chapter 7

Introduction to the Skeletal System and the Axial Skeleton

CHAPTER OVERVIEW

OBJECTIVES

1. Describe the gross anatomy and structure of a long bone
2. Describe and compare the underlying histology of spongy and compact bone.
3. List the five general shapes of bones.
4. Describe and compare the different kinds of bone markings visible on the skeleton.
5. Identify the components of the axial skeleton: cranial, facial, hyoid, vertebra, ribs and sternum.

7.1 Introduction to the Skeletal System

The skeletal system serves to support the body's soft tissues and to protect the body's soft internal organs. Another important function that the bones have is to store materials such as calcium, phosphorus and lipids. Additionally, blood cells are synthesized in the red bone marrow to be released into the bloodstream. Bones serve as levers for the muscular system, working with them to produce movement and maintain posture.

The human body contains 2 major kinds of bone tissue: compact and spongy. **Compact bone** (dense bone) is found on the outer surface of bones and serves as a place to absorb most of the stress on the bones. **Spongy bone** (cancellous tissue) is found on the inside of the compact bone layer. In this lab, you will be introduced to the histology of bone tissue and learn about the different categorization of bone types and start exploring the bones of the axial skeleton.

7.2 Bone Structure

Bones are surrounded and protected by a membrane called the **periosteum**, a tough fibrous layer of tissue that gives bones their shiny appearance. This layer can actually be broken up into 2 thin layers: the outer fibrous layer that is a point of insertion for tendons and ligaments (attaching muscles and bones, respectively) and the inner cellular layer where the production of osteoblasts occurs. **Osteoblasts** are immature bone cells that are important for bone growth and repair. These cells mature into **osteocytes**, that maintain and help to store the minerals and proteins of the bone matrix.

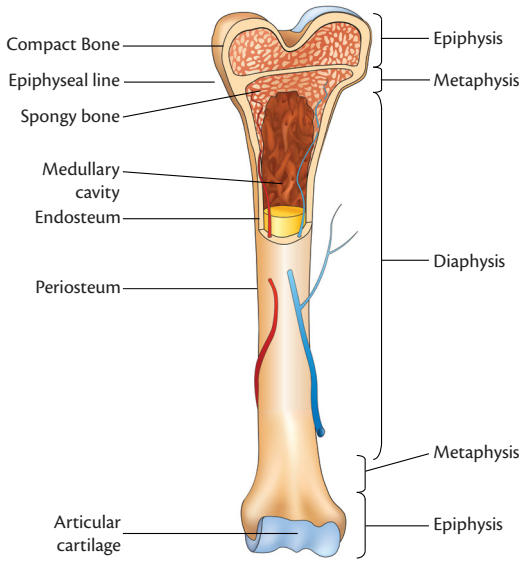
One of the general types of bones is a long bone, such as the femur, and can be broken up into several segments. The shaft segment of the long bone is called the **diaphysis**. On the ends of the diaphysis are the **epiphysis** segments. Sandwiched in between these two segments are **metaphysis** layers. The epiphysis, which is the segment that articulates or connects with other bones, is covered with a layer of hyaline cartilage, called the **articular cartilage**.

The outside layer of the diaphysis is a thick layer of compact bone, lined with a thin layer of spongy bone. This surrounds a hollow cavity called the **medullary cavity** (marrow cavity), which is a storage space for bone marrow, a loose connective tissue that contains a high concentration of lipids (yellow marrow). Lining the medullary cavity is a membrane called the **endosteum** which contain osteoclasts, cells that secrete carbonic acid to dissolve bone in order to rebuild with stronger, younger bone, or to release the stored minerals into the blood. Flat bones, like those found in the skull, do not have a medullary cavity, but have a layer of spongy bone sandwiched between the outer layers of compact bone. This spongy bone layer contains red marrow, a loose connective tissue made of stem cells that produce red blood cells, platelets and white blood cells.

The metaphysis layer is important for bone growth during early years of life. In children, the metaphysis is called the epiphyseal plate, made of hyaline cartilage, that allows the bone to grow in length. As one reaches adulthood, ossification occurs which fuses the epiphysis to the diaphysis and bone growth stops. The line of fusion between the diaphysis and epiphysis is now called the epiphyseal line.

Figure 7-1 Bone Structure

The structure of a long bone (the femur) with a partial longitudinal section



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ACTIVITY 7-1 *Bone Structure and Anatomy*

Materials: long bone (such as a femur bone)

1. Obtain a long bone from the box of loose bones.
2. Locate the anatomical regions typical of a long bone as shown in Figure 7-1.
3. In your lab report, label the photograph of a long bone and answer the questions related to it.

7.3 Bone Histology

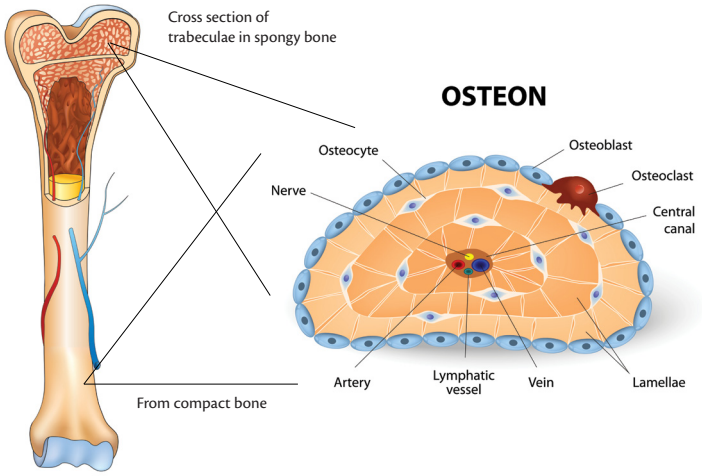
Looking closer at the histology of bone tissue, compact bone is made up of supportive columns called **osteons**. An osteon consists of rings of a calcified matrix, called **concentric lamellae**. Between these layers, or lamellae, are **lacunae**, small spaces that contain the mature bone cells, **osteocytes**. Bones receive nutrients and oxygen via **perforating canals (Volkmanns canals)** that allow nerves, blood vessels and lymphatic vessels to pass through the periosteum at a perpendicular angel to the osteons. **Central canals** connect with the perforating canals at the center of every osteon. Tiny channels, called **canaliculi**, radiate out from the central canal, and act as a way for nutrients and oxygen and waste to diffuse throughout the osteon.

Bones, especially weight-bearing bones, continuously remodel and build as a way to maintain strength. Older osteons are partially removed and are left with **interstitial lamellae** found between complete osteons. This occurs more often in the distal end of a long bone as this segment receives more stress and weight than middle areas of the diaphysis. Other lamellae that wrap around the entire bone just under the periosteum are called **circumferential lamellae**.

Spongy bone is not made up of tightly packed osteons, rather it is structured as a meshwork of bony structures called **trabeculae**. Each single trabecula is made up of small layers of lamellae with canaliculi interspersed throughout. The spaces between the trabeculae serve to store red marrow.

Figure 7-2 Bone Histology

A. Both compact bone and trabeculae are formed from osteon units. In compact bone interstitial lamellae (partially removed osteons) and circumferential lamellae form rings at the outside of the long bone. B. Cross section microscopic image of bone tissue highlighting groups of osteons made up of concentric lamellae, a central canal and lacunae with osteocytes inside. In between the osteons are interstitial lamellae.



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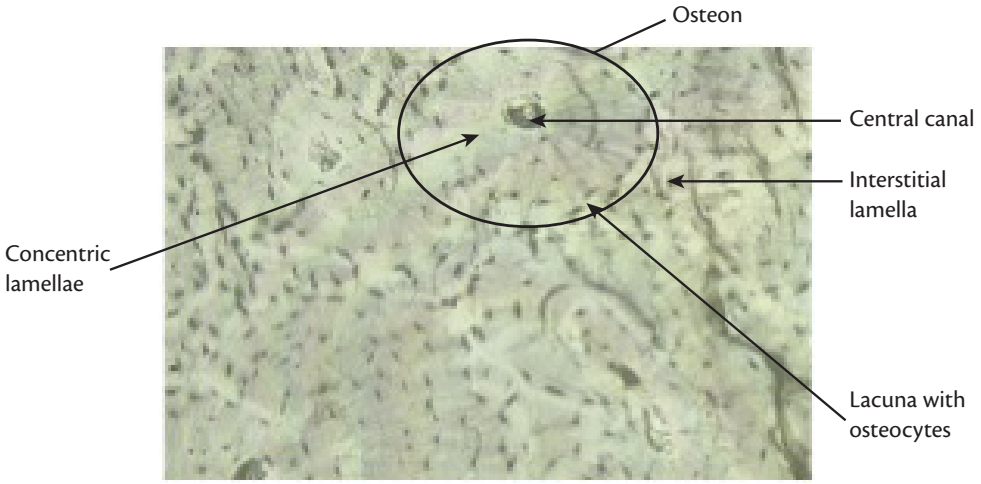

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ACTIVITY 7-2 *Bone Histology*

Materials: Compound microscope, slide of bone tissue cross section

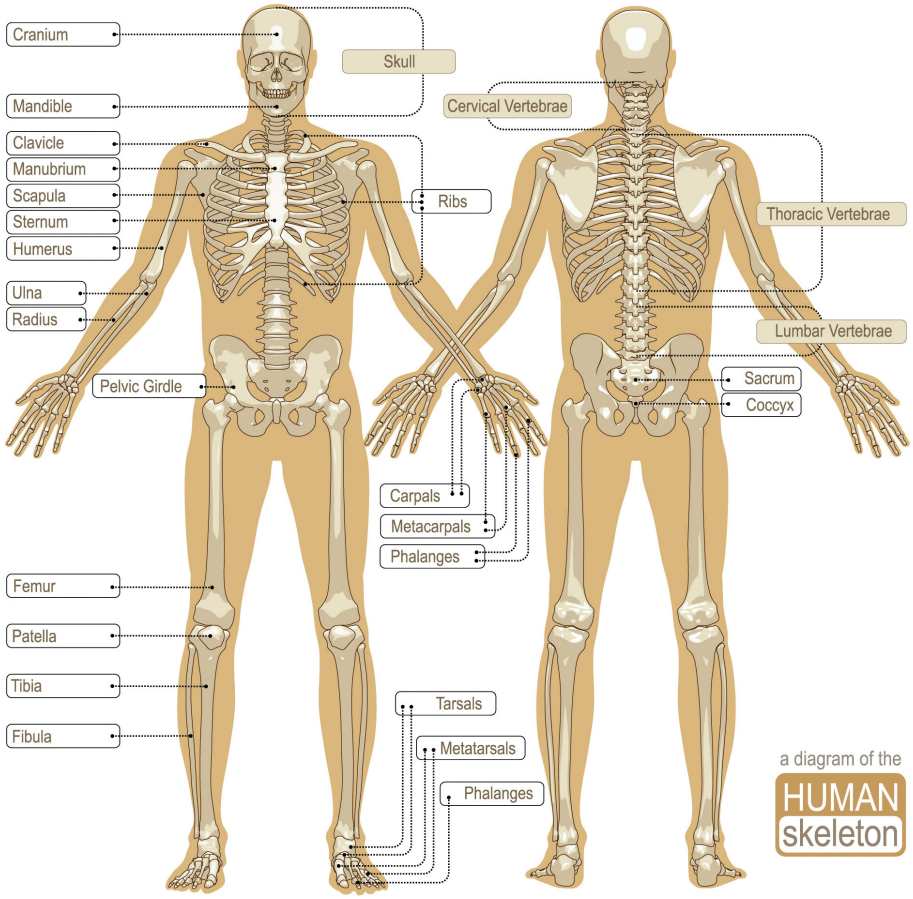
1. Review the histology in Chapter 5 and this chapter of the lab manual.
2. Obtain a microscope slide of bone tissue.
3. Observe the slide at low magnification first. View the overall organization of the bone tissue. Count the number of osteons in your section and record this in your lab report.
4. Choose one osteon and view it at higher magnification. Sketch this osteon and add labels for the **central canal**, **canaliculi**, **lacunae**, **concentric lamellae**, and any **interstitial lamellae** around the osteon that you can find.
5. Answer the follow up questions in your lab report.

7.4 The Human Skeleton: Axial and Appendicular Divisions

There are a total of 206 bones in the adult skeleton. There are two major divisions of the skeleton: the **axial** and **appendicular** divisions. The axial division, with a total of 80 bones includes the **skull**, **facial bones**, **vertebral column**, **sternum**, **ribs** and **hyoid bone**. We will focus on learning these bones in this lab. The appendicular division contains the rest of the bones (126) and consists of the **pectoral girdle**, the **pelvic girdle** as well as the **upper** and **lower limbs**. The pectoral girdle includes the **right** and **left scapula** (shoulder blade) and **clavicle** (collar bone). The pelvic girdle consists of two **coxal** bones, which are actually made up of 3 fused bones: the **ilium**, the **ischium** and the **pubis**. The upper limb is formed from the **humerus** (upper arm), which articulates at the elbow to the **ulna** and **radius** (together forming the forearm) and then continuing on to the **carpal** bones (wrist), **metacarpal** bones (palm) and **phalanges** (fingers). The lower limb is similar, forming from the **femur** (upper leg), continuing onto the **tibia** and **fibula** (forming the lower leg), the **patella** (knee bone), then onto the **tarsal** bones (ankle), **metatarsal** bones (arch) and **phalanges** (toes)(Figure 7-3).

Figure 7-3 The Human Skeleton

Major bones are labeled.



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ACTIVITY 7-3 *Major Skeletal Divisions: Axial and Appendicular*

Materials: Articulated Skeleton

1. Using Figure 7-3 and the articulated skeleton, locate all of the terms introduced, and associate each with either the axial or appendicular skeleton.
2. Label the image of the skeleton with the correct anatomical terms in the lab report.
3. In the table of your lab report, indicate whether each bone listed is a part of the axial or appendicular skeleton.
4. Answer all additional questions in the lab report.

7.5 Bone Classification and Markings

Bones can be classified based on their shape into 6 majors groups. **Long bones**, which were introduced previously, are greater in length than they are in width. These are found in bones of the arm, forearm, thigh and leg. **Flat bones** are thin, like plates, and are found in the skull

and sternum. **Short bones** are about as wide as they are long. These are found in the wrist and ankle. **Irregular bones** are irregular in shape, like those of the vertebrae. Finally, **sesamoid bones** are those that form inside tendons, such as the patella (Figure 7-4).

Additionally, bones contain a number of markings and anatomical features. **Bone markings** may be unique to the specific bone or may occur throughout the skeleton. There are 5 groups of bone markings you need to be aware of: Projections/elevations; Processes where tendons or ligaments attach; Processes for articulations with other bones; Depressions; and Openings. Table 7-1 summarizes these groups.

Figure 7-4 Classification of Bone Shape

Each classification of bone shape is shown with examples.

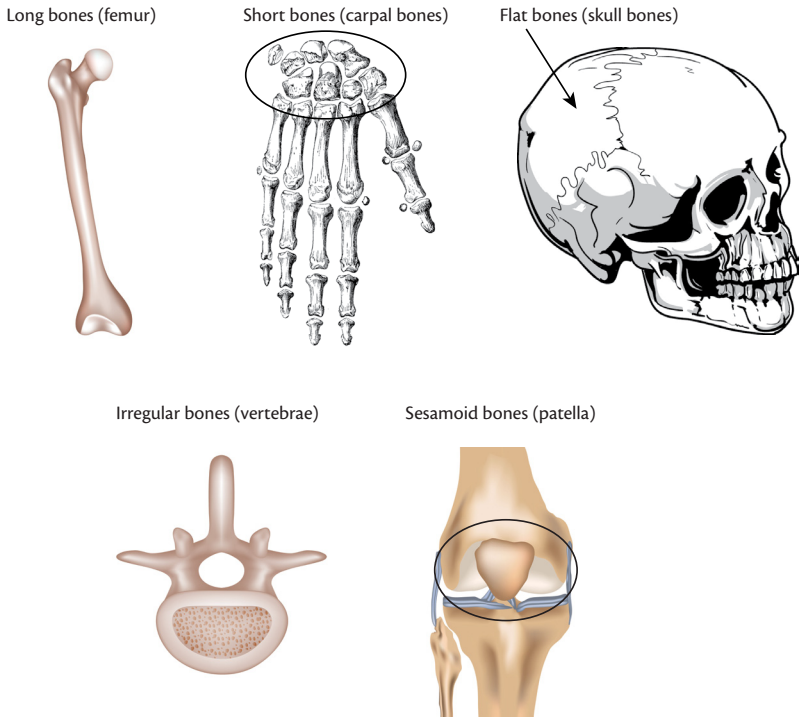

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Table 7-1 Bone Marking Classification

General Marking Group	Anatomical Term	Definition
Elevations and Projections	Process	Projection or bump
	Ramus	Extension of a bone making an angle with a structure
Processes formed where tendons or ligaments attach	Trochanter	Large, round projection
	Tuberosity	Smaller, rough projection
	Tubercle	Small, rounded projection
	Crest	Prominent ridge
	Line	Low ridge
	Spine	Pointed process

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General Marking Group	Anatomical Term	Definition
Processes formed for articulation with adjacent bones	Head	Expanded articular end of the epiphysis
	Neck	Narrow connection between the epiphysis and diaphysis
	Condyle	Smooth rounded articular process.
	Trochlea	Smooth, grooved articular process, like a pulley
	Facet	Small, flat articular surface
Depressions	Fossa	Shallow depression
	Sulcus	Narrow groove
Openings	Foramen	Rounded passageway for blood vessels or nerves
	Canal	Passageway through the substance of a bone
	Fissure	Elongated cleft
	Sinus/antrum	Chamber within a bone, filled with air

ACTIVITY 7-4 *Bone Classification and Markings*

Materials: articulated skeleton

1. Use the skeleton to count the number of bones of each general type: long, short, flat, irregular and sesamoid. Record these counts in your lab report.
2. Using Table 7-1 as a reference, locate an example of each of the markings and describe where it is and what it looks like in your lab report.
3. Answer all additional questions in your lab report.

7.6 Axial Skeleton

The axial skeleton provides an attachment for the appendicular skeleton and protection for the body's internal organs. This part of the skeleton is composed of 80 bones which make up the **skull** (**cranial** and **facial** bones), **thoracic cage** with the **ribs** and **sternum**, the **vertebral column** ending with the **sacrum** and **coccyx**. This part of the lab will survey each of these regions in detail.

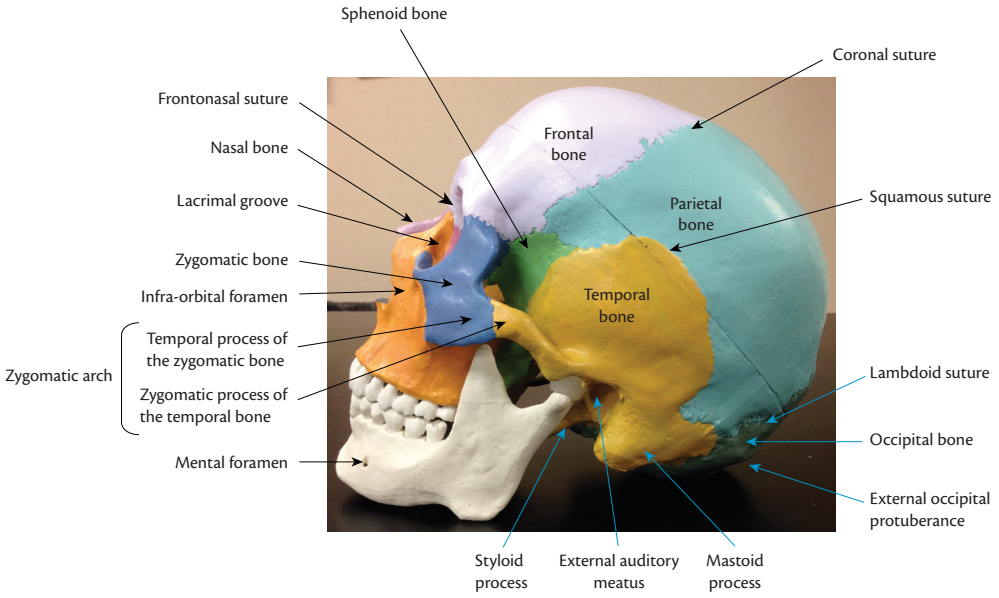
7.6a Cranium

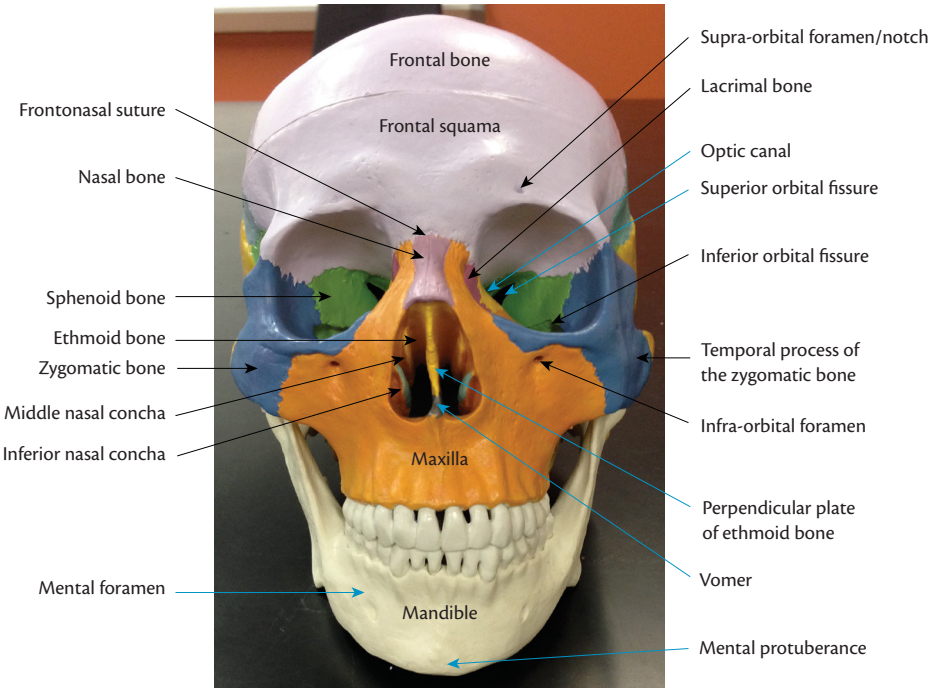
The **cranium** is formed from bones that enclose the brain and also houses major sensory organs for vision, hearing, balance, taste and smell. It is also a set of bones that contain numerous bone markings introduced in the previous section. Of the many bones that form the cranium and face, only two joints or articulations can move: the jaw and the joint between the skull and vertebral column.

The cranium is composed of 8 bones, a **frontal** bone, 2 **parietal** bones, 2 **temporal** bones, an **occipital** bone, a **sphenoid** bone, and an **ethmoid** bone (Figure 7-5). The frontal bone extends from the forehead posteriorly to the **coronal suture** that meets with the two parietal bones. The parietal bones form much of the lateral sides of the head, joined at the superior end by the **sagittal suture**. The two temporal bones join with the parietal bones at the **squamous suture**. The posterior side of the cranium is formed by the occipital bone. This bone forms a suture with the parietal bones at the **lambdoid suture**. The sphenoid bone is an irregular shaped bone visible from the cranial floor, anterior to the temporal bone. This

bone forms part of the floor and lateral walls of the cranium as well the posterolateral part of the **orbit** (socket for the eyeball). Finally the ethmoid bone is a small rectangular bone on the posterior side of the nose bridge, anterior to the sphenoid bone. This bone is also part of both orbits.

Figure 7-5 Cranial and Facial Bones





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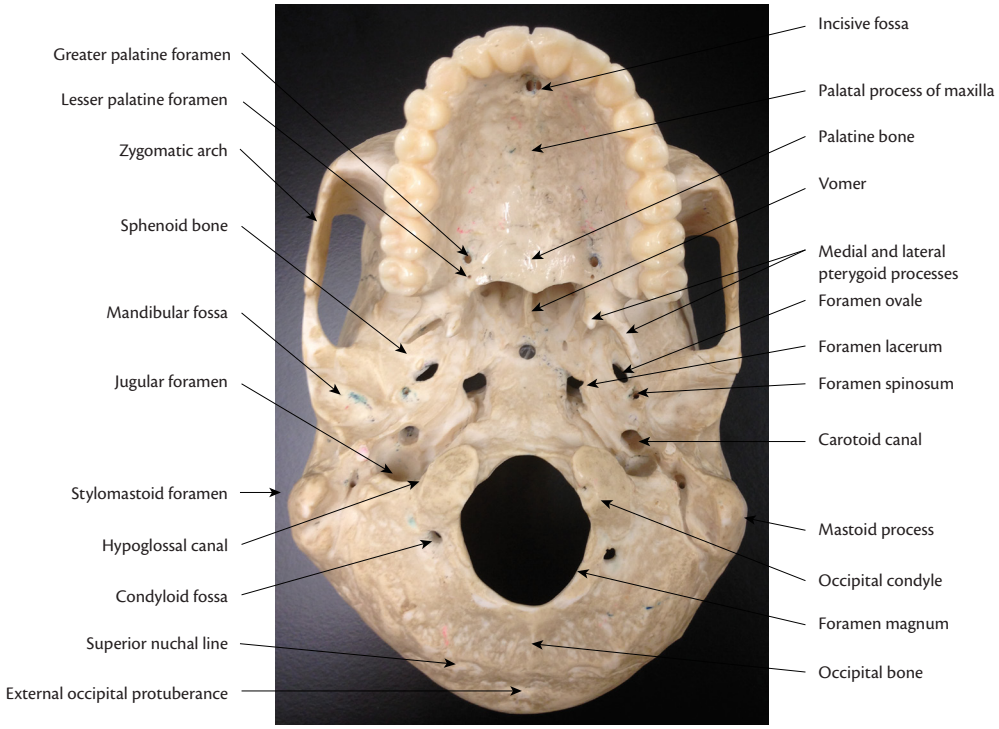
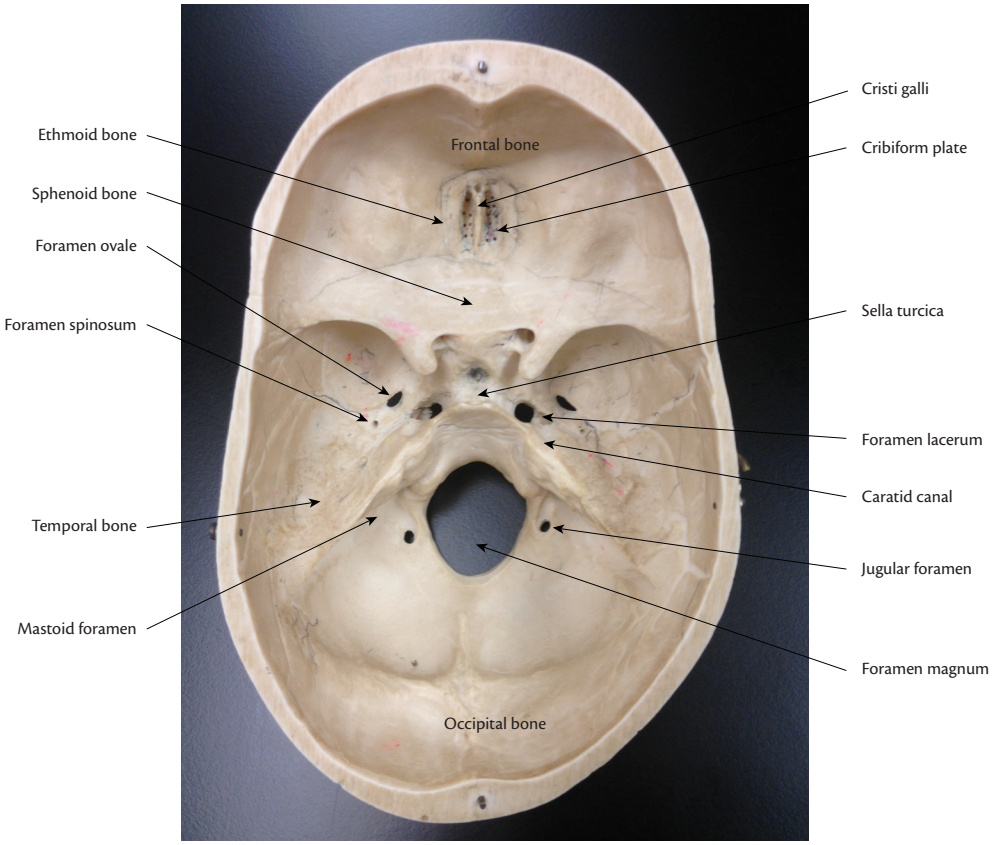




Frontal

The frontal bone forms the roof, walls and floor of the anterior part of the cranium and there are several major markings to summarize. The **frontal squama** is a flattened area, otherwise

known as the forehead. At the center is found the **frontal suture**, where the two frontal bones fuse early in childhood, and usually is gone by adulthood as a result of bone remodeling. The **supra-orbital foramen** is a small hole or notch (called the **supra-orbital notch**) is found above the eye orbit. Finally the **lacrimal fossa** is an indentation on the inner part of each orbit that contains the lacrimal gland, which works to lubricate the eye.

Occipital

The occipital bone forms the posterior part of the cranium and several markings are found on this bone. The **foramen magnum** is a large hold where the spinal cord enters the skull and meets the brain. **Occipital condyles** are found on the lateral margins of the foramen magnum and these articulate with the first vertebra of the spine. The **hypoglossal canal** is found above each occipital condyle, forming a passageway for the hypoglossal nerve that connects to the tongue and throat. On the outside of the bone, the **external occipital crest** is a ridge that travels posteriorly from the foramen magnum and meets the **external occipital protuberance**. Traveling laterally are the **superior** and **inferior nuchal lines** where muscles of the neck attach to the bone.

Parietal

These two bones form the roof of the cranium and are joined by the **sagittal suture**. The two major markings here are the **superior** and **inferior temporal lines**, where mastication or chewing muscles attach.

Temporal

These two bones form the inferior lateral walls of the cranium and part of the floor as well. Of the major markings, the **zygomatic arch** is the point at which the zygomatic bone of the face articulates with the temporal bones, formed by two processes: the **zygomatic** (from the temporal bone) and **temporal process** (from the zygomatic bone). Posterior to this is the **articular tubercle**, and posterior to this is the **mandibular fossa**, a depression for the articulation of the mandible bone. The **squamous region** of the bone is the flattened superior surface, and the **external acoustic meatus** is a hole found inferiorly to this, which allows sound waves to travel inside the skull towards the eardrum. Posteriorly to this is the **mastoid process** that allows for attachment of a muscle tendon. The **styloid process** is a long needle-shaped bone that allows for ligaments of the jaw joint to attach. Finally, the **stylomastoid foramen** is a hole that allows for the exit of the facial nerve. On the floor of this bone, the **petrous part** houses the organs for hearing and balance and includes the **internal acoustic meatus** on the posterior surface. At the junction between the temporal and occipital bones, the **jugular foramen** is a hole that allows for cranial nerves and the jugular vein to exit the brain. Finally, the **carotid canal**, on the anterior portion of the petrous part, allows the carotid artery to enter the brain.

Sphenoid

This bone forms the base of the cranium and is the one bone that every other cranial bone articulates with. On the anterior side, the bone contributes to forming the orbits of eye sockets. Two **lesser wings** and 2 **greater wings** that are found on each side of the medial line form the superior surface of this bone. The greater wing has an orbital surface, forming part of the orbital wall. The **sella tucica** forms the center of this bone. The **pterygoid process** extends vertically from the inferior surface and divides into the **lateral** and **medial plate**, allowing for mouth muscles to attach. The **pterygoid canal**, allows the passageway for cranial nerves. There are 4 pairs of **foramina** (small foramen), on the sides of the bone, allowing for passage of cranial nerves: The **foramen ovale** and **foramen spinosum** allow for trigeminal nerves to pass. The **foramen rotundum** is anterior to the foramen ovale, allowing the passageway for a facial nerve. Medial to this is the **foramen lacerum**, where the auditory

tube passes. Superior to the foramen rotundum is the **superior orbital fissure**, a cleft allowing nerves of the ocular muscle to pass through. The **inferior orbital fissure** is found on the inferior margin of the sphenoid. The **optic canal**, found at the base of the anterior clinoid process, allows for the optic nerve to enter.

Ethmoid

Last but not least, the ethmoid bone is found anterior to the sphenoid and helps to form the roof of the noise and part of the nasal septum as well as the anteromedial cranial floor. The **crista galli** is a region where membranes protecting the brain attach. At the base of this, the **cribiform plate**, is a structure full of many small **olfactory foramina**, allowing passage of the olfactory nerve. The inferior part of the bone contains the **perpendicular plate**, a thin sheet of vertical bone, helps to separate the nasal cavity. The **superior** and **middle nasal conchae** extend inferiorly.

7.6b Facial

There are 14 total facial bones: 2 **nasal**, 2 **maxillae**, 2 **lacrimal**, 2 **zygomatic**, 2 **palatine**, 2 **inferior nasal conchae**, 1 **vomer**, and 1 **mandible**. The 2 nasal bones form the hard bridge of the noes, lateral to this are the maxillae, forming the floor of the eye orbits and upper jaw. The zygomatic bones, also known as the cheekbones are below this. The small lacrimal bones are found lateral to the bridge of the nose and are the medial parts of the eye orbits. The inferior nasal conchae are the lower shelves of the nasal cavity (the other shelves are from the ethmoid bone). The lower jaw is the mandible bone. On the inferior surface of the skull, the palatine bones form the roof of the mouth and the vomer, a thin bone is part of the nasal cavity separation. (Figure 7-5)

Maxillae

These 2 bones are located on the inferior surface of the eye orbits. The **infra-orbital foramen** is located inferior to the orbit. The **alveolar process** is a U-shaped ridge that holds the upper teeth. The **palatal process** is the anterior part of the roof of the mouth, the hard palate.

Zygomatic

These 2 bones form the inferior and lateral walls of the orbits. The posterior process called the **temporal process** joins with the zygomatic process found on the temporal bone and together they form the **zygomatic arch**.

Nasal

These 2 small bones form the hard bridge of the nose, articulating with the frontal bone at the **frontonasal suture**.

Lacrimal

These 2 bones form the anterior portion of the medial wall of the eye orbits. Found in the **lacrimal fossa** on these bones are the lacrimal glands that produce tears to lubricate and protect the eyeball.

Inferior Nasal Conchae

These form shelves in the medial portion of the nasal wall. The structure allows air to swirl in the cavity so that the moist mucous membrane covering the wall can warm, cleanse and moisten the air.

Palatine

These bones are posterior to the maxilla's palatine process. These contribute to the roof of the mouth and separate the oral and nasal cavities. The two major foramen of this bone are the **greater** and **lesser palatine foramen** (Figure 7-5).

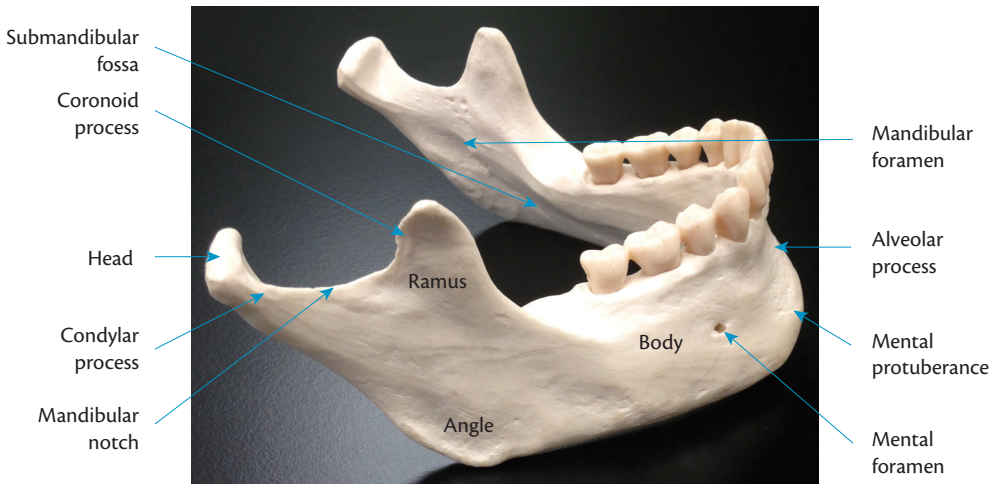
Vomer

This single bone forms the inferior portion of the nasal septum, the wall that partitions the nasal chamber into the right and left cavities (Figure 7-5).

Mandible

This bone forms the lower portion of the jaw, the movable portion. The bone can be broken up into the horizontal **body** that extends laterally to the posterior **angle** where the bones turn up to the raised **ramus**. The **mandibular notch** is the end of the ramus that has two processes: the **anterior coronoid process** and **posterior condylar process**. The articular surface of the condylar head articulates with the **mandibular fossa** on the temporal bone at the **temporomandibular joint (TMJ)**. The lower teeth articulate with the mandible at the **alveolar process**. The **mental protuberance** is lateral to the chin and contains the **mental foramen**. On the medial surface is the **submandibular fossa**, a depression where the submandibular salivary gland sits near the bone. Posterior to this is the **mandibular foramen**, a passageway for sensory nerves (Figure 7-6).

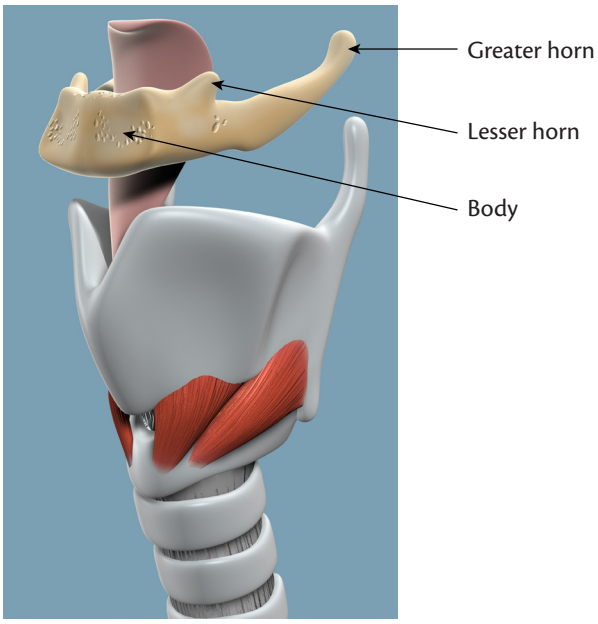
Figure 7-6 Mandible



7.6c Hyoid Bone

The single hyoid bone is located inferior to mandible and is the only bone in the body that does not articulate with any other bone. It is surrounded by ligaments and muscles of the throat and neck. Unique markings of this bone function as attachment points for muscles: the **lesser horn (cornua)**, located anteriority and the **greater horn (cornua)**, located posterioraly (Figure 7-7).

Figure 7-7 Hyoid bone



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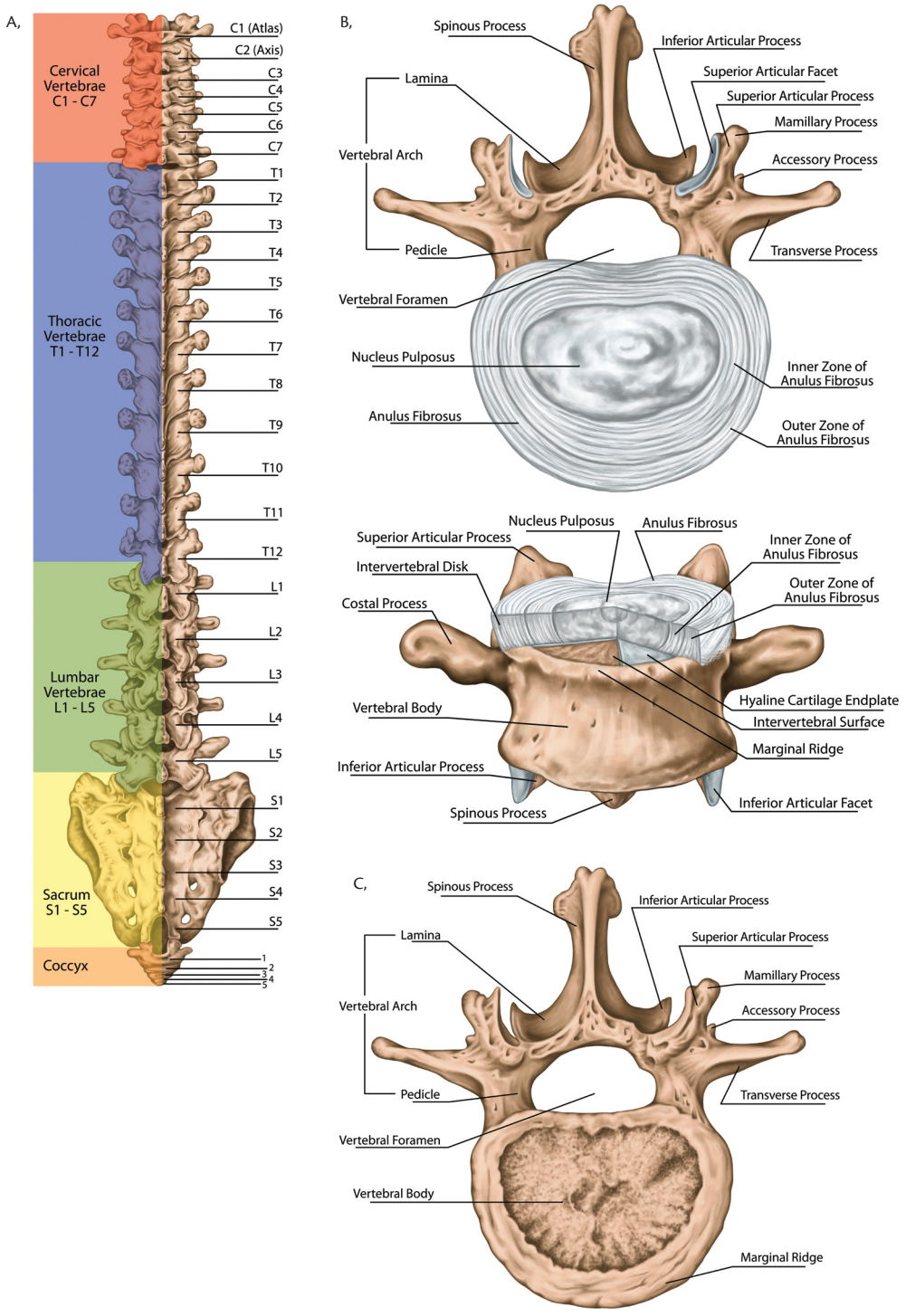
7.6d Vertebral Column

The vertebral column or spine encases the spinal cord, and made up of 26 bones (24 vertebra) and 1 sacrum and 1 coccyx. It begins at the base of the skull and ends at the pelvic girdle, passing through the ribs. The bones, which are reviewed below, are grouped into 5 regions, based on their anatomical features and location. Briefly, below the brain are the 7 **cervical vertebrae**; following this are the 12 **thoracic vertebrae**; the lower back contains the 5 **lumbar vertebrae**, and this ends with a single **sacrum** bone (composed of 5 fused sacral vertebrae) and ending with the **coccyx**, or tailbone which consists of 4 fused coccygeal vertebrae (Figure 7-8a).

Spinal curves are the curves in the spine that form to help balance the body's weight. At the end of gestation, the thoracic and sacral regions develop **accommodation curves** to open space for the internal organs. These are the first and **primary curves** of the spine. After birth, **compensation** or **secondary curves** develop in the cervical and lumbar regions to counter the weight and strain on the body. In between each vertebra are **intervertebral discs** (Figure 7-8b), cushions of fibrocartilage that help to absorb stress on the bones. Each disc contains and outer fibrocartilage, **annulus fibrosus**, layer. The inside tissue, **nucleus pulposus**, is made of water and elastic fibers in a gelatinous material.

Figure 7-8 Vertebral Column

A. The five regions of the column are highlighted. B. A typical vertebra with an intravertebral disc—labeled C. A an example vertebra—labeled



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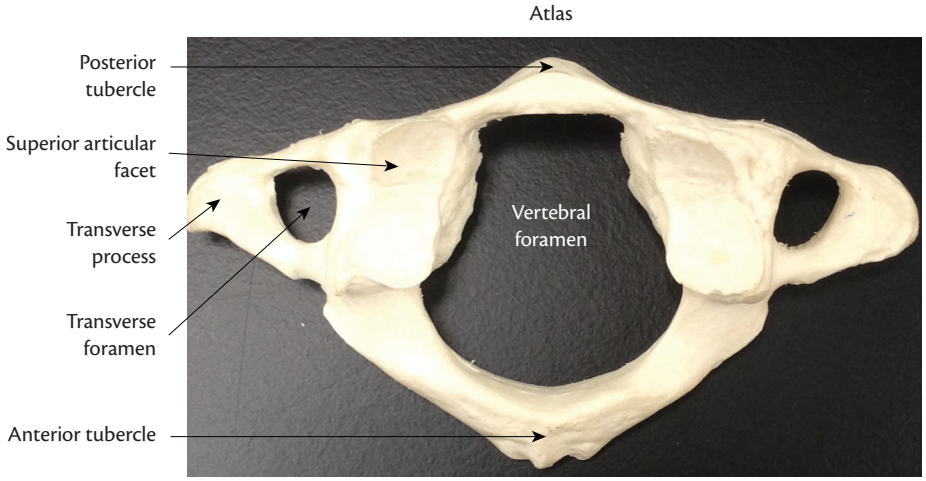
Vertebra

While each region of vertebrae contain slightly different anatomical features, there are common features among them all (Figure 7-8c). The **vertebral body** is a large anterior disc shaped region that connects with a posterior elongated **spinous process.** Lateral to each spinous process is a **transverse process** and in between these is a flat plate of bone called the **lamina** and forms the curved **vertebral arch**. The **pedicle** is a small strut of bone extending posterioraly from the vertebral body. The **vertebral foramen** is formed from the pedicle and lamina on each side, which helps to hold the spinal cord. Inferior to the pedicle is a region called the **inferior vertebral notch**, this forms an articulation with the adjacent vertebra at its pedicle. The joints between each vertebra are found at smooth articular surfaces called **facets** projecting from articular processes. The **superior articular process** is on the superior surface of the pedicle of each vertebra and has a **superior articular facet** at the posterior tip. The **inferior articular process** is a downward projection of the inferior lamina wall and the **inferior articular facet** is found on the anterior tip.

Cervical Vertebrae

There are 7 cervical vertebrae in the neck, and are distinct from other vertebrae by their transverse foramen on each transverse process. This is the foramen that allows the passage of the vertebral artery into the skull. The first 2 cervical vertebrae are distinct from other cervical vertebrae, for these form the first articulation with the skull. The first cervical vertebra, called the **atlas**, is the direct contact with the skull. The superior facets of the atlas are enlarged to fit the condyles of the occipital bone. The atlas is also different in that is lacks a vertebral body and spinous process, but has a large vertebral foramen, formed by an anterior and posterior arch. The **posterior tubercle** is a small rough process that is found where the spinous process would be. The **axis** is the 2nd cervical foramen, and articulates with the atlas. The **dens**, a peglike process, is found superiorly from the body, and fits against the anterior wall of the vertebral foramen of the atlas (Figure 7-9).

Figure 7-9 Cervical Vertebrae: Atlas (top) and Axis (bottom)



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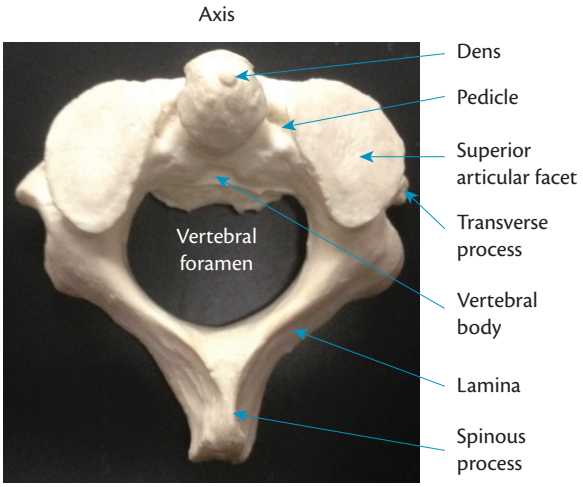
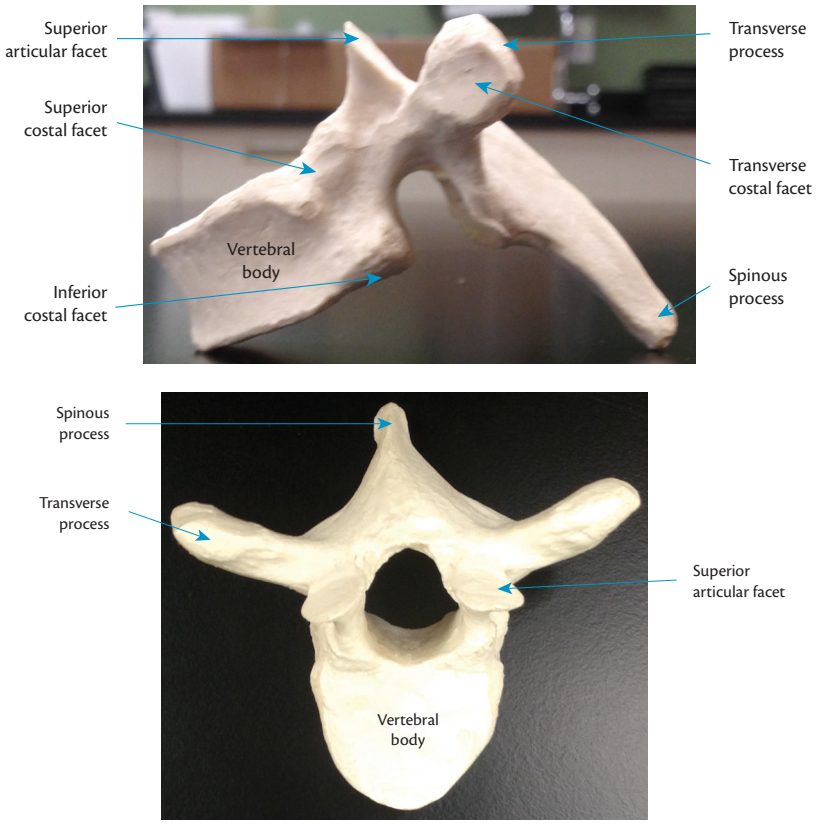


Thoracic Vertebrae

There are 12 thoracic vertebrae and these articulate with 12 pairs of ribs. The vertebrae are larger than the cervical vertebrae and increase in size as they approach the lumbar region. Most ribs attach to the vertebra at 2 sites on the bone—on a **transverse costal facet** at the tip of the transverse process and on a **costal facet** on the posterior side of the vertebral body. There are usually 2 costal facets on each vertebral body, the **superior** and **inferior**. These facets are unique to the thoracic vertebrae (Figure 7-10).

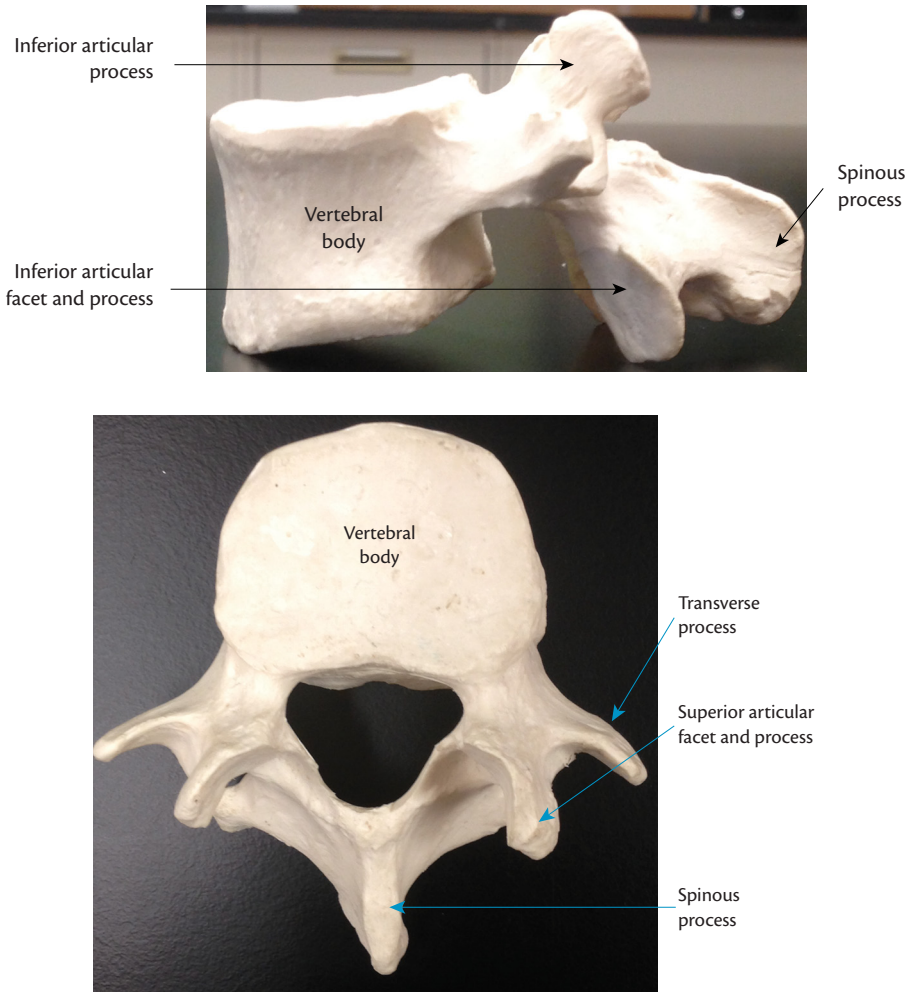
Figure 7-10 Thoracic Vertebrae



Lumbar Vertebrae

There are 5 lumbar vertebrae and these are the largest and heaviest in order to support the weight of the body. These vertebrae have the largest vertebral body and a blunt and horizontal spinous process, with shorter transverse processes. The vertebral foramen are smaller in these vertebrae than others (Figure 7-11).

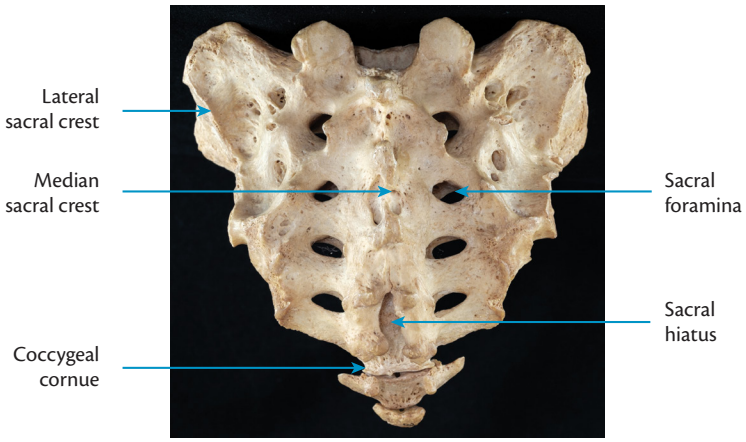
Figure 7-11 Lumbar Vertebrae



Sacral and Coccygeal Vertebrae

After birth, the sacrum is a single bony element that is composed of 5 fused smaller bones, fused prior to birth. It articulates with the ilium of the pelvic girdle to form the posterior wall of the pelvis. The vertebral canal forms the sacral canal after fusion and opens at the end, the **sacral hiatus**. The **sacral foramina** is found along the lateral margin of the fused vertebrae, and the fused spinous processes form the **median sacral crest**. A **lateral sacral crest** extends along the lateral edge. The coccyx articulates with the 5th sacral vertebra at the **coccygeal cornu**, and can form from 3–5 bones, most people containing 4 (Figure 7-12).

Figure 7-12 Sacrum and Coccyx



Source: Shutterstock

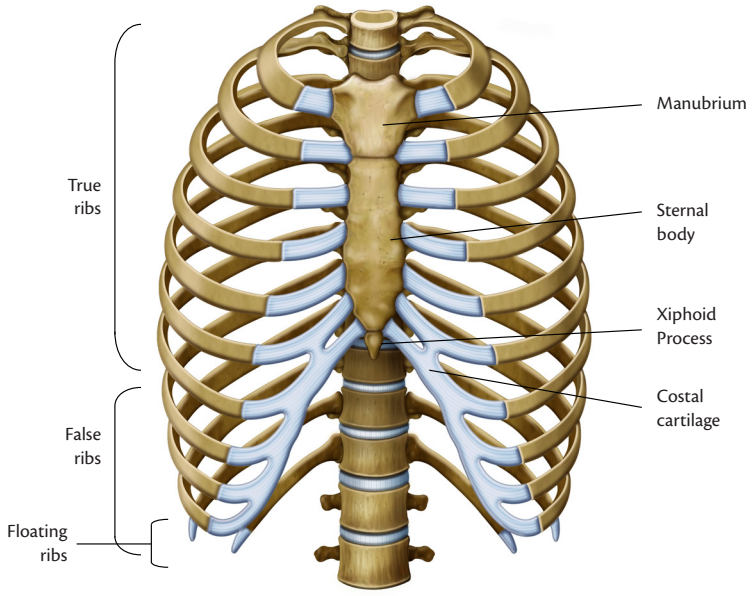
7.6e Thoracic Cage

There are 12 pairs of ribs that articulate with the thoracic vertebrae on the posterior side and the **sternum** anteriorally. This cage encloses the internal organs such as the heart and lungs. During breathing, muscles move the ribs to enlarge the space, to allow for an increase in space for the lungs to expand (Figure 7-13).

Sternum

The sternum is a flat bone anterior to the thoracic cage. The 3 bony elements of the sternum are the **manubrium** (superior), **sternal** (middle) and **xiphoid process**(inferior). The manubrium articulates with the clavicle and first pair of ribs. The sternal body is elongated and attaches to the costal cartilage of ribs 2–7. Finally, the xiphoid process projects inferiorally.

Figure 7-13 Human Rib Cage



Source: Shutterstock

Ribs

The pairs of ribs are classified and named based on how they articulate with the sternum. The first 7 ribs are also known as **true ribs**, or **vertebrosternal** ribs because their costal cartilage attaches directly to the sternum. Rib pairs 8–12 are also known as **false ribs** or **vertebrochondral** ribs because their costal cartilage does not directly contact the sternum, but fuses with the costal cartilage of rib 7. Ribs 11 and 12 are classified as **floating ribs** because they do not articulate with the sternum. Each rib has a **head** or **capitulum** with 2 **articular facets** for articulating with the costal facets of the thoracic vertebrae. The **tubercle** of the rib articulates with the transverse costal facet of the ribs vertebra. A **neck** is found between the head and tubercle (Figure 7-14).

Figure 7-14 Human Rib Bone

ACTIVITY 7-5 *Axial Skeleton*

Materials: Articulated skeleton, loose (disarticulated) bones from the axial skeleton: skull, hyoid bone, vertebral column, rib bones

A. Cranial Bones

1. Review the cranial bones in Figure 7-5.
2. Locate the Frontal bone on the skull: identify the frontal squama, supraorbital foramen and lacrimal fossa
3. Locate the Parietal bones on the skull: identify the superior and inferior temporal lines
4. Locate the Occipital bone on the skull: identify (internally) the foramen magnum, occipital condyles, hypoglossal canal; identify (externally) the occipital crest, external occipital protuberance and superior/inferior nuchal lines.
5. Examine the Temporal bones on the skull: identify the squamous and petrous parts, mastoid process, zygomatic process and mandibular fossa. Find the major passageways of the temporal bone: external and internal auditory meatuses, jugular foramen and carotid canal. Finally, identify the styloid process and stylomastoid foramen.
6. Examine the sphenoid bone and locate where it articulates with the other bones of the skull. Identify the lesser wings, the greater wings, and sella turcica. Find the foramen: ovale and rotundum. Locate the optic canal and superior/inferior orbital fissure. Finally, locate on the inferior surface, the pterygoid processes and pterygoid plates.

7. Identify the ethmoid bone: locate the crista galli, cribriform plate and olfactory foramina. Find the perpendicular plate in the nasal cavity.
8. Now: correctly label the images of the skull in your lab report and answer any follow up questions.

B. Facial Bones

1. Review the facial bones in Figures 7-5 and 7-6.
2. Locate the Maxillae: identify the infraorbital foramen below the orbit and locate the alveolar process and incisive fossa.
3. Identify the Palatine bones: find the greater palatine formen.
4. Identify the Zygomatic bones: locate the zygomaticofacial foramen and the temporal process of the zygomatic arch.
5. Examine the Lacrimal bone: find the lacrimal fossa
6. Locate the Nasal bones.
7. Locate the Vomer bone.
8. Find the Inferior Nasal Conchae in the nasal cavity.
9. Identify the Mandible (usually disarticulated in lab): find the body, angle and ramus; identify the mandibular notch and condylar process; on the medial surface find the mandibular groove and mandibular foramen.
10. Now: correctly label the images of the skull in your lab report and answer any follow up questions.

C. Hyoid Bone

1. Review the hyoid bone in Figure 7-7.
2. Identify the greater and lesser horns.
3. Now: correctly label the images of the hyoid bone in your lab report and answer any follow up questions.

D. Vertebral Column

1. Review the Vertebral Column and Vertebrae in Figures 7-8 through 7-11.
2. Identify the 4 major regions on an articulated vertebral column.
3. Find 1 of each kind of vertebrae (1 from each region) in the box of disarticulated vertebrae. In your lab report sketch each vertebra that you chose, indicating what region it is from and the major anatomical features. Identify the spinous process, transverse process and superior articular facet.
4. Identify and sacrum and coccyx.
5. Correctly label the articulated vertebra in your lab report as well as the disarticulated vertebra example and answer any follow up questions.

E. Thoracic Cage

1. Review the Thoracic Cage and Rib anatomy in Figures 7-12 and 7-13.
2. Identify the manubrium, body and xiphoid process of the sternum.
3. Examine a single rib: identify the head, articular facets and neck.
4. Correctly label the rib cage and sternum image in your lab report and answer any follow up questions.

Lab Report for Chapter 7
Introduction to the Skeletal System and the Axial Skeleton

ACTIVITY 7-1

Label this photograph of a femur bone (a long bone) with arrows pointing to the correct locations using all of the terms listed here: **diaphysis**, **metaphysis**, **epiphysis**, **periosteum**. Here are terms of anatomical locations found inside the bone and not visible from this photograph: indicate with an arrow and label where you would find these as well: **endosteum**, **medullary cavity**, **compact bone**, **spongy bone**.

Questions:

1. What are the names and locations of the 2 membranes found on long bones?

2. Where is spongy bone located and what kind of tissue is stored here?

ACTIVITY 7-2

1. How many osteons do you count in your slide of the bone tissue? _____

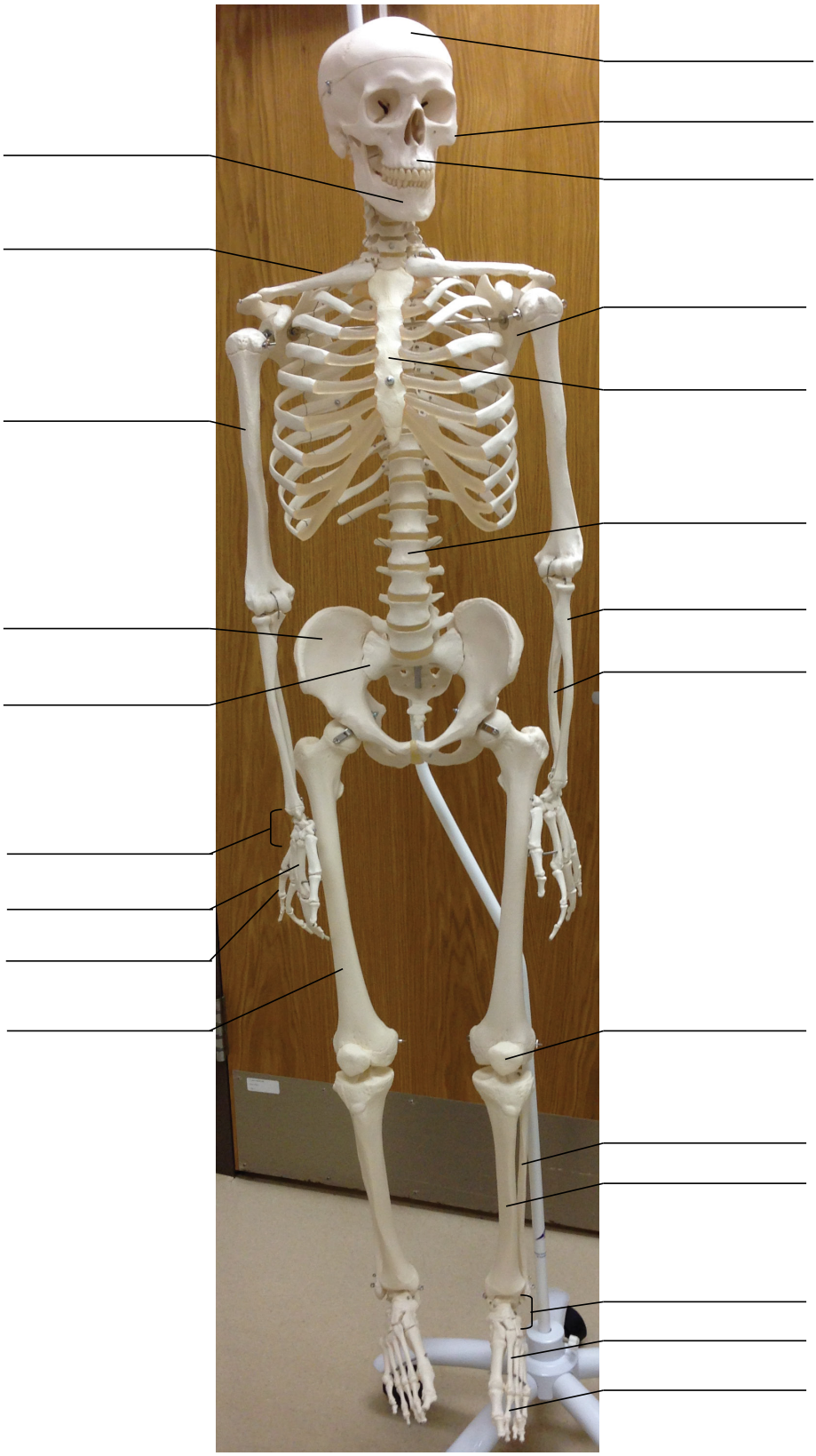
2. Sketch the osteon that you are focused on in higher magnification, labeling the **central canal**, **canaliculi**, **lacunae**, **concentric lamellae**, and **interstitial lamellae**.

3. What kind of cell is found inside the lacunae?

4. What is the function of the central canal?

ACTIVITY 7-3

A. Label this photograph of the skeleton with the correct anatomical terms.



B. Indicate in the table whether each bone listed in the left column is part of the appendicular or axial skeleton.

Bone	Appendicular or Axial?
Rib	
Skull Bones	
Cervical Vertebrae	
Sternum	
Patella	
Metatarsal Bones	
Ulna	
Fibula	
Lumbar Vertebrae	
Nasal Bones	
Phalanges	
Femur	
Carpals	
Coxal Bone	
Scapula	

1. What 3 bones form the coxal bone?

2. What 2 bones together make the pectoral girdle?

3. What bones together make up the lower limb?

ACTIVITY 7-4

A. Record the number of bones you count that fall into each of the general classification of bone shapes.

Group	# bones found
Long	
Short	
Flat	
Irregular	
Sesamoid	

B. Using Table 7-1 as a reference, locate an example of each of the markings and describe where it is and what it looks like.

General Marking Group	Anatomical Term	Location and description
Elevations and Projections	Process	
	Ramus	
Processes formed where tendons or ligaments attach	Trochanter	
	Tuberosity	
	Tubercle	
	Crest	
	Line	
	Spine	
Processes formed for articulation with adjacent bones	Head	
	Neck	
	Condyle	
	Trochlea	
	Facet	
Depressions	Fossa	
	Sulcus	
Openings	Foramen	
	Canal	
	Fissure	
	Sinus/antrum	

C. Questions

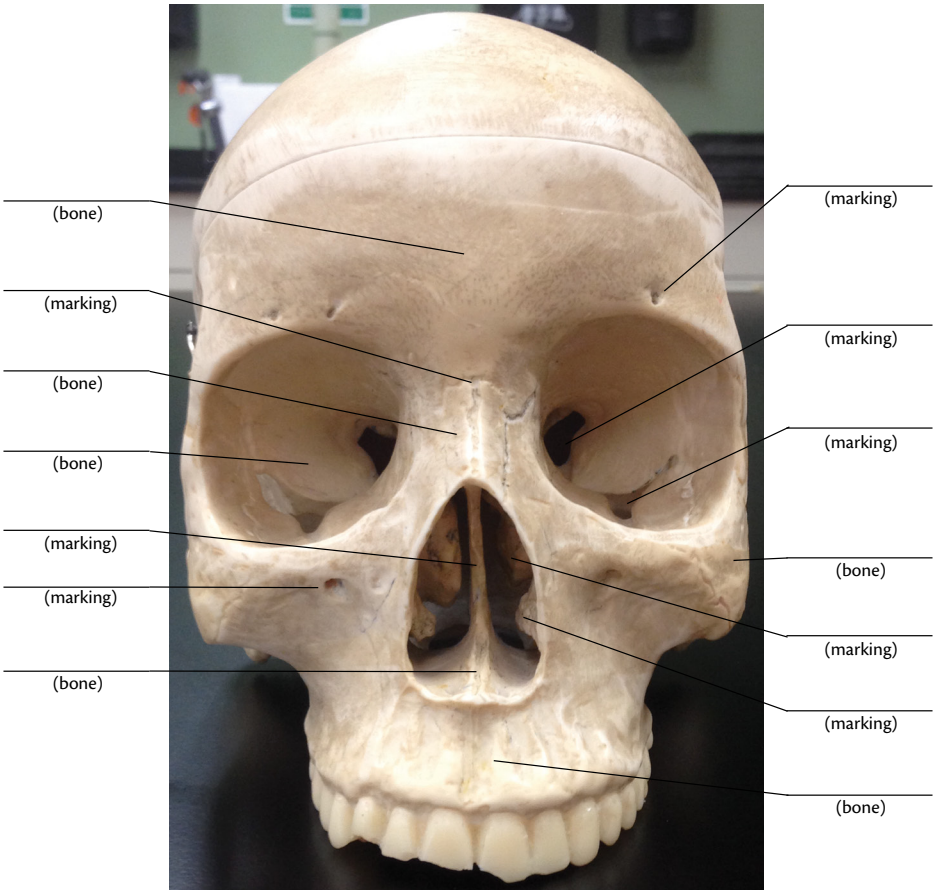
1. How is a fossa different from a foreman?

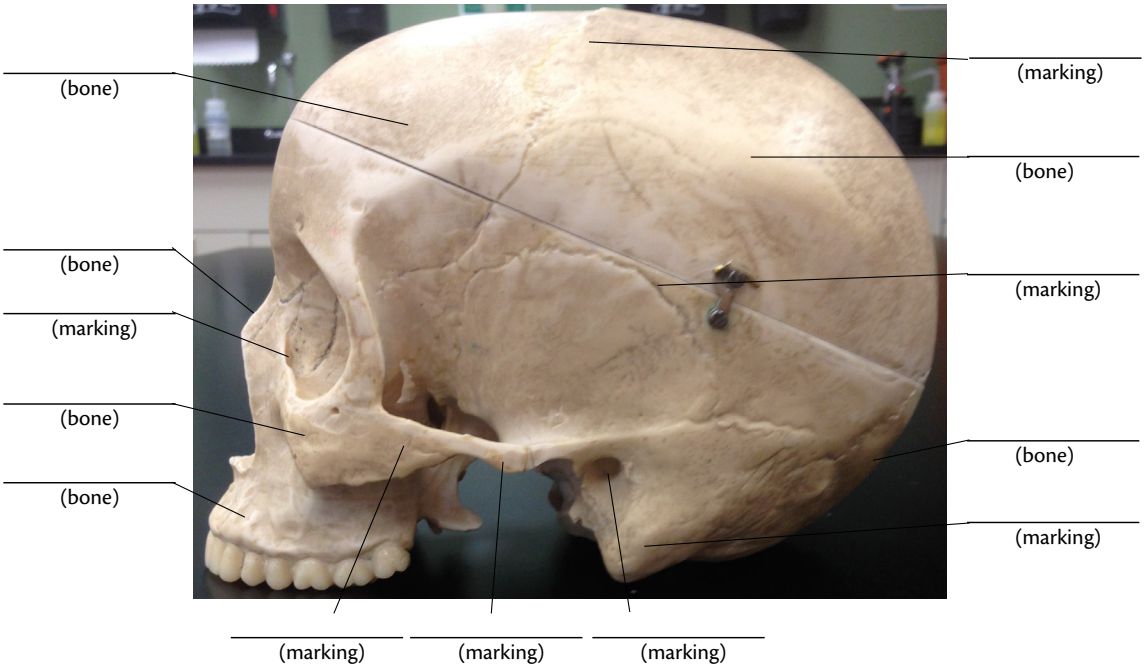
2. A head is a marking found on the femur—what other bones contain a head?

3. What is the importance of a foreman or fissure?

ACTIVITY 7-5

A. and B. Cranium and Facial: Correctly label all the *cranial* and *facial* bones and any markings in these images that were introduced in the activity.

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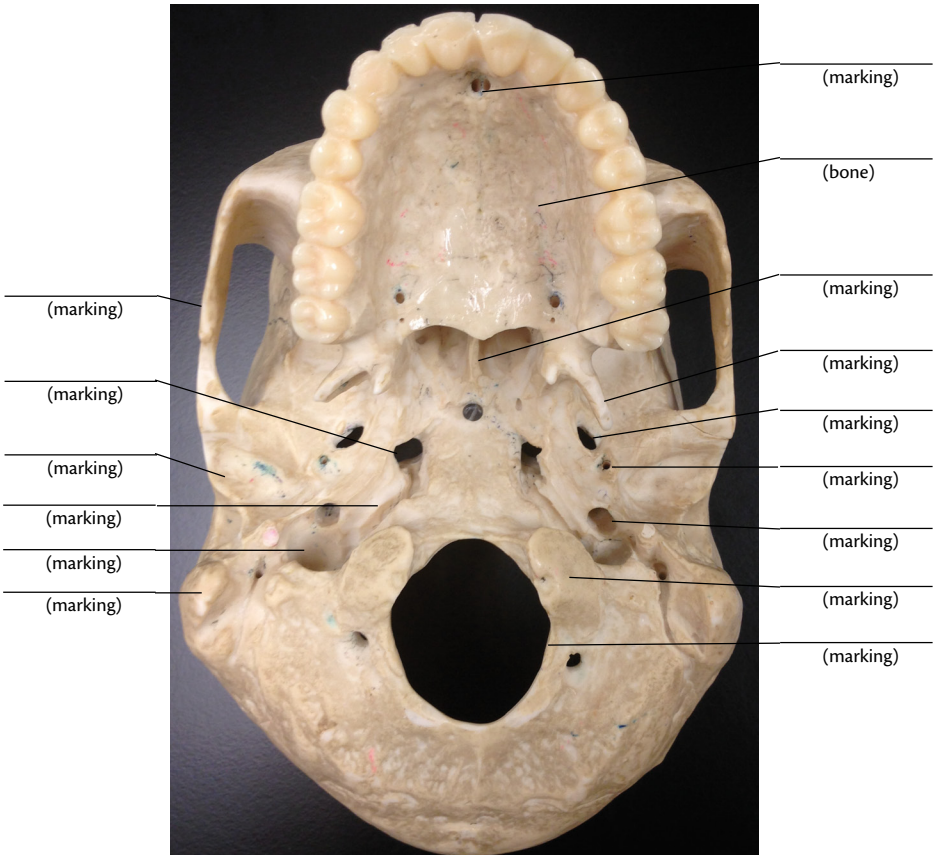
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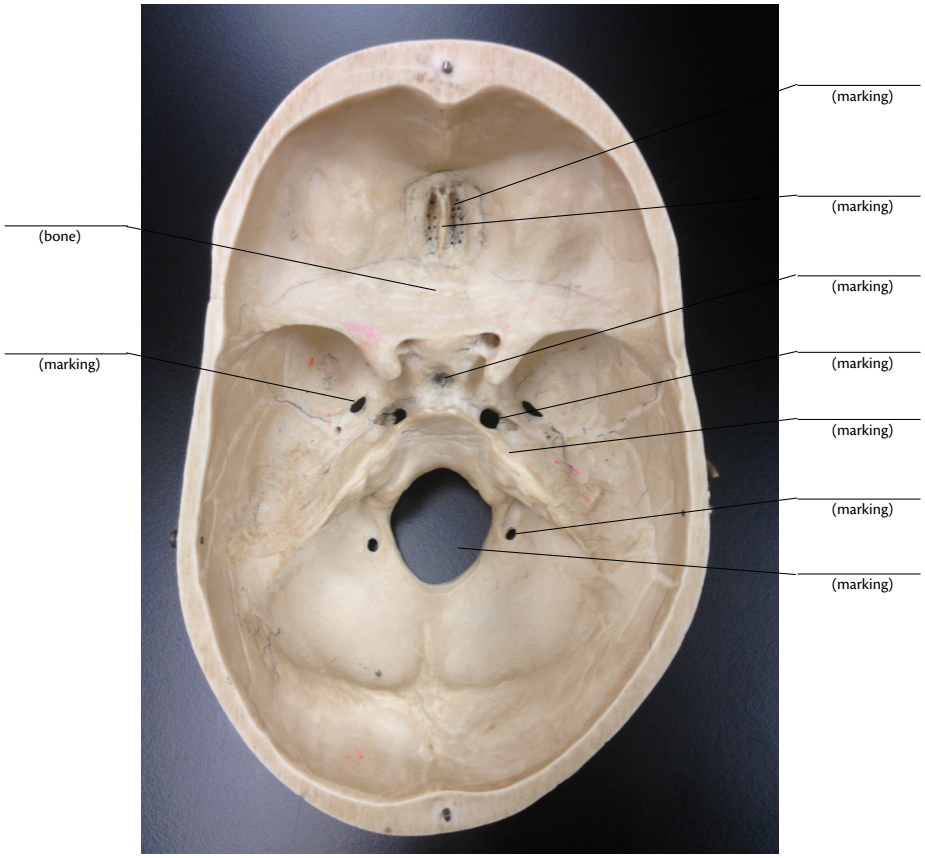


Questions:

1. What bone contains the sella turcica?

2. Where are the squamous and petrous parts of the temporal bone located?

3. The zygomatic process is found on the _____ bone.

4. The foramen magnum is found on the _____ bone.

Questions:

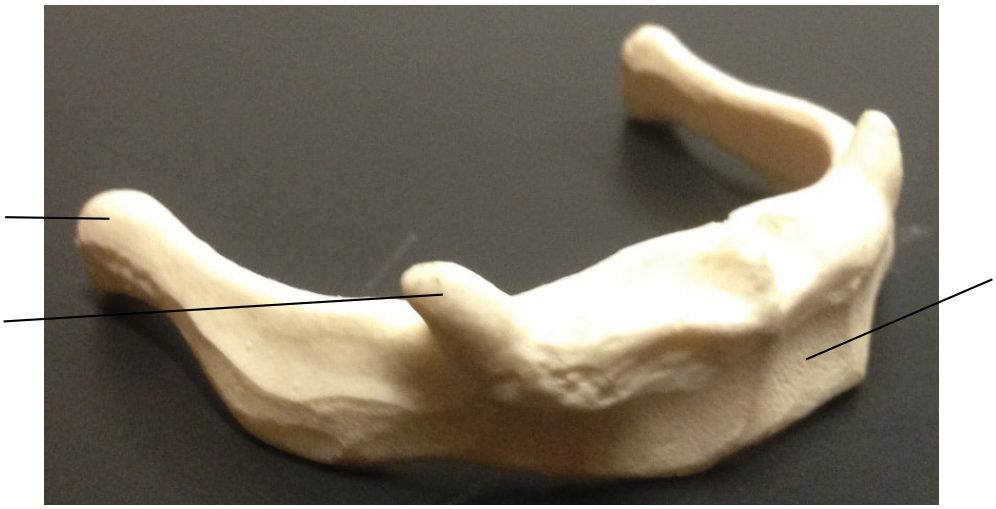
1. Which facial bones contribute to the orbit of eye?

2. How does the mandible bone articulate with the cranium?

3. Which bone contains the zygomaticofacial foreman?

4. The infra-orbital foreman is located on the _____ bone.

C. Hyoid Bone: Correctly label the image of the hyoid bone.



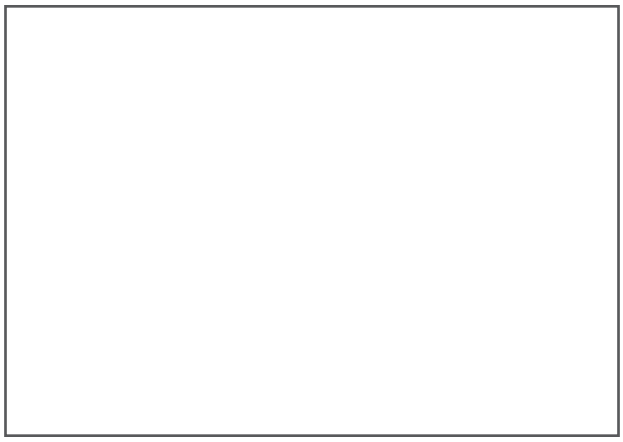
Questions:

1. Where is the hyoid bone located?

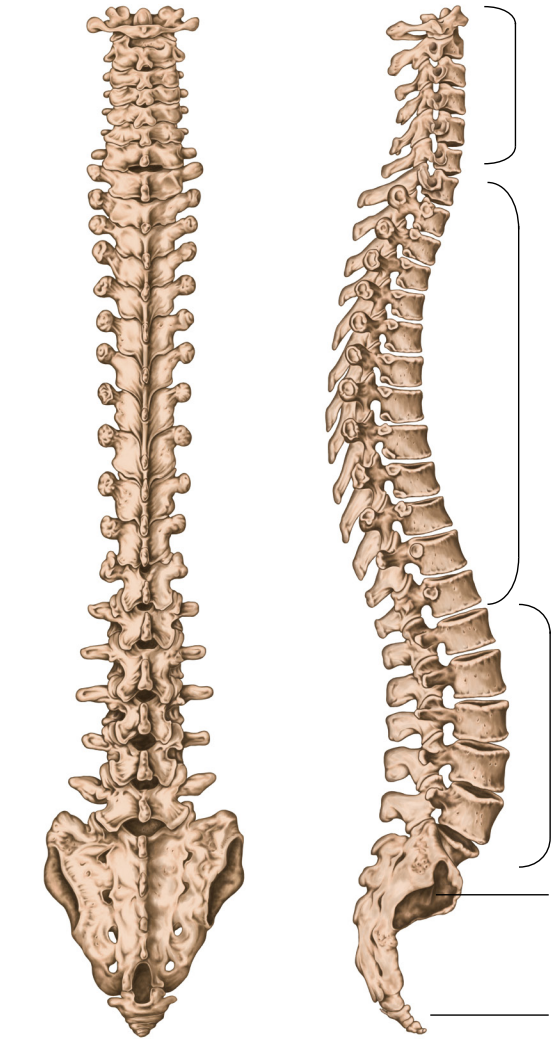
2. What other bones does the hyoid bone articulate with?

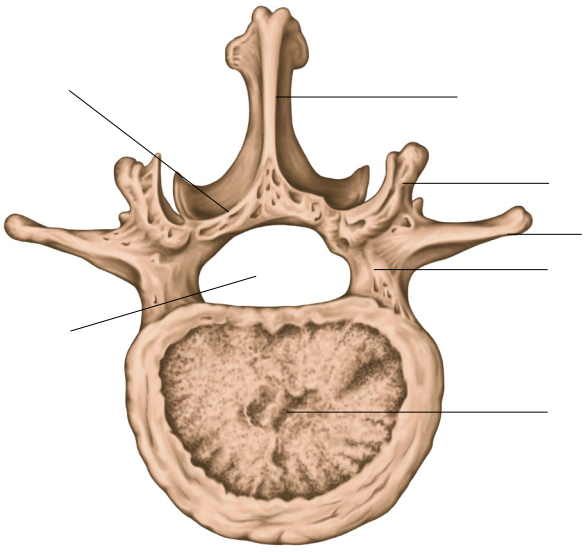
D. Vertebral Column

1. Sketch and label a disarticulated example of each: **cervical**, **thoracic** and **lumbar** vertebrae.



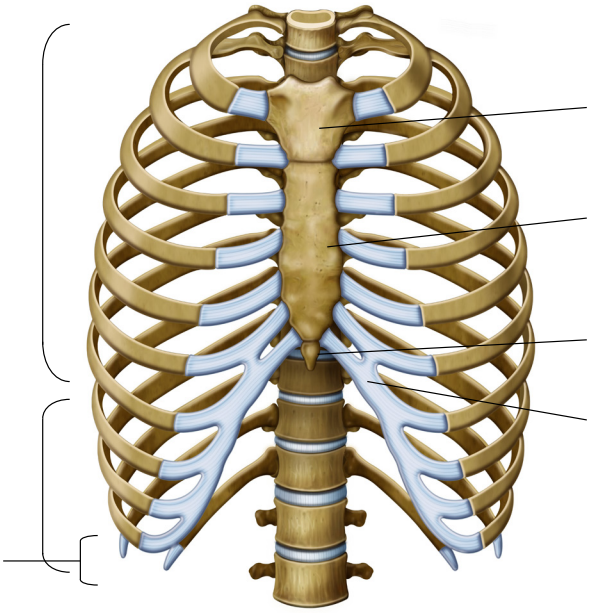
2. Correctly label each of the 5 sections of the vertebral column and this image of a disarticulated vertebra:





E. Thoracic Cage

Correctly label this image of the thoracic cage.



Critical Thinking Questions

1. Where does spongy bone occur in the skeleton?

2. How are the upper limbs attached to the axial skeleton?

3. Where does growth in length occur in a long bone?

4. Explain how your compact bones may respond to long term changes in weight, pressure and stress on different bones of your body.

5. A patient has to have a deviated nasal septum. Which bones and other facial features may be involved in this surgery?