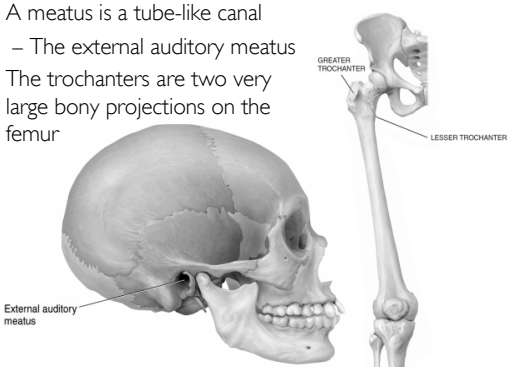


TABLE 7.2

Bone Surface Markings

MARKING	DESCRIPTION	EXAMPLE
DEPRESSIONS AND OPENINGS: SITES ALLOWING THE PASSAGE OF SOFT TISSUE (NERVES, BLOOD VESSELS, LIGAMENTS, TENDONS) OR FORMATION OF JOINTS		
Fissure (FISH-ur)	Narrow slit between adjacent parts of bones through which blood vessels or nerves pass.	Superior orbital fissure of sphenoid bone (Figure 7.12).
Foramen (fō-RĀ-men = hole; plural is *foramina*)	Opening through which blood vessels, nerves, or ligaments pass.	Optic foramen of sphenoid bone (Figure 7.12).
Fossa (FOS-a = trench; plural is *fossae*, FOS-ē)	Shallow depression.	Coronoid fossa of humerus (Figure 8.5a).
Sulcus (SUL-kus = groove; plural is *sulci*, SUL-sī)	Furrow along bone surface that accommodates blood vessel, nerve, or tendon.	Intertubercular sulcus of humerus (Figure 8.5a).
Meatus (mē-Ā-tus = passageway; plural is *meati*, mē-Ā-tī)	Tubelike opening.	External auditory meatus of temporal bone (Figure 7.4b).

TABLE 7.2

Bone Surface Markings

MARKING	DESCRIPTION	EXAMPLE
PROCESSES: PROJECTIONS OR OUTGROWTHS ON BONE THAT FORM JOINTS OR ATTACHMENT POINTS FOR CONNECTIVE TISSUE, SUCH AS LIGAMENTS AND TENDONS		
Processes that form joints		
Condyle (KON-dil; *condylus* = knuckle)	Large, round protuberance with a smooth articular surface at end of bone.	Lateral condyle of femur (Figure 8.13a).
Facet (FAS-et or fa-SET)	Smooth, flat, slightly concave or convex articular surface.	Superior articular facet of vertebra (Figure 7.18d).
Head	Usually rounded articular projection supported on neck (constricted portion) of bone.	Head of femur (Figure 8.13a).
Processes that form attachment points for connective tissue		
Crest	Prominent ridge or elongated projection.	Iliac crest of hip bone (Figure 8.10b).
Epicondyle (*epi-* = above)	Typically roughened projection above condyle.	Medial epicondyle of femur (Figure 8.13a).
Line (*linea*)	Long, narrow ridge or border (less prominent than crest).	Linea aspera of femur (Figure 8.13b).
Spinous process	Sharp, slender projection.	Spinous process of vertebra (Figure 7.17).
Trochanter (trō-KAN-ter)	Very large projection.	Greater trochanter of femur (Figure 8.13b).
Tubercle (TOO-ber-kul; *tuber-* = knob)	Variably sized rounded projection.	Greater tubercle of humerus (Figure 8.5a).
Tuberosity	Variably sized projection that has a rough, bumpy surface.	Ischial tuberosity of hip bone (Figure 8.10b).

7.4 Skull

- Objectives
  - Name the cranial and facial bones and indicate whether they are paired or single
  - Describe the following special features of the skull: sutures, paranasal sinuses, and fontanels

General Features & Functions

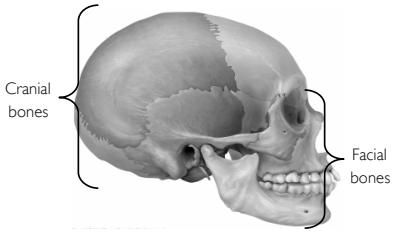
•The skull protects and supports the brain and special sense organs

•Besides forming the large cranial cavity, the skull also forms several smaller cavities

- •Nasal cavity
- •Orbits (eye sockets)
- •Paranasal sinuses
- •Small cavities which house organs involved in hearing and equilibrium

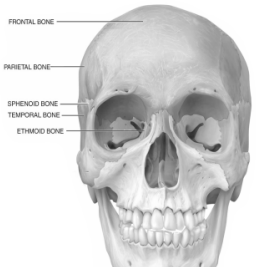
- Besides protecting the brain, the skull provides a framework for:
  - Attachment of muscles that move various parts of the head
  - Attachment for muscles that produce facial expressions
- The facial bones form the framework of the face and provide support for the entrances to the digestive and respiratory system

- The 22 bones of the skull are grouped into two categories
  - Cranial bones
  - Facial bones

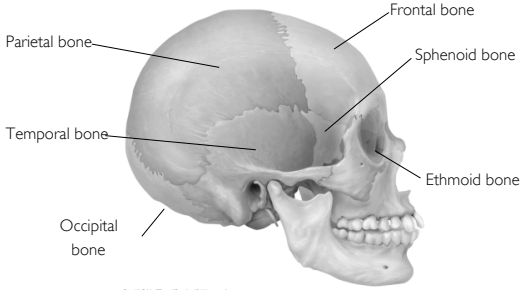


- 8 Cranial Bones (Bones of the Braincase)
  - Frontal bone (1)
  - Parietal bone (2)
  - Temporal bone (2)
  - Occipital bone (1)
  - Sphenoid bone (1)
  - Ethmoid bone (1)
- 14 Facial Bones
  - Mandible (1)
  - Maxilla (2)
  - Zygomatic bone (2)
  - Nasal bones (2)
  - Lacrimal bones (2)
  - Palatine bones (2)
  - Inferior nasal conchae (2)
  - Vomer (1)

- The braincase (neurocranium) has 8 bones
  - Single frontal, occipital (not shown on this graphic), ethmoid, and sphenoid bones, and paired temporal and parietal bones



Bones of the Braincase



Nasal Septum

- Consists of the vomer, perpendicular plate of the ethmoid, and septal cartilage
  - – Divides the nasal cavity into left and right sides

Orbits

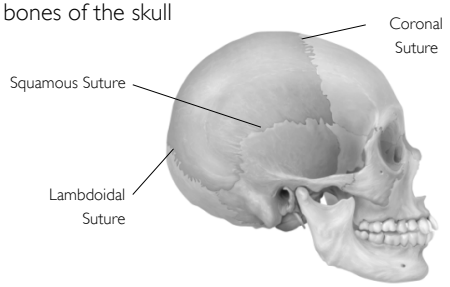
- Seven skull bones form each of the orbits (eye sockets)

Foramina

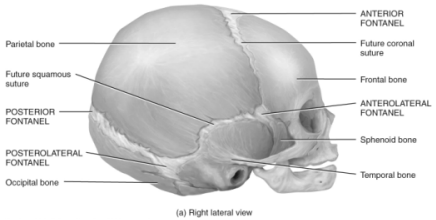
- Provides passages for nerves and blood vessels

Unique Features of the Skull

- A suture is a "seam," an immovable joint between bones of the skull

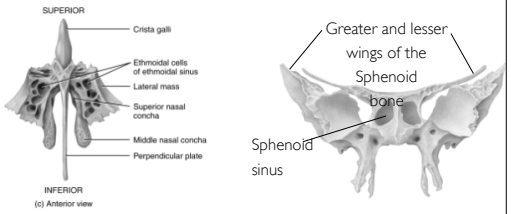


- Fontanels ("little fountains") are soft, mesenchyme-filled spaces between cranial bones in fetuses and infants
  - They will become suture joints in adults



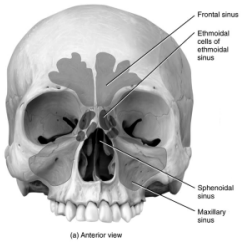
(a) Right lateral view

- The paranasal sinuses are prominent features of the frontal bone, ethmoid bone, sphenoid bone, and maxillary bones
  - Connected to the nasal cavity



Ethmoid bone (top) showing the "air cells" that make up the Ethmoid sinuses. Sphenoid bone (right)

- With the exception of the ethmoid sinuses, the other paranasal sinuses are paired
  - They are lined with mucus membranes that humidify and warm the air
  - Reduce weight in the skull
  - Help to resonate the sound of our voice



Ex. 7A Frontal Bone

- Forms the forehead, the roofs of the orbits, and the most anterior part of the cranial floor

Ex. 7B Parietal Bones

- Form the greater portions of the sides and roof of the cranial cavity
- Inner surfaces contain many protrusions and depressions that accommodate the blood vessels supplying the dura mater (CT covering the brain)

Ex. 7C Temporal Bones

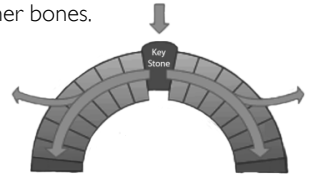
- Forms the inferior lateral aspects of the cranium and part of the cranial floor

Ex. 7D Occipital Bone

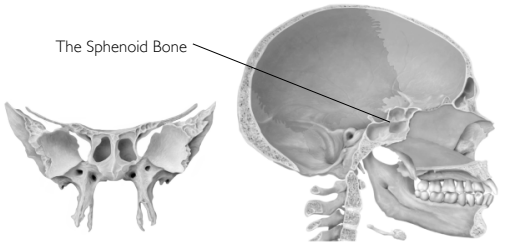
- Forms the posterior part and most of the base of the cranium

Ex. 7E Sphenoid Bone

- Of the 8 cranial bones that fit together to form the braincase, the sphenoid bone is the "keystone"
  - Like the keystone of a roman arch, the sphenoid is the "center brick" that balances the outward thrust of the other bones.



- The rest of the braincase bones are dependent for support on the sphenoid bone (with its greater and lesser wings)



Ex. 7F Ethmoid Bone

- Located in the anterior part of the cranial floor medial to the orbits and is sponge-like in appearance

Ex. 7G Facial Bones

- Growth of the face ceases around 16 years of age
- 14 facial bones total
- Nasal Bones
- Lacrimal Bones
- Palatine Bones
- Inferior Nasal Conchae
- Vomer
- Maxillae
- Zygomatic Bones
- Mandible

7.5 Hyoid Bone

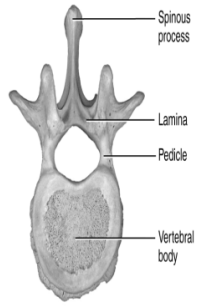
- Objectives
  - Describe the relationship of the hyoid bone to the skull

- The hyoid bone if a U-shaped bone that does not articulate with any other bone
- It supports the tongue and provides attachments for some tongue muscles and for some muscles of the pharynx and neck

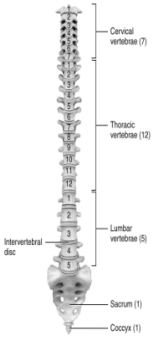
7.6 Vertebral Column

- Objectives
  - Identify the regions and normal curves of the vertebral column
  - Describe the structural and functional features of the bones in various regions of the vertebral column

- The vertebral column, sternum, and ribs constitute the skeleton of the body's trunk
- There are 26 bones in the adult vertebral column
- The spine is composed of a series of bones called vertebrae
- Vertebrae typically consist of
  - A body (weight bearing)
  - A pedicle and lamina forming the vertebral arch (surrounds the spinal cord)
  - Several processes (points of attachment for muscles)

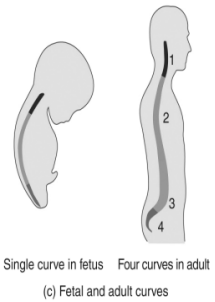


- There are 7 cervical vertebrae in the neck region labeled C_1-C_7
- There are 12 thoracic vertebrae that articulate with the ribs (T_1-T_{12})
- There are 5 lumbar vertebrae that support the lower back labeled L_1-L_5
- The sacrum and coccyx are single bones that result from the fusion of several vertebrae
  - Sacrum (5 fused vertebrae)
  - Coccyx (4 fused vertebrae)



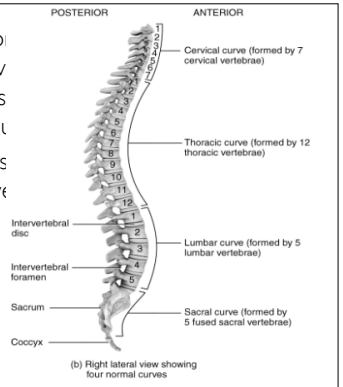
Normal Curves of the Vertebral Column

- When viewed from the front, a normal adult vertebral column appears straight
- When viewed from the side, it has four slight bends which constitute the normal spinal curvatures



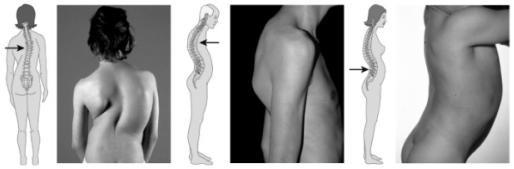
(c) Fetal and adult curves

- Relative to the fro
  the body, the cerv
  and lumbar curves
  convex (bulging ou
- The thoracic and s
  curves are concave
  (cupping in)



(b) Right lateral view showing four normal curves

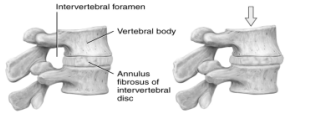
- The curves provide strength, support, and balance
- Various conditions may exaggerate the normal spinal curves, sometimes causing severe disability



(a) Scoliosis (b) Kyphosis (c) Lordosis

Intervertebral Discs

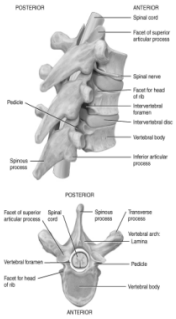
- A tough fibrocartilage intervertebral disc is found between the bodies of adjacent vertebrae
  - It functions to absorb vertical shock and form joints which are strong yet still permit movement of the spine



(d) Intervertebral disc

Parts of a Typical Vertebra

- Each vertebrae consists of a vertebral body, vertebral arch, and seven processes
- From the cervical region to the sacrum, each vertebra has a large central hole, or vertebral foramen in which the spinal cord can travel
- At each segmental level, on both the right and left sides, an intervertebral foremen is formed for the exiting spinal nerves



Regions of the Vertebral Column

- Five Regions
  - Cervical
  - Thoracic
  - Lumbar
  - Sacral
  - Coccygeal

TABLE 7.4

Comparison of Major Structural Features of Cervical, Thoracic, and Lumbar Vertebrae

CHARACTERISTIC	CERVICAL	THORACIC	LUMBAR
Overall structure			
Size	Small.	Larger.	Largest.
Foramina	One vertebral and two transverse.	One vertebral.	One vertebral.
Spinous processes	Slender, often bifid (C2–C6).	Long, fairly thick (most project inferiorly).	Short, blunt (project posteriorly rather than inferiorly).
Transverse processes	Small.	Fairly large.	Large and blunt.
Articular facets for ribs	Absent.	Present.	Absent.
Direction of articular facets			
Superior	Posterosuperior.	Posterolateral.	Medial.
Inferior	Anteroinferior.	Anteromedial.	Lateral.
Size of intervertebral discs	Thick relative to size of vertebral bodies.	Thin relative to size of vertebral bodies.	Thickest.

Age Related Changes in the Vertebral Column

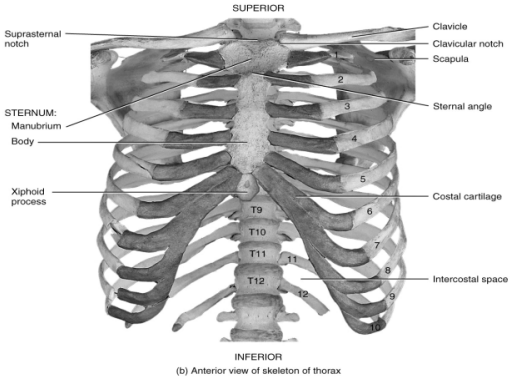
- Reduction in the mass and density of the bone
- Reduction in the collagen-to-mineral content within the bone making the bones more brittle and susceptible to damage
- Articular cartilage deteriorates and bony growths take their place
- Bony growths around invertebral discs

7.1 Thorax

- Objectives
  - Identify the bones of the thorax and their functions

- The thoracic cage is the final part of the axial skeleton
  - Thoracic vertebrae
  - The sternum
  - The ribs and costal cartilages
- Its functions are to enclose and protect the organs in the thoracic and abdominal cavities
  - Provide support for the bones of the upper limbs
  - Play a role in breathing

- The sternum or "breastbone" is located anteriorly in the center of the thoracic wall
  - Consists of the manubrium, body, xiphoid process
- The 12 pairs of ribs give structural support to the sides of the thoracic cavity
- The costal (having to do with the ribs) cartilages are bars of hyaline cartilage connecting the sternum to the ribs
  - Contribute to the elasticity of the thoracic cage

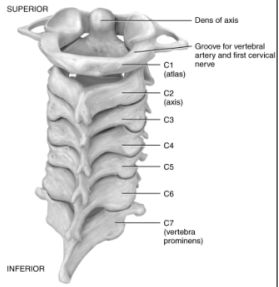


(b) Anterior view of skeleton of thorax

Ex. 7H Cervical Vertebrae

- The cervical vertebrae comprise the bony spine in the neck:
  - C_1 is called the Atlas because it holds up the head the way the Titan of Greek mythology supported the world
  - C_2 is called the Axis because it provides a pivot, allowing the head to turn on the neck

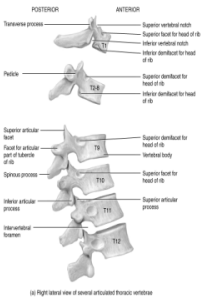
- Without these first two specialized cervical vertebra, the head-on-neck range of motion would be very limited



Ex. 7I Thoracic Vertebrae

- Below the neck, each of the 12 pairs of thoracic vertebrae articulate with a rib to form the posterior part of the thoracic cage

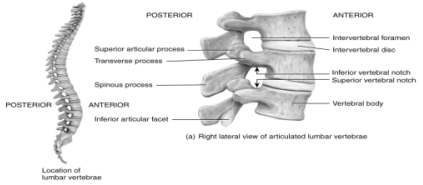
Location of thoracic vertebrae



(a) Right lateral view of several articulated thoracic vertebrae

Ex. 7J Lumbar Vertebrae

- Because the lumbar vertebrae (5) bear greater loads, they are much stouter than their more superior cousins (the cervical and thoracic vertebrae)

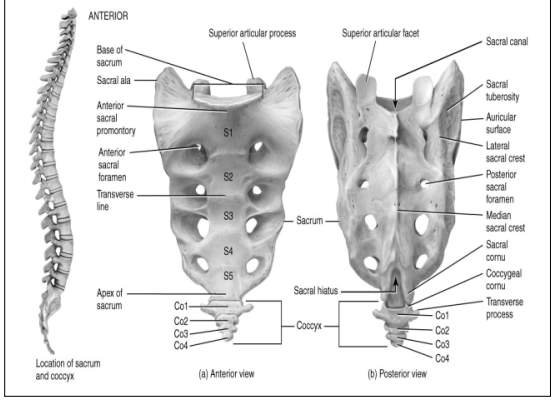


(a) Right lateral view of articulated lumbar vertebrae

Location of lumbar vertebrae

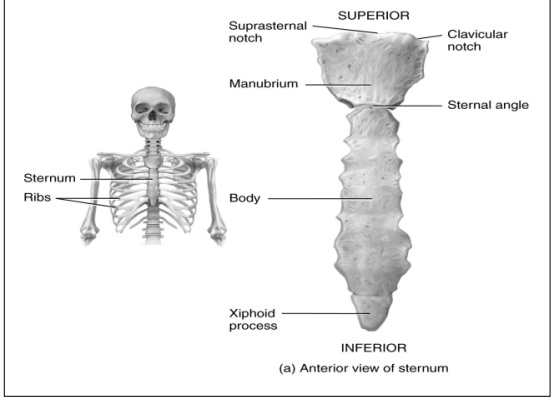
Ex. 7K Sacral & Coccygeal Vertebrae

- The sacrum is a single triangular body formed from a fusion of 5 separate vertebrae in-utero (during fetal development)
- The coccyx, commonly referred to as the tailbone, is the final segment of the bony spine
  - It is also an in-utero fusion of 3–5 separate vertebrae



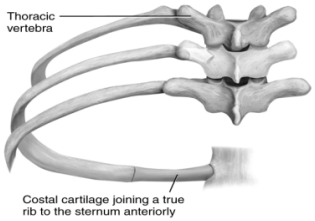
Ex. 7L Sternum (Breastbone)

- Flat, narrow bone located in the center of the anterior thoracic wall that measures about 15cm in length
- Manubrium, body, and xiphoid process



Ex. 7M Ribs

- The upper 7 rib pairs are called true ribs because they attach "directly" to the sternum (with just a small piece of costal cartilage)



- The bottom 5 pairs of ribs (and this number can vary from one individual to another) are called false ribs
  - They attach indirectly to the sternum with an elongated piece of costal cartilage
  - or not at all (ribs 11 and 12 are called floating ribs)
- Spaces between the ribs (intercoastal spaces) are occupied by intercoastal muscles, blood vessels, and nerves