CHAPTER 7

Anatomy of Bones and Joints

Photo: Brittle bone disease (see osteogenesis imperfecta, p. 128) is a genetic disorder that causes an increased risk for broken bones. Even very young babies, like the one in this photo, can suffer a greater incidence of bone trauma with even minor falls or bumps. Knowing someone with brittle bone disease allows us to be more appreciative of a healthy skeletal system.

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Module 5: Skeletal System

Learning Outcomes

AFTER YOU COMPLETE THIS CHAPTER YOU SHOULD BE ABLE TO:

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1. Define the general anatomical terms for various bone features and explain the functional significance of each.

7.2 Axial Skeleton 150

2. List the bones of the braincase and of the face.
3. Describe the locations and functions of the auditory ossicles and the hyoid bone.
4. Describe the major features of the skull as seen from different views.
5. Describe the structures and functions of the vertebral column and individual vertebrae.
6. List the features that characterize different types of vertebrae.
7. Describe the thoracic cage and give the number of true, false, and floating ribs.

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8. Describe the bones of the pectoral girdle and upper limb.
9. Describe the bones of the pelvic girdle and lower limb.

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10. Define the term *articulation* and explain how joints are named and classified.
11. List the general features of a fibrous joint, describe the three classes of fibrous joints, and give examples of each class.
12. List the general features of a cartilaginous joint, describe the two types of cartilaginous joints, and give examples of each class.
13. Describe the general features of a synovial joint.
14. Define a bursa and a tendon sheath.
15. Describe and give examples of the types of synovial joints.

7.5 Types of Movement 183

16. Define and be able to demonstrate the movements occurring at the joints of the body.

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17. Describe the temporomandibular, shoulder, elbow, hip, knee, and ankle joints and the foot arches.

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18. Discuss the age-related changes that occur in joints.

Introduction

If the body had no skeleton, it would look somewhat like a poorly stuffed rag doll. Without a skeletal system, we would have no framework to help maintain shape and we would not be able to move normally. Bones of the skeletal system surround and protect organs, such as the brain and heart. Human bones are very strong and can resist tremendous bending and compression forces without breaking. Nonetheless, each year nearly 2 million Americans break a bone.

Muscles pull on bones to make them move, but movement would not be possible without joints between the bones. Humans would resemble statues, were it not for the joints between bones that allow bones to move once the muscles have provided the pull. Machine parts most likely to wear out are those that rub together, and they require the most maintenance. Movable joints are places in the body where the bones rub together, yet we tend to pay little attention to them. Fortunately, our joints are self-maintaining, but damage to or disease of a joint can make movement very difficult. We realize then how important the movable joints are for normal function.

The skeletal system includes the bones, cartilage, ligaments, and tendons. To study skeletal gross anatomy, however, dried, prepared bones are used. This allows the major features of individual bones to be seen clearly without being obstructed by associated soft tissues, such as muscles, tendons, ligaments, cartilage, nerves, and blood vessels. The important relationships among bones and soft tissues should not be ignored, however.

7.1 General Considerations of Bones

The average adult skeleton has 206 bones (figure 7.1). Although this is the traditional number, the actual number of bones varies from person to person and decreases with age as some bones become fused. Bones can be categorized as paired or unpaired. A **paired bone** is two bones of the same type located on the right and left sides of the body, whereas an **unpaired bone** is a bone located on the midline of the body. For example, the bones of the upper and lower limbs are paired bones, whereas the bones of the vertebral column are unpaired bones. There are 86 paired and 34 unpaired bones.

Many of the anatomical terms used to describe the features of bones are listed in table 7.1. Most of these features are based on the relationship between the bones and associated soft tissues. If a bone has a **tubercle** (too′ber-kl, lump) or **process** (projection), such structures usually exist because a ligament or tendon was attached to that tubercle or process during life. If a bone has a **foramen** (fō-rā′men, pl. *foramina,* fō-ram′i-nă, a hole) in it, that foramen was occupied by something, such as a nerve or blood vessel. If a bone has a **condyle** (kon′dīl, knuckle), it has a smooth, rounded end, covered with articular cartilage (see chapter 6), that is part of a joint.

The skeleton is divided into the axial and appendicular skeletons.

Table 7.1 General Anatomical Terms for Various Features of Bones

Term	Description
Body	Main part
Head	Enlarged, often rounded end
Neck	Constriction between head and body
Margin or border	Edge
Angle	Bend
Ramus	Branch off the body beyond the angle
Condyle	Smooth, rounded articular surface
Facet	Small, flattened articular surface
Ridges	
Line or linea	Low ridge
Crest or crista	Prominent ridge
Spine	Very high ridge
Projections	
Process	Prominent projection
Tubercle	Small, rounded bump
Tuberosity or tuber	Knob; larger than a tubercle
Trochanter	Tuberosities on the proximal femur
Epicondyle	Upon a condyle
Openings	
Foramen	Hole
Canal or meatus	Tunnel
Fissure	Cleft
Sinus or labyrinth	Cavity
Depressions	
Fossa	General term for a depression
Notch	Depression in the margin of a bone
Groove or sulcus	Deep, narrow depression

1. How many bones are in an average adult skeleton? What are paired and unpaired bones?
2. How are lumps, projections, and openings in bones related to soft tissues?

7.2 Axial Skeleton

The **axial skeleton** forms the upright axis of the body (see figure 7.1). It is divided into the skull, auditory ossicles, hyoid bone, vertebral column, and thoracic cage, or rib cage. The axial skeleton protects the brain, the spinal cord, and the vital organs housed within the thorax.

3. List the parts of the axial skeleton and its functions.

Skull

The bones of the head form the **skull,** or **cranium** (krā′nē-ŭm). The 22 bones of the skull are divided into two groups: those of the braincase and those of the face. The **braincase** consists of 8 bones that

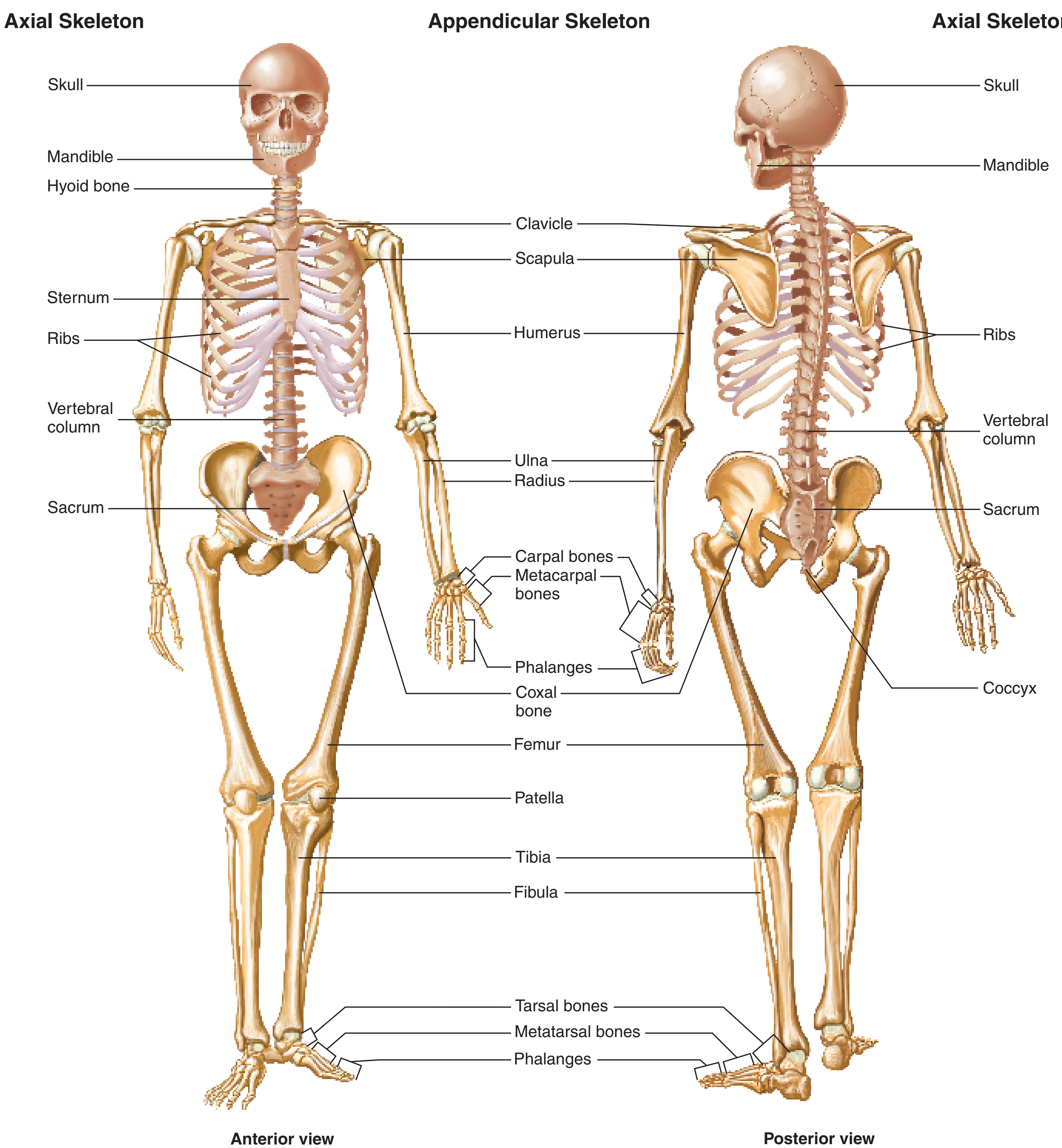


Figure 7.1 Complete Skeleton AP|R

Bones of the axial skeleton are listed in the far left- and right-hand columns; bones of the appendicular skeleton are listed in the center. (The skeleton is not shown in the anatomical position.)

immediately surround and protect the brain. The bones of the braincase are the paired parietal and temporal bones and the unpaired frontal, occipital, sphenoid, and ethmoid bones. The **facial bones** form the structure of the face. The 14 facial bones are the maxilla (2), zygomatic (2), palatine (2), lacrimal (2), nasal (2), inferior nasal concha (2), mandible (1), and vomer (1) bones. The frontal and ethmoid bones, which are part of the braincase, also contribute to the face. The facial bones support the organs of vision, smell, and taste. They also provide attachment points for the muscles involved in **mastication** (mas-ti-kā′shŭn, chewing), facial expression, and eye movement. The jaws (mandible and maxillae) hold the teeth (see chapter 21) and the temporal bones hold the **auditory ossicles,** or ear bones (see chapter 14).

The bones of the skull, except for the mandible, are not easily separated from each other. It is convenient to think of the skull, except for the mandible, as a single unit. The top of the skull is called the **calvaria** (kal-vā′rē-ă), or skullcap. It is usually cut off to reveal the skull's interior. Selected features of the intact skull are listed in table 7.2.

4 Name the bones of the braincase and the facial bones. What functions are accomplished by each group of bones?

Superior View of the Skull

The skull appears quite simple when viewed from above (figure 7.2). The paired **parietal bones** are joined at the midline by the **sagittal suture,** and the parietal bones are connected to the **frontal bone** by the **coronal suture.**

Predict 1

Explain the basis for the names *sagittal* and *coronal sutures.*

Posterior View of the Skull

The parietal bones are joined to the **occipital bone** by the **lambdoid** (lam′doyd, the shape resembles the Greek letter lambda) **suture** (figure 7.3). Occasionally, extra small bones called **sutural** (soo′choor-ăl), or wormian, **bones** form along the lambdoid suture.

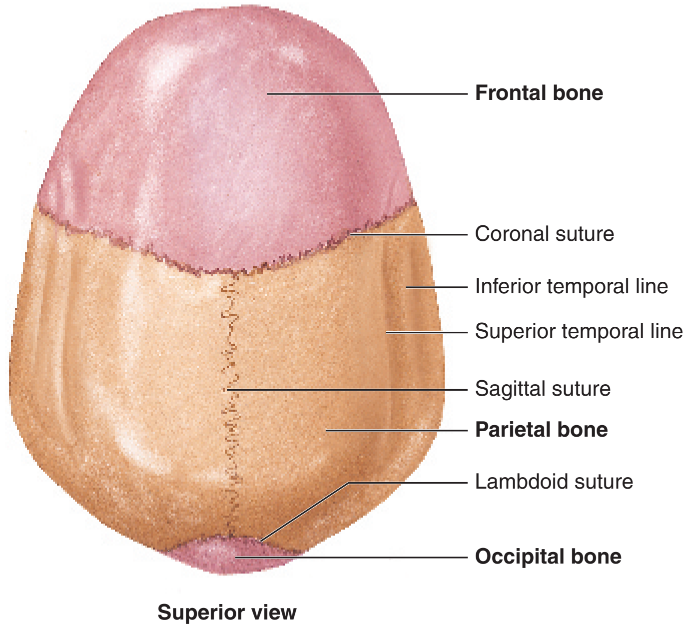


Figure 7.2 **Superior View of the Skull**
The names of the bones are in bold.

An **external occipital protuberance** is present on the posterior surface of the occipital bone. It can be felt through the scalp at the base of the head and varies considerably in size from person to person. The external occipital protuberance is the site of attachment of the

Table 7.2 Processes and Other Features of the Skull

Feature	Bone on Which Feature Is Found	Description
External Features		
Alveolar process	Mandible, maxilla	Ridges on the mandible and maxilla containing the teeth
Coronoid process	Mandible	Attachment point for the temporalis muscle
Horizontal plate	Palatine	The posterior third of the hard palate
Mandibular condyle	Mandible	Region where the mandible articulates with the temporal bone
Mandibular fossa	Temporal	Depression where the mandible articulates with the skull
Mastoid process	Temporal	Enlargement posterior to the ear; attachment site for several muscles that move the head
Nuchal lines	Occipital	Attachment points for several posterior neck muscles
Occipital condyle	Occipital	Point of articulation between the skull and the vertebral column
Palatine process	Maxilla	Anterior two-thirds of the hard palate
Pterygoid hamulus	Sphenoid	Hooked process on the inferior end of the medial pterygoid plate, around which the tendon of one palatine muscle passes; an important dental landmark
Pterygoid plates (medial and lateral)	Sphenoid	Bony plates on the inferior aspect of the sphenoid bone; the lateral pterygoid plate is the site of attachment for two muscles of mastication (chewing)
Styloid process	Temporal	Attachment site for three muscles (to the tongue, pharynx, and hyoid bone) and some ligaments
Temporal lines	Parietal	Where the temporalis muscle, which closes the jaw, attaches
Internal Features		
Crista galli	Ethmoid	Process in the anterior part of the cranial vault to which one of the connective tissue coverings of the brain (dura mater) connects
Petrous portion	Temporal	Thick, interior part of temporal bone containing the middle and inner ears and the auditory ossicles
Sella turcica	Sphenoid	Bony structure resembling a saddle in which the pituitary gland is located

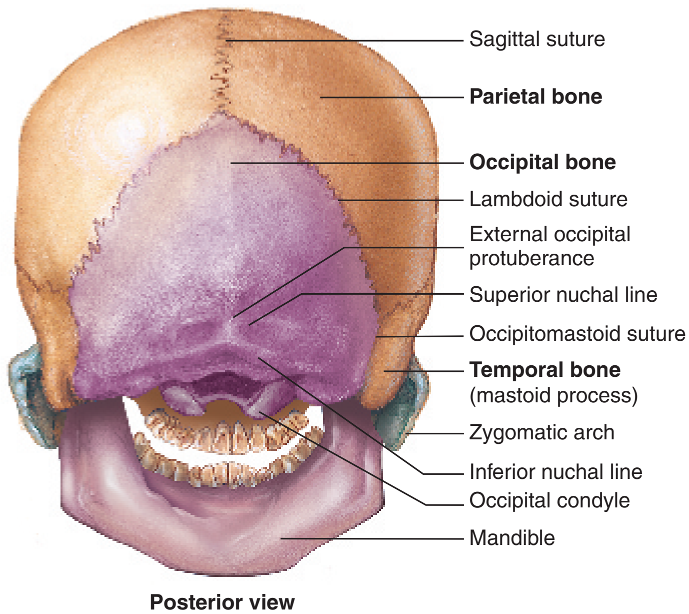


Figure 7.3 **Posterior View of the Skull**
The names of the bones are in bold.

ligamentum nuchae (noo′kē, nape of neck), an elastic ligament that extends down the neck and helps keep the head erect by pulling on the occipital region of the skull. **Nuchal lines** are a set of small ridges that extend laterally from the protuberance and are the points of attachment for several neck muscles.

Lateral View of the Skull

The parietal bone and the temporal bone form a large part of the side of the head (figure 7.4). The term *temporal* means related to time, and the temporal bone is so named because the hair of the temples is often the first to turn white, indicating the passage of time. The **squamous suture** joins the parietal and temporal bones. A prominent feature of the temporal bone is a large hole, the **external acoustic meatus,** or **auditory meatus** (mē-ā′tŭs, passageway or tunnel), which transmits sound waves toward the eardrum. Just posterior and inferior to the external auditory meatus is a large inferior projection, the **mastoid** (mas′toyd, resembling a breast) **process.** The process can be seen and felt as a prominent lump just posterior to the ear. The process is not solid bone but is filled with cavities called **mastoid air cells,** which are connected to the middle ear. Neck muscles involved in rotation of the head attach to the mastoid process. The superior and inferior **temporal lines** arch across the lateral

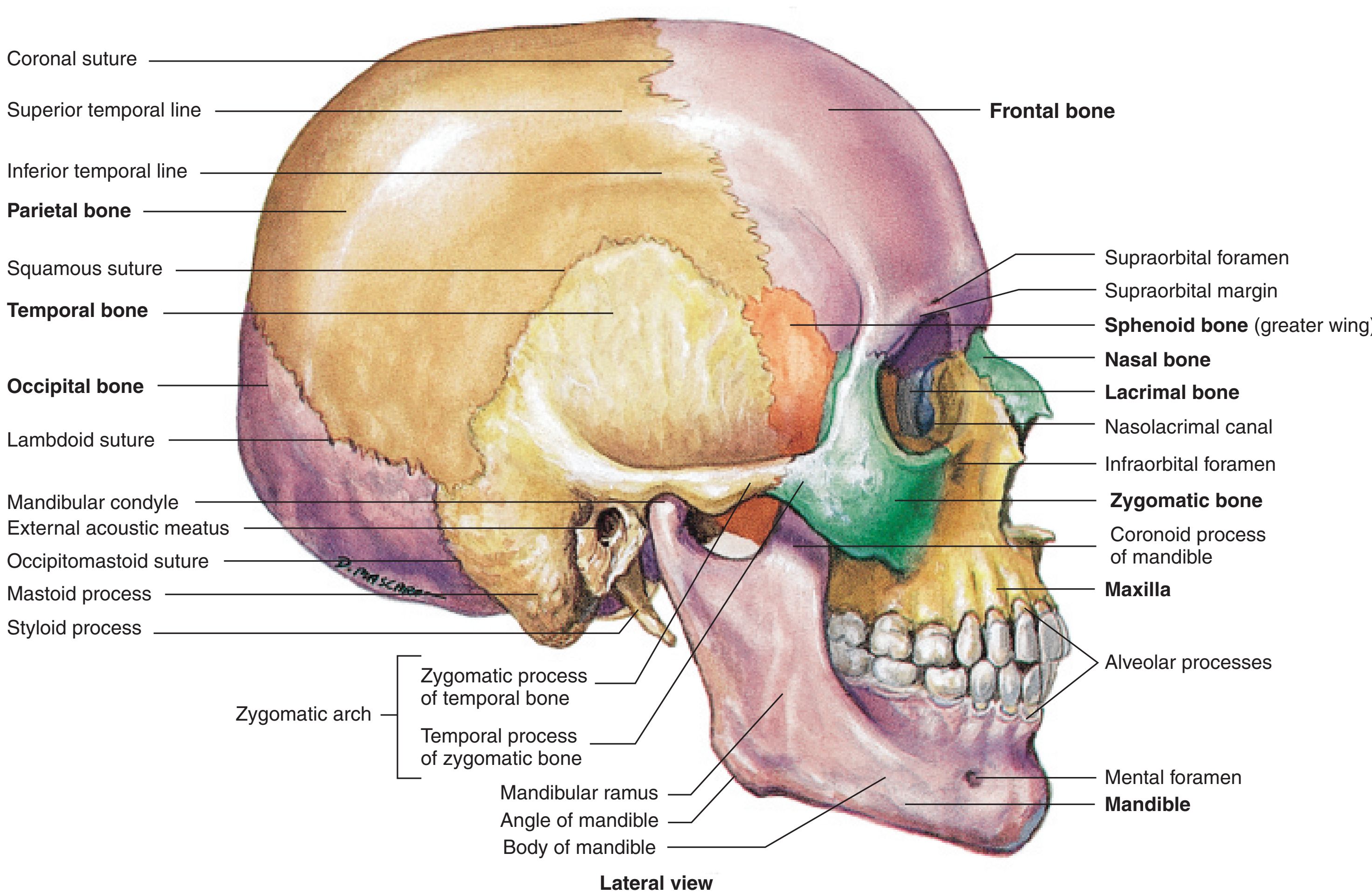


Figure 7.4 **Right Lateral View of the Skull**
The names of the bones are in bold.

surface of the parietal bone. They are attachment points of the temporalis muscle, one of the muscles of mastication.

The lateral surface of the **greater wing** of the **sphenoid** (sfē′noyd, wedge-shaped) **bone** is anterior to the temporal bone (see figure 7.4). Although appearing to be two bones, one on each side of the skull, the sphenoid bone is actually a single bone that extends completely across the skull. Anterior to the sphenoid bone is the **zygomatic** (zī′gō-mat′ik, a bar or yoke) **bone,** or cheekbone, which can be easily seen and felt on the face (figure 7.5).

The **zygomatic arch,** which consists of joined processes from the temporal and zygomatic bones, forms a bridge across the side of the skull (see figure 7.4). The zygomatic arch is easily felt on the side of the face, and the muscles on each side of the arch can be felt as the jaws are opened and closed.

The **maxilla** (mak-sil′ă), or upper jaw, is anterior to the zygomatic bone. The **mandible,** or lower jaw, is inferior to the maxilla (see figure 7.4). The mandible consists of two main parts: the **body** and the **ramus** (branch). The body and ramus join at the **angle of the mandible.** The superior end of the ramus has a **mandibular condyle,** which articulates with the temporal bone, allowing movement of the mandible. The **coronoid** (kōr′ŏ-noyd, shaped like a crow's beak) **process** is the attachment site of the temporalis muscle to the mandible. The maxillae and mandible have **alveolar** (al-vē′ō-lăr) **processes** with sockets for the attachment of the teeth.

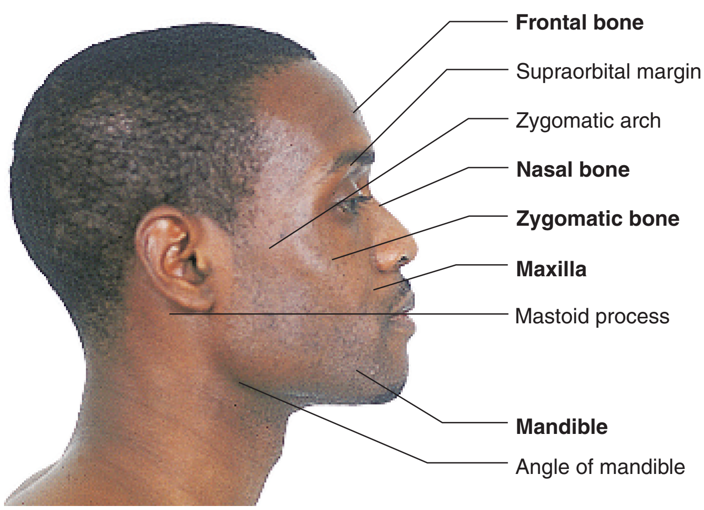


Figure 7.5 **Lateral View of Bony Landmarks on the Face**
The names of the bones are in bold.

Anterior View of the Skull

The major bones seen from the anterior view are the frontal bone (forehead), the zygomatic bones (cheekbones), the maxillae, and the mandible (figure 7.6). The teeth, which are very prominent in this

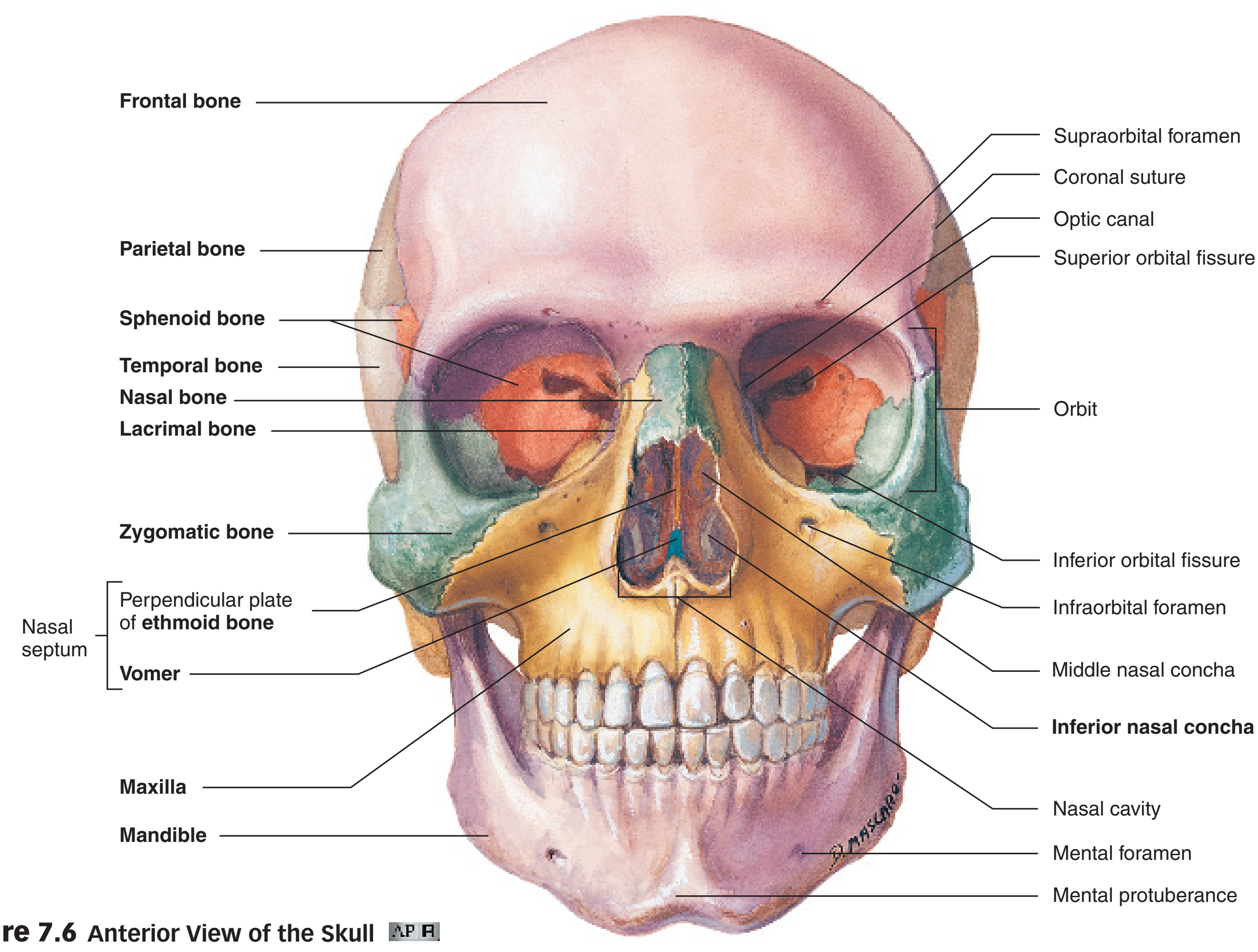


Figure 7.6 **Anterior View of the Skull** APR
The names of the bones are in bold.

view, are discussed in chapter 24. Many bones of the face can be easily felt through the skin of the face (figure 7.7).

Two prominent cavities of the skull are the orbits and the nasal cavity (see figure 7.6). The **orbits** are so named because of the rotation of the eyes within them. The bones of the orbits (figure 7.8) provide protection for the eyes and attachment points for the muscles moving the eyes. The major portion of each eyeball is within the orbit, and the portion of the eye visible from the outside is relatively small. Each orbit contains blood vessels, nerves, and fat, as well as the eyeball and the muscles that move it.

The orbit has several openings through which structures communicate between the orbit and other cavities (see figure 7.8). The largest of these are the **superior** and **inferior orbital fissures.** They provide openings through which nerves and blood vessels communicate with the orbit or pass to the face. The optic nerve, for the sense of vision, passes from the eye through the **optic canal** and enters the cranial cavity. The **nasolacrimal** (nā-zō-lak′ri-măl, *nasus,* nose + *lacrima,* tear) **canal** passes from the orbit into the nasal cavity. It contains a duct that carries tears from the eyes to the nasal cavity (see chapter 14).

The nasal cavity is divided into right and left halves by a **nasal septum** (sep′tŭm, wall) (see figure 7.6; figure 7.9). The bony part of the nasal septum consists primarily of the **vomer** (vō′mer, shaped like a plowshare) inferiorly and the **perpendicular plate** of the **ethmoid** (eth′moyd, sieve-shaped) **bone** superiorly. The anterior part of the nasal septum is formed by hyaline cartilage called **septal cartilage** (see figure 7.9*a*). The external part of the nose has some bone but is mostly hyaline cartilage (see figure 7.9*b*), which is absent in the dried skeleton.

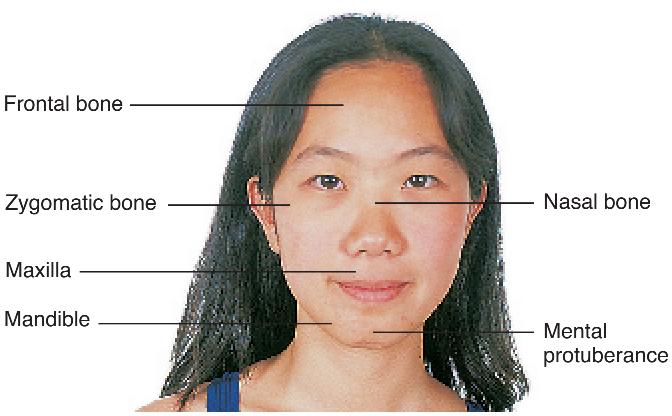


Figure 7.7 **Anterior View of Bony Landmarks on the Face**
The names of the bones are in bold.

Deviated Nasal Septum

The nasal septum usually is located in the median plane until a person is 7 years old. Thereafter, it tends to deviate, or bulge slightly to one side. The septum can also deviate abnormally at birth or, more commonly, as a result of injury. Deviations can be severe enough to block one side of the nasal passage and interfere with normal breathing. The repair of severe deviations requires surgery.

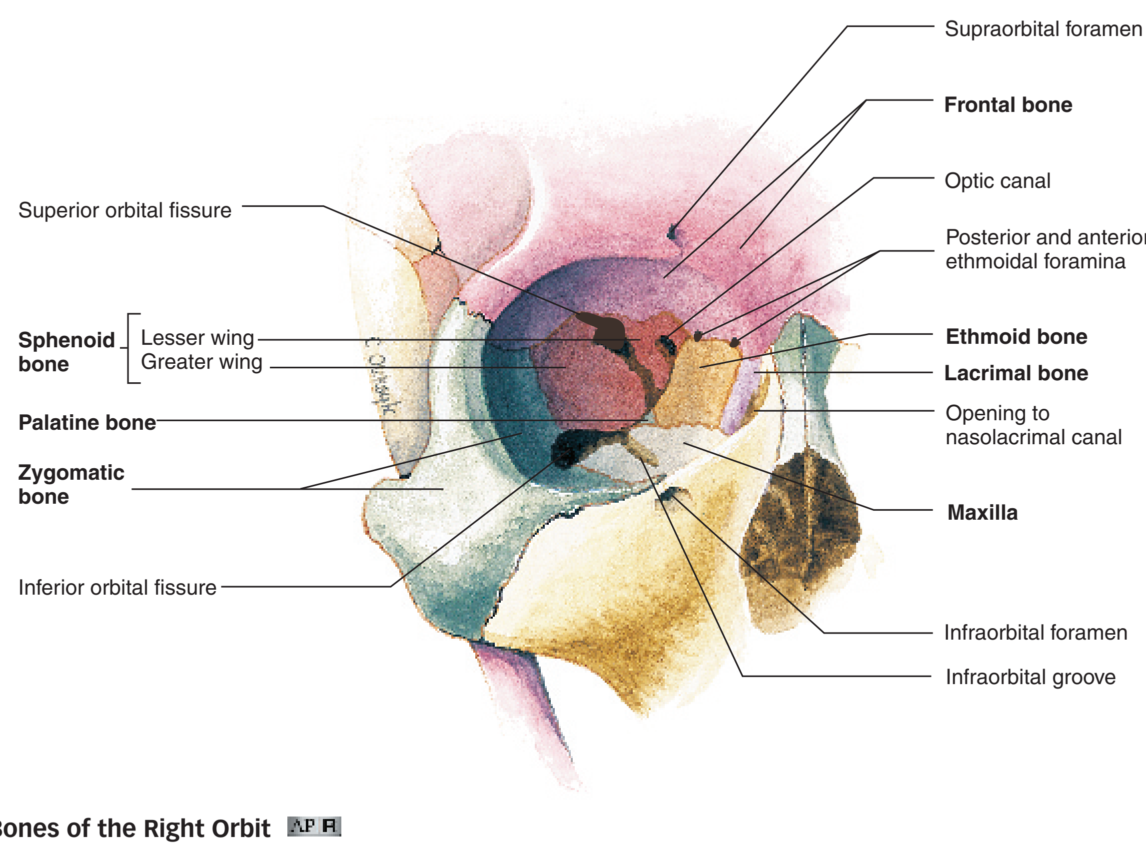


Figure 7.8 **Bones of the Right Orbit**
The names of the bones are in bold.

Predict 2

A direct blow to the nose may result in a "broken nose." Using figures 7.6 and 7.9, list the bones most likely to be broken.

The lateral wall of the nasal cavity has three bony shelves, the **nasal conchae** (kon′kē, resembling a conch shell) (see figure 7.9*b*). The inferior nasal concha is a separate bone, and the middle and superior nasal conchae are projections from the ethmoid bone. The conchae and the nasal septum increase the surface area in the nasal cavity, which promotes the moistening and warming of inhaled air and the removal of particles from the air by overlying mucous membranes.

Several of the bones associated with the nasal cavity have large, air-filled cavities within them called the **paranasal sinuses,** which open into the nasal cavity (figure 7.10). The sinuses decrease the weight of the skull and act as resonating chambers during voice production. Compare a normal voice with the voice of a person who has a cold and whose sinuses are "stopped up." The paranasal sinuses are named for the bones in which they are located and include the paired **frontal, sphenoidal,** and **maxillary sinuses.** The **ethmoidal sinuses** consist of 3 large to 18 small air-filled cavities on each side and are also called ethmoid air cells. The air cells interconnect to form the ethmoidal labyrinth.

Inferior View of the Skull

Seen from below with the mandible removed, the base of the skull is complex, with a number of foramina and specialized surfaces (figure 7.11 and table 7.3). The prominent **foramen magnum,** through which the

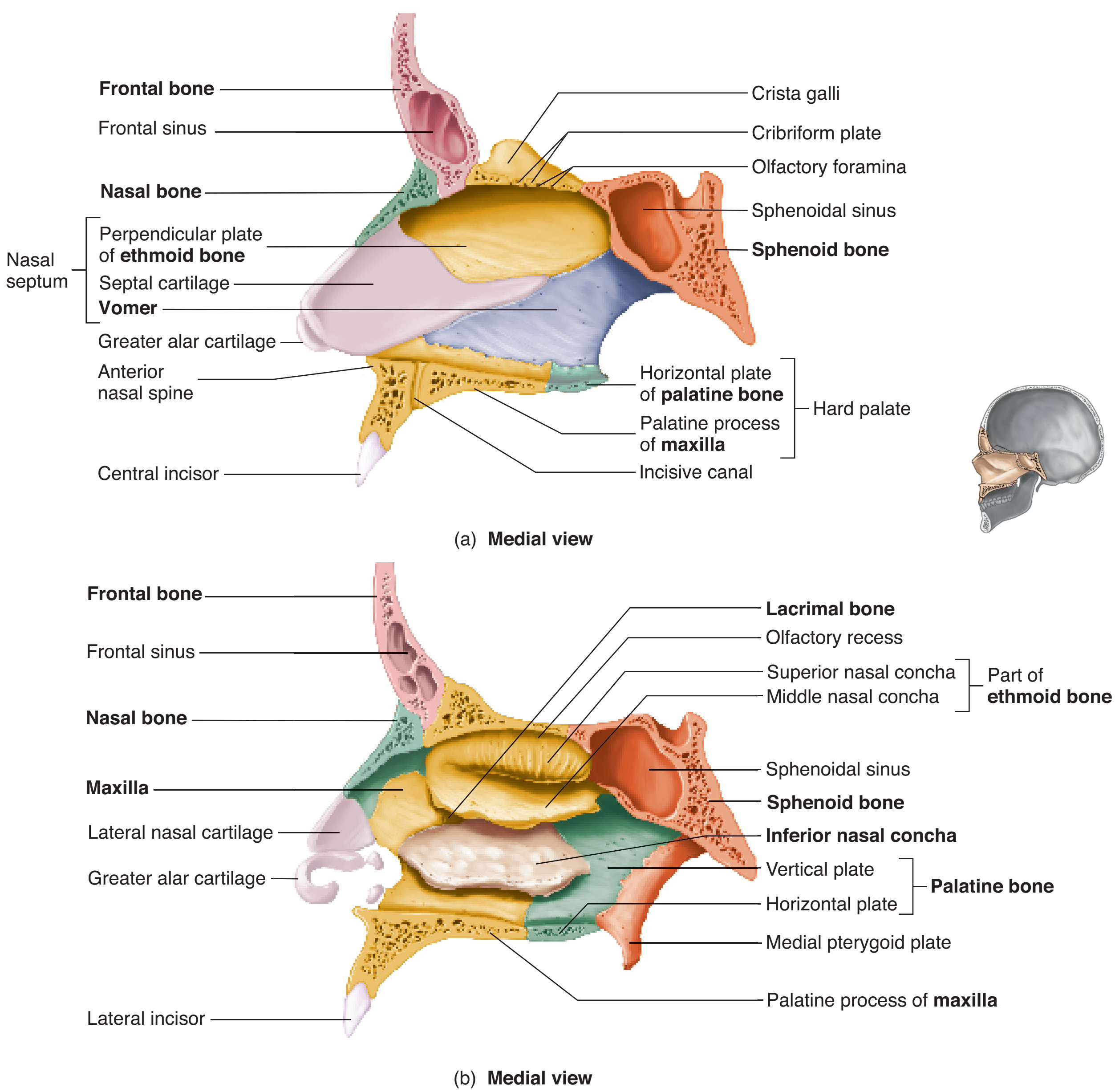


Figure 7.9 Bones of the Nasal Cavity
The names of the bones are in bold. (*a*) Nasal septum as seen from the left nasal cavity. (*b*) Right lateral nasal wall as seen from inside the nasal cavity with the nasal septum removed.

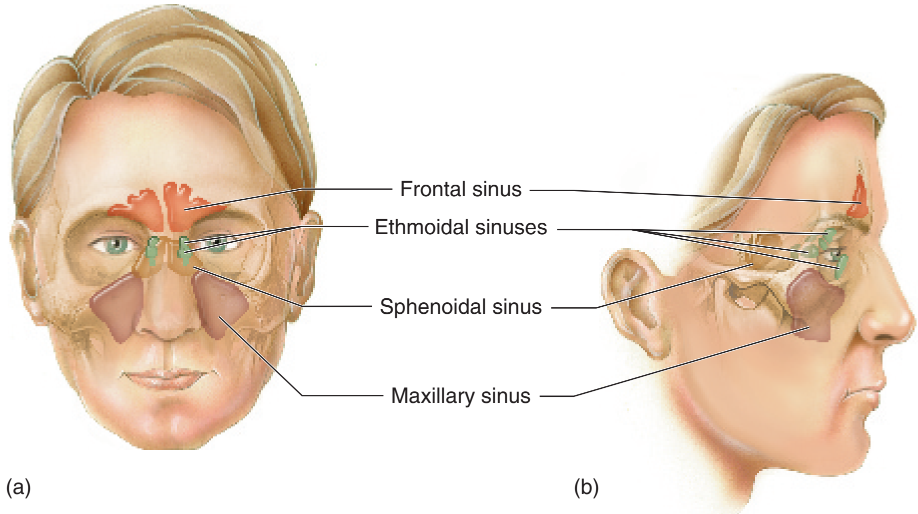


Figure 7.10 **Paranasal Sinuses**
(*a*) Anterior view. (*b*) Lateral view.

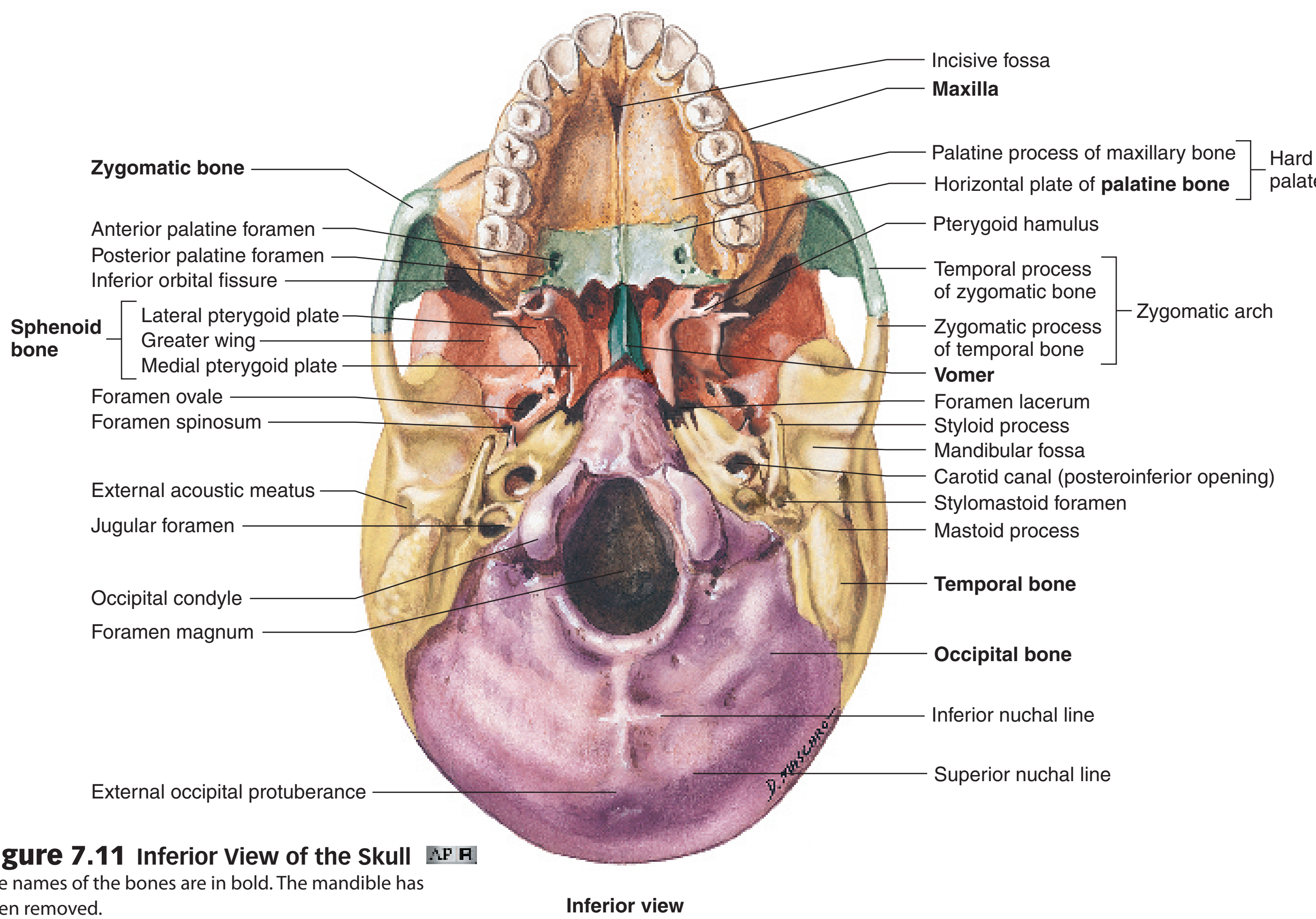


Figure 7.11 **Inferior View of the Skull** APR
The names of the bones are in bold. The mandible has been removed.

spinal cord and brain are connected, is located in the occipital bone. The **occipital condyles,** located next to the foramen magnum, articulate with the vertebral column, allowing movement of the skull.

The major entry and exit points for blood vessels that supply the brain can be seen from this view. Blood is carried to the brain by the internal carotid arteries, which pass through the **carotid** (ka-rot′id, put to sleep) **canals,** and the vertebral arteries, which pass through the foramen magnum. Most blood leaves the brain through the internal jugular veins, which exit through the **jugular foramina** located lateral to the occipital condyles.

Two long, pointed **styloid** (stī′loyd, stylus- or pen-shaped) **processes** project from the inferior surface of the temporal bone (see figures 7.4 and 7.11). Muscles involved in movement of the tongue, hyoid bone, and pharynx attach to each process. The **mandibular**

Table 7.3 Skull Foramina, Fissures, and Canals

Opening	Bone Containing the Opening	Structures Passing Through Openings
Carotid canal	Temporal	Carotid artery and carotid sympathetic nerve plexus
External acoustic meatus	Temporal	Sound waves en route to the eardrum
Foramen lacerum	Between temporal, occipital, and sphenoid	The foramen is filled with cartilage during life; the carotid canal and pterygoid canal cross its superior part but do not actually pass through it
Foramen magnum	Occipital	Spinal cord, accessory nerves, and vertebral arteries
Foramen ovale	Sphenoid	Mandibular division of trigeminal nerve
Foramen rotundum	Sphenoid	Maxillary division of trigeminal nerve
Foramen spinosum	Sphenoid	Middle meningeal artery
Hypoglossal canal	Occipital	Hypoglossal nerve
Incisive fossa	Between maxillae	Nasopalatine nerve
Inferior orbital fissure	Between sphenoid and maxilla	Infraorbital nerve and blood vessels and zygomatic nerve
Infraorbital foramen	Maxilla	Infraorbital nerve
Internal acoustic meatus	Temporal	Facial nerve and vestibulocochlear nerve
Jugular foramen	Between temporal and occipital	Internal jugular vein, glossopharyngeal nerve, vagus nerve, and accessory nerve
Mandibular foramen	Mandible	Inferior alveolar nerve to the mandibular teeth
Mental foramen	Mandible	Mental nerve
Nasolacrimal canal	Between lacrimal and maxilla	Nasolacrimal (tear) duct
Olfactory foramina	Ethmoid	Olfactory nerves
Optic canal	Sphenoid	Optic nerve and ophthalmic artery
Stylomastoid foramen	Temporal	Facial nerve
Superior orbital fissures	Sphenoid	Oculomotor nerve, trochlear nerve, ophthalmic division of trigeminal nerve, abducent nerve, and ophthalmic veins
Supraorbital foramen or notch	Frontal	Supraorbital nerve and vessels

fossa, where the mandibular condyle articulates with the skull, is anterior to the mastoid process.

The posterior opening of the nasal cavity is bounded on each side by the vertical bony plates of the sphenoid bone: the **medial pterygoid** (ter′i-goyd, wing-shaped) **plates** and the **lateral pterygoid plates.** Muscles that help move the mandible attach to the lateral pterygoid plates (see chapter 9). The **vomer** forms most of the posterior portion of the nasal septum.

The **hard palate,** or **bony palate,** forms the floor of the nasal cavity. Sutures join four bones to form the hard palate; the palatine processes of the two maxillary bones form the anterior two-thirds of the palate, and the horizontal plates of the two palatine bones form the posterior one-third of the palate. The tissues of the soft palate extend posteriorly from the hard palate. The hard and soft palates separate the nasal cavity from the mouth, enabling humans to chew and breathe at the same time.

Cleft Lip or Palate

During development, the facial bones sometimes fail to fuse with one another. A **cleft lip** results if the maxillae do not form normally, and a **cleft palate** occurs when the palatine processes of the maxillae do not fuse with one another. A cleft palate produces an opening between the nasal and oral cavities, making it difficult to eat or drink or to speak distinctly. A cleft lip and cleft palate may also occur in the same person.

Interior of the Cranial Cavity

The **cranial cavity** is the cavity in the skull occupied by the brain. When the floor of the cranial cavity is viewed from above with the calvaria cut away (figure 7.12), it can be divided into **anterior, middle,** and **posterior cranial fossae,** which are formed as the developing skull conforms to the shape of the brain.

The **crista galli** (kris′tă găl′ē, rooster's comb) of the ethmoid bone is a prominent ridge located in the center of the anterior fossa. It is a point of attachment for one of the **meninges** (mĕ-nin′jēz), a thick connective tissue membrane that supports and protects the brain (see chapter 11). On each side of the crista galli are the **cribriform** (krib′ri-fōrm, sievelike) **plates** of the ethmoid bone. The olfactory nerves extend from the cranial cavity into the roof of the nasal cavity through sievelike perforations in the cribriform plate called **olfactory foramina** (see chapter 14).

The sphenoid bone extends from one side of the skull to the other. The center of the sphenoid bone is modified into a structure resembling a saddle, the **sella turcica** (sel′ă tŭr′si-kă, Turkish saddle), which is occupied by the pituitary gland in life.

The **petrous** (rocky) **part** of the temporal bone is a thick, bony ridge lateral to the foramen magnum. It is hollow and contains the middle and inner ears. The auditory ossicles are located in the middle ear. An internal carotid artery enters the external opening of each carotid canal (see figure 7.11) and passes through the carotid canal, which runs anteromedially within the petrous part of the temporal bone.

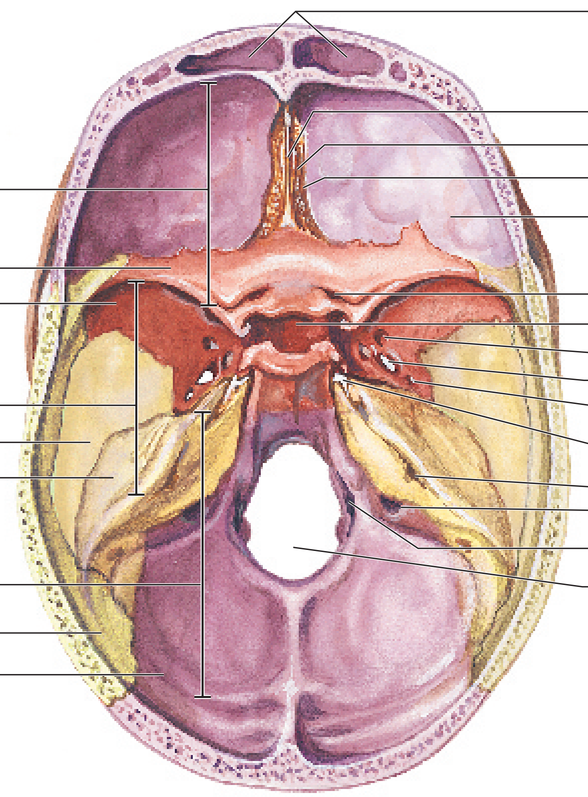


Figure 7.12 **Floor of the Cranial Cavity** APR

The names of the bones are in bold. The roof of the skull has been removed, and the floor is seen from a superior view.

A thin plate of bone separates the carotid canal from the middle ear, making it possible for a person to hear his or her own heartbeat—for example, when frightened or after running.

Most of the foramina seen in the interior view of the skull, such as the foramen magnum and optic canals, can also be seen externally. A few foramina, such as the **internal acoustic meatus,** do not open to the outside. The vestibulocochlear nerve for hearing and balance passes through the internal acoustic meatus and connects to the inner ear within the temporal bone.

5 Name the major sutures separating the frontal, parietal, occipital, and temporal bones.

6 Name the parts of the bones that connect the skull to the vertebral column and that connect the mandible to the temporal bone.

7 Describe the bones and cartilage found in the nasal septum.

8 What is a sinus? What are the functions of sinuses? Give the location of the paranasal sinuses. Where else in the skull are there air-filled spaces?

9 Name the bones that form the hard palate. What is the function of the hard palate?

10 Through what foramen does the brainstem connect to the spinal cord? Name the foramina that contain nerves for the senses of vision (optic nerve), smell (olfactory nerves), and hearing (vestibulocochlear nerve).

11 Name the foramina through which the major blood vessels enter and exit the skull.

12 List the places where the following muscles attach to the skull: neck muscles, throat muscles, muscles of mastication, muscles of facial expression, and muscles that move the eyeballs.

Hyoid Bone

The **hyoid bone** (figure 7.13), which is unpaired, is often listed among the facial bones because it has a developmental origin in common with the bones of the face. It is not, however, part of the adult skull. The hyoid bone has no direct bony attachment to the skull. Instead, muscles and ligaments attach it to the skull, so the hyoid "floats" in the superior aspect of the neck just below the mandible. The hyoid bone provides an attachment point for some tongue muscles, and it is an attachment point for important neck muscles that elevate the larynx during speech or swallowing.

13 Where is the hyoid bone located and what does it do?

Vertebral Column

The **vertebral** (*verto,* to turn) **column,** or backbone, is the central axis of the skeleton, extending from the base of the skull to slightly past the end of the pelvis (see figure 7.1). The vertebral column performs five major functions: (1) It supports the weight of the head and trunk, (2) it protects the spinal cord, (3) it allows spinal nerves to exit the spinal cord, (4) it provides a site for muscle attachment, and (5) it permits movement of the head and trunk.

The vertebral column usually consists of 26 individual bones, grouped into five regions (figure 7.14). Seven **cervical** (ser′vĭ-kal, neck) **vertebrae**, 12 **thoracic** (thō-ras′ik, chest) **vertebrae,** 5 **lumbar**

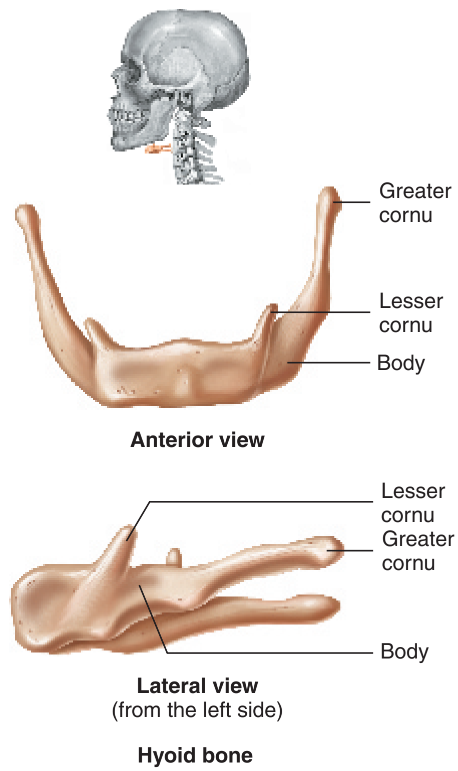


Figure 7.13 **Hyoid Bone**

(lŭm′bar, loin) **vertebrae,** 1 **sacral** (sā′krăl, sacred) **bone,** and 1 **coccygeal** (kok-sij′ē-ăl, shaped like a cuckoo's bill) **bone** make up the vertebral column. The cervical vertebrae are designated "C," thoracic "T," lumbar "L," sacral "S," and coccygeal "CO." A number after the letter indicates the number of the vertebra, from superior to inferior, within each vertebral region. The developing embryo has 33 or 34 vertebrae, but the 5 sacral vertebrae fuse to form 1 bone, and the 4 or 5 coccygeal bones usually fuse to form 1 bone.

The five regions of the adult vertebral column have four major curvatures (see figure 7.14). The primary thoracic and sacral curves appear during embryonic development and reflect the C-shaped curve of the embryo and fetus within the uterus. When the infant raises its head in the first few months after birth, a secondary curve, which is concave posteriorly, develops in the neck. Later, when the infant learns to sit and then walk, the lumbar portion of the column also becomes concave posteriorly.

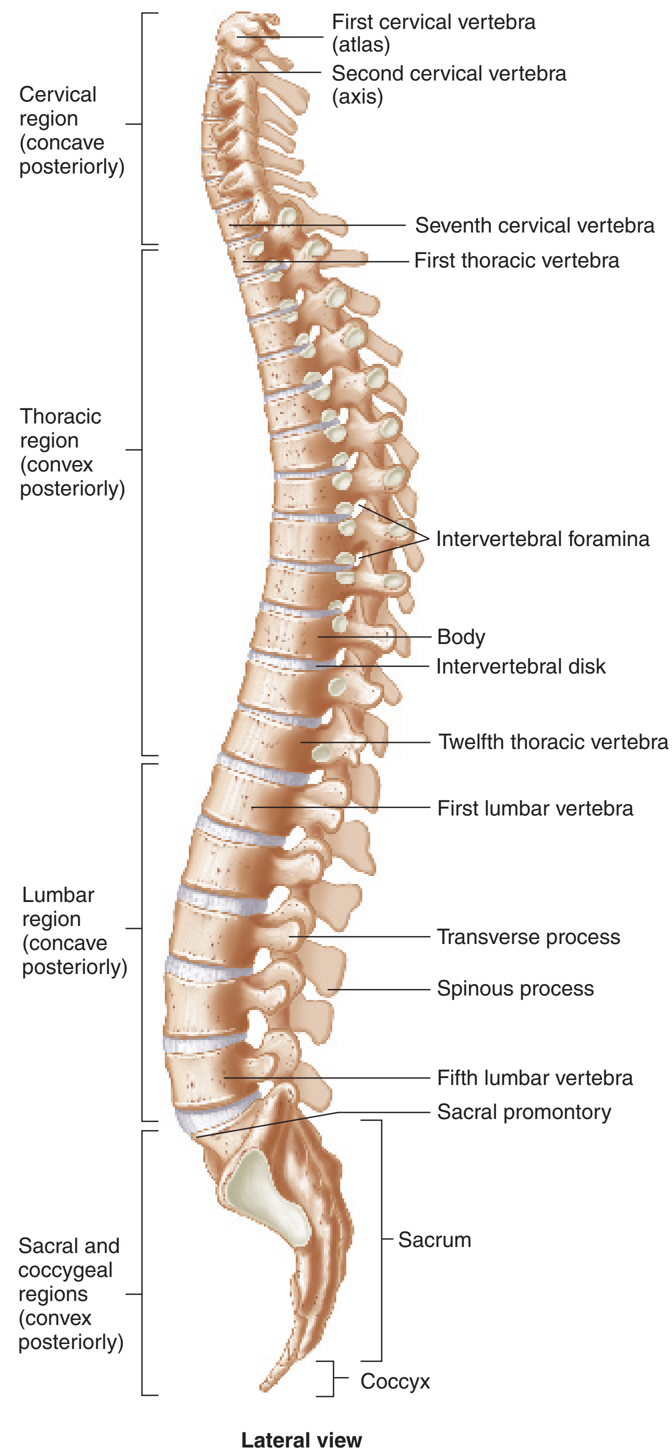


Figure 7.14 **Complete Vertebral Column Viewed from the Left Side** AP|R

Viewed from the back, the vertebral column has four curvatures. The cervical and lumbar curvatures are concave posteriorly (curve in) and the thoracic and sacral curvatures are convex posteriorly (curve out).

Abnormal Spinal Curvatures

Lordosis (lōr-dō′sis, hollow back) is an exaggeration of the concave curve of the lumbar region, resulting in a swayback condition. **Kyphosis** (kī-fō′sis, hump back) is an exaggeration of the convex curve of the thoracic region, resulting in a hunchback condition. **Scoliosis** (skō′lē-ō′sis) is an abnormal lateral and rotational curvature of the vertebral column, which is often accompanied by secondary abnormal curvatures, such as kyphosis.

14 What are the functions of the vertebral column?

15 Name and give the number of the bones forming the vertebral column.

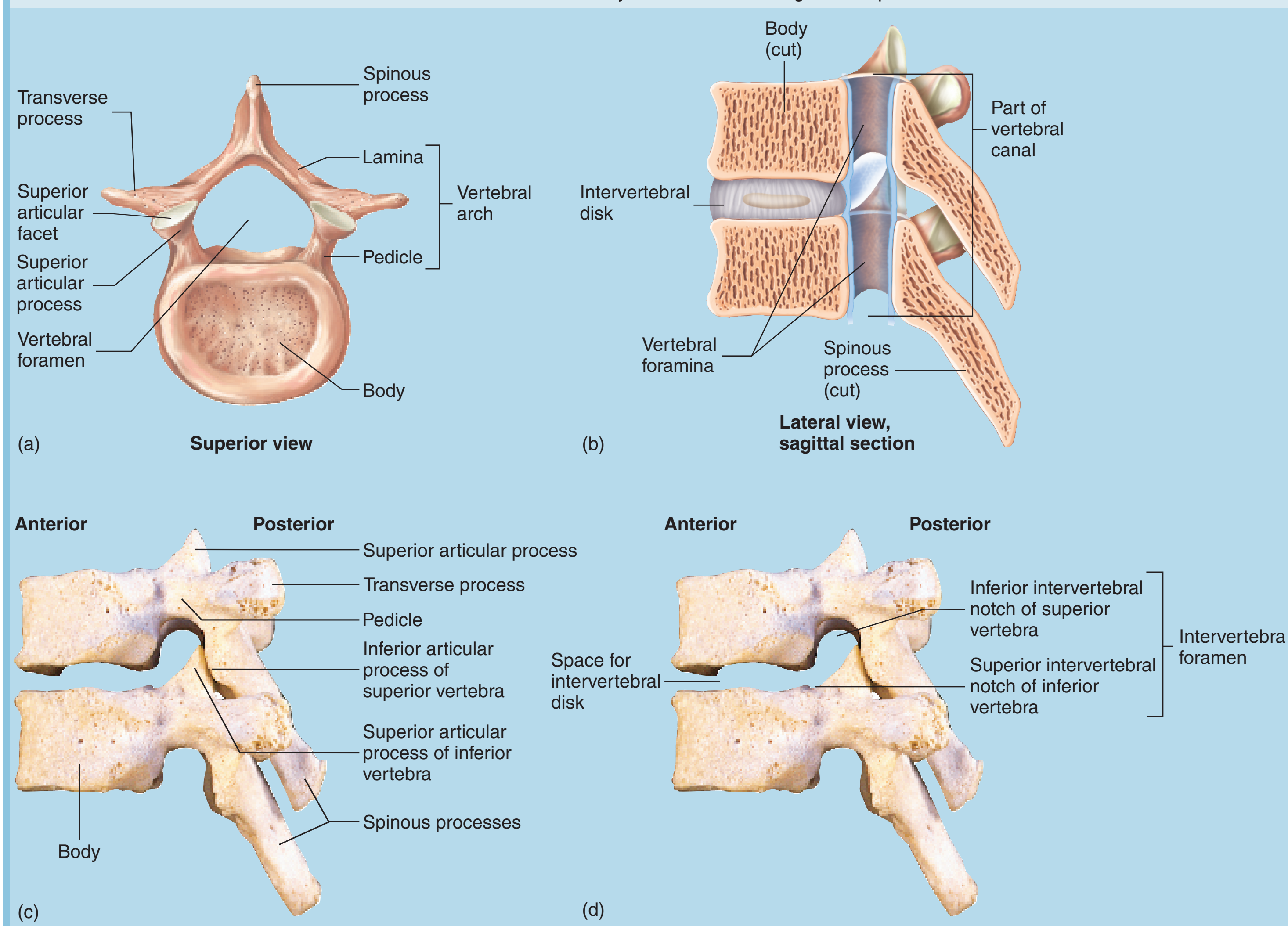
16 Describe the four major curvatures of the vertebral column and how they develop.

General Plan of the Vertebrae

Each vertebra consists of a body, an arch, and various processes. The weight-bearing portion of the vertebra is the **body** (table 7.4*a*). The **vertebral arch** projects posteriorly from the body. Each vertebral arch consists of two **pedicles** (ped′ĭ-klz, feet), which are attached to the body, and two **laminae** (lam′i-nē, thin plates), which extend from the transverse processes to the spinous process. The vertebral arch and the posterior part of the body surround a large opening called the **vertebral foramen.** The vertebral foramina of adjacent vertebrae combine to form the **vertebral canal** (table 7.4*b*), which

Table 7.4 General Structure of a Vertebra

Feature	Description
Body	Disk-shaped; usually the largest part with flat surfaces directed superiorly and inferiorly; forms the anterior wall of the vertebral foramen; intervertebral disks are located between the bodies
Vertebral foramen	Hole in each vertebra through which the spinal cord passes; adjacent vertebral foramina form the vertebral canal
Vertebral arch	Forms the lateral and posterior walls of the vertebral foramen; possesses several processes and articular surfaces
Pedicle	Foot of the arch with one on each side; forms the lateral walls of the vertebral foramen
Lamina	Posterior part of the arch; forms the posterior wall of the vertebral foramen
Transverse process	Process projecting laterally from the junction of the lamina and pedicle; a site of muscle attachment
Spinous process	Process projecting posteriorly at the point where the two laminae join; a site of muscle attachment; strengthens the vertebral column and allows for movement
Articular processes	Superior and inferior projections containing articular facets where vertebrae articulate with each other; strengthen the vertebral column and allow for movement
Intervertebral notches	Form intervertebral foramina between two adjacent vertebrae through which spinal nerves exit the vertebral canal



contains the spinal cord and cauda equina, which is a collection of spinal nerves (see chapter 11). The vertebral arches and bodies protect the spinal cord and cauda equina.

A **transverse process** extends laterally from each side of the arch between the lamina and pedicle, and a single **spinous process** is present at the junction between the two laminae (see table 7.4*a*). The spinous processes can be seen and felt as a series of lumps down the midline of the back (figure 7.15). The transverse and spinous processes are attachment sites for muscles moving the vertebral column.

Support and movement of the vertebral column are made possible by the articular processes. Each vertebra has two **superior** and two **inferior articular processes,** with the superior processes of one vertebra articulating with the inferior processes of the next superior vertebra (table 7.4*c*). Overlap of these processes helps hold the vertebrae together. Each articular process has a smooth **articular facet** (fas′et, little face), which allows movement between the processes (see table 7.4*a*).

Spinal nerves exit the vertebral canal through the **intervertebral foramina** (see table 7.4*d* and figure 7.14). Each intervertebral foramen is formed by **intervertebral notches** in the pedicles of adjacent vertebrae.

Spina Bifida

Sometimes vertebral laminae partly or completely fail to fuse (or even fail to form) during fetal development, resulting in a condition called **spina bifida** (spī′nă bif′i-dă, split spine). This defect is most common in the lumbar region. If the defect is severe and involves the spinal cord (figure A), it may interfere with normal nerve function below the point of the defect.

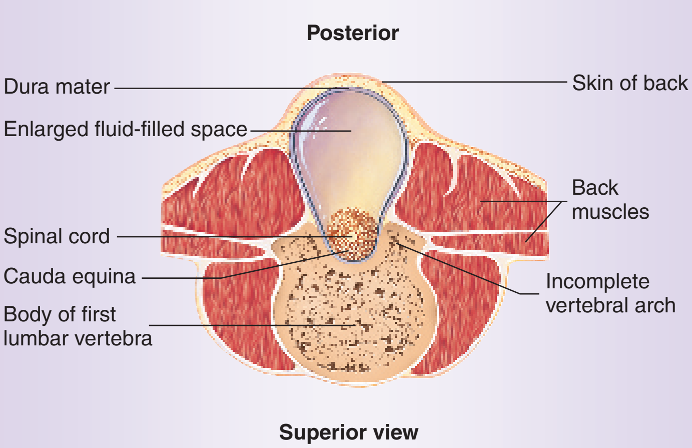


Figure A Spina Bifida

17 What is the weight-bearing part of a vertebra?
18 Describe the structures forming the vertebral foramen and the vertebral canal. What structures are found within them?
19 What are the functions of the transverse and spinous processes?
20 Describe how superior and inferior articular processes help support and allow movement of the vertebral column.
21 Where do spinal nerves exit the vertebral column?

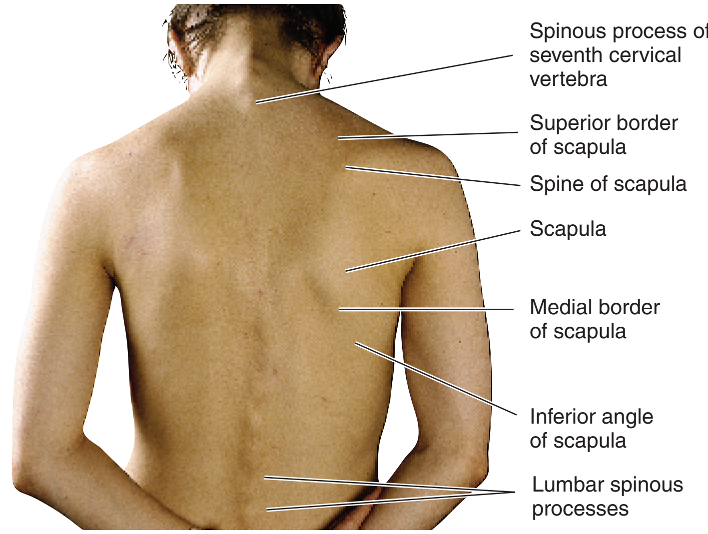


Figure 7.15 Surface View of the Back Showing the Scapula and Vertebral Spinous Processes

Intervertebral Disks

Intervertebral disks are pads of fibrocartilage located between the bodies of adjacent vertebrae (figure 7.16). They act as shock absorbers between the vertebral bodies and allow the vertebral column to bend. The intervertebral disks consist of an external **annulus fibrosus** (an′ū-lŭs fī-brō′sŭs, fibrous ring) and an internal, gelatinous **nucleus pulposus** (pŭl-pō′sŭs, pulp). The disk becomes more compressed with increasing age so that the distance between vertebrae and therefore the overall height of the individual decreases. The annulus fibrosus also becomes weaker with age and more susceptible to herniation.

Herniated, or Ruptured, Intervertebral Disk

A **herniated,** or **ruptured, disk** results from the breakage or ballooning of the annulus fibrosus with a partial or complete release of the nucleus pulposus (figure B). The herniated part of the disk may push against and compress the spinal cord, cauda equina, or spinal nerves, compromising their normal function and producing pain. Herniation of the inferior lumbar intervertebral disks is most common, but herniation of the inferior cervical disks is almost as common.

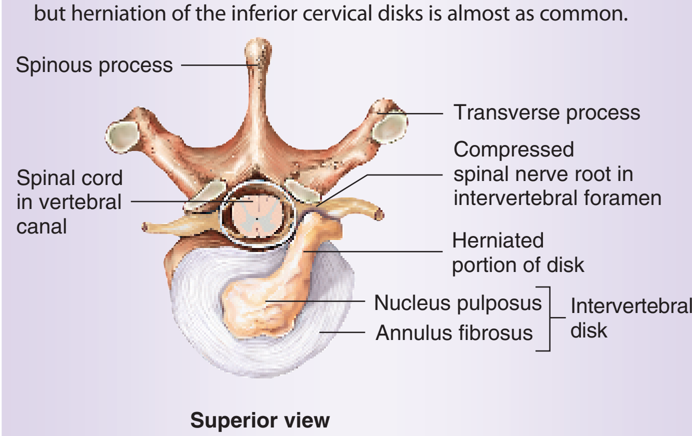


Figure B Herniated Disk
Part of the annulus fibrosus has been removed to reveal the nucleus pulposus in the center of the disk and in the intervertebral foramen.

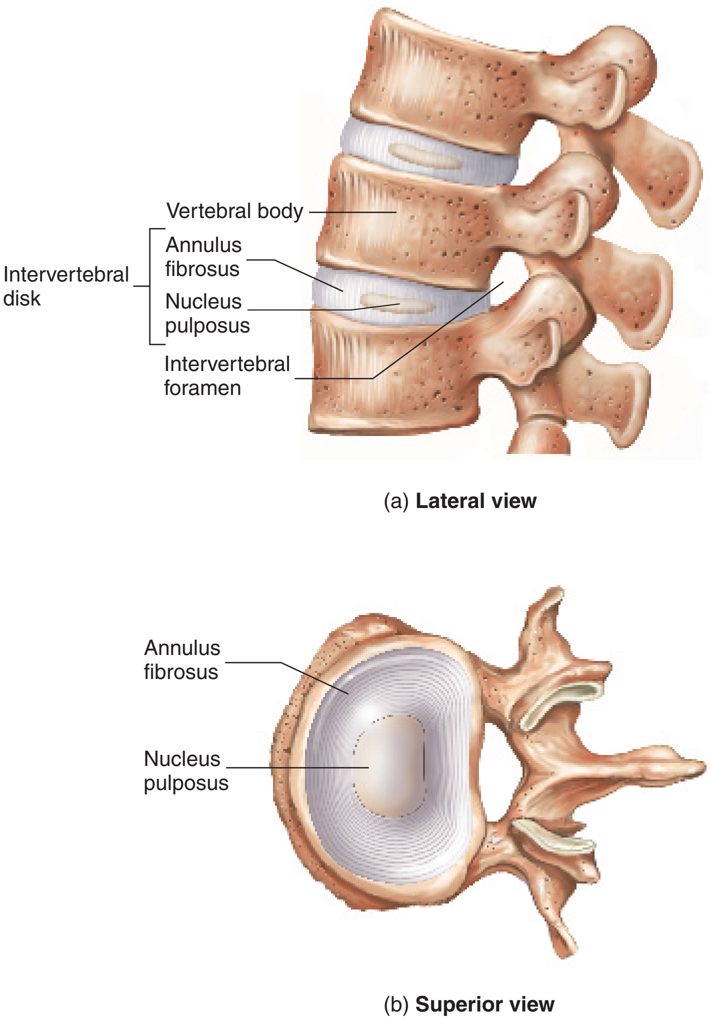


Figure 7.16 **Intervertebral Disk** APR

22 What is the function of the intervertebral disks? Name the two parts of the disk.

Regional Differences in Vertebrae

The vertebrae of each region of the vertebral column have specific characteristics that tend to blend at the boundaries between regions (figure 7.17 and table 7.5). The **cervical vertebrae** all have a **transverse foramen** in each transverse process through which the vertebral arteries extend toward the head.

The first cervical vertebra is called the **atlas** (see figure 7.17*a*) because it holds up the head, just as Atlas in classical mythology held up the world. The atlas has no body, but it has large superior articular facets where it articulates with the occipital condyles on the base of the skull. This joint allows the head to move in a "yes" motion or to tilt from side to side. The second cervical vertebra is called the **axis** (see figure 7.17*b*) because it has a projection around which the atlas rotates to produce a "no" motion of the head. The projection is called the **dens** (denz, tooth-shaped) or **odontoid** (ō-don′toyd, tooth-shaped), **process.**

The atlas does not have a spinous process (see figure 7.17*a*). The spinous process of most cervical vertebrae end in two parts and are called **bifid** (bī′fid, split) **spinous processes** (see figure 7.17*b* and *c*). The spinous process of the seventh cervical vertebra is not bifid; it is often quite pronounced and often can be seen and felt as a lump between the shoulders (see figure 7.15) called the **vertebra prominens.** Although the vertebra prominens usually marks the division between the cervical and thoracic vertebrae, sometimes it is part of the sixth cervical vertebra or the first thoracic vertebra.

The **thoracic vertebrae** (see figure 7.14; figure 7.17*d*) have attachment sites for the ribs. The first 10 thoracic vertebrae have articular facets on their transverse processes, where they articulate with the tubercles of the ribs. Additional articular facets are on the superior and inferior margins of the body where the heads of the ribs articulate (see "Ribs and Costal Cartilages," p. 165). Thoracic vertebrae have long, thin spinous processes, which are directed inferiorly.

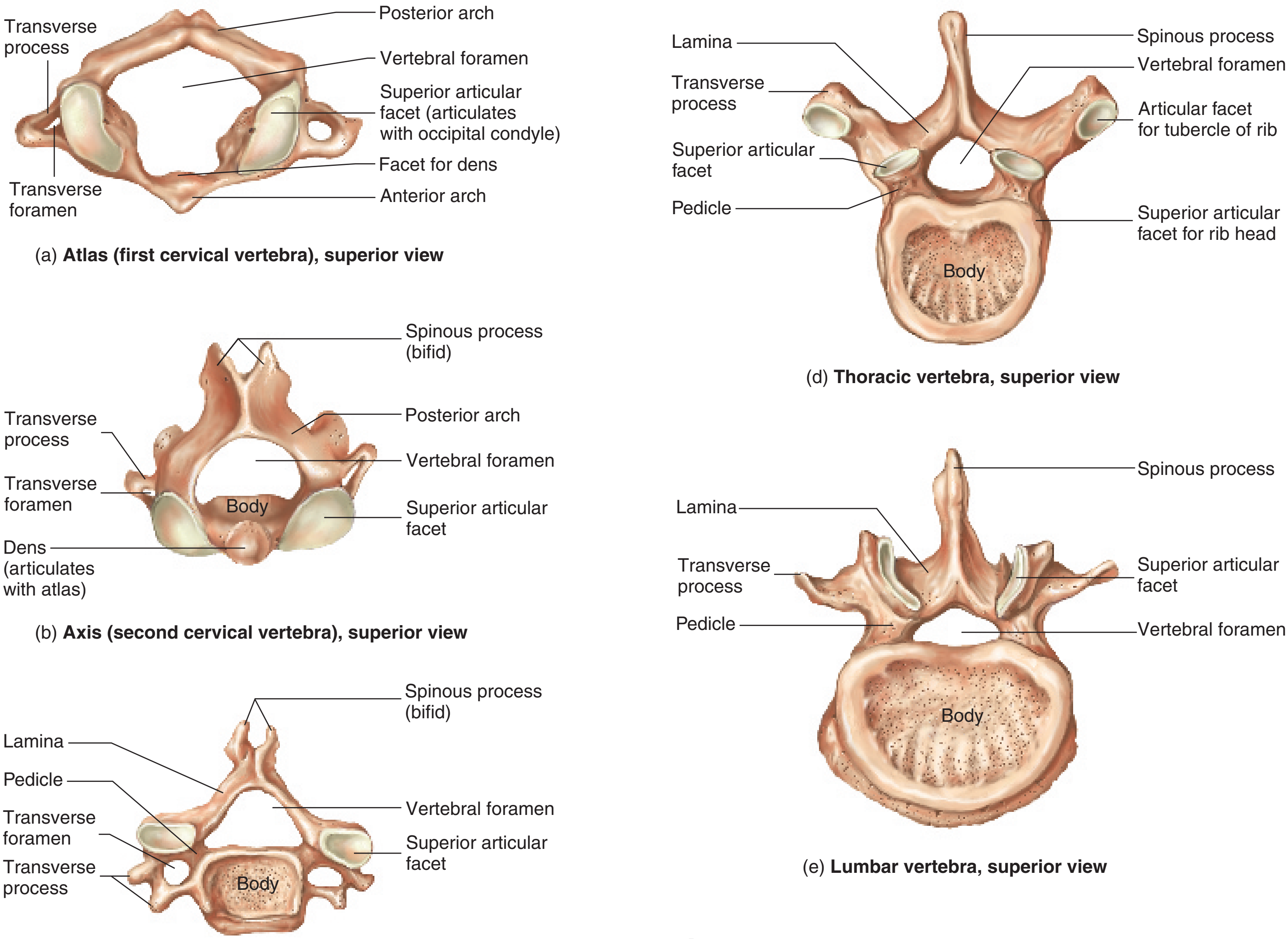
The **lumbar vertebrae** (see figure 7.14; figure 7.17*e*) have large, thick bodies and heavy, rectangular transverse and spinous processes. The superior articular facets face medially, and the inferior articular facets face laterally. When the superior articular surface of one lumbar vertebra joins the inferior articulating surface of another lumbar vertebra, the arrangement tends to "lock" adjacent lumbar vertebrae together, giving the lumbar part of the vertebral column more stability and limiting rotation of the lumbar vertebrae. The articular facets in other regions of the vertebral column have a more "open" position, allowing for more movement but less stability.

Predict 3

Cervical vertebrae have small bodies, whereas lumbar vertebrae have large bodies. Explain.

The five **sacral** (sā′krăl) **vertebrae** (see figure 7.14; figure 7.18) are fused into a single bone called the **sacrum** (sā′krŭm). Although the margins of the sacral bodies unite after the twentieth year, the interior of the sacrum is not ossified until midlife. The transverse processes fuse to form the lateral parts of the sacrum. The superior lateral part of the sacrum forms wing-shaped areas called the **alae** (ā′lē, wings). Much of the lateral surfaces of the sacrum are ear-shaped **auricular surfaces,** which join the sacrum to the pelvic bones. The spinous processes of the first four sacral vertebrae partially fuse to form projections, called the **median sacral crest.** The spinous process of the fifth sacral vertebra does not form, thereby leaving a **sacral hiatus** (hī-ā′tŭs), or gap, which exposes the sacral canal. The vertebral canal within the sacrum is called the **sacral canal.** The sacral hiatus is used to gain entry into the sacral canal to administer anesthetic injections—for example, just before childbirth. The anterior edge of the body of the first sacral vertebra bulges to form the **sacral promontory,** a landmark that separates the abdominal cavity from the pelvic cavity. The sacral promontory can be felt during a vaginal examination, and it is used as a reference point during measurement to determine if the pelvic openings are large enough to allow for normal vaginal delivery of a baby.

The **coccyx** (kok′siks, shaped like a cuckoo's bill), or tailbone, usually consists of four more or less fused vertebrae (see figure 7.18). The vertebrae of the coccyx do not have the typical structure of most other vertebrae. They consist of extremely reduced vertebral bodies, without the foramina or processes, usually fused into a single bone.



(a) **Atlas (first cervical vertebra), superior view**

(b) **Axis (second cervical vertebra), superior view**

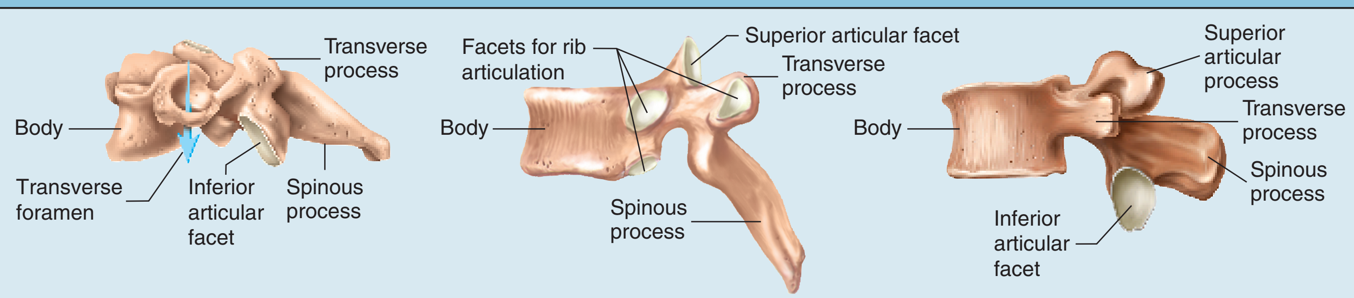
(c) **Fifth cervical vertebra, superior view**

(d) **Thoracic vertebra, superior view**

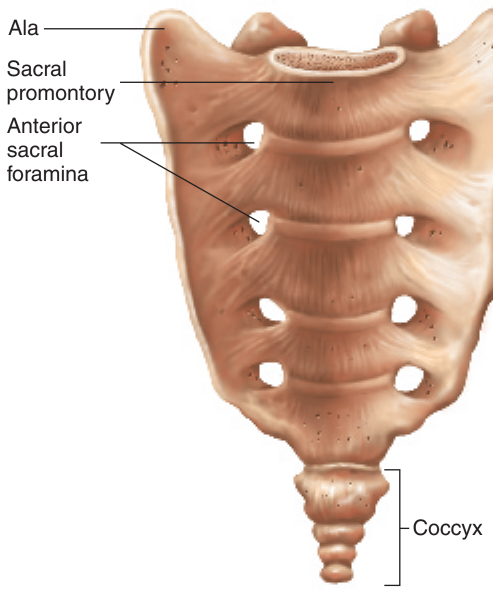
(e) **Lumbar vertebra, superior view**

Figure 7.17 Regional Differences in Vertebrae
Posterior is shown at the top of each illustration.

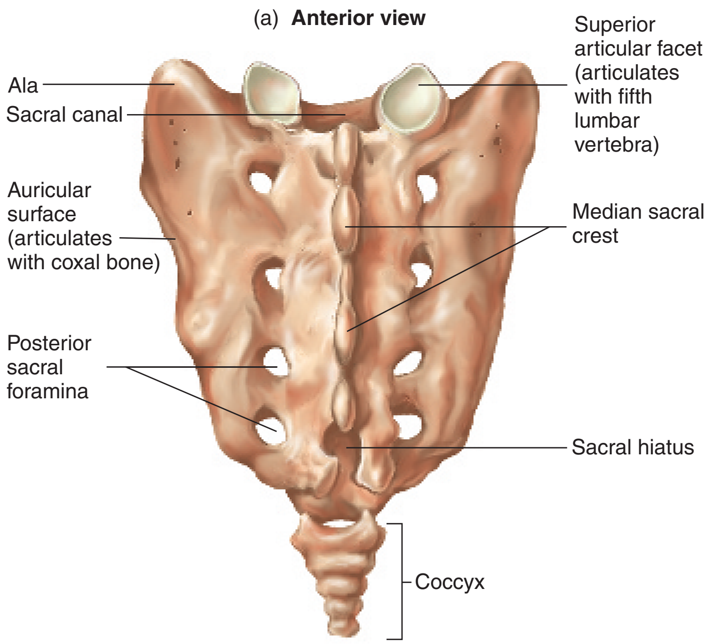
Table 7.5 Comparison of Vertebral Regions



Feature	Cervical	Thoracic	Lumbar
Body	Absent in C1, small in others	Medium-sized with articular facets for ribs	Large
Transverse process	Transverse foramen	Articular facets for ribs, except T11 and T12	Square
Spinous process	Absent in C1, bifid in others, except C7	Long, angled inferiorly	Square
Articular facets	Face superior/inferior	Face obliquely	Face medial/lateral



(a) **Anterior view**



(b) **Posterior view**

Figure 7.18 **Sacrum**

The coccyx is easily broken in a fall in which a person sits down hard on a solid surface. Also, a mother's coccyx may be fractured during childbirth.

23 Describe the characteristics that distinguish the different types of vertebrae.

24 Describe the movements of the head produced by the atlas and axis.

Predict 4

Which bone is the loneliest bone in the body?

Thoracic Cage

The **thoracic cage,** or **rib cage,** protects the vital organs within the thorax and forms a semirigid chamber that can increase and decrease in volume during breathing. It consists of the thoracic vertebrae, the ribs with their associated costal (rib) cartilages, and the sternum (figure 7.19*a*).

Ribs and Costal Cartilages

There are 12 pairs of **ribs,** which are numbered 1 through 12, starting with the most superior rib. All of the ribs articulate posteriorly with the thoracic vertebrae. **Costal cartilages** attach many of the ribs anteriorly to the sternum. Movement of the ribs relative to the vertebrae and the flexibility of the costal cartilages allow the thoracic cage to change shape during breathing.

The ribs are classified by their anterior attachments as true or false ribs. The **true ribs** attach directly through their costal cartilages to the sternum. The superior seven pairs of ribs are true ribs. The **false ribs** do not attach to the sternum. The inferior five pairs of ribs are false ribs. On each side, the three superior false ribs are joined by a common cartilage to the costal cartilage of the seventh true rib, which in turn is attached to the sternum. The two inferior pairs of false ribs are also called **floating ribs** because they do not attach to the sternum.

Most ribs have two points of articulation with the thoracic vertebrae (figure 7.19*b* and *c*). First, the **head** articulates with the bodies of two adjacent vertebrae and the intervertebral disk between them. The head of each rib articulates with the inferior articular facet of the superior vertebra and the superior articular facet of the inferior vertebra. Second, the **tubercle** articulates with the transverse process of the inferior vertebra. The **neck** is between the head and tubercle, and the **body,** or shaft, is the main part of the rib. The **angle** of the rib is located just lateral to the tubercle and is the point of greatest curvature.

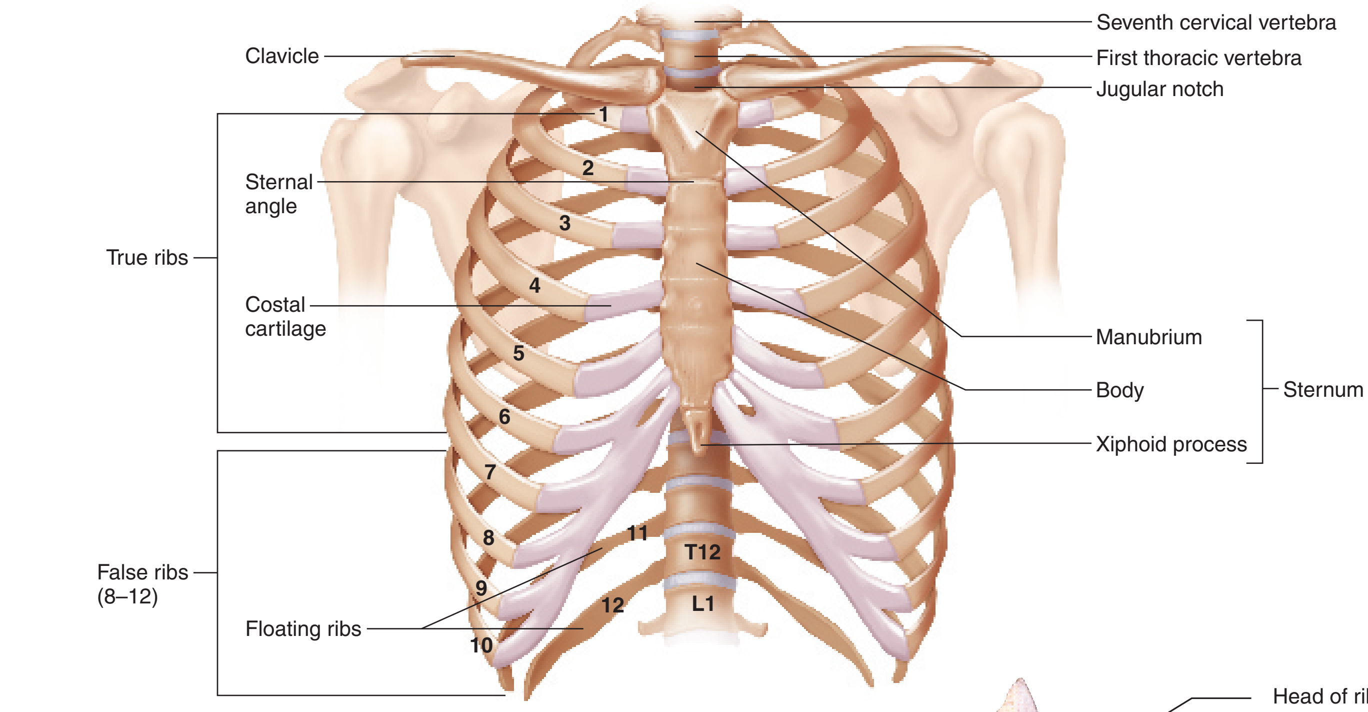
Rib Defects

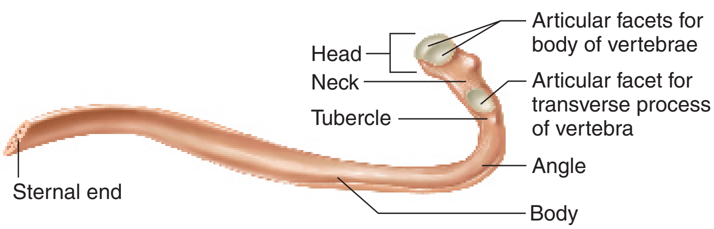
A **separated rib** is a dislocation between a rib and its costal cartilage. As a result of the dislocation, the rib can move, override adjacent ribs, and cause pain. Separation of the tenth rib is the most common.

The angle is the weakest part of the rib and may be fractured in a crushing accident, such as an automobile accident. Broken rib ends can damage internal organs, such as the lungs, spleen, liver, and diaphragm.

Sternum

The **sternum,** or breastbone, has three parts (see figure 7.19*a*): the **manubrium** (mă-noo′brē-ŭm, handle), the **body,** and the **xiphoid** (zi′foyd, sword) **process.** The sternum resembles a sword, with the manubrium forming the handle, the body forming the blade, and the xiphoid process forming the tip. At the superior end of the sternum, a depression, called the **jugular notch,** is located between the ends of the clavicles where they articulate with the manubrium of the sternum. The jugular notch can easily be found at the base of the neck (figure 7.20). A slight ridge, called the **sternal angle,** can be felt at the junction of the manubrium and the body of the sternum.





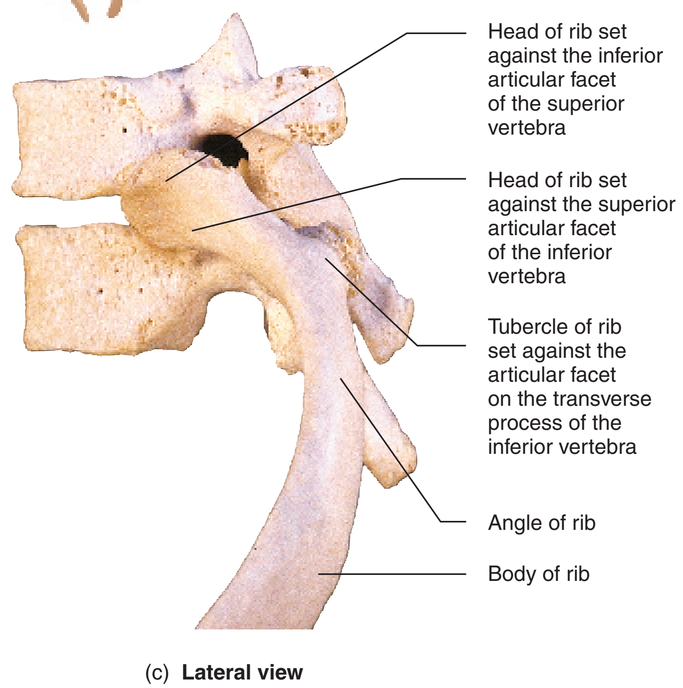


Figure 7.19 **Thoracic Cage** AP|R

(*a*) Entire thoracic cage as seen from an anterior view. (*b*) Typical rib, inferior view. (*c*) Photograph of two thoracic vertebrae and the proximal end of a rib, as seen from the left side, showing the relationship between the vertebra and the head and tubercle of the rib.

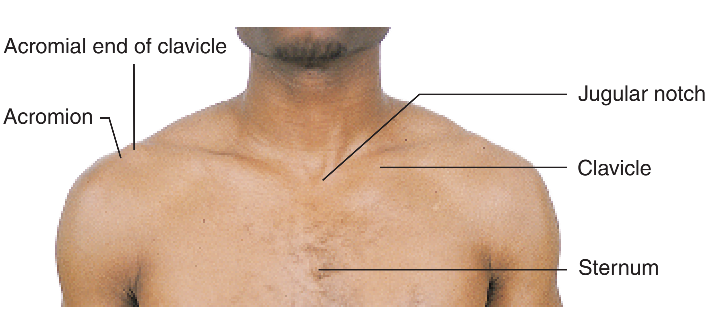


Figure 7.20 **Surface Anatomy Showing Bones of the Upper Thorax**

Clinical Importance of the Sternum

The sternal angle is important clinically because the second rib is found lateral to it and can be used as a starting point for counting the other ribs. Counting ribs is important because they are landmarks used to locate structures in the thorax, such as areas of the heart. The sternum often is used as a site for taking red bone marrow samples because it is readily accessible. Because the xiphoid process of the sternum is attached only at its superior end, it may be broken during cardiopulmonary resuscitation (CPR) and then may lacerate the underlying liver.

25 What are the functions of the thoracic (rib) cage? Distinguish among true, false, and floating ribs, and give the number of each type.
26 Describe the articulation of the ribs with thoracic vertebrae.
27 Describe the parts of the sternum. What structures attach to the sternum?

7.3 Appendicular Skeleton

The appendicular skeleton (see figure 7.1) consists of the bones of the **upper** and **lower limbs** and the **girdles** by which they are attached to the body. The term *girdle* means a belt or a zone and refers to the two zones, pectoral and pelvic, where the limbs are attached to the body. The pectoral girdle attaches the upper limbs to the body and allows considerable movement of the upper limbs. This freedom of movement allows the hands to be placed in a wide range of positions to accomplish their functions. The pelvic girdle attaches the lower limbs to the body, providing support while allowing movement. The pelvic girdle is stronger and attached much more firmly to the body than is the pectoral girdle, and the lower limb bones in general are thicker and longer than those of the upper limb.

Pectoral Girdle

The **pectoral** (pek′tŏ-răl) **girdle**, or **shoulder girdle,** consists of two **scapulae** (skap′ū-lăē), or shoulder blades, and two **clavicles** (klav′i-klz, key), or collarbones (see figure 7.1). Each humerus (arm bone) attaches to a scapula, which is connected by a clavicle to the sternum (figure 7.21). The scapula is a flat, triangular bone (figure 7.22) that can easily be seen and felt in a living person (see figure 7.15). The **glenoid** (glen′oyd) **cavity** is a depression where the humerus connects to the scapula. The scapula has three fossae where muscles extending to the arm are attached. The **scapular spine,** which runs across the posterior surface of the scapula, separates two of these fossae. The **supraspinous fossa** is superior to the spine and the **infraspinous fossa** is inferior to it. The **subscapular fossa** is on the anterior surface of the scapula. The **acromion** (ă-krō′mē-on, *akron,* tip + *omos,* shoulder) is an extension of the spine forming the point of the shoulder. The acromion forms a protective cover for the shoulder joint and is the attachment site for the clavicle and some of the shoulder muscles. The **coracoid** (kōr′ă-koyd, crow's beak) **process** curves below the clavicle and provides attachment for arm and chest muscles.

The clavicle is a long bone with a slight sigmoid (S-shaped) curve (figure 7.23) and is easily seen and felt in the living human (see figure 7.20). The **acromial (lateral) end** of the clavicle articulates with the acromion of the scapula, and the **sternal (medial) end** articulates with the manubrium of the sternum. The pectoral girdle's only attachment to the axial skeleton is at the sternum. Mobility of the upper limb is enhanced by movement of the scapula, which is possible because the clavicle can move relative to the sternum. For example, feel the movement of the clavicle when shrugging the shoulders.

28 Name the bones that make up the pectoral girdle. Describe their functions.
29 What are the functions of the acromion and the coracoid process of the scapula?

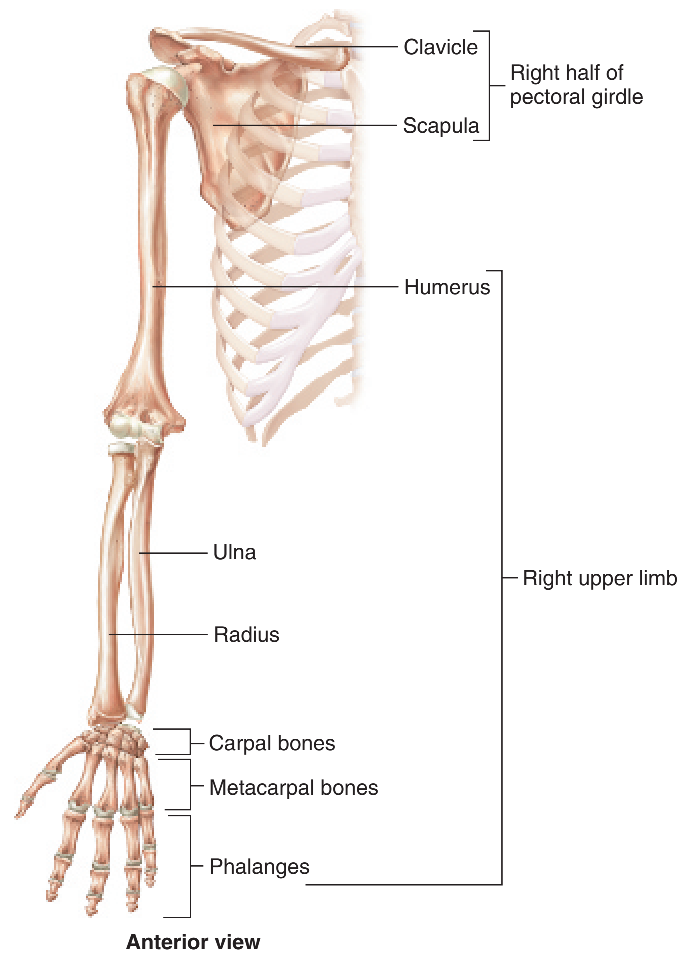


Figure 7.21 Bones of the Pectoral Girdle and Upper Limb AP|R

Predict 5

How does a broken clavicle change the position of the upper limb?

Upper Limb

The upper limb consists of the bones of the arm, forearm, wrist, and hand (see figure 7.21).

Arm

The arm is the part of the upper limb from the shoulder to the elbow. It contains only one bone, the **humerus** (figure 7.24). The humeral **head** articulates with the glenoid cavity of the scapula. The **anatomical neck,** around the head of the humerus, is where connective tissue holding the shoulder joint together attaches. The **surgical neck** is so named because it is a common fracture site that often requires surgical repair. If it becomes necessary to remove the humeral head because of disease or injury, it is removed down to the surgical neck. The **greater tubercle** and the **lesser tubercle** are sites of muscle attachment. The **intertubercular groove,** or **bicipital** (bī-sip′i-tăl) **groove,** between the tubercles contains one tendon of the biceps brachii muscle. The **deltoid tuberosity** is located on the lateral surface of the humerus a little more than a third of the way along its length and is the attachment site for the deltoid muscle.

Condyles on the distal end of the humerus articulate with the two forearm bones. The **capitulum** (kă-pit′ū-lŭm, head-shaped) is

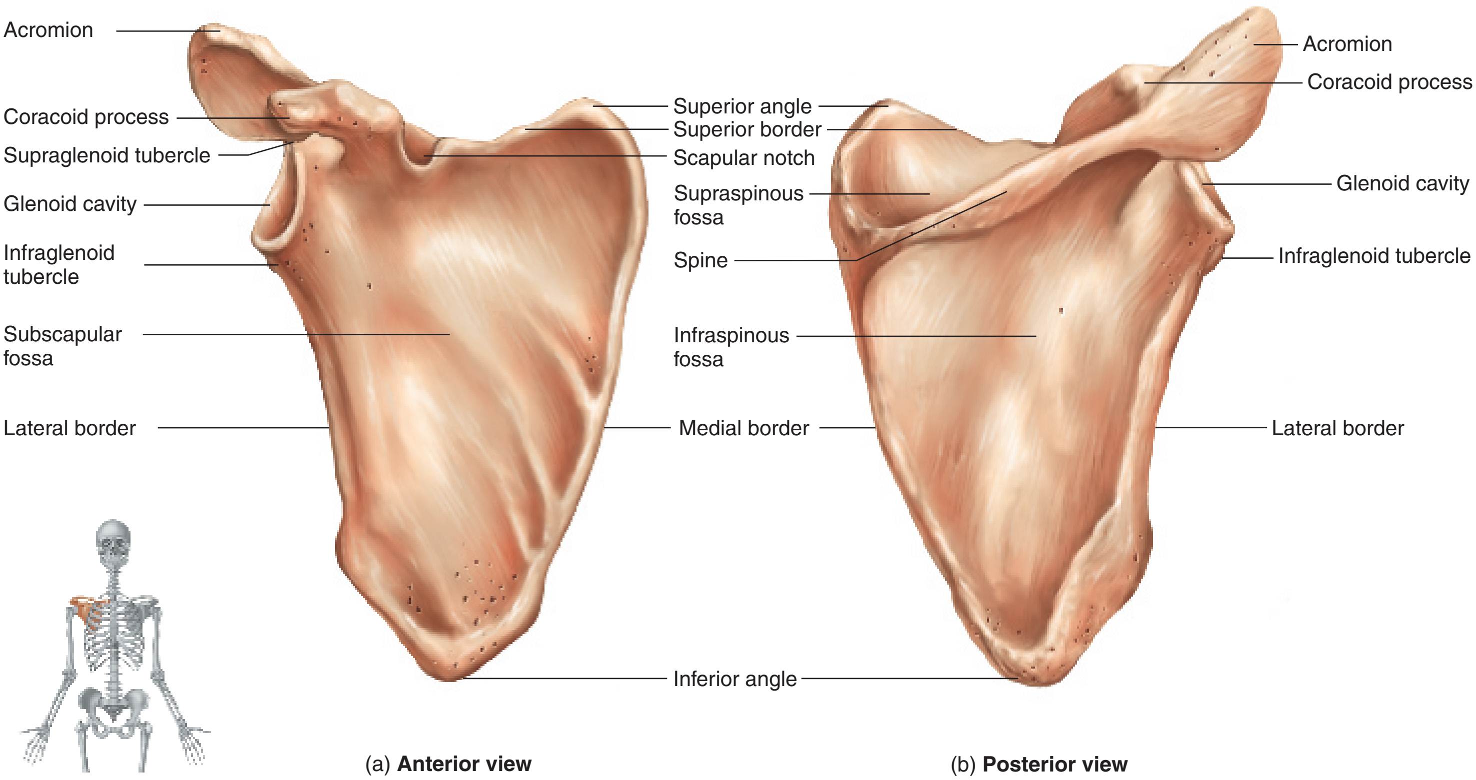


Figure 7.22 **Right Scapula**

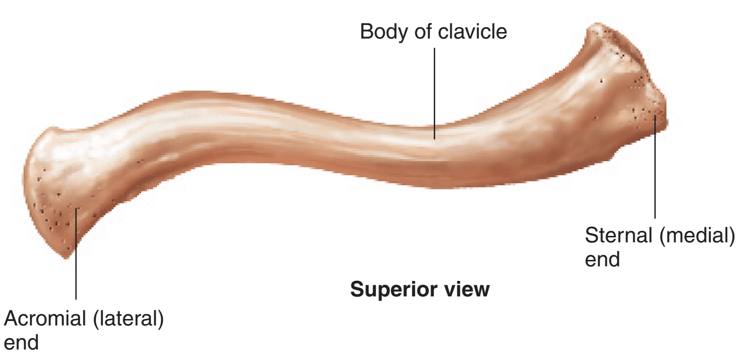


Figure 7.23 **Right Clavicle**

very rounded and articulates with the radius. The **trochlea** (trok′lē-ă, spool) somewhat resembles a spool or pulley and articulates with the ulna. Proximal to the capitulum and the trochlea are the **medial** and **lateral epicondyles,** which are points of muscle attachment for the muscles of the forearm. They can be found as bony protuberances proximal to the elbow (figure 7.25).

Forearm

The forearm has two bones (figure 7.26). The **ulna** is on the medial (little finger) side of the forearm, whereas the **radius** is on the lateral (thumb) side of the forearm.

The proximal end of the ulna has a C-shaped articular surface called the **trochlear notch,** or **semilunar notch,** that fits over the trochlea of the humerus, forming most of the elbow joint. The trochlear notch is bounded by two processes. The **olecranon** (ō-lek′ră-non, the point of the elbow) is the posterior process forming the tip of the elbow (see figure 7.25). It can easily be felt and is commonly referred to as "the elbow." Posterior arm muscles attach to the olecranon. The smaller, anterior process is the **coronoid** (kōr′ŏ-noyd, crow's beak) **process.**

The proximal end of the radius is the **head.** It is concave and articulates with the capitulum of the humerus. Movements of the radial head relative to the capitulum and of the trochlear notch relative to the trochlea allow the elbow to bend and straighten. The lateral surfaces of the radial head form a smooth cylinder where the radius rotates against the **radial notch** of the ulna. As the forearm supinates and pronates (see "Types of Movements," p. 183), the proximal end of the ulna stays in place and the radius rotates.

Predict 6

Explain the functions of the olecranon, coronoid, and radial fossae on the distal humerus (see figure 7.24).

Just distal to the elbow joint, the **radial tuberosity** and the **ulnar tuberosity** are attachment sites for arm muscles.

The distal end of the ulna has a small **head,** which articulates with both the radius and the carpal (wrist) bones (see figure 7.26). The head can be seen as a prominent lump on the posterior, medial (ulnar) side of the distal forearm (see figure 7.25). The distal end of the radius, which articulates with the ulna and the carpal bones, is somewhat broadened. The ulna and radius have small **styloid** (stī′loyd, shaped like a stylus or writing instrument) **processes** to which ligaments of the wrist are attached.

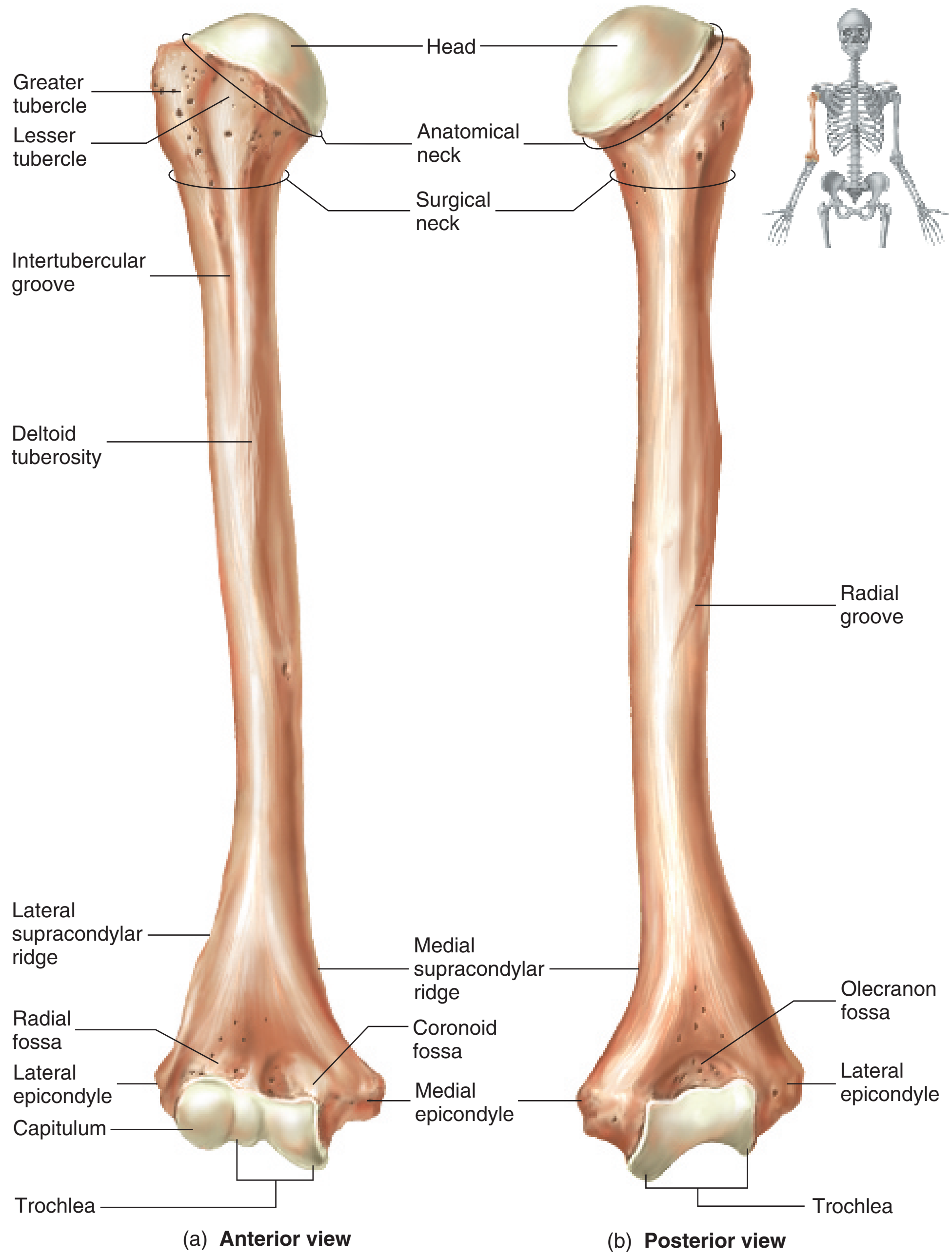


Figure 7.24 **Right Humerus** AP|R

> ### Radius Fractures
> The radius is the most commonly fractured bone in people over 50 years old. It is often fractured as the result of a fall on an outstretched hand, which results in posterior displacement of the hand. Typically, there is a complete transverse fracture of the radius 2.5 cm proximal to the wrist. The fracture is often comminuted or impacted. Such a fracture is called a **Colles fracture.**

Wrist

The wrist is a relatively short region between the forearm and hand; it is composed of eight **carpal** (kar′păl) **bones** arranged into two rows of four each (figure 7.27). The proximal row of carpal bones, lateral to medial, includes the **scaphoid** (skaf′oyd, boat-shaped), **lunate** (loo′nāt, moon-shaped), **triquetrum** (trī-kwē′trŭm, trī-kwet′rŭm, three-cornered), and **pisiform** (pis′i-fōrm, pea-shaped). The distal row of carpal bones, from medial to lateral, includes the **hamate** (ha′māt, hook), **capitate** (kap′i-tāt, head), **trapezoid** (trap′ĕ-zoyd, a four-sided geometric form with two parallel sides), and **trapezium** (tra-pē′zē-ŭm, a four-sided geometric form with no two sides parallel). A number of mnemonics have been developed to help students remember the carpal bones. The following mnemonic allows students to remember them in order from lateral to medial for the proximal row (top) and from medial to lateral (by the thumb) for the distal row: **S**o **L**ong **T**op **P**art, **H**ere **C**omes **T**he **T**humb—that is **S**caphoid, **L**unate, **T**riquetrum, **P**isiform, **H**amate, **C**apitate, **T**rapezoid, and **T**rapezium.

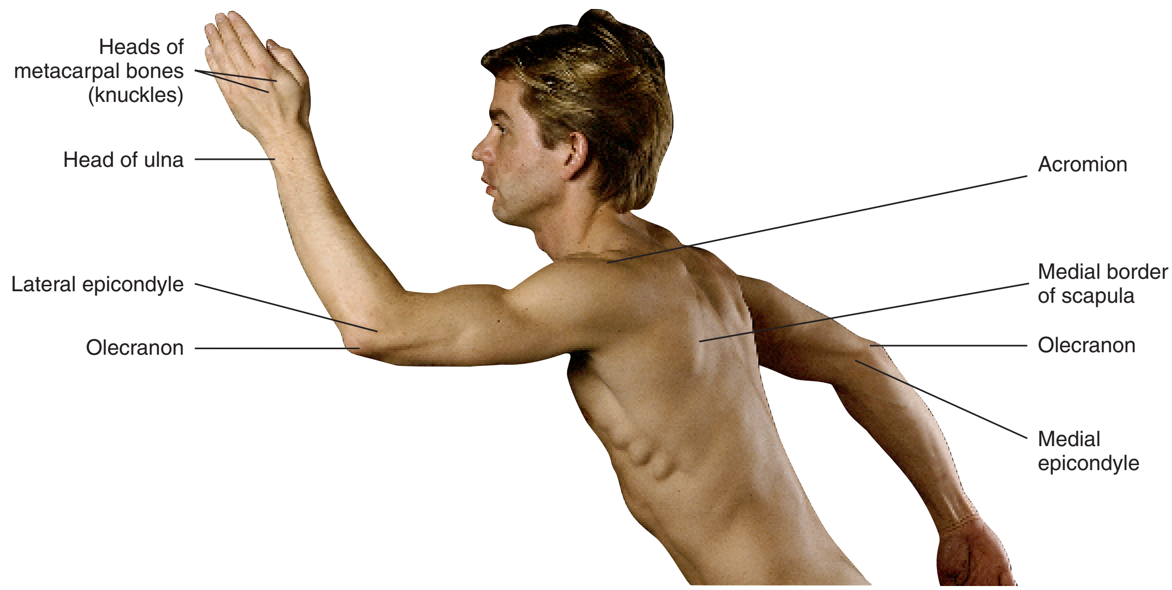


Figure 7.25 **Surface Anatomy Showing Bones of the Pectoral Girdle and Upper Limb**

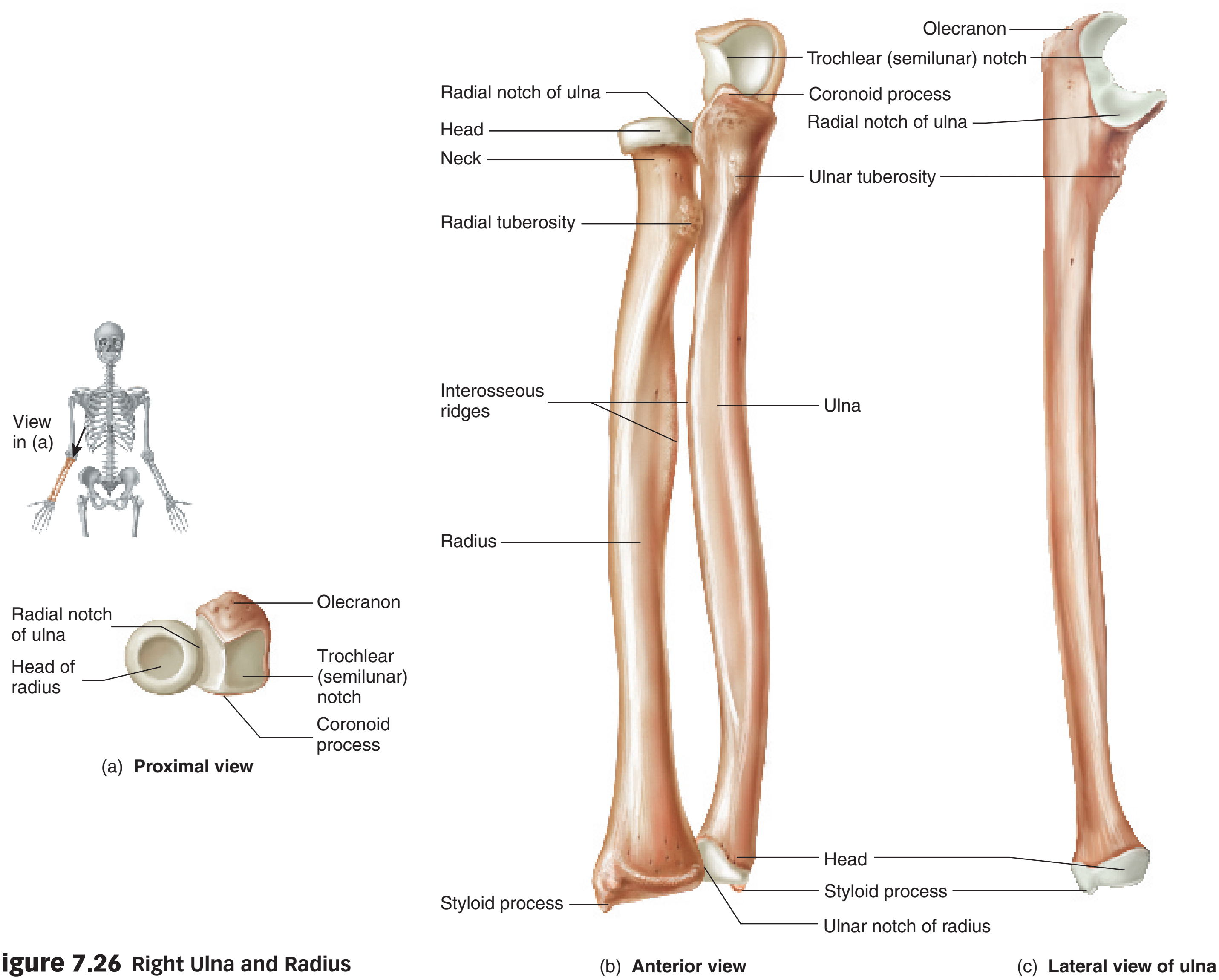


Figure 7.26 **Right Ulna and Radius**

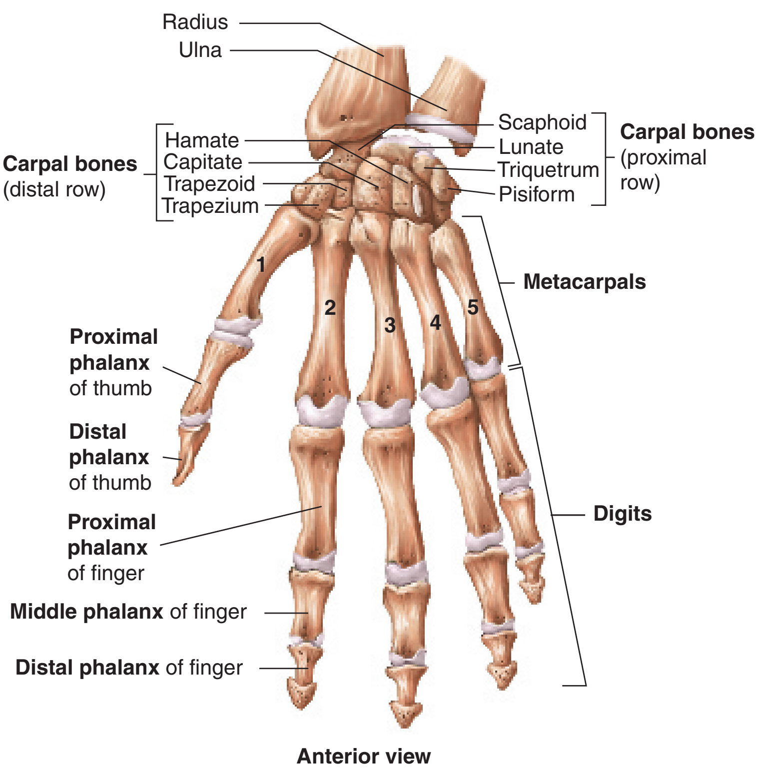


Figure 7.27 Bones of the Right Wrist and Hand APR

Carpal Tunnel Syndrome

The bones and ligaments on the anterior side of the wrist form a **carpal tunnel,** which does not have much "give." Tendons and nerves pass from the forearm through the carpal tunnel to the hand. Fluid and connective tissue can accumulate in the carpal tunnel as a result of inflammation associated with overuse or trauma. The inflammation can also cause the tendons in the carpal tunnel to enlarge. The accumulated fluid and enlarged tendons can apply pressure to a major nerve passing through the tunnel. The pressure on this nerve causes **carpal tunnel syndrome,** the symptoms of which are tingling, burning, and numbness in the hand

Hand

Five **metacarpal** (met′ă-kar′păl, after the carpals) **bones** are attached to the carpal bones and constitute the bony framework of the hand (see figure 7.27). They are numbered 1 through 5, starting with the most lateral metacarpal, at the base of the thumb. The distal ends of the metacarpal bones help form the knuckles of the hand (see figure 7.25).

The five **digits** of each hand include one thumb and four fingers. The digits are also numbered 1 through 5, starting from the thumb. Each digit consists of small long bones called **phalanges** (fă-lan′jēz, sing. *phalanx,* a line or wedge of soldiers holding their spears, tips outward, in front of them). The thumb has two phalanges, called proximal and distal. Each finger has three phalanges designated proximal, middle, and distal. One or two **sesamoid** (ses′ă-moyd, resembling a sesame seed) **bones** (not shown in figure 7.27) often form near the junction between the proximal phalanx and the metacarpal of the thumb. Sesamoid bones are small bones located within some tendons, increasing their mechanical advantage where they cross joints.

30 Distinguish between the anatomical and surgical necks of the humerus.
31 Name the important sites of muscle attachment on the humerus.
32 Give the points of articulation between the scapula, humerus, radius, ulna, and wrist bones.
33 What is the function of the radial and ulnar tuberosities? Of the styloid processes?
34 Name the part of the ulna commonly referred to as "the elbow."
35 List the eight carpal bones.
36 What bones form the hand? The knuckles?
37 Name the phalanges in a thumb and in a finger.

Predict 7

Explain why a dried, articulated skeleton appears to have much longer "fingers" than are seen in a hand with the soft tissue intact.

Pelvic Girdle

The pelvic girdle is the place of attachment for the lower limbs, it supports the weight of the body, and it protects internal organs (figure 7.28). The right and left **coxal** (kok′sul) **bones,** os coxae, or hipbones, join each other anteriorly and the **sacrum** posteriorly to form a ring of bone called the **pelvic girdle.** The **pelvis** (pel′vis, basin) includes the pelvic girdle and the coccyx (figure 7.29). Because the pelvic girdle is a complete bony ring, it provides more stable support but less mobility than the incomplete ring of the pectoral girdle. In addition, the pelvis in a woman protects a developing fetus and forms a passageway through which the fetus passes during delivery.

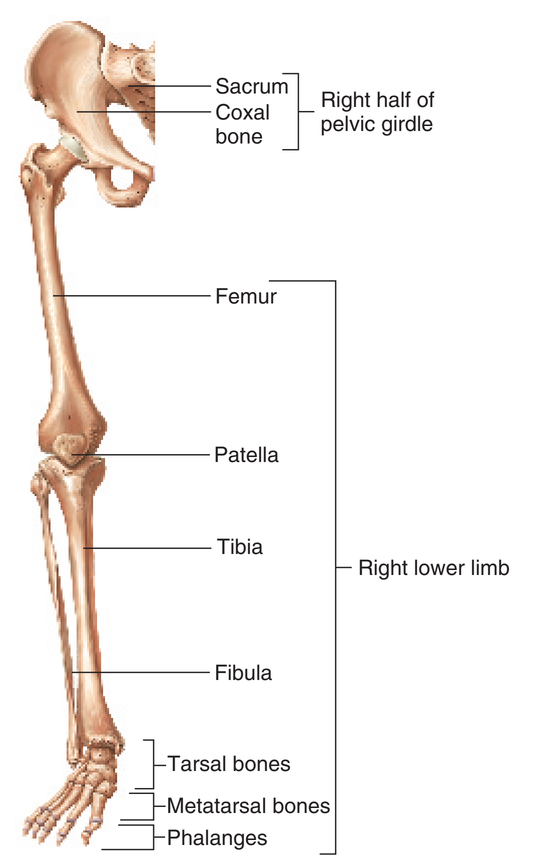


Figure 7.28 Bones of the Pelvic Girdle and Lower Limb

Each coxal bone is formed by three bones fused to one another to form a single bone (see figure 7.29). The **ilium** (il′ē-ŭm, groin) is the superior, the **ischium** (is′kē-ŭm, hip) is inferior and posterior, and the **pubis** (pū′bis, genital hair) is inferior and anterior. The coxal bones join anteriorly at the **symphysis** (sim′fi-sis, a coming together) **pubis,** or **pubic symphysis.** Posteriorly, each coxal bone joins the sacrum at the **sacroiliac joint.**

A fossa called the **acetabulum** (as-ĕ-tab′ū-lŭm, a shallow vinegar cup—a common household item in ancient times) is located on the lateral surface of each coxal bone (figure 7.30*a*). In a child, the joints between the ilium, ischium, and pubis can be seen. The bones fuse together in some locations by the seventh or eighth year. Complete fusion within the acetabulum occurs between the sixteenth and eighteenth years. The acetabulum is the point of articulation of the lower limb with the pelvic girdle. The articular, **lunate surface** of the acetabulum is crescent-shaped and occupies only the superior and lateral aspects of the fossa (figure 7.30*b*). Inferior to the acetabulum is the large **obturator** (ob′too-rā-tŏr, to occlude or close up) **foramen.** In life, the obturator foramen is almost completely closed off by a connective tissue membrane, which separates the pelvic cavity from more superficial structures. Despite its large size, only a few small blood vessels and nerves pass through the obturator foramen.

The superior portion of the ilium is called the **iliac crest** (see figure 7.30*b;* figure 7.30*c*). The crest ends anteriorly as the **anterior superior iliac spine** and posteriorly as the **posterior superior iliac spine.** The crest and anterior spine can be felt and even seen in thin individuals (figure 7.31). The anterior superior iliac spine is an important anatomical landmark used, for example, to find the correct location for giving gluteal injections into the hip. A dimple overlies the posterior superior iliac spine just superior to the buttocks.

Gluteal Injections

The large gluteal (hip) muscles (see chapter 9) are a common site for intramuscular injections. Gluteal injections are made in the superolateral region of the hip (figure C) so as to avoid a large nerve (the sciatic nerve) (see chapter 11) located more posteriorly. The landmarks for such an injection are the anterior superior iliac spine and the tubercle of the iliac crest, which lies about one-third of the way along the iliac crest from anterior to posterior.

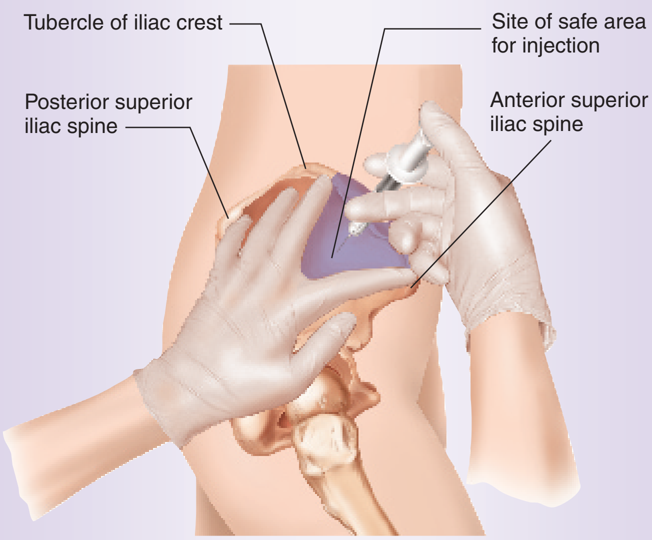


Figure C **Gluteal Injection Site**

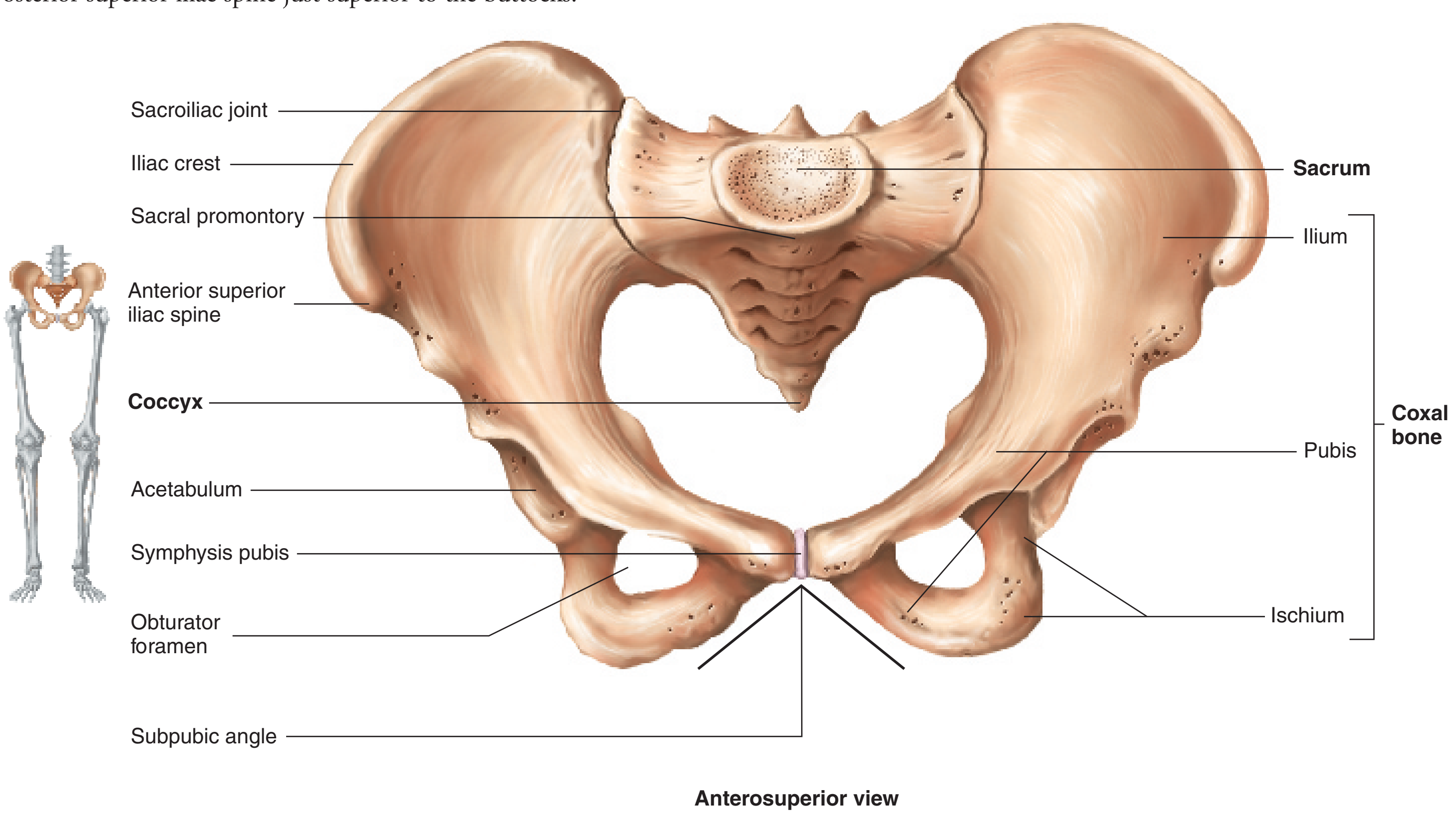


Figure 7.29 **Pelvis**

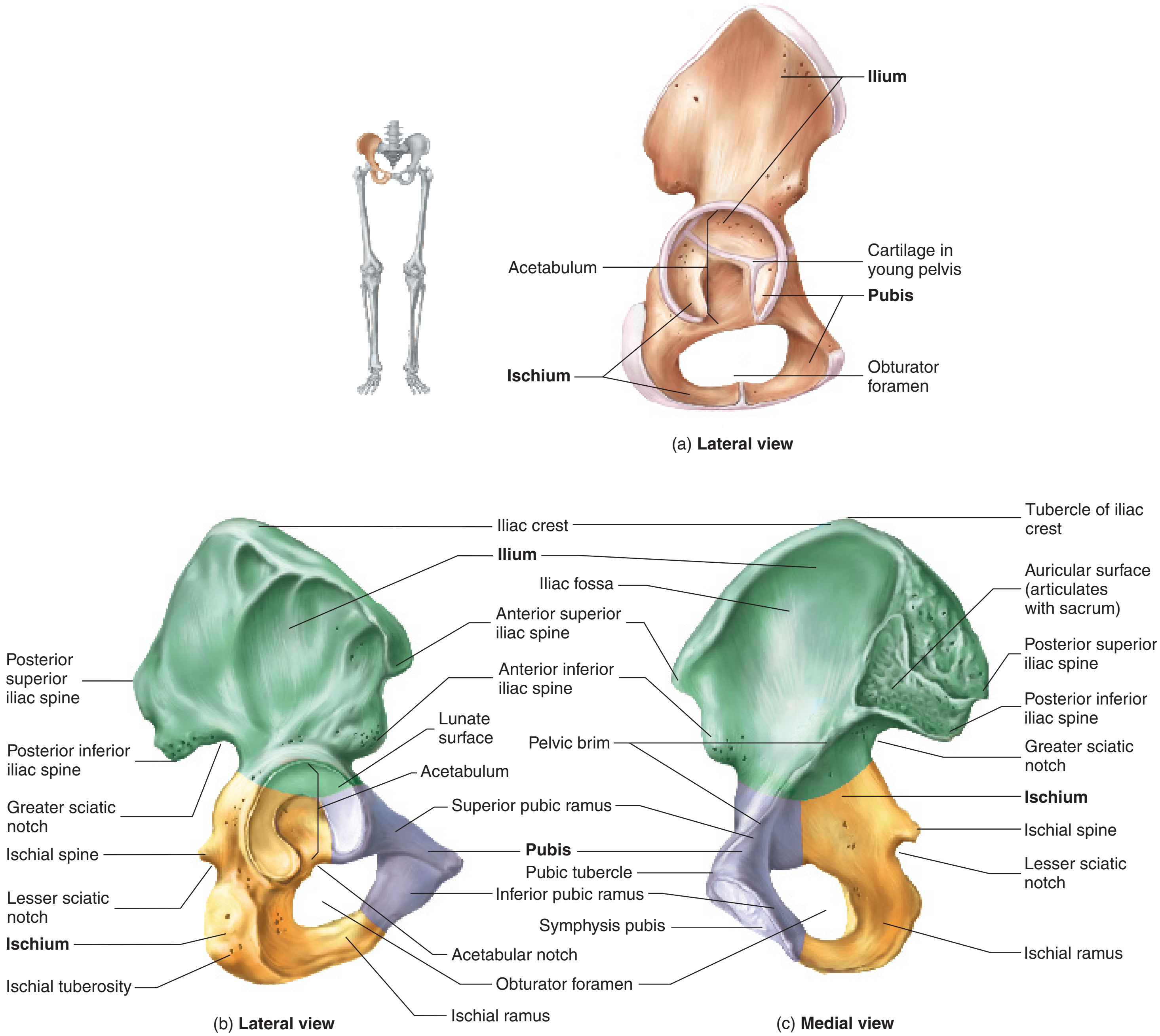


Figure 7.30 **Coxal Bone** APR

(*a*) Right coxal bone of a young adolescent. The ilium, ischium, and pubis (in bold) form the incompletely ossified coxal bone. They are joined near the center of the acetabulum by cartilage. (*b*) Right coxal bone of an adult, lateral view. (*c*) Right coxal bone of an adult, medial view. The ilium (*green*), ischium (*gold*), and pubis (*purple*) fuse together to form a single bone.

Inferior to the anterior superior iliac spine is the **anterior inferior iliac spine** (see figure 7.30). The anterior iliac spines are attachment sites for anterior thigh muscles. Inferior to the superior posterior iliac spine are the **posterior inferior iliac spine, ischial spine,** and **ischial tuberosity.** The posterior iliac spines and ischial tuberosity are attachment sites for ligaments anchoring the coxal bone to the sacrum. The **auricular surface** of the ilium (see figure 7.30*c*) joins the auricular surface of the sacrum (see figure 7.18) to form the sacroiliac joint. The ischial tuberosity is also an attachment site for posterior thigh muscles, and it is the part of the coxal bone on which a person sits.

The **greater sciatic notch** is superior to the ischial spine and the **lesser sciatic notch** is inferior to it (see figure 7.30). Nerves and blood vessels pass through the sciatic notches.

The pelvis is divided into the **false pelvis** and the **true pelvis** by an imaginary plane passing from the sacral promontory to the pubic crest. The **pelvic brim** is the bony boundary of this plane (figure 7.32). The false pelvis, which is the expanded part of the pelvis superior to the pelvic brim, is also the inferior part of the abdominal cavity (see figure 1.15). The true pelvis is inferior to the pelvic brim and is completely surrounded by bone. The **pelvic inlet** is the superior opening of the true pelvis formed by the pelvic brim. The **pelvic**

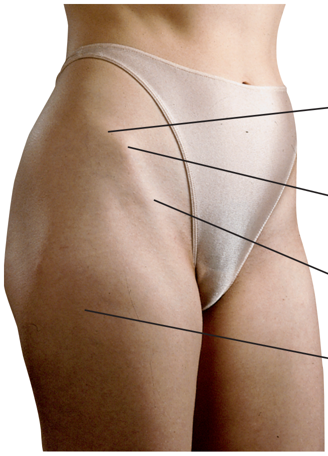


Figure 7.31 **Surface Anatomy Showing an Anterolateral View of the Coxal Bone and Femur**

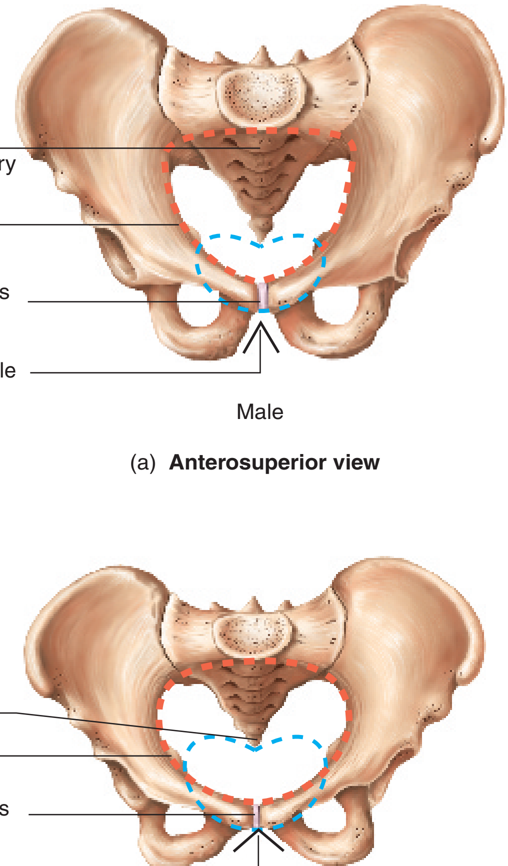


Figure 7.32 **Comparison of the Male and Female Pelvis**
(*a*) Male. The pelvic inlet (*red dashed line*) and outlet (*blue dashed line*) are small, and the subpubic angle is less than 90 degrees. (*b*) Female. The pelvic inlet (*red dashed line*) and outlet (*blue dashed line*) are larger, and the subpubic angle is 90 degrees or greater.

outlet is the inferior opening of the true pelvis bordered by the inferior margin of the pubis, the ischial spines, the ischial tuberosities, and the coccyx. In life, muscles of the pelvic diaphragm span the pelvic outlet (see chapter 9). The **pelvic cavity** is the space between the pelvic inlet and the pelvic diaphragm.

Comparison of the Male and Female Pelvis

The male pelvis usually is more massive than the female pelvis as a result of the greater weight and size of the male, but the female pelvis is broader and has a larger, more rounded pelvic inlet and outlet (see figure 7.32), consistent with the need to allow a fetus to pass through these openings in the female pelvis during delivery. If the pelvic outlet is too small for normal delivery, it can be accomplished by **cesarean section,** which is the surgical removal of the fetus through the abdominal wall. Table 7.6 lists additional differences between the male and female pelvis.

38 Define the pelvic girdle. What bones fuse to form each coxal bone? Where and with what bones does each coxal bone articulate?
39 Name the important sites of muscle and ligament attachment on the pelvis.
40 Distinguish between the true pelvis and the false pelvis.
41 Describe the differences between a male and a female pelvis.

Lower Limb

The lower limb consists of the bones of the thigh, leg, ankle, and foot (see figure 7.28).

Thigh

The thigh is the region between the hip and the knee. The thigh, like the arm, contains a single bone, called the **femur** (figure 7.33). The **head** of the femur articulates with the acetabulum of the coxal bone, and the **neck** of the femur connects the head to the **body** (shaft) of the femur. The **greater trochanter** (trō-kan′ter, runner) and the **lesser trochanter** are attachment sites for muscles that fasten the hip to the thigh. The greater trochanter and its attached muscles form a bulge that can be seen as the widest part of the hips (see figure 7.31). The **pectineal line, gluteal tuberosity,** and the **linea aspera** are

Table 7.6 **Differences Between the Male and Female Pelvis (See Figure 7.32)**

Area	Description
General	In females, somewhat lighter in weight and wider laterally but shorter superiorly to inferiorly and less funnel-shaped; less obvious muscle attachment points in females than in males
Sacrum	Broader in females, with the inferior part directed more posteriorly; the sacral promontory does not project as far anteriorly in females
Pelvic inlet	Heart-shaped in males; oval in females
Pelvic outlet	Broader and more shallow in females
Subpubic angle	Less than 90 degrees in males; 90 degrees or more in females
Ilium	More shallow and flared laterally in females
Ischial spines	Farther apart in females
Ischial tuberosities	Turned laterally in females and medially in males

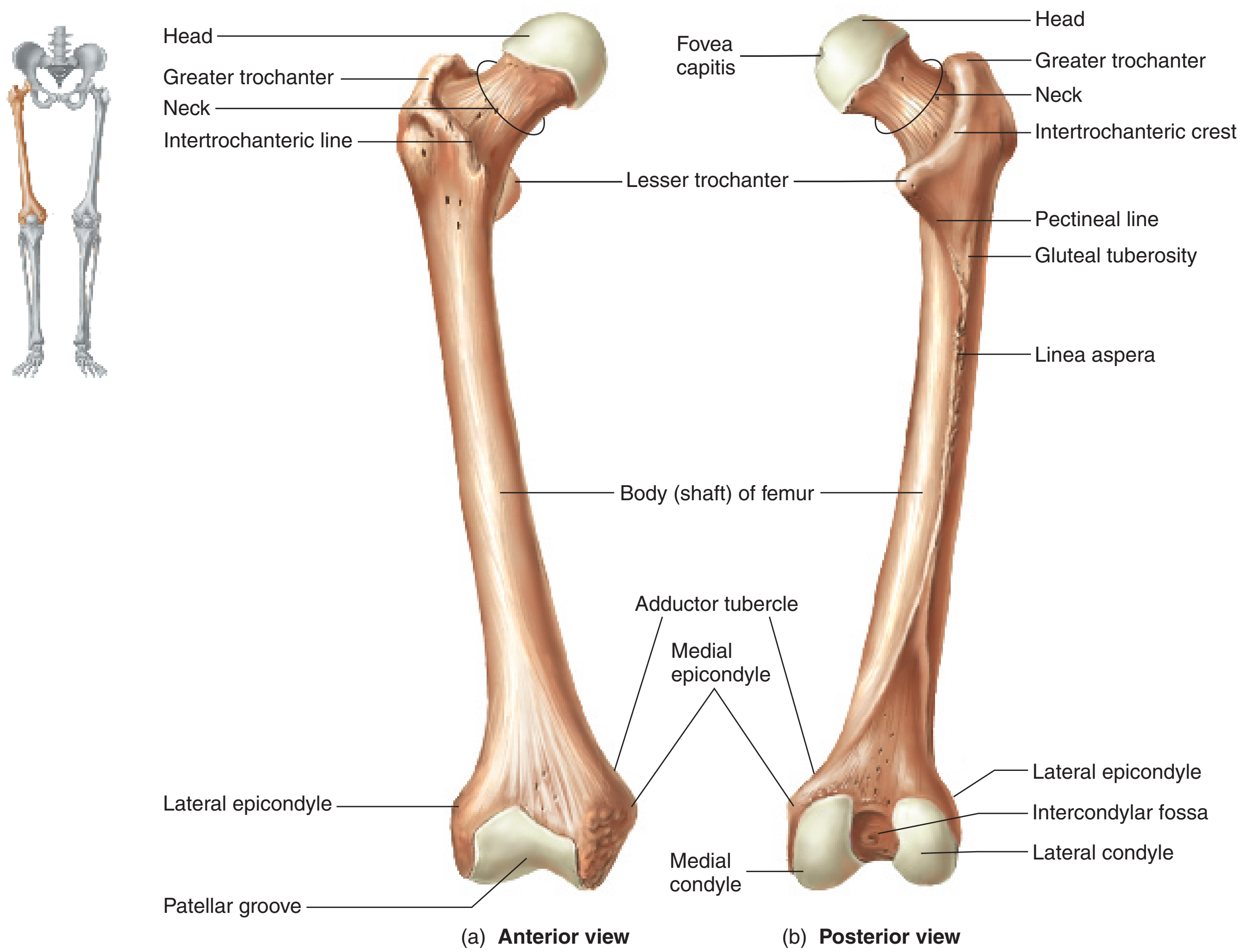


Figure 7.33 Right Femur

other muscle attachment sites. The distal end of the femur has **medial** and **lateral condyles** that articulate with the tibia (leg bone). Located proximally to the condyles are the **medial** and **lateral epicondyles,** important sites of ligament attachment. The epicondyles can be felt just proximal to the knee joint (figure 7.34). An **adductor tubercle,** to which muscles attach, is located just proximal to the medial epicondyle.

CASE STUDY | Fracture of the Femoral Neck

An 85-year-old woman who lived alone was found lying on her kitchen floor by her daughter, who had come to check on her mother. The woman could not rise, even with help, and when she tried she experienced extreme pain in her right hip. Her daughter immediately dialed 911, and paramedics took her mother to the hospital.

The elderly woman's hip was x-rayed in the emergency room, and it was determined that she had a fracture of the right femoral neck. A femoral neck fracture is commonly, but incorrectly, called a broken hip. Two days later, she received a partial hip replacement in which the head and neck of the femur, but not the acetabulum, were replaced. In falls involving femoral neck fracture, it is not always clear whether the fall caused the femoral neck to fracture or whether a fracture of the femoral neck caused the fall. Femoral neck fractures are among the most common injuries resulting in morbidity (disease) and mortality (death) in older adults. Four percent of women over age 85 experience femoral neck fractures each year. Only about 25% of victims fully recover from the injury. Despite treatment with anticoagulants and antibiotics, about 5% of patients with femoral neck fractures develop deep vein thrombosis (blood clot) and about 5% develop wound infections, either of which can be life-threatening. Hospital mortality is 1%–7% among patients with femoral neck fractures, and nearly 20% of femoral neck fracture victims die within 3 months of the fracture.

Predict 8

The risk of fracture of the femoral neck increases dramatically with age, and 81% of victims are women. The average age of those who suffer such an injury is 82. Why is the femoral neck so commonly injured? (*Hint:* See figure 7.1.) Why are elderly women most commonly affected?

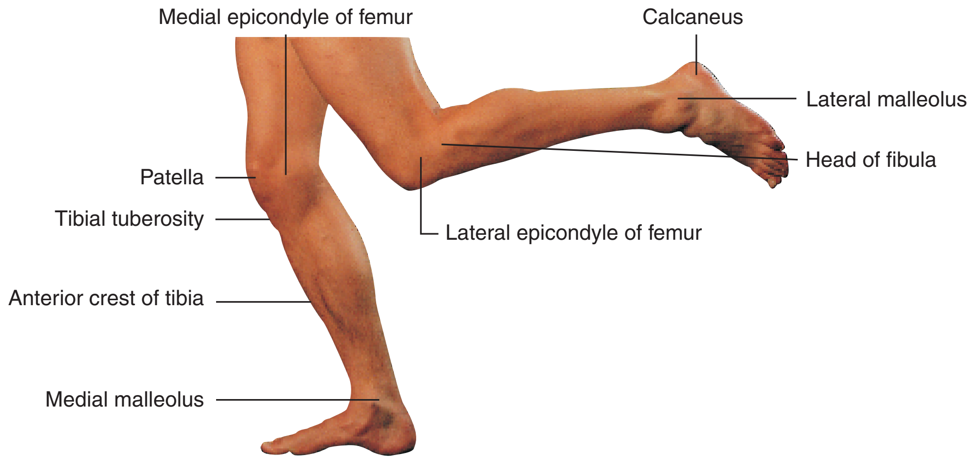


Figure 7.34 **Surface Anatomy Showing Bones of the Lower Limb**

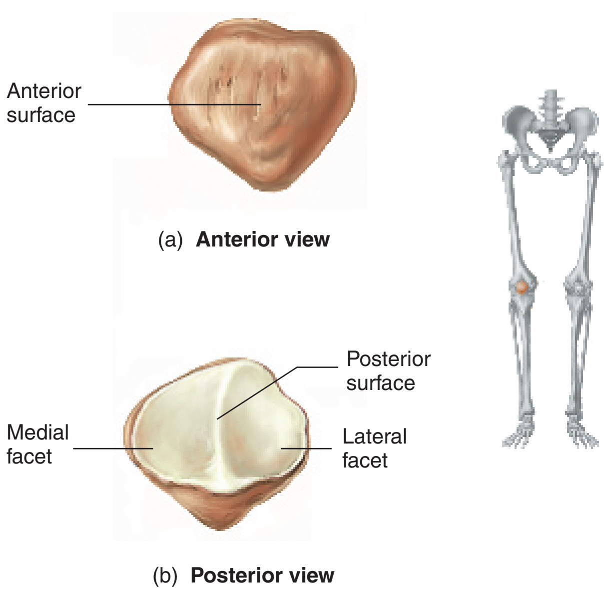


Figure 7.35 **Right Patella**

The **patella** (figure 7.35), or kneecap, articulates with the **patellar groove** of the femur (see figure 7.33). It is a large sesamoid bone located within the tendon of the quadriceps femoris muscle group, which is the major muscle group of the anterior thigh. The patella holds the tendon away from the distal end of the femur and therefore changes the angle of the tendon between the quadriceps femoris muscle and the tibia, where the tendon attaches. This change in angle increases the force that can be applied from the muscle to the tibia. As a result of this increase in applied force, less muscle contraction force is required to move the tibia.

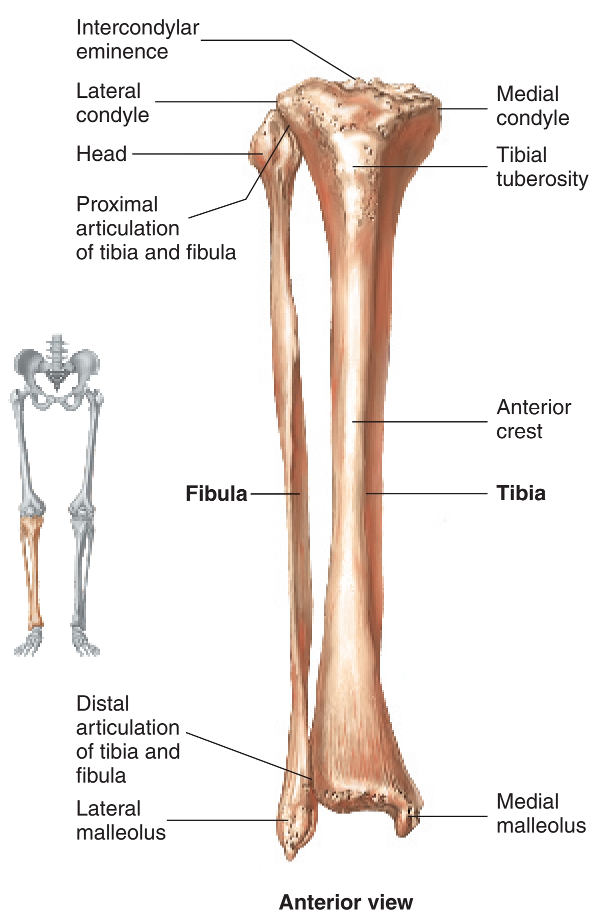


Figure 7.36 **Right Tibia and Fibula**

Leg

The leg is the part of the lower limb between the knee and the ankle. Like the forearm, it consists of two bones: the larger **tibia** (tib′ē-ă), or shinbone, and the smaller **fibula** (fib′ū-lă, resembling a clasp or buckle) (figure 7.36). The rounded condyles of the femur rest on the flat **medial** and **lateral condyles** on the proximal end of the tibia. Body weight is transmitted from the femur through the tibia to the ankle.

The **intercondylar eminence** is a ridge between the condyles. A **tibial tuberosity,** which is the attachment point for the quadriceps femoris muscle group, can easily be seen and felt just inferior to the patella (see figure 7.35). The **anterior crest** forms a sharp edge on the shin. The distal end of the tibia is enlarged to form the **medial malleolus** (ma-lē′ō-lŭs, mallet-shaped), which helps form the medial side of the ankle joint.

The fibula does not articulate with the femur but has a small proximal **head** where it articulates with the tibia. The distal end of the fibula is also slightly enlarged as the **lateral malleolus** to create the lateral wall of the ankle joint. The lateral and medial malleoli can be felt and seen as prominent lumps on both sides of the ankle (see figure 7.35).

Foot

The proximal portion of the foot consists of seven **tarsal** (tar′săl, the sole of the foot) **bones** (figure 7.37). The tarsal bones are the **talus** (tā′lŭs, ankle bone), **calcaneus** (kal-kā′nē-ŭs, heel), **cuboid** (kū′boyd, cube-shaped), and **navicular** (nă-vik′yū-lăr, boat-shaped) bones and the medial, intermediate, and lateral **cuneiforms** (kū′nē-i-fōrmz, wedge-shaped). A mnemonic for the distal row of bones is **MILC**—that is, **M**edial, **I**ntermediate, and **L**ateral cuneiforms and the **C**uboid. The mnemonic for the proximal three bones is **No Thanks Cow**—that is, **N**avicular, **T**alus, and **C**alcaneus.

The talus articulates with the tibia and fibula to form the ankle joint. It is an unusual bone in that no muscles attach to it. The calcaneus forms the heel and is the attachment point for the large calf muscles.

Fractures of the Malleoli

Turning the plantar surface of the foot outward so that it faces laterally is called eversion. Forceful eversion of the foot, such as when a person slips and twists the ankle or jumps and lands incorrectly on the foot, may cause the distal ends of the tibia and/or fibula to fracture (figure D*a*). When the foot is forcefully everted, the medial malleolus moves inferiorly toward the ground or floor and the talus slides laterally, forcing the medial and lateral malleoli to separate. The ligament holding the medial malleolus to the tarsal bones is stronger than the bones it connects, and often it does not tear as the malleoli separate. Instead, the medial malleolus breaks. Also, as the talus slides laterally, the force can shear off the lateral malleolus or, more commonly, can cause the fibula to break superior to the lateral malleolus. This type of injury to the tibia and fibula is often called a **Pott fracture.**

Turning the plantar surface of the foot inward so that it faces medially is called inversion. Forceful inversion of the foot can fracture the fibula just proximal to the lateral malleolus (figure D*b*). More often, because the ligament holding the medial malleolus to the tarsal bones is weaker than the bones it connects, the inversion of the foot causes a sprain in which ligaments are damaged.

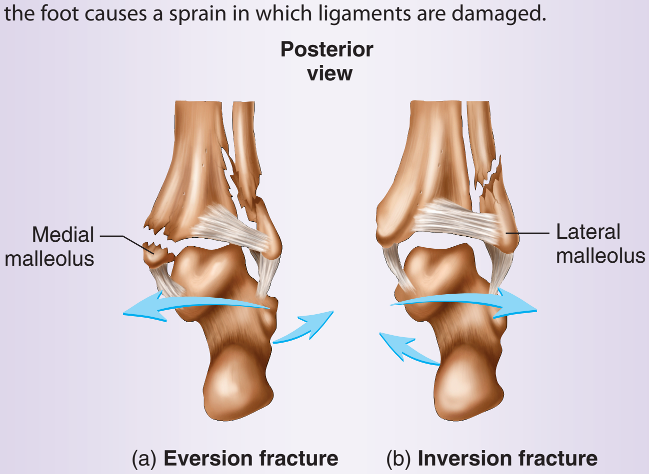


Figure D Fracture of the Medial or Lateral Malleolus

The **metatarsal bones** and **phalanges** of the foot are arranged in a manner very similar to that of the metacarpal bones and phalanges of the hand, with the great toe analogous to the thumb (see figure 7.37). Small sesamoid bones often form in the tendons of muscles attached to the great toe. The ball of the foot is mainly formed by the distal heads of the metatarsal bones.

The foot bones form three major **arches,** which distribute the weight of the body between the heel and the ball of the foot during standing and walking (see figure 7.37*b*). As the foot is placed on the ground, weight is transferred from the tibia and the fibula to the talus. From there, the weight is distributed first to the heel (calcaneus) and then through the arch system along the lateral side of the foot to the ball of the foot (heads of the metatarsal bones). This effect can be observed when a person with wet, bare feet walks across a dry surface; the print of the heel, the lateral border of the foot, and the ball of the foot can be seen, but the middle of the plantar surface and the medial border leave no impression. The medial side leaves no mark because the arches on this side of the foot are higher than those on the lateral side. The shape of the arches is maintained by the configuration of the bones, the ligaments connecting them, and the muscles acting on the foot.

42 Name the bones of the thigh and leg.
43 Give the points of articulation among the pelvic girdle, femur, leg, and ankle.
44 What is the function of the greater trochanter and the lesser trochanter? The medial and lateral epicondyles?
45 Describe the function of the patella.
46 What is the function of the tibial tuberosity?
47 Name the seven tarsal bones. Which bones form the ankle joint? What bone forms the heel?
48 What bones form the ball of the foot? How many phalanges are in each toe?
49 List the three arches of the foot and describe their function.

7.4 Joints

A **joint,** or **articulation,** is a place where two or more bones come together. We usually think of joints as being movable, but that is not always the case. Many joints allow only limited movement, and others allow no apparent movement. The structure of a given joint is directly correlated with its degree of movement. Fibrous joints have much less movement than joints containing fluid and having smooth articulating surfaces.

Joints are commonly named according to the bones or portions of bones that are united at the joint, such as the temporomandibular joint between the temporal bone and the mandible. Some joints are simply given the Greek or Latin equivalent of the common name, such as the **cubital** (kū′bi-tăl, cubit, elbow or forearm) **joint** for the elbow joint.

The three major kinds of joints are classified structurally as fibrous, cartilaginous, and synovial. In this classification scheme, joints are categorized according to the major connective tissue type that binds the bones together and whether or not a fluid-filled joint capsule is present.

50 What criteria are used to name joints and classify?

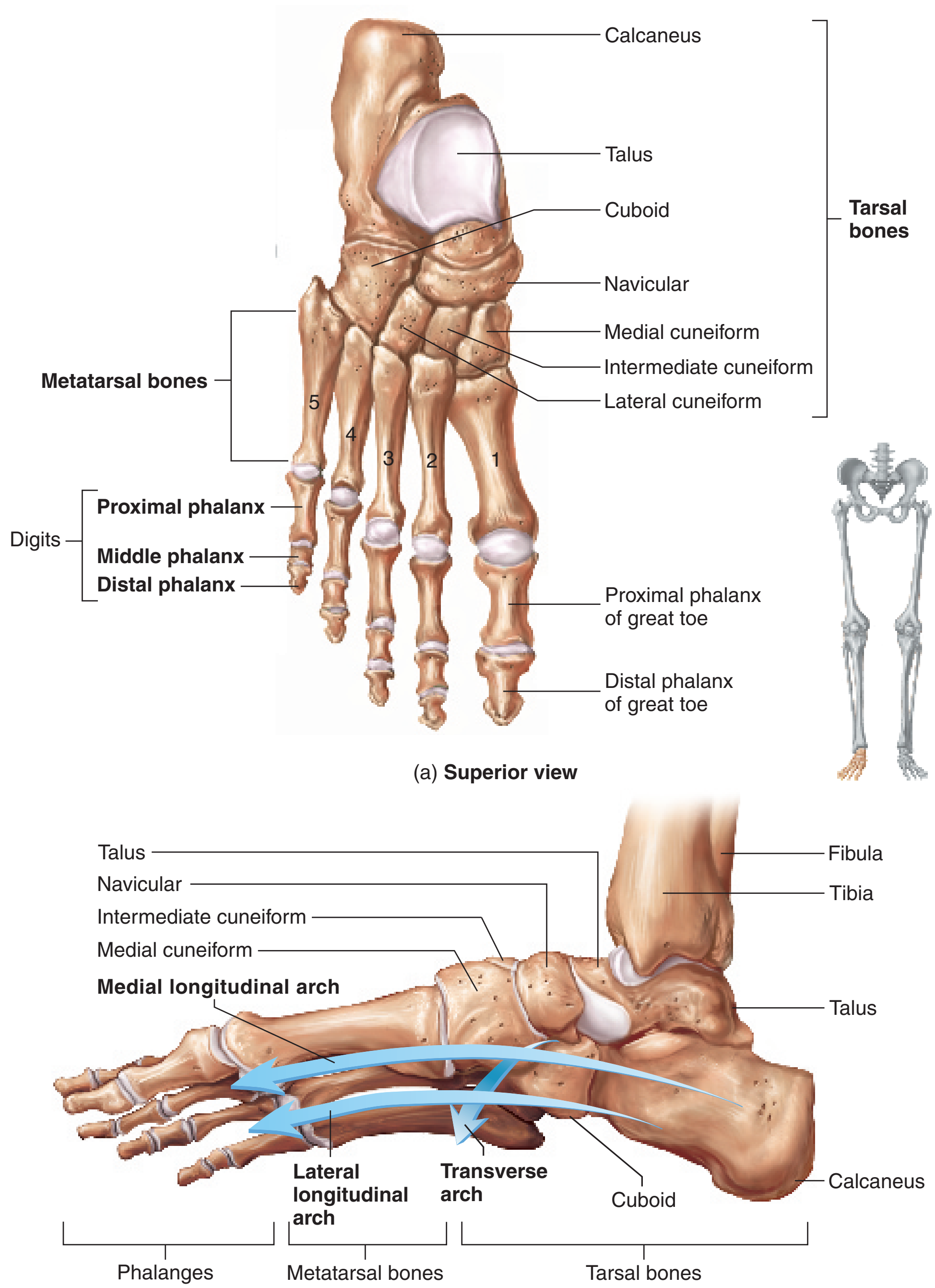


Figure 7.37 **Bones of the Right Foot** AP|R

The medial longitudinal arch is formed by the calcaneus, the talus, the navicular, the cuneiforms, and three medial metatarsal bones. The lateral longitudinal arch is formed by the calcaneus, the cuboid, and two lateral metatarsal bones. The transverse arch is formed by the cuboid and cuneiforms.

Predict 9

What is the name of the joint between the metacarpal bones and the phalanges?

Fibrous Joints

Fibrous joints consist of two bones that are united by fibrous connective tissue, have no joint cavity, and exhibit little or no movement. Joints in this group are classified further as sutures, syndesmoses, or gomphoses (table 7.7), based on their structure.

Sutures

Sutures (soo′choorz) are fibrous joints between the bones of the skull (see figure 7.2). The type of connective tissue in fibrous joints is dense regular collagenous connective tissue. The bones in a suture often have interlocking, fingerlike processes that add stability to the joint.

Table 7.7 Fibrous and Cartilaginous Joints

Class and Example of Joint	Bones or Structures Joined	Movement
Fibrous Joints		
Sutures		
Coronal	Frontal and parietal	None
Lambdoid	Occipital and parietal	None
Sagittal	The two parietal bones	None
Squamous	Parietal and temporal	Slight
Syndesmoses		
Radioulnar	Ulna and radius	Slight
Stylohyoid	Styloid process and hyoid bone	Slight
Stylomandibular	Styloid process and mandible	Slight
Tibiofibular	Tibia and fibula	Slight
Gomphoses		
Dentoalveolar	Tooth and alveolar process	Slight
Cartilaginous Joints		
Synchondroses		
Epiphyseal plate	Diaphysis and epiphysis of a long bone	None
Sternocostal	Anterior cartilaginous part of first rib; between rib and sternum	Slight
Sphenooccipital	Sphenoid and occipital	None
Symphyses		
Intervertebral	Bodies of adjacent vertebrae	Slight
Manubriosternal	Manubrium and body of sternum	None
Symphysis pubis	The two coxal bones	None except during childbirth
Xiphisternal	Xiphoid process and body of sternum	None

In a newborn, intramembranous ossification of the skull bones along their margins is incomplete. A large area of unossified membrane between some bones is called a **fontanel** (fon′tă-nel′, little fountain, so named because the membrane can be seen to move with the pulse), or soft spot (figure 7.38). The unossified membrane makes the skull flexible during the birth process and allows for growth of the head after birth. The fontanels have usually ossified by 2 years of age.

The margins of bones within sutures are sites of continuous intramembranous bone growth, and many sutures eventually become ossified. For example, ossification of the suture between the two frontal bones occurs shortly after birth so that they usually form a single frontal bone in the adult skull. In most normal adults, the coronal, sagittal, and lambdoid sutures are not fused. In some very old adults, however, even these sutures become ossified. A **synostosis** (sin-os-tō′sis, joined by bone) results when two bones grow together across a joint to form a single bone.

Predict 10

Predict the result of a sutural synostosis that occurs prematurely in a child's skull before the brain has reached its full size.

Syndesmoses

A **syndesmosis** (sin′dez-mō′sis, to fasten or bind) is a fibrous joint in which the bones are farther apart than in a suture and are joined by ligaments. Some movement may occur at syndesmoses because of flexibility of the ligaments, such as in the radioulnar syndesmosis, which binds the radius and ulna together (figure 7.39).

Gomphoses

Gomphoses (gom-fō′sēz) consist of pegs held in place within sockets by fibrous tissue. The joints between the teeth and the sockets (alveoli) of the mandible and maxillae are gomphoses (figure 7.40). The connective tissue bundles between the teeth and their sockets are called **periodontal** (per′ē-ō-don′tăl) **ligaments.**

Gingivitis and Periodontal Disease

The **gingiva,** or gums, are the soft tissues covering the alveolar processes. Neglect of the teeth can result in **gingivitis,** an inflammation of the gingiva, often resulting from bacterial infection. Left untreated, gingivitis can spread to the tooth socket, resulting in **periodontal disease,** the leading cause of tooth loss in the United States. Periodontal disease involves an accumulation of plaque and bacteria, resulting in inflammation and the gradual destruction of the periodontal ligaments and the bone. Eventually, the teeth may become so loose that they come out of their sockets. Proper brushing, flossing, and professional cleaning to remove plaque can usually prevent gingivitis and periodontal disease.

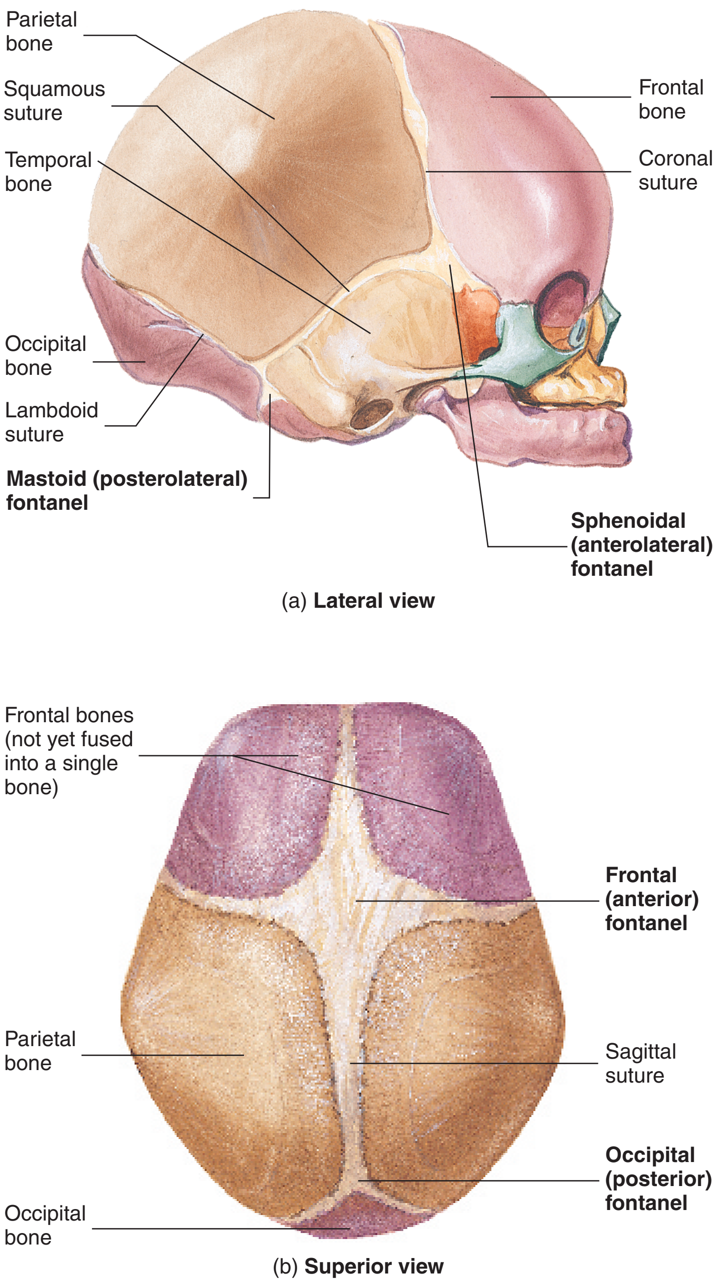


Figure 7.38 **Fetal Skull Showing Fontanels and Sutures**

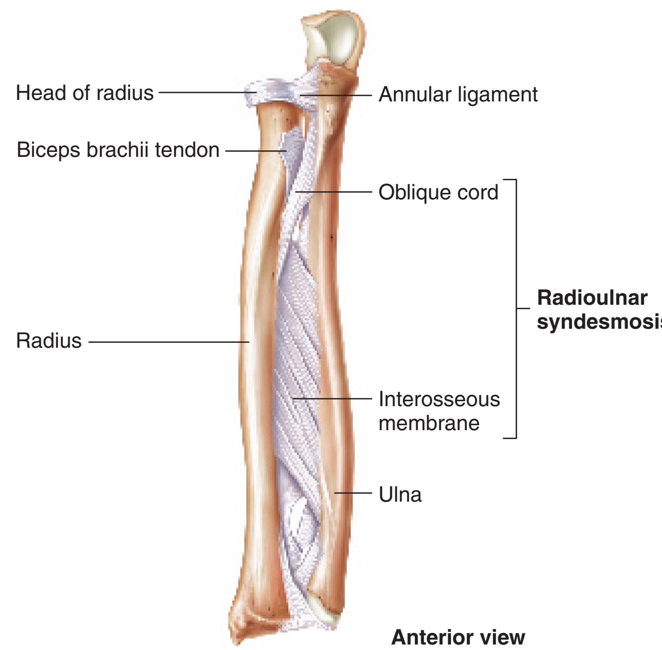


Figure 7.39 **Right Radioulnar Syndesmosis**

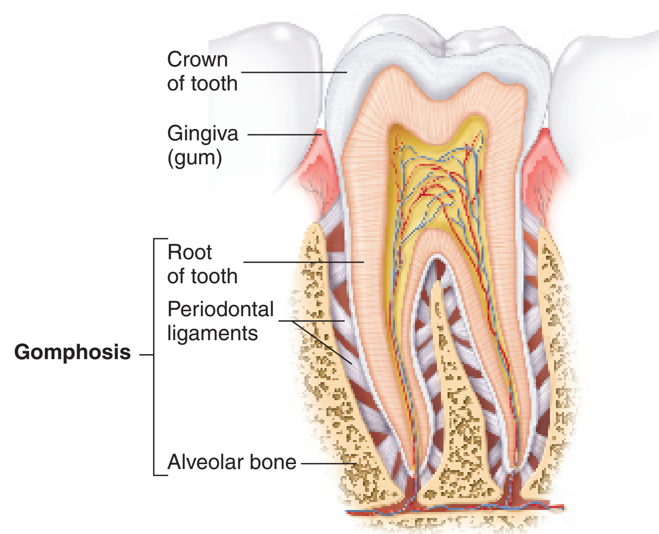


Figure 7.40 **Gomphosis Between a Tooth and Alveolar Bone of the Mandible**

51 Define *fibrous joint,* describe three types, and give an example of each.

52 What is a synostosis?

Cartilaginous Joints

Cartilaginous joints unite two bones by means of either hyaline cartilage or fibrocartilage (see table 7.7).

Synchondroses

A **synchondrosis** (sin′kon-drō′sis, joined by cartilage) consists of two bones joined by hyaline cartilage where little or no movement occurs. The joints between the ilium, ischium, and pubis before those bones fuse together are examples of synchondroses (see figure 7.30*a*). The epiphyseal plates of growing bones are synchondroses (see figure 6.5). Most synchondroses are temporary, with bone eventually replacing them to form synostoses. On the other hand, some synchondroses persist throughout life. An example is the sternocostal synchondrosis between the first rib and the sternum by way of the first costal cartilage (see figure 7.19). The remaining costal cartilages attach to the sternum by synovial joints (see "Synovial Joints," p. 181).

Symphyses

A **symphysis** (sim′fi-sis, a growing together) consists of fibrocartilage uniting two bones. Symphyses include the junction between the manubrium and the body of the sternum (see figure 7.19), the symphysis pubis (see figure 7.29), and the intervertebral disks (see figure 7.16). Some of these joints are slightly movable because of the somewhat flexible nature of fibrocartilage.

53 Define *cartilaginous joints*, describe two types, and give an example of each.

Synovial Joints

Synovial (si-nō′vē-ăl, joined by a fluid resembling egg albumin) **joints** are freely movable joints that contain **synovial fluid** in a cavity surrounding the ends of articulating bones. Most joints that unite the bones of the appendicular skeleton are large synovial joints, whereas many of the joints that unite the bones of the axial skeleton are not. This pattern reflects the greater mobility of the appendicular skeleton, compared with the axial skeleton.

The articular surfaces of bones within synovial joints are covered with a thin layer of hyaline cartilage called **articular cartilage,** which provides a smooth surface where the bones meet (figure 7.41). In some synovial joints, a flat plate or pad of fibrocartilage, called an **articular disk,** is located between the articular cartilages of bones. Articular disks absorb and distribute the forces between the articular cartilages as the bones move. Examples of joints with articular disks are the temporomandibular, sternoclavicular, and acromioclavicular joints. A **meniscus** (mĕ-nis′kŭs, crescent-shaped) is an incomplete, crescent-shaped fibrocartilage pad found in joints such as the knee and wrist. A meniscus is much like an articular disk with a hole in the center.

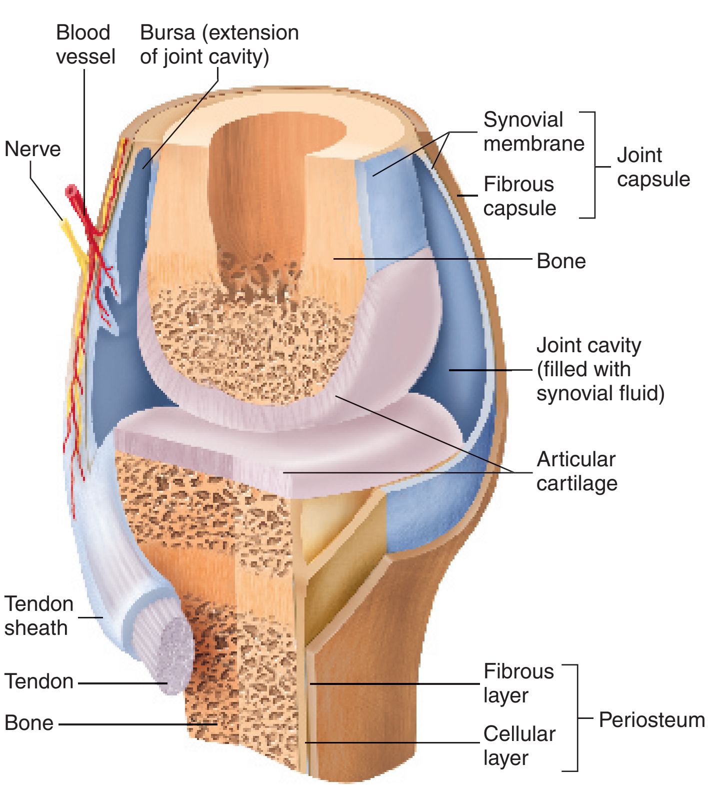


Figure 7.41 **Structure of a Synovial Joint** AP|R

A **joint capsule** (see figure 7.41) surrounds the ends of the bones forming synovial joints, forming a **joint cavity.** The capsule helps hold the bones together while allowing for movement. The joint capsule consists of two layers: an outer **fibrous capsule** and an inner **synovial membrane** (see figure 7.41). The fibrous capsule consists of dense irregular connective tissue and is continuous with the fibrous layer of the periosteum that covers the bones united at the joint. Portions of the fibrous capsule may thicken and the collagen fibers become regularly arranged to form ligaments. In addition, ligaments and tendons may be present outside the fibrous capsule, thereby contributing to the strength and stability of the joint while limiting movement in some directions.

The synovial membrane lines the joint cavity, except over the articular cartilage and articular disks. It is a thin, delicate membrane consisting of modified connective tissue cells. The membrane produces synovial fluid, which consists of a serum (blood fluid) filtrate and secretions from the synovial cells. Synovial fluid coats and lubricates articular cartilage, preventing friction damage during movement. It is a complex mixture, containing hyaluronic acid (a polysaccharide), lubricin (a proteoglycan), and surface-active phospholipid (SAPL).

Predict 11

What would happen if a synovial membrane covered the articular cartilage?

In certain synovial joints, such as the shoulder and knee, the synovial membrane extends as a pocket, or sac, called a **bursa** (ber′să, pocket) for a distance away from the rest of the joint cavity (see figure 7.41). Bursae contain synovial fluid, providing a cushion between structures that otherwise would rub against each other, such as tendons rubbing on bones or other tendons. Some bursae, such as the subcutaneous olecranon bursae, are not associated with joints but provide a cushion between the skin and underlying bony prominences, where friction could damage the tissues. Other bursae extend along tendons for some distance, forming **tendon sheaths. Bursitis** (ber-sī′tis) is the inflammation of a bursa; it may cause considerable pain around the joint and restrict movement.

54 Describe the structure of a synovial joint. How do the different parts of the joint permit joint movement? What are articular disks and menisci?

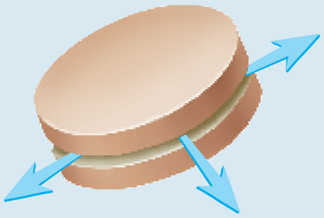
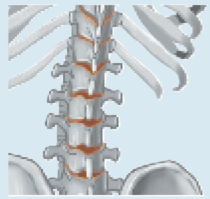
55 Define *bursa* and *tendon sheath*. What is their function?

Types of Synovial Joints

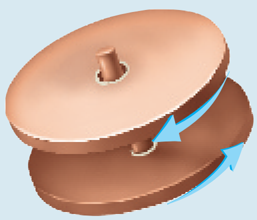
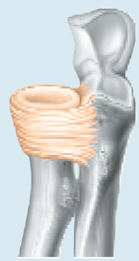
Synovial joints are classified according to the shapes of the adjoining articular surfaces. The six types of synovial joints are plane, saddle, hinge, pivot, ball-and-socket, and ellipsoid (table 7.8). Movements at synovial joints are described as **uniaxial** (occurring around one axis), **biaxial** (occurring around two axes situated at right angles to each other), or **multiaxial** (occurring around several axes).

Plane joints, or **gliding joints,** consist of two opposed flat surfaces of about equal size in which a slight amount of gliding motion can occur between the bones. These joints are considered uniaxial because some rotation is also possible but is limited by

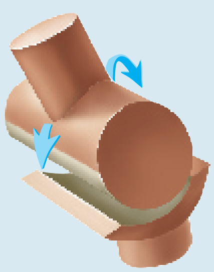
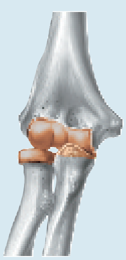
Table 7.8 Types of Synovial Joints

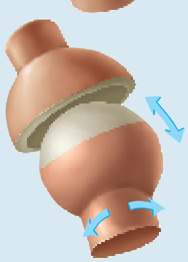
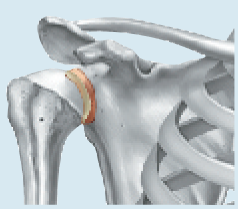
Plane

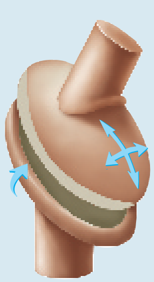
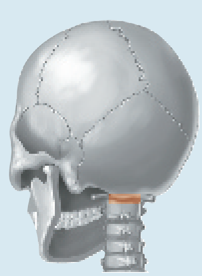
Pivot

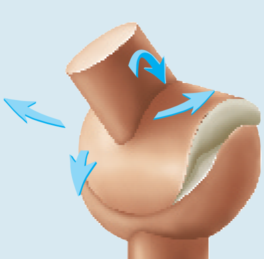
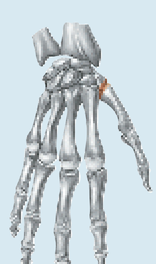
Hinge

Ball-and-socket

Elipsoid

Saddle

Class and Example of Joint	Structures Joined	Movement
Plane		
Acromioclavicular	Acromion of scapula and clavicle	Slight
Carpometacarpal	Carpal bones and metacarpal bones two through five	Multiple axes as a group
Costovertebral	Ribs and vertebrae	Slight
Intercarpal	Between carpal bones	Slight
Intermetatarsal	Between metatarsal bones	Slight
Intertarsal	Between tarsal bones	Slight
Intervertebral	Between articular processes of adjacent vertebrae	Slight
Sacroiliac	Sacrum and coxa (complex joint with several planes and synchondroses)	Slight
Tarsometatarsal	Tarsal bones and metatarsals bones	Slight
Pivot		
Medial atlantoaxial	Atlas and axis	Rotation
Proximal radioulnar	Radius and ulna	Rotation
Distal radioulnar	Radius and ulna	Rotation
Hinge		
Cubital (elbow)	Humerus, ulna, and radius	One axis
Genu (knee)	Femur and tibia	One axis
Interphalangeal	Between phalanges	One axis
Talocrural (ankle)	Talus, tibia, and fibula	Multiple axes, one predominates
Ball-and-Socket		
Humeral (shoulder)	Scapula and humerus	Multiple axes
Coxal (hip)	Coxal bone and femur	Multiple axes
Ellipsoid		
Atlantooccipital	Atlas and occipital bone	Two axes
Metacarpophalangeal (knuckles)	Metacarpal bones and phalanges	Two axes
Metatarsophalangeal (ball of foot)	Metatarsal bones and phalanges	Two axes
Radiocarpal (wrist)	Radius and carpal bones	Multiple axes
Temporomandibular	Mandible and temporal bone	Multiple axes, one predominates
Saddle		
Carpometacarpal pollicis	Carpal and metacarpal bones of thumb	Two axes
Intercarpal	Between carpal bones	Slight
Sternoclavicular	Manubrium of sternum and clavicle	Slight

ligaments and adjacent bone. Examples are the articular processes between vertebrae.

Pivot joints consist of a relatively cylindrical bony process that rotates within a ring composed partly of bone and partly of ligament. They are uniaxial joints that restrict movement to rotation around a single axis. The articulation between the head of the radius and the proximal end of the ulna is an example (see figures 7.26*a* and 7.39). The articulation between the dens and the atlas is another example (see figure 7.17*a* and *b*).

Hinge joints consist of a convex cylinder in one bone applied to a corresponding concavity in the other bone. They are uniaxial joints. Examples include the elbow and knee joints.

Ball-and-socket joints consist of a projection rounded like a baseball that fits into a concave surface or socket. This type of joint is multiaxial, allowing a wide range of movement in almost any direction. Examples are the shoulder and hip joints.

Ellipsoid joints are modified ball-and-socket joints in which the projection is shaped like a football. Ellipsoid joints are biaxial, because the shape of the joint limits its range of movement almost to a hinge motion in two axes and restricts rotation. An example is the atlantooccipital joint between the atlas and the occipital condyles, which allows a "yes" movement and a tilting, side-to-side movement of the head.

Saddle joints consist of two saddle-shaped articulating surfaces oriented at right angles to each other so that complementary surfaces articulate with each other. Saddle joints are biaxial joints. The carpometacarpal joint between the carpal (trapezium) and metacarpal of the thumb is a saddle joint.

56 On what basis are synovial joints classified? Describe the types of synovial joints, and give examples of each. What movements does each type of joint allow?

7.5 Types of Movement

The types of movement occurring at a given joint are related to the structure of that joint. Some joints are limited to only one type of movement, whereas others permit movement in several directions. All the movements are described relative to the anatomical position. Because most movements are accompanied by movements in the opposite direction, they are listed in pairs.

Gliding Movements

Gliding movements are the simplest of all the types of movement. These movements occur in plane joints between two flat or nearly flat surfaces where the surfaces slide or glide over each other. These joints often give only slight movement, such as between carpal bones.

Angular Movements

Angular movements are those in which one part of a linear structure, such as the body as a whole or a limb, is bent relative to another part of the structure, thereby changing the angle between the two parts. Angular movements also involve the movement of a solid rod, such as a limb, that is attached at one end to the body so that the angle at which it meets the body changes. The most common angular movements are flexion and extension and abduction and adduction.

Flexion and Extension

Flexion and extension can be defined in a number of ways, but in each case exceptions to the definition exist. The literal definition for flexion is to bend; for extension, to straighten. This bending and straightening can easily be seen in the elbow (figure 7.42*a*). Flexion and extension can also be defined in relation to the coronal plane. Starting from the anatomical position, **flexion** is the movement of a body part anterior to the coronal plane, or in the anterior direction. **Extension** is the movement of a body part posterior to the coronal plane, or in the posterior direction (figure 7.42*b–d*).

The exceptions to defining flexion and extension according to the coronal plane are the knee and foot. At the knee, flexion moves the leg in a posterior direction and extension moves it in an anterior direction (figure 7.42*e*). Movement of the foot toward the plantar surface, such as when standing on the toes, is commonly called **plantar flexion;** movement of the foot toward the shin, such as when walking on the heels, is called **dorsiflexion** (figure 7.42*f*).

Hyperextension can be defined as an abnormal, forced extension of a limb or part beyond its normal range of motion. For example, when a car is rear-ended, passengers in the car may experience whiplash, resulting in hyperextension of the head and neck. Some health professionals, however, define hyperextension as the normal movement of structures, except the leg, into the space posterior to the anatomical position.

Abduction and Adduction

Abduction (to take away) is movement away from the median plane (midline of the body); **adduction** (to bring together) is movement toward the median plane. Moving the upper limbs away from the body, such as in the outward portion of doing jumping jacks, is abduction of the arm, and bringing the upper limbs back toward the body is adduction of the arm (figure 7.43*a*). Abduction of the fingers involves spreading the fingers apart, away from the midline of the hand, and adduction is bringing them back together (figure 7.43*b*). Abduction of the thumb moves it anteriorly, away from the palm. Abduction of the wrist is movement of the hand away from the midline of the body, and adduction of the wrist results in movement of the hand toward the midline of the body. Abduction of the neck tilts the head to one side and is commonly called lateral flexion of the neck. Bending at the waist to one side is usually called **lateral flexion** of the vertebral column, rather than abduction.

57 Define *flexion* and *extension* and demonstrate flexion and extension of the limbs and trunk. What is hyperextension?

58 Define *plantar flexion* and *dorsiflexion*.

59 Contrast abduction and adduction. Describe these movements for the arm, fingers, wrist, neck, and vertebral column. For what part of the body is the term *lateral flexion* used?

Circular Movements

Circular movements involve the rotation of a structure around an axis or movement of the structure in an arc.

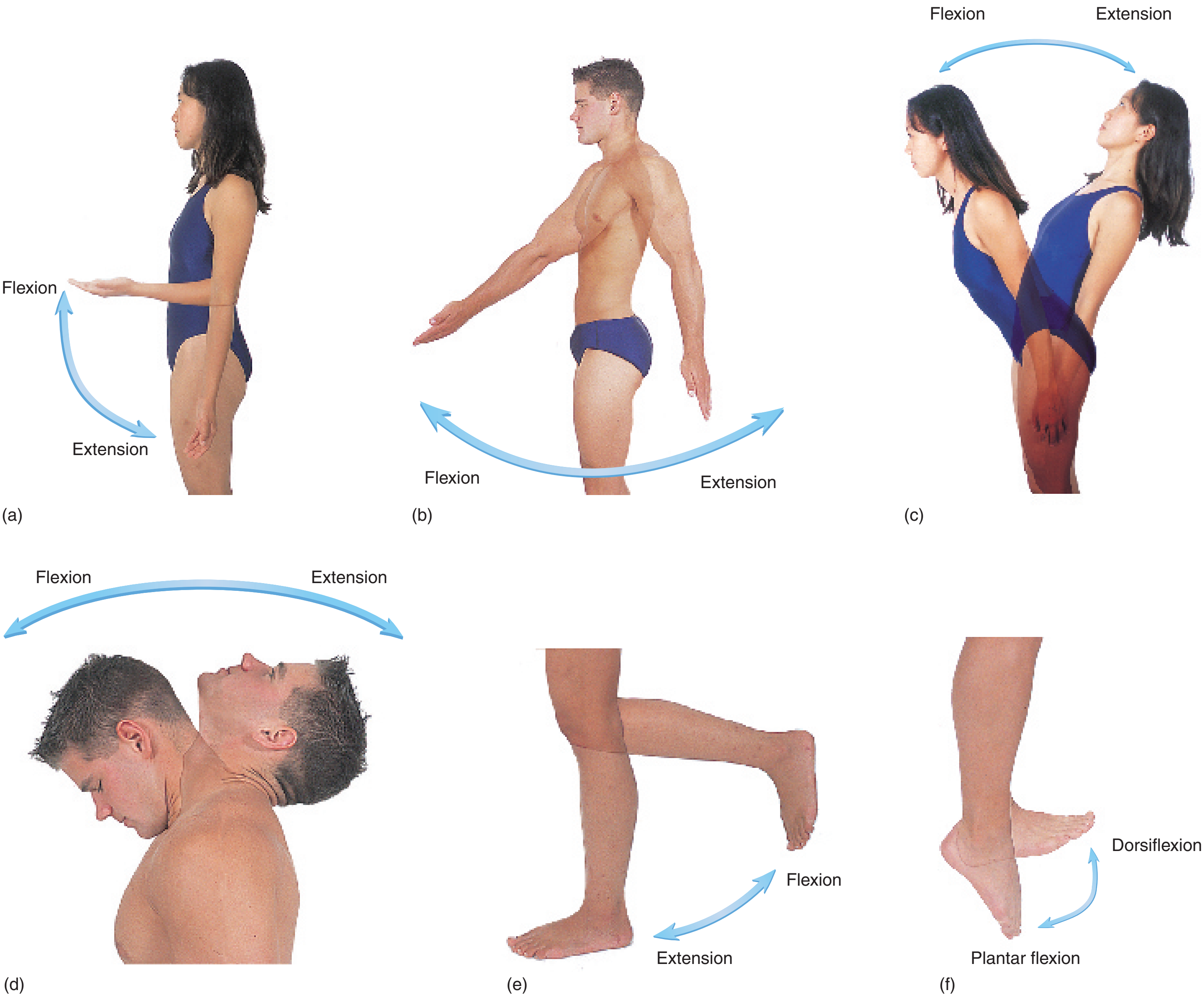


Figure 7.42 **Flexion and Extension**
Flexion and extension of (*a*) the elbow, (*b*) the shoulder, (*c*) the hip, (*d*) the neck, and (*e*) the knee. (*f*) Dorsiflexion and plantar flexion of the foot.

Rotation

Rotation is the turning of a structure around its long axis, such as the movement of the atlas around the axis when shaking the head "no." Medial rotation of the humerus with the forearm flexed brings the hand toward the body. Rotation of the humerus so that the hand moves away from the body is lateral rotation (figure 7.44).

Pronation and Supination

Pronation (prō-nā′shŭn) and **supination** (soo′pi-nā′shūn) refer to the unique rotation of the forearm (figure 7.45). The word *prone* means lying facedown; the word *supine* means lying faceup. When the elbow is flexed to 90 degrees, pronation is rotation of the forearm so that the palm of the hand faces inferiorly. Supination is rotation of the forearm so that the palm faces superiorly. In pronation, the radius and ulna cross; in supination, they are in a parallel position. The head of the radius rotates against the radial notch of the ulna during supination and pronation (see figure 7.26*a*).

Circumduction

Circumduction is a combination of flexion, extension, abduction, and adduction (figure 7.46). It occurs at freely movable joints, such as the shoulder. In circumduction, the arm moves so that it describes a cone with the shoulder joint at the apex.

60 Distinguish among rotation, circumduction, pronation, and supination. Give an example of each.

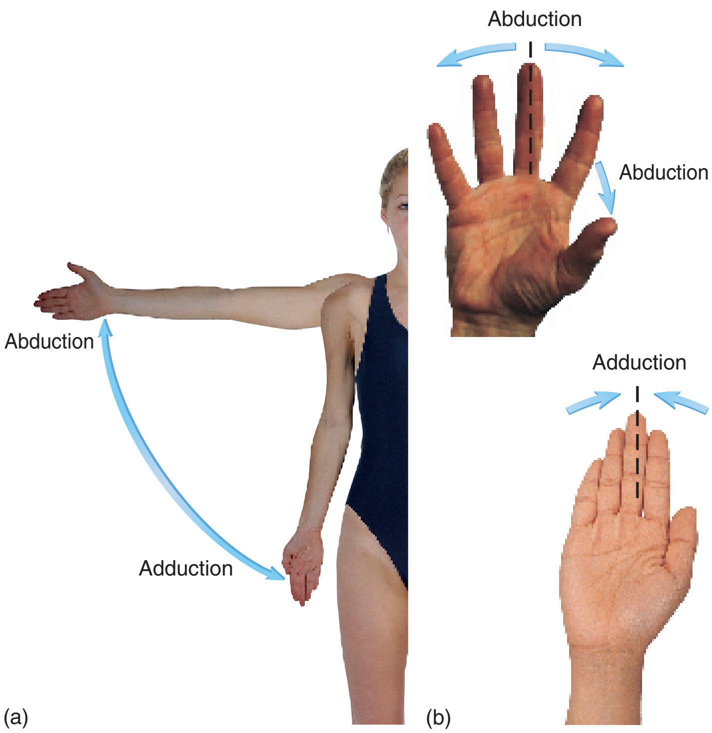


Figure 7.43 Abduction and Adduction
Abduction and adduction of (*a*) the arm and (*b*) the fingers.

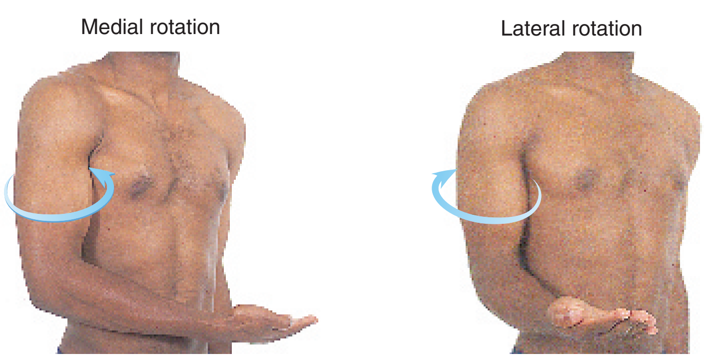


Figure 7.44 Medial and Lateral Rotation of the Arm

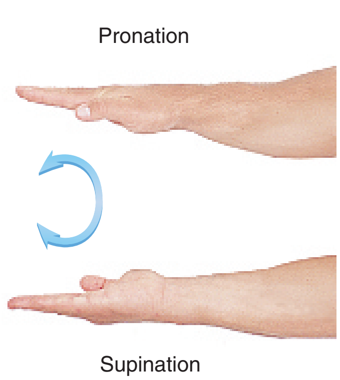


Figure 7.45 Pronation and Supination of the Forearm

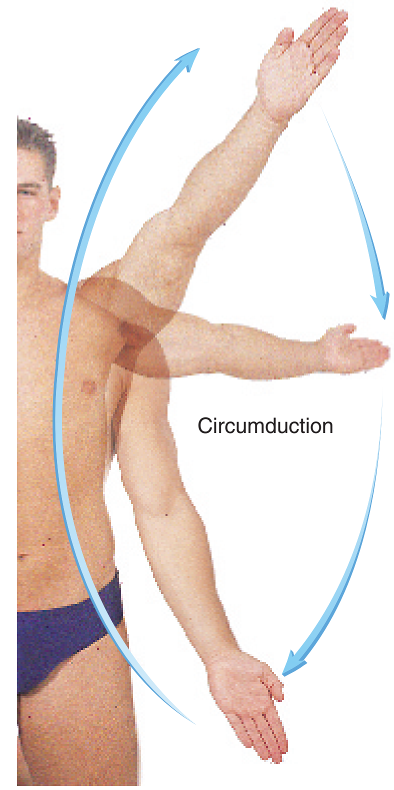


Figure 7.46 Circumduction

Special Movements

Special movements are those movements unique to only one or two joints; they do not fit neatly into one of the other categories.

Elevation and Depression

Elevation moves a structure superiorly; **depression** moves it inferiorly. The scapulae and mandible are primary examples. Shrugging the shoulders is an example of scapular elevation. Depression of the mandible opens the mouth, and elevation closes it.

Protraction and Retraction

Protraction consists of moving a structure in a gliding motion in an anterior direction. **Retraction** moves the structure back to the anatomical position or even more posteriorly. As with elevation and depression, the mandible and scapulae are primary examples. Pulling the scapulae back toward the vertebral column is retraction.

Excursion

Lateral excursion is moving the mandible to either the right or left of the midline, such as in grinding the teeth or chewing. **Medial excursion** returns the mandible to the neutral position.

Opposition and Reposition

Opposition is a unique movement of the thumb and little finger. It occurs when these two digits are brought toward each other across the palm of the hand. The thumb can also oppose the other digits, but those digits flex to touch the tip of the opposing thumb.

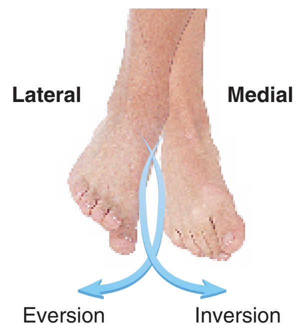


Figure 7.47 Inversion and Eversion of the Right Foot

Reposition is the movement returning the thumb and little finger to the neutral, anatomical position.

Inversion and Eversion

Inversion of the foot consists of turning the ankle so that the plantar surface of the foot faces medially, toward the opposite foot. **Eversion** of the foot is turning the ankle so that the plantar surface faces laterally (figure 7.47). Inversion of the foot is sometimes called supination, and eversion is called pronation.

61 Define the following jaw movements: protraction, retraction, lateral excursion, medial excursion, elevation, and depression.

62 Define *opposition* and *reposition*. Define inversion and eversion of the foot.

Combination Movements

Most movements that occur in the course of normal activities are combinations of the movements named previously and are described by naming the individual movements involved in the combined movement. For example, when a person steps forward at a 45-degree angle to the side, the movement at the hip is a combination of flexion and abduction.

63 What are combination movements?

Predict 12

What combination of movements is required at the shoulder and elbow joints for a person to move the right upper limb from the anatomical position to touch the right side of the head with the fingertips?

7.6 Description of Selected Joints

It is impossible in a limited space to describe all the joints of the body; therefore, only selected joints are described in this chapter, and they have been chosen because of their representative structure, important function, or clinical significance.

Temporomandibular Joint

The mandible articulates with the temporal bone to form the **temporomandibular joint (TMJ).** The mandibular condyle fits into the mandibular fossa of the temporal bone (figure 7.48*a*). A fibrocartilage articular disk is located between the mandible and the temporal bone, dividing the joint into superior and inferior joint cavities. The joint is surrounded by a fibrous capsule, to which the articular disk is attached at its margin, and it is strengthened by lateral and accessory ligaments.

The temporomandibular joint is a modified ellipsoid joint. As mandibular depression begins, the mandibular condyle and articular disk move anteriorly in a gliding motion. As mandibular depression continues, a hinge motion occurs between the mandibular condyle and articular disk. The mandibular condyle also allows protraction, retraction, and excursion of the mandible. The movements of the mandibular condyle can easily be felt by placing your fingers over it while the mandible is moved.

Temporomandibular Disorder

Temporomandibular disorder (TMD) is the second most common cause of orofacial pain, after toothache. TMD is broadly subdivided into muscle-related TMD and joint-related TMD. Muscle-related TMD is the more common form and is related to muscle hyperactivity and malalignment of the teeth. Muscle hyperactivity results in grinding of the teeth during sleep and jaw clenching during the day in a stressed person. Radiographs may reveal no obvious destructive changes of the joint.

Joint-related TMD can be caused by disk displacement, degeneration of the joint, arthritis, infections, and other causes. Abnormal movement of the disk can produce a characteristic popping or clicking sound. An abnormal position of the disk may make it impossible to open the mouth fully.

Treatment includes teaching the patient to reduce jaw movements that aggravate the problem and to reduce stress and anxiety. Physical therapy may help relax the muscles and restore function. Analgesic and anti-inflammatory drugs may be used, and oral splints may be helpful, especially at night.

Shoulder Joint

The **shoulder joint,** or **glenohumeral joint,** is a ball-and-socket joint (figure 7.48*b*) in which stability is reduced and mobility is increased, compared with the other ball-and-socket joint, the hip. Flexion, extension, abduction, adduction, rotation, and circumduction can all occur at the shoulder joint. The rounded head of the humerus articulates with the shallow glenoid cavity of the scapula. The rim of the glenoid cavity is built up slightly by a fibrocartilage ring, the **glenoid labrum,** to which the joint capsule is attached. A **subacromial bursa** is located near the joint cavity but is separated from the cavity by the joint capsule.

The stability of the joint is maintained primarily by ligaments and four muscles referred to collectively as the **rotator cuff,** which help hold the head of the humerus in the glenoid cavity. These muscles are discussed in more detail in chapter 9. The head of the humerus is also supported against the glenoid cavity by a tendon from the biceps brachii muscle. This tendon attaches to the supraglenoid tubercle (see figure 7.22*a*), crosses over the head of the humerus within the joint cavity (see figure 7.48*b*), and passes through the intertubercular groove (see figure 7.24*a*) to join the biceps brachii in the anterior arm.

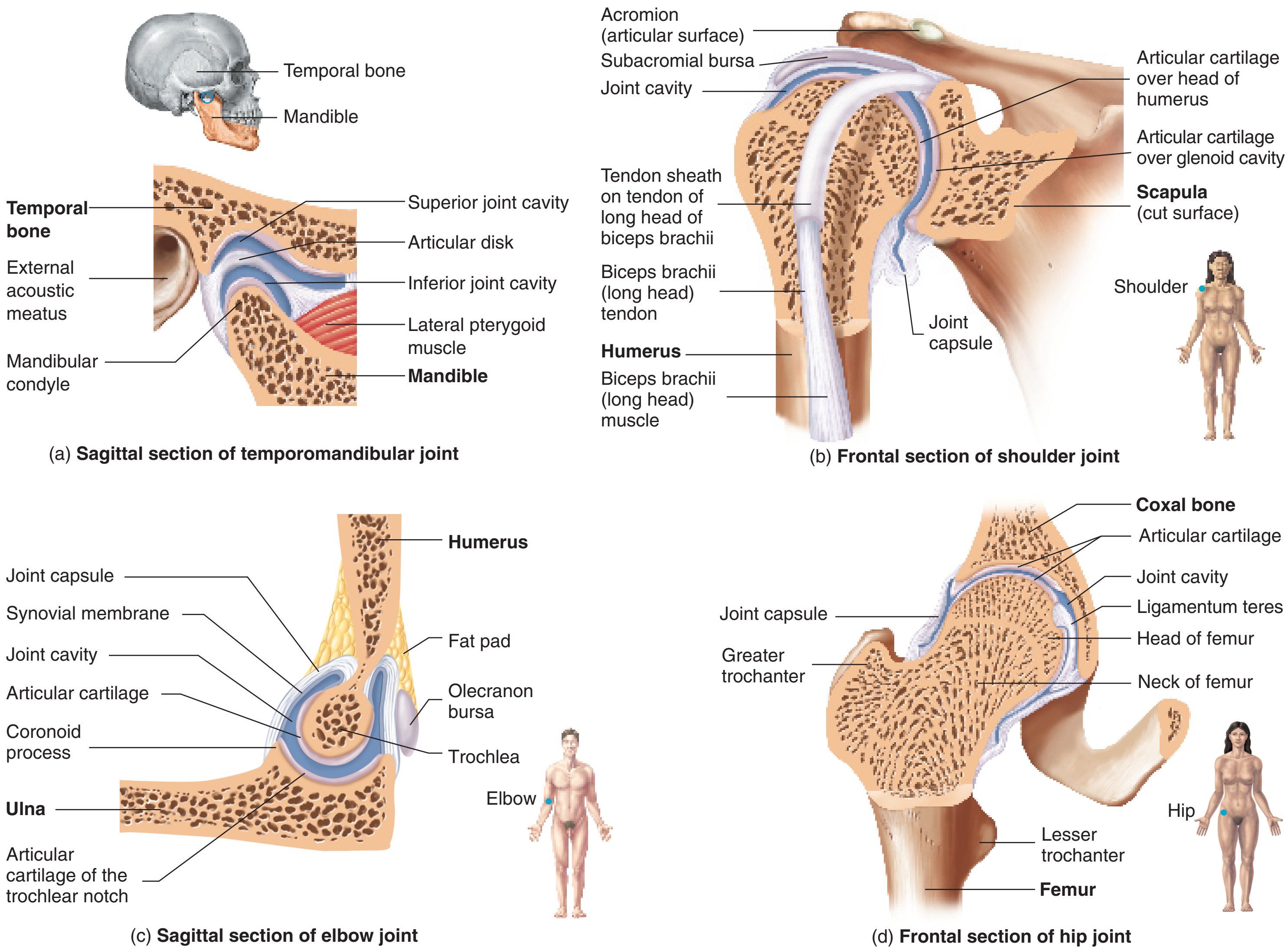


Figure 7.48 **Examples of Synovial Joints**
(*a*) Temporomandibular joint. (*b*) Shoulder joint. (*c*) Elbow joint. (*d*) Hip joint.

Shoulder Disorders

The most common traumatic shoulder disorders are **dislocation** and muscle or tendon **tears.** The shoulder is the most commonly dislocated joint in the body. The major ligaments cross the superior part of the shoulder joint, and no major ligaments or muscles are associated with the inferior side. As a result, dislocation of the humerus is most likely to occur inferiorly into the axilla. Because the axilla contains very important nerves and arteries, severe and permanent damage may occur when the humeral head dislocates inferiorly. The axillary nerve is the most commonly damaged (see chapter 11).

Chronic shoulder disorders include tendonitis (inflammation of tendons), bursitis (inflammation of bursae), and arthritis (inflammation of joints). Bursitis of the subacromial bursa can become very painful when the large shoulder muscle, called the deltoid muscle, compresses the bursa during shoulder movement.

Elbow Joint

The **elbow joint** (figure 7.48*c*) is a compound hinge joint consisting of the **humeroulnar joint,** between the humerus and ulna, and the **humeroradial joint,** between the humerus and radius. The **proximal radioulnar joint,** between the proximal radius and ulna, is also closely related. The shape of the trochlear notch and its association with the trochlea of the humerus limit movement at the elbow joint to flexion and extension. The rounded radial head, however, rotates in the radial notch of the ulna and against the capitulum of the humerus (see figure 7.26*a*), allowing pronation and supination of the forearm.

The elbow joint is surrounded by a joint capsule and is reinforced by ligaments. A subcutaneous **olecranon bursa** covers the proximal and posterior surfaces of the olecranon.

Clinical Relevance

Knee Injuries and Disorders

Damage to a collateral ligament can result from a blow to the opposite side of the knee. A common type of football injury results from a block or tackle to the lateral side of the knee, which can cause the knee to bend inward, tearing the tibial (medial) collateral ligament and opening the medial side of the joint (figure E). Injuries to the medial side of the knee are much more common than injuries to the lateral side because blows to the lateral side occur more frequently than to the medial side. In addition, the tibial (medial) collateral ligament is weaker than the fibular (lateral) collateral.

The medial meniscus is fairly tightly attached to the tibial (medial) collateral ligament and is damaged 20 times more often in a knee injury than the lateral meniscus, which is thinner and not attached to the fibular (lateral) collateral ligament. A **torn meniscus** may result in a "clicking" sound during extension of the leg; if the damage is more severe, the torn piece of cartilage may move between the articulating surfaces of the tibia and femur, causing the knee to "lock" in a partially flexed position.

In severe medial knee injuries, the anterior cruciate ligament is also damaged (see figure E). Tearing of the tibial (medial) collateral ligament, medial meniscus, and anterior cruciate ligament is often referred to as "the unhappy triad of injuries."

If the knee is driven anteriorly or if the knee is hyperextended, the anterior cruciate ligament may be torn, which causes the knee joint to be very unstable. If the knee is flexed and the tibia is driven posteriorly, the posterior cruciate ligament may be torn. Surgical replacement of a cruciate ligament with a transplanted or an artificial ligament repairs the damage.

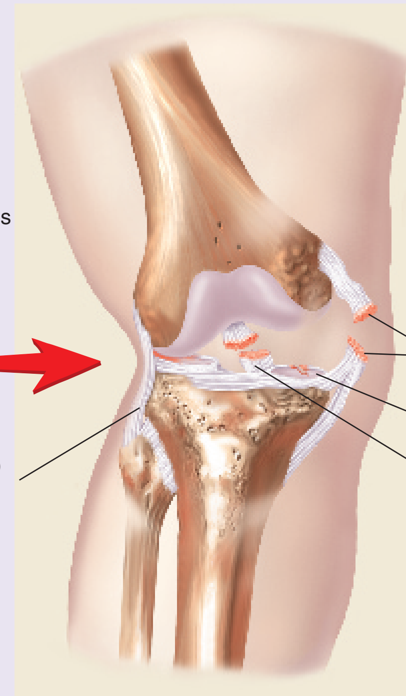


Figure E **Injury to the Right Knee**

Bursitis in the subcutaneous prepatellar bursa (see figure 7.49*b*), commonly called "housemaid's knee," may result from prolonged work performed while on the hands and knees. Another bursitis, "clergyman's knee," results from excessive kneeling and affects the subcutaneous infrapatellar bursa. This type of bursitis is common among carpet layers and roofers.

Other common knee problems are **chondromalacia** (kon′drō-mă-lā′shē-ă), or softening of the cartilage, which results from abnormal movement of the patella within the patellar groove, and **fat pad syndrome,** which consists of an accumulation of fluid in the fat pad posterior to the patella. An acutely swollen knee appearing immediately after an injury is usually a sign of blood accumulation within the joint cavity and is called a **hemarthrosis** (hē′mar-thrō′sis, hem′ar-thrō′sis). A slower accumulation of fluid, "water on the knee," may be caused by bursitis.

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Elbow Problems

Olecranon bursitis is an inflammation of the olecranon bursa. This inflammation can be caused by excessive rubbing of the elbow against a hard surface and is sometimes referred to as **student's elbow.** The radial head can become subluxated (partially dislocated) from the annular ligament of the radius (see figure 7.39). This condition is called **nursemaid's elbow.** If a child is lifted by one hand, the action may subluxate the radial head.

Hip Joint

The **hip joint** is a ball-and-socket joint between the coxal bone and femur. The femoral head articulates with the relatively deep, concave acetabulum of the coxal bone (figure 7.48*d*). The hip joint is capable of a wide range of movement, including flexion, extension, abduction, adduction, rotation, and circumduction.

The acetabulum is deepened and strengthened by a lip of fibrocartilage called the **acetabular labrum.** An extremely strong joint capsule, reinforced by several ligaments, extends from the rim of the acetabulum to the neck of the femur. The **ligament of the head**

of the femur (round ligament of the femur) is located inside the hip joint between the femoral head and the acetabulum. This ligament does not contribute much toward strengthening the hip joint; however, it does carry a small nutrient artery to the head of the femur in about 80% of the population. The acetabular labrum, ligaments of the hip, and surrounding muscles make the hip joint much more stable but less mobile than the shoulder joint.

Hip Dislocation

Dislocation of the hip may occur when the hip is flexed and the femur is driven posteriorly, such as when a person sitting in an automobile is involved in an accident. The head of the femur usually dislocates posterior to the acetabulum, tearing the acetabular labrum, the fibrous capsule, and the ligaments. Fracture of the femur and the coxal bone often accompanies hip dislocation.

Knee Joint

At the knee, the femur joins the tibia and the patella and the fibula joins the tibia (figure 7.49). The patella is located within the tendon of the quadriceps femoris muscle. The **knee joint** is a modified hinge joint between the femur and the tibia that allows flexion, extension, and a small amount of rotation of the leg. The distal end of the femur has two large, rounded condyles with a deep intercondylar fossa between them (see figure 7.33*b*). The femur articulates with the proximal condyles of the tibia, which are flattened, with a crest called the intercondylar eminence between them (see figure 7.36). The **lateral** and **medial menisci** build up the margins of the tibial condyles and deepen their articular surfaces (see figure 7.49*b–d*).

Two ligaments extend between the tibia and the intercondylar fossa of the femur. The **anterior cruciate** (kroo′shē-āt, crossed) **ligament** attaches to the tibia anterior to the intercondylar eminence (see figure 7.49*c*) and prevents anterior displacement of the tibia relative to the femur. The **posterior cruciate ligament** attaches to the tibia posterior to the intercondylar eminence (see figure 7.49*d*) and prevents posterior displacement of the tibia. The **fibular (lateral) collateral ligament** and the **tibial (medial) collateral ligament** strengthen the sides of the knee joint and prevent the femur from tipping side to side on the tibia. Other ligaments and the tendons of the thigh muscles, which extend around the knee, also provide stability.

A number of bursae surround the knee (see figure 7.49*b*). The largest is the **suprapatellar bursa,** which is a superior extension of the joint capsule that allows for movement of the anterior thigh muscles over the distal end of the femur. Other knee bursae include the **subcutaneous prepatellar bursa** and the **deep infrapatellar bursa.**

Ankle Joint and Arches of the Foot

The distal tibia and fibula form a highly modified hinge joint with the talus called the **ankle joint,** or **talocrural** (tā′lō-kroo′răl) **joint.** The medial and lateral malleoli of the tibia and fibula, which form the medial and lateral margins of the ankle, are rather extensive, whereas the anterior and posterior margins are almost nonexistent (see figure 7.36). As a result, a hinge joint is created. Body weight is transmitted from the tibia to the talus (see figure 7.37*b*). Ligaments extending from the lateral and medial malleoli attach to the tarsal bones, stabilizing the joint (figure 7.50). Dorsiflexion, plantar flexion, and limited inversion and eversion can occur at the ankle joint.

The arches of the foot (see figure 7.37*b*) are supported by ligaments (see figure 7.50). These ligaments hold the bones of the arches in their proper relationship and provide ties across the arch somewhat like a bowstring. As weight is transferred through the arch system, some of the ligaments are stretched, giving the foot more flexibility and allowing it to adjust to uneven surfaces. When weight is removed from the foot, the ligaments recoil and restore the arches to their unstressed shape.

Ankle Injury and Arch Problems

The ankle is the most frequently injured major joint in the body. A **sprained ankle** results when the ligaments of the ankle are torn partially or completely. The most common ankle injuries result from forceful inversion of the foot and damage to the lateral ligaments (figure F). Eversion of the foot and medial ligament damage is rare and usually involves fracture of the malleoli (see figure F).

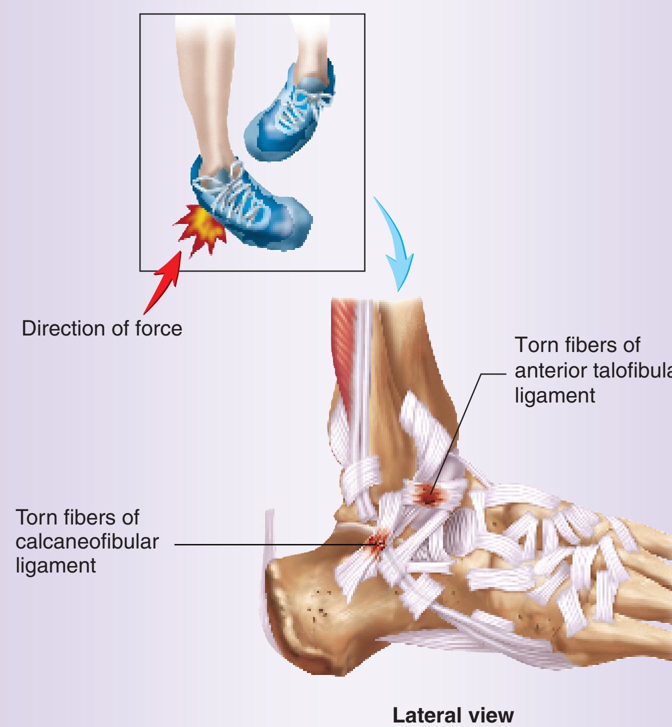
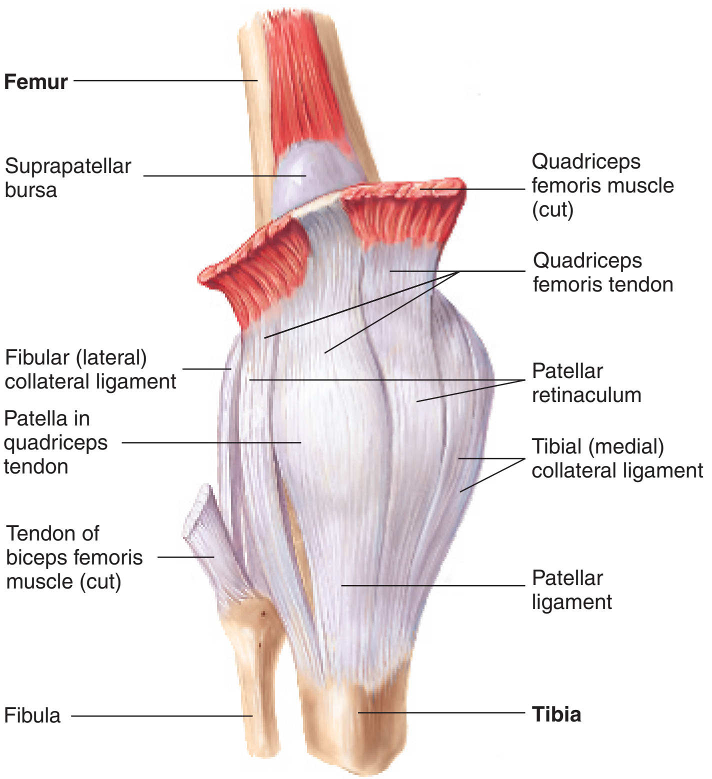
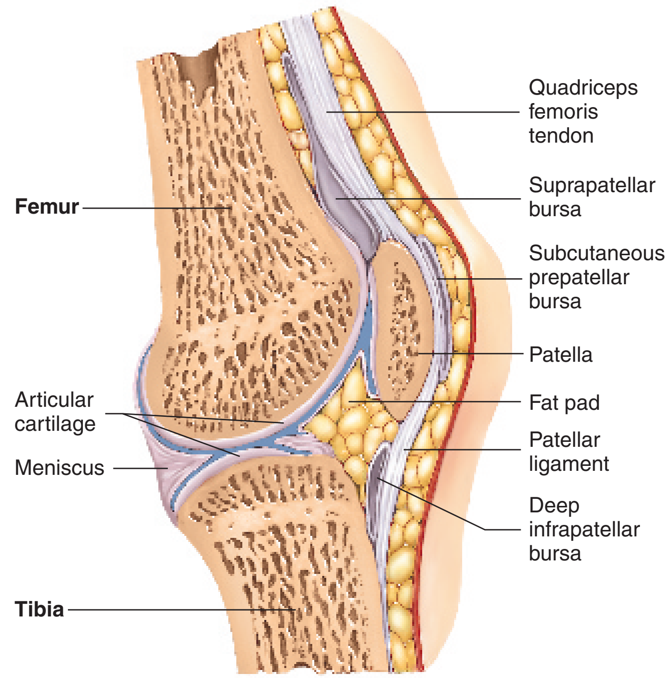


Figure F Injury to the Right Ankle

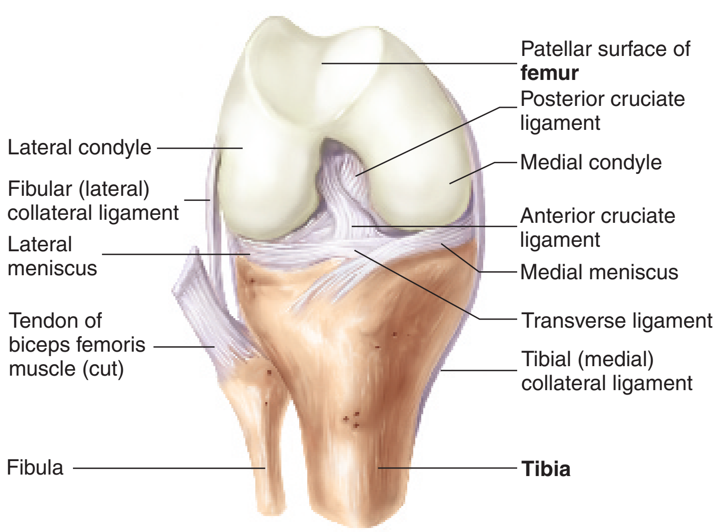
The arches of the foot normally form early in fetal life. Failure to form results in congenital **flat feet,** or fallen arches, a condition in which the arches, primarily the medial longitudinal arch (see figure 7.37), are depressed or collapsed. This condition is not always painful. Flat feet may also occur when the muscles and ligaments supporting the arch fatigue and allow the arch, usually the medial longitudinal arch, to collapse. During prolonged standing, the plantar calcaneonavicular ligament may stretch, flattening the medial longitudinal arch. The transverse arch may also become flattened. The strained ligaments can become painful.



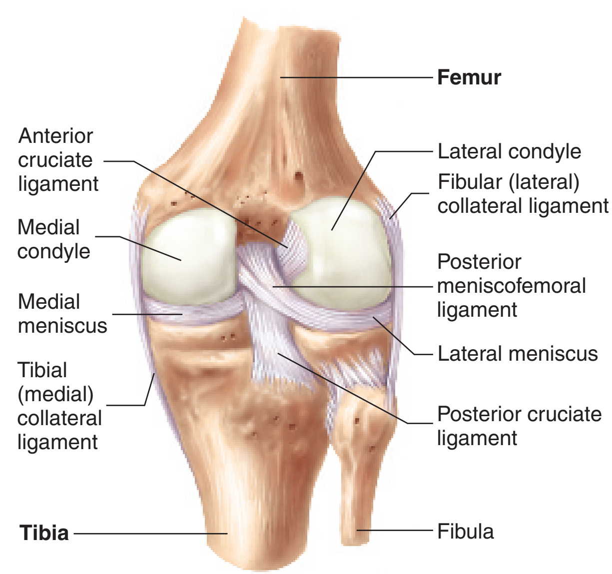
(a) **Anterior view**



(b) **Sagittal section**



(c) **Anterior view**



(d) **Posterior view**

Figure 7.49 Right Knee Joint AP|R

Clinical Relevance — Arthritis

Arthritis, an inflammation of any joint, is the most common and best known of the joint disorders, affecting 10% of the world's population and 14% of the U.S. population. There are over 37 million cases of arthritis in the United States alone. More than 100 types of arthritis exist. Classification is often based on the cause and progress of the arthritis. Its causes include infectious agents, metabolic disorders, trauma, and immune disorders. Mild exercise retards joint degeneration and enhances mobility. Swimming and walking are recommended for people with arthritis, but running, tennis, and aerobics are not recommended. Therapy depends on the type of arthritis but usually includes the use of anti-inflammatory drugs.

Osteoarthritis (OA), or **degenerative arthritis,** is the most common type of arthritis, affecting 10% of people in the United States (85% of those over age 70). OA may begin as a molecular abnormality in articular cartilage, with heredity and normal wear and tear of the joint important contributing factors. Slowed metabolic rates with increased age also seem to contribute to OA. Inflammation is usually secondary in this disorder. It tends to occur in the weight-bearing joints, such as the knees, and is more common in overweight individuals. OA is becoming more common in younger people as a result of increasing rates of childhood obesity.

Rheumatoid arthritis (RA) is the second most common type of arthritis. It affects about 3% of all women and about 1% of all men in the United States. It is a general connective tissue disorder that affects the skin, vessels, lungs, and other organs, but it is most pronounced in the joints. It is severely disabling and most commonly destroys small joints, such as those in the hands and feet. The initial cause is unknown but may involve a transient **infection** or an **autoimmune disease** (an immune reaction to one's own tissues) (see chapter 19) that develops against collagen. A genetic predisposition may also exist. Whatever the cause, the ultimate course appears to be immunologic. People with classic RA have a protein, **rheumatoid factor,** in their blood. In RA, the synovial fluid and associated connective tissue cells proliferate, forming a **pannus** (clothlike layer), which causes the joint capsule to become thickened and which destroys the articular cartilage. In advanced stages, opposing joint surfaces can become fused.

As a result of recent advancements in biomedical technology, many joints of the body can be replaced by artificial joints. Joint replacement, called **arthroplasty,** was first developed in the late 1950s. One of the major reasons for its use is to eliminate unbearable pain in patients near ages 55 to 60 with joint disorders. Osteoarthritis is the leading disease requiring joint replacement and accounts for two-thirds of the patients. Rheumatoid arthritis accounts for more than half of the remaining cases.

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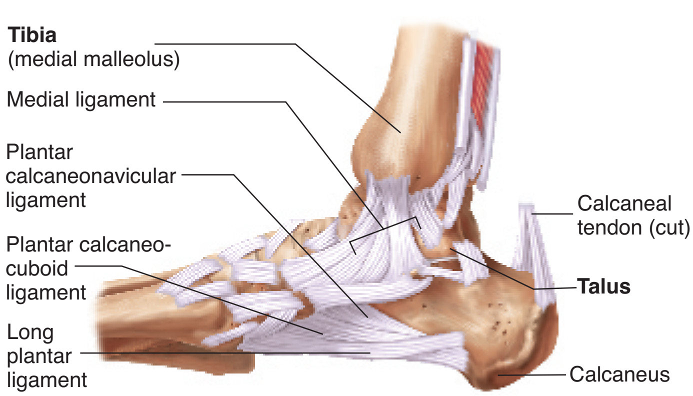

Figure 7.50 **Ligaments of the Right Ankle Joint** AP|R

64 For each of the following joints, name the bones of the joint, the specific part of the bones that form the joint, the type of joint, and the possible movement(s) at the joint: temporomandibular, shoulder, elbow, hip, knee, and ankle.

7.7 Effects of Aging on the Joints

A number of changes occur within many joints as a person ages. Those that occur in synovial joints have the greatest effect and often present major problems for elderly people. With use, the cartilage covering articular surfaces can wear down. When a person is young, production of new, resilient matrix compensates for the wear. As a person ages, the rate of replacement declines and the matrix becomes more rigid, thus adding to its rate of wear. The production rate of lubricating synovial fluid also declines with age, further contributing to the wear of the articular cartilage. Many people also experience arthritis, an inflammatory degeneration of joints, with advancing age. In addition, the ligaments and tendons surrounding a joint shorten and become less flexible with age, resulting in a decrease in the range of motion of the joint. Furthermore, older people often experience a general decrease in activity, which causes the joints to become less flexible and their range of motion to decrease.

65 What age-related factors contribute to cartilage wear in synovial joints? To loss of flexibility and loss of range of motion in synovial joints?

Summary

7.1 General Considerations of Bones (p. 150)

1. Bones are paired or unpaired.
2. Bones have processes, smooth surfaces, and holes that are associated with ligaments, muscles, joints, nerves, and blood vessels.

7.2 Axial Skeleton (p. 150)

The axial skeleton consists of the skull, hyoid bone, vertebral column, and thoracic cage.

Skull

1. The skull is composed of 22 bones.
   - The braincase protects the brain.
   - The facial bones protect the sensory organs of the head and are muscle attachment sites (mastication, facial expression, and eye muscles).
   - The mandible and maxillae hold the teeth, and the auditory ossicles, which function in hearing, are located inside the temporal bones.
2. The parietal bones are joined at the midline by the sagittal suture; they are joined to the frontal bone by the coronal suture, to the occipital bone by the lambdoid suture, and to the temporal bone by the squamous suture.
3. The external occipital protuberance is an attachment site for an elastic ligament. Nuchal lines are the points of attachment for neck muscles.
4. Several skull features are seen from a lateral view.
   - The external acoustic meatus transmits sound waves toward the eardrum.
   - Neck muscles attach to the mastoid process, which contains mastoid air cells.
   - The temporal lines are attachment points of the temporalis muscle.
   - The zygomatic arch, from the temporal and zygomatic bones, forms a bridge across the side of the skull.
   - The mandible articulates with the temporal bone.
5. Several skull features are seen from an anterior view.
   - The orbits contain the eyes.
   - The nasal cavity is divided by the nasal septum.
   - Sinuses within bone are air-filled cavities. The paranasal sinuses, which connect to the nasal cavity, are the frontal, sphenoidal, maxillary, and ethmoidal sinuses.
6. Several features are on the inferior surface of the skull.
   - The spinal cord and brain are connected through the foramen magnum.
   - Occipital condyles are points of articulation between the skull and the vertebral column.
   - Blood reaches the brain through the internal carotid arteries, which pass through the carotid canals, and the vertebral arteries, which pass through the foramen magnum.
   - Most blood leaves the brain through the internal jugular veins, which exit through the jugular foramina.
   - Styloid processes provide attachment points for three muscles involved in movement of the tongue, hyoid bone, and pharynx.
   - The hard palate separates the oral cavity from the nasal cavity.
7. Several skull features are inside the cranial cavity.
   - The crista galli is a point of attachment for one of the meninges.
   - The olfactory nerves extend into the roof of the nasal cavity through the olfactory foramina of the cribriform plate.
   - The sella turcica is occupied by the pituitary gland.

Hyoid Bone

The hyoid bone, which “floats” in the neck, is the attachment site for throat and tongue muscles.

Vertebral Column

1. The vertebral column provides flexible support and protects the spinal cord.
2. The vertebral column has four major curvatures: cervical, thoracic, lumbar, and sacral/coccygeal. Abnormal curvatures are lordosis (lumbar), kyphosis (thoracic), and scoliosis (lateral).
3. A typical vertebra consists of a body, a vertebral arch, and various processes.
   - Part of the body and the vertebral arch (pedicle and lamina) form the vertebral foramen, which contains and protects the spinal cord.
   - The transverse and spinous processes are points of muscle and ligament attachment.
   - Vertebrae articulate with one another through the superior and inferior articular processes.
   - Spinal nerves exit through the intervertebral foramina.
4. Adjacent bodies are separated by intervertebral disks. The disk has a fibrous outer covering (annulus fibrosus) surrounding a gelatinous interior (nucleus pulposus).
5. Several types of vertebrae can be distinguished.
   - All seven cervical vertebrae have transverse foramina, and most have bifid spinous processes.
   - The 12 thoracic vertebrae have attachment sites for ribs and are characterized by long, downward-pointing spinous processes.
   - The five lumbar vertebrae have thick, heavy bodies and processes. Their superior articular facets face medially and their inferior articular facets face laterally.
   - The sacrum consists of five fused vertebrae and attaches to the coxal bones to form the pelvis.
   - The coccyx consists of four fused vertebrae attached to the sacrum.

Thoracic Cage

1. The thoracic cage (consisting of the ribs, their associated costal cartilages, and the sternum) protects the thoracic organs and changes volume during respiration.
2. Twelve pairs of ribs attach to the thoracic vertebrae. They are divided into seven pairs of true ribs and five pairs of false ribs. Two pairs of false ribs are floating ribs.
3. The sternum is composed of the manubrium, the body, and the xiphoid process.

7.3 Appendicular Skeleton (p. 167)

The appendicular skeleton consists of the upper and lower limbs and the girdles that attach the limbs to the body.

Pectoral Girdle

1. The pectoral girdle consists of the scapulae and clavicles.
2. The scapula articulates with the humerus (at the glenoid cavity) and the clavicle (at the acromion). It is an attachment site for shoulder, back, and arm muscles.
3. The clavicle holds the shoulder away from the body and allows movement of the scapula, resulting in free movement of the arm.

Upper Limb

1. The arm bone is the humerus.
   - The humerus articulates with the scapula (head), the radius (capitulum), and the ulna (trochlea).
   - Sites of muscle attachment are the greater and lesser tubercles, the deltoid tuberosity, and the epicondyles.
2. The forearm contains the ulna and radius.
   - The ulna and radius articulate with each other and with the humerus and wrist bones.
   - The wrist ligaments attach to the styloid processes of the radius and ulna.
3. Eight carpal, or wrist, bones are arranged in two rows.
4. The hand consists of five metacarpal bones.
5. The phalanges are bones of the digits. Each finger has three phalanges, and the thumb has two phalanges.

Pelvic Girdle

1. The lower limb is attached solidly to the coxal bone and functions in support and movement.
2. The pelvic girdle consists of the right and left coxal bones and sacrum. Each coxal bone is formed by the fusion of the ilium, the ischium, and the pubis.
   - The coxal bones articulate with each other (symphysis pubis) and with the sacrum (sacroiliac joint) and the femur (acetabulum).
   - Muscles attach to the anterior iliac spines and the ischial tuberosity; ligaments attach to the posterior iliac spines, ischial spine, and ischial tuberosity.
   - The female pelvis has a larger pelvic inlet and outlet than the male pelvis.

Lower Limb

1. The thigh bone is the femur.
   - The femur articulates with the coxal bone (head), the tibia (medial and lateral condyles), and the patella (patellar groove).
   - Sites of muscle attachment are the greater and lesser trochanters, as well as the adductor tubercle.
   - Sites of ligament attachment are the lateral and medial epicondyles.
2. The leg consists of the tibia and the fibula.
   - The tibia articulates with the femur, the fibula, and the talus. The fibula articulates with the tibia and the talus.
   - Tendons from the thigh muscles attach to the tibial tuberosity.
3. Seven tarsal bones form the proximal portion of the foot and five metatarsal bones form the distal portion.
4. The toes have three phalanges each, except for the big toe, which has two.
5. The bony arches transfer weight from the heels to the toes and allow the foot to conform to many different positions.

7.4 Joints (p. 177)

1. A joint, or articulation, is a place where two bones come together.
2. Joints are named according to the bones or parts of bones involved.
3. Joints are classified according to function or type of connective tissue that binds them together and whether fluid is present between the bones.

Fibrous Joints

1. Fibrous joints are those in which bones are connected by fibrous tissue with no joint cavity. They are capable of little or no movement.
2. Sutures have interlocking fingerlike processes held together by dense fibrous connective tissue. They occur between most skull bones.
3. Syndesmoses are joints consisting of fibrous ligaments.
4. Gomphoses are joints in which pegs fit into sockets and are held in place by periodontal ligaments (teeth in the jaws).
5. Some sutures and other joints can become ossified (synostosis).

Cartilaginous Joints

1. Synchondroses are joints in which bones are joined by hyaline cartilage. Epiphyseal plates are examples.
2. Symphyses are slightly movable joints made of fibrocartilage.

Synovial Joints

1. Synovial joints are capable of considerable movement. They consist of the following:
   - Articular cartilage on the ends of bones provides a smooth surface for articulation. Articular disks and menisci can provide additional support.
   - A joint cavity is surrounded by a joint capsule of fibrous connective tissue, which holds the bones together while permitting flexibility, and a synovial membrane produces synovial fluid that lubricates the joint.
2. Bursae are extensions of synovial joints that protect skin, tendons, or bone from structures that could rub against them.

Types of Synovial Joints

Synovial joints are classified according to the shape of the adjoining articular surfaces: plane (two flat surfaces), pivot (cylindrical projection inside a ring), hinge (concave and convex surfaces), ball-and-socket (projection shaped like a baseball into a concave surface), ellipsoid (projection shaped like a football into a concave surface), and saddle (two saddle-shaped surfaces).

7.5 Types of Movement (p. 183)

Gliding Movements

Gliding movements occur when two flat surfaces glide over one another.

Angular Movements

Angular movements include flexion and extension, plantar and dorsiflexion, and abduction and adduction.

Circular Movements

Circular movements include rotation, pronation and supination, and circumduction.

Special Movements

Special movements include elevation, depression, protraction, retraction, excursion, opposition, reposition, inversion and eversion.

Combination Movements

Combination movements involve two or more other movements.

7.6 Description of Selected Joints (p. 186)

Temporomandibular Joint

1. The temporomandibular joint is a modified ellipsoid joint between the temporal and mandibular bones.
2. The temporomandibular joint is capable of elevation, depression, protraction, retraction, and lateral and medial excursion movements.

Shoulder Joint

1. The shoulder joint is a ball-and-socket joint between the head of the humerus and the glenoid cavity of the scapula. It is strengthened by ligaments and the muscles of the rotator cuff. The tendon of the biceps brachii passes through the joint capsule.
2. The shoulder joint is capable of flexion, extension, abduction, adduction, rotation, and circumduction.

Elbow Joint

1. The elbow joint is a compound hinge joint between the humerus, ulna, and radius.
2. Movement at this joint is limited to flexion and extension.

Hip Joint

1. The hip joint is a ball-and-socket joint between the head of the femur and the acetabulum of the coxal bone.
2. The hip joint is capable of flexion, extension, abduction, adduction, rotation, and circumduction.

Knee Joint

1. The knee joint is a modified hinge joint between the femur and the tibia that is supported by many ligaments.
2. The joint allows flexion, extension, and slight rotation of the leg.

Ankle Joint and Arches of the Foot

1. The ankle joint is a modified hinge joint of the tibia, fibula, and talus that allows dorsiflexion, plantar flexion, inversion, and eversion of the foot.
2. Ligaments of the foot arches hold the bones in an arch and transfer weight in the foot.

7.7 Effects of Aging on the Joints (p. 191)

With age, the connective tissue of the joints becomes less flexible and less elastic. The resulting joint rigidity increases the rate of wear in the articulating surfaces. The change in connective tissue also reduces the range of motion.

Review and Comprehension

7.1 General Considerations of Bones (p. 150)

1. Which of the following statements is true?
   a. Unpaired bones are located on either the right or left side of the body.
   b. A condyle is a smooth, rounded end of a bone, covered by articular cartilage.
   c. A tubercle is a hole through which a blood vessel or nerve extends.
   d. A foramen is a small bump to which a ligament or tendon attaches.
   e. A sinus is a general term for a depression.

7.2 Axial Skeleton (p. 150)

2. The superior and middle nasal conchae are formed by projections of the
   a. sphenoid bone.
   b. vomer bone.
   c. palatine process of the maxillae.
   d. palatine bone.
   e. ethmoid bone.
3. The perpendicular plate of the ethmoid and the ______________ form the nasal septum.
   a. palatine process of the maxilla
   b. horizontal plate of the palatine
   c. vomer
   d. nasal bone
   e. lacrimal bone
4. Which of these bones does *not* contain a paranasal sinus?
   a. ethmoid
   b. sphenoid
   c. frontal
   d. temporal
   e. maxilla
5. The mandible articulates with the skull at the
   a. styloid process.
   b. occipital condyle.
   c. mandibular fossa.
   d. zygomatic arch.
   e. medial pterygoid.
6. The nerves for the sense of smell pass through the
   a. cribriform plate.
   b. nasolacrimal canal.
   c. internal acoustic meatus.
   d. optic canal.
   e. orbital fissure.
7. The major blood supply to the brain enters through the
   a. foramen magnum.
   b. carotid canals.
   c. jugular foramina.
   d. both a and b.
   e. all of the above.
8. A herniated disk occurs when
   a. the annulus fibrosus ruptures.
   b. the intervertebral disk slips out of place.
   c. the spinal cord ruptures.
   d. too much fluid builds up in the nucleus pulposus.
   e. all of the above.
9. The weight-bearing portion of a vertebra is the
   a. vertebral arch.
   b. articular process.
   c. body.
   d. transverse process.
   e. spinous process.
10. Transverse foramina are found only in
    a. cervical vertebrae.
    b. thoracic vertebrae.
    c. lumbar vertebrae.
    d. the sacrum.
    e. the coccyx.
11. Articular facets on the bodies and transverse processes are found only on
    a. cervical vertebrae.
    b. thoracic vertebrae.
    c. lumbar vertebrae.
    d. the sacrum.
    e. the coccyx.
12. Which of these statements concerning ribs is true?
    a. The true ribs attach directly to the sternum with costal cartilage.
    b. There are five pairs of floating ribs.
    c. The head of the rib attaches to the transverse process of the vertebra.
    d. Floating ribs do not attach to vertebrae.

7.3 Appendicular Skeleton (p. 167)

13. The point where the scapula and clavicle connect is the
    a. coracoid process.
    b. styloid process.
    c. glenoid cavity.
    d. acromion.
    e. capitulum.
14. The distal medial process of the humerus to which the ulna joins is the
    a. epicondyle.
    b. deltoid tuberosity.
    c. malleolus.
    d. capitulum.
    e. trochlea.
15. The bone/bones of the foot on which the tibia rests is (are) the
    a. talus.
    b. calcaneus.
    c. metatarsal bones.
    d. navicular.
    e. phalanges.
16. The projection on the coxal bone of the pelvic girdle that is used as a landmark for finding an injection site is the
    a. ischial tuberosity.
    b. iliac crest.
    c. anterior superior iliac spine.
    d. posterior inferior iliac spine.
    e. ischial spine.
17. When comparing the pectoral girdle with the pelvic girdle, which of these statements is true?
    a. The pectoral girdle has greater mass than the pelvic girdle.
    b. The pelvic girdle is more firmly attached to the body than the pectoral girdle.
    c. The pectoral girdle has the limbs more securely attached than the pelvic girdle.
    d. The pelvic girdle allows greater mobility than the pectoral girdle.

18. When comparing a male pelvis with a female pelvis, which of these statements is true?
    a. The pelvic inlet in males is larger and more circular.
    b. The subpubic angle in females is less than 90 degrees.
    c. The ischial spines in males are closer together.
    d. The sacrum in males is broader and less curved.
19. A site of muscle attachment on the proximal end of the femur is the
    a. greater trochanter. c. greater tubercle. e. condyle.
    b. epicondyle. d. intercondylar eminence.
20. The process that forms the large lateral bump in the ankle is the lateral
    a. malleolus. c. epicondyle. e. tubercle.
    b. condyle. d. tuberosity.

7.4 Joints (p. 177)

21. Given these types of joints:
    1. gomphosis 3. symphysis 5. syndesmosis
    2. suture 4. synchondrosis

    Which types are classified as fibrous joints?
    a. 1,2,3 b. 1,2,5 c. 2,3,5 d. 3,4,5 e. 1,2,3,4,5
22. Which of these joints is *not* matched with the correct joint type?
    a. parietal bone to occipital bone—suture
    b. between the coxal bones—symphysis
    c. humerus and scapula—synovial
    d. shafts of the radius and ulna—synchondrosis
    e. teeth in alveolar process—gomphosis
23. In which of these joints are periodontal ligaments found?
    a. sutures c. symphyses e. gomphoses
    b. syndesmoses d. synovial
24. The intervertebral disks are an example of
    a. sutures. c. symphyses. e. gomphoses.
    b. syndesmoses. d. synovial joints.
25. Joints containing hyaline cartilage are called ______________, and joints containing fibrocartilage are called ______________.
    a. sutures, synchondroses d. synchondroses, symphyses
    b. syndesmoses, symphyses e. gomphoses, synchondroses
    c. symphyses, syndesmoses
26. The inability to produce the fluid that keeps most joints moist would likely be caused by a disorder of the
    a. cruciate ligaments. c. articular cartilage. e. tendon sheath.
    b. synovial membrane. d. bursae.
27. Which of these is *not* associated with synovial joints?
    a. perichondrium on the surface of articular cartilage
    b. fibrous capsule d. synovial fluid
    c. synovial membrane e. bursae
28. Assume that a sharp object penetrated a synovial joint. From this list of structures:
    1. tendon or muscle 4. fibrous capsule (of joint capsule)
    2. ligament 5. skin
    3. articular cartilage 6. synovial membrane (of joint capsule)

    Choose the order in which they would most likely be penetrated.
    a. 5,1,2,6,4,3 c. 5,1,2,6,3,4 e. 5,1,2,4,6,3
    b. 5,2,1,4,3,6 d. 5,1,2,4,3,6
29. Which of these do hinge joints and saddle joints have in common?
    a. Both are synovial joints.
    b. Both have concave surfaces that articulate with a convex surface.
    c. Both are uniaxial joints.
    d. Both a and b are correct.
    e. All of the above are correct.
30. Which of these joints is correctly matched with the type of joint?
    a. atlas to occipital condyle—pivot
    b. tarsal bones to metatarsal bones—saddle
    c. femur to coxal bone—ellipsoid
    d. tibia to talus—hinge
    e. scapula to humerus—plane

7.5 Types of Movement (p. 183)

31. Once a doorknob is grasped, what movement of the forearm is necessary to unlatch the door—that is, turn the knob in a clockwise direction? (Assume using the right hand.)
    a. pronation c. supination e. extension
    b. rotation d. flexion
32. After the door is unlatched, what movement of the elbow is necessary to open it? (Assume the door opens in, and you are on the inside.)
    a. pronation c. supination e. extension
    b. rotation d. flexion
33. After the door is unlatched, what movement of the shoulder is necessary to open it? (Assume the door opens in, and you are on the inside.)
    a. pronation c. supination e. extension
    b. rotation d. flexion
34. When grasping a doorknob, the thumb and little finger undergo
    a. opposition. c. lateral excursion. e. dorsiflexion.
    b. reposition. d. medial excursion.
35. A runner notices that the lateral side of her right shoe is wearing much more than the lateral side of her left shoe. This could mean that her right foot undergoes more ______________ than her left foot.
    a. eversion c. plantar flexion e. lateral excursion
    b. inversion d. dorsiflexion
36. For a ballet dancer to stand on her toes, her feet must
    a. evert. c. plantar flex. e. abduct.
    b. invert. d. dorsiflex.

7.6 Description of Selected Joints (p. 186)

37. A meniscus is found in the
    a. shoulder joint. c. hip joint. e. ankle joint.
    b. elbow joint. d. knee joint.
38. A lip (labrum) of fibrocartilage deepens the joint cavity of the
    a. temporomandibular joint. c. elbow joint. e. ankle joint.
    b. shoulder joint. d. knee joint.
39. Which of these structures helps stabilize the shoulder joint?
    a. rotator cuff muscles d. articular disk
    b. cruciate ligaments e. all of the above
    c. medial and lateral collateral ligaments

7.7 Effects of Aging on the Joints (p. 191)

40. With age,
    a. articular cartilage wears down.
    b. articular cartilage matrix becomes more rigid.
    c. the rate of production of synovial fluid decreases.
    d. inflammatory degeneration of joints can increase.
    e. all of the above

Answers in Appendix E

Critical Thinking

1. A patient has an infection in the nasal cavity. Name seven adjacent structures to which the infection could spread.
2. A patient is unconscious. Radiographic films reveal that the superior articular process of the atlas has been fractured. Which of the following could have produced this condition: falling on the top of the head or being hit in the jaw with an uppercut? Explain.
3. If the vertebral column is forcefully rotated, what part of the vertebra is most likely to be damaged? In what area of the vertebral column is such damage most likely?
4. An asymmetric weakness of the back muscles can produce which of the following: scoliosis, kyphosis, or lordosis? Which can result from pregnancy? Explain.
5. A decubitus ulcer is a chronic ulcer that appears in pressure areas of skin overlying a bony prominence in bedridden or otherwise immobilized patients. Where are likely sites for decubitus ulcers to occur?
6. What might be the consequences of a broken forearm involving both the ulna and the radius when the ulna and radius fuse to each other during repair of the fracture?
7. Suppose you need to compare the length of one lower limb with the length of the other in an individual. Using bony landmarks, suggest an easy way to accomplish the measurements.
8. Why are more women than men knock-kneed?
9. On the basis of bone structure of the lower limb, explain why it is easier to turn the foot medially (sole of the foot facing toward the midline of the body) than laterally. Why is it easier to cock the wrist medially than laterally?
10. Justin Time leaped from his hotel room to avoid burning to death in a fire. If he landed on his heels, what bone was likely fractured? Unfortunately for Justin, a 240-lb firefighter ran by and stepped heavily on the proximal part of Justin's foot (not the toes). What bones could have been broken?
11. For each of the following muscles, describe the motion(s) produced when the muscle contracts. It may be helpful to use an articulated skeleton.
    a. The biceps brachii muscle attaches to the coracoid process of the scapula (one head) and the radial tuberosity of the radius. Name two movements that the muscle accomplishes in the forearm.
    b. The rectus femoris muscle attaches to the anterior inferior iliac spine and the tibial tuberosity. How does contraction move the thigh? The leg?
    c. The supraspinatus muscle is located in and attached to the supraspinatus fossa of the scapula. Its tendon runs over the head of the humerus to the greater tubercle. When it contracts, what movement occurs at the glenohumeral (shoulder) joint?
    d. The gastrocnemius muscle attaches to the medial and lateral condyles of the femur and to the calcaneus. What movement of the leg results when this muscle contracts? Of the foot?
12. Crash McBang hurt his knee in an auto accident by ramming it into the dashboard. The doctor tested the knee for ligament damage by having Crash sit on the edge of a table with his knee flexed at a 90-degree angle. The doctor attempted to pull the tibia in an anterior direction (the anterior drawer test) and then tried to push the tibia in a posterior direction (the posterior drawer test). No unusual movement of the tibia occurred in the anterior drawer test but movement did occur during the posterior drawer test. Explain the purpose of each test, and tell Crash which ligament he has damaged.

Answers in Appendix F

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