CHAPTER 6
Anatomy and Physiology

- **Lesson Purpose**

  To give the student a proper introduction to human anatomy and physiology.

- **Lesson Objective**

  Upon completion the student will:

  - Learn the fundamental elements of the skeletal system; specifically the axial skeleton, appendicular skeleton, bones and articulations
  - Learn the basic components of the muscular system
  - Understand the basic structure and function of the nervous system
  - Learn the components of other major body systems, including:

    *Cardiovascular System
    *Endocrine System
    *Respiratory System
    *Urinary System
    *Lymphatic System
    *Integumentary System
    *Digestive System
    *Reproductive System

"I saw the angel in the marble and carved until I set him free."

–Michelangelo

Introduction to Anatomy and Physiology

The knowledge of anatomy and physiology is essential to understanding the human body. The human body, like other living things, has certain characteristics that separate it from non-living things. In this chapter you will learn the major systems of the body as well as the function and structure of these systems. The body's framework and capabilities depend on how it is constructed. **Anatomy** is the study of the body's structure. There are many subdivisions of anatomy. Gross anatomy concerns body structures seen without the use of the microscope. Histology is the study of cells, tissue, and organs as observed with a microscope. Developmental anatomy deals with the development of the individual from the fertilized egg to the adult form. **Physiology** is the study of the function and activities of the body.

At the simplest level, the human body is composed of atoms. Atoms are units of elements such as oxygen, carbon, nitrogen, and sodium. Molecules are atoms combined with one another. The most important molecules found in the human body include water, sodium chloride, proteins, carbohydrates and lipids.

The cell is the fundamental unit of living things. Among the different types of cells in the body are nerve cells, muscle cells, and blood cells; each with its own unique structure and function. The next level of cellular structure is the **tissue**. This group of cells works together and performs the same function. The four basic tissue types are: epithelial tissue (skin), connective tissue (blood and bone tissue), muscle tissue, and nerve tissue.

Next are the **organs.** An organ is made up of two or more different kinds of tissue and is specific to a particular function. A **system** is a collection of organs and structures sharing a common function. Organs and structures of a single system occupy diverse regions in the body and are not necessarily grouped together. The last of these important organizational structures are the organ systems. Organ systems in the body include the digestive, respiratory, nervous, and circulatory systems. Systems, all working together, form the organism, which is a sign of true body organization. In this chapter, you will study the body systems and the role they play in the human body.

The Skeletal System

The human body contains **206 bones**. Together they create an organized structure called **the skeletal system**. The bones' primary responsibility is to support the body and protect the organs. Bone is the hardest connective tissue in the human body. Various types of cells and minerals exist in bone that contribute to its hardness.

The skeletal system consists of bones and joints, or articulations. Joints are the areas where two or more bones come together to form articulations. The skeletal system is subdivided into two divisions, the axial skeleton and the appendicular skeleton. The **axial skeleton** includes bones that are around the body's center of gravity (See Figure 6.A). The **appendicular skeleton** includes the bones outside the center of gravity, including limbs (See Figure 6.B). The skeleton is constructed of two of the most supportive tissues found in the human body – cartilage and bone. Along with supporting and protecting the internal framework of the body, the skeleton provides a system of levers the skeletal muscles used to help the body move. The bones also have the important job of housing substances like lipids and calcium. Blood cell formation occurs within the bones red marrow cavities.

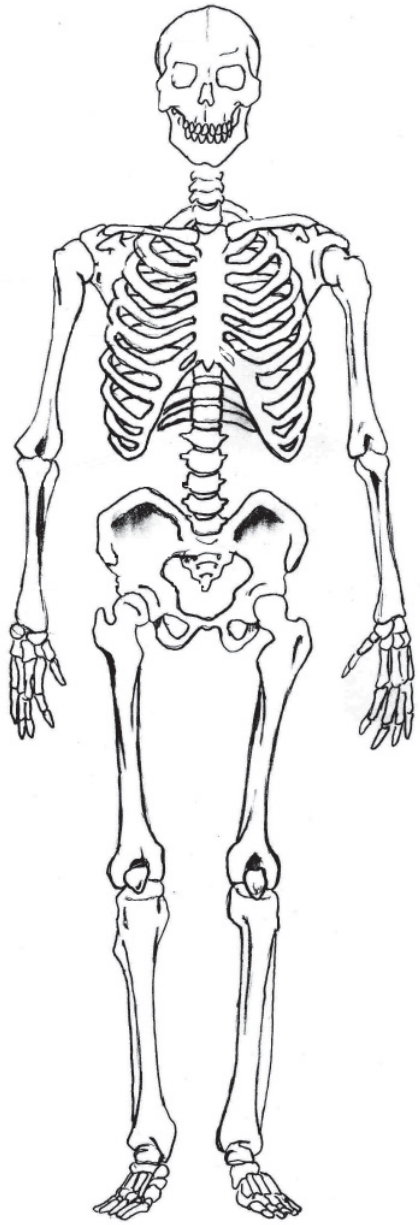


Figure 6.a: Axial Skeleton

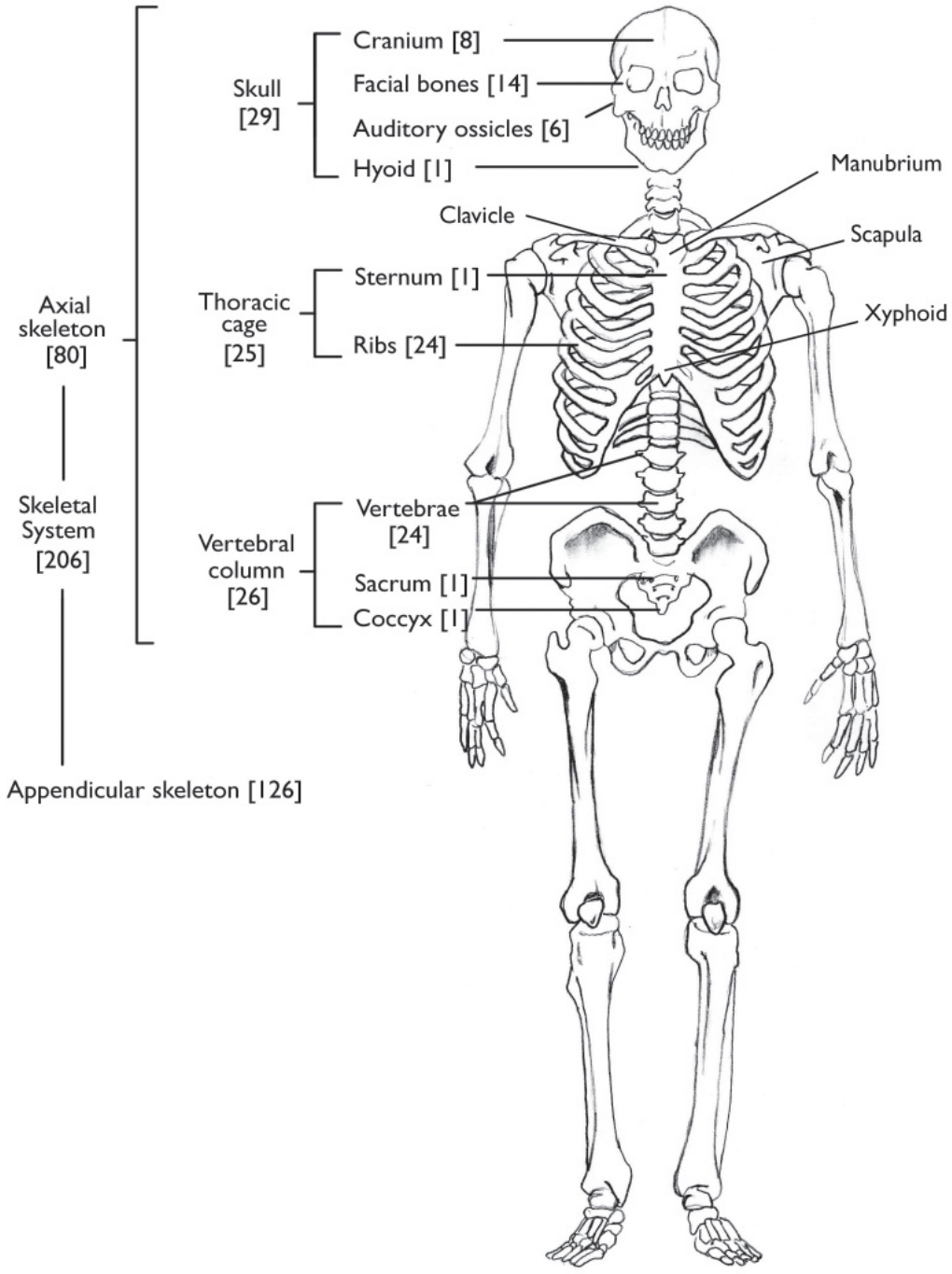
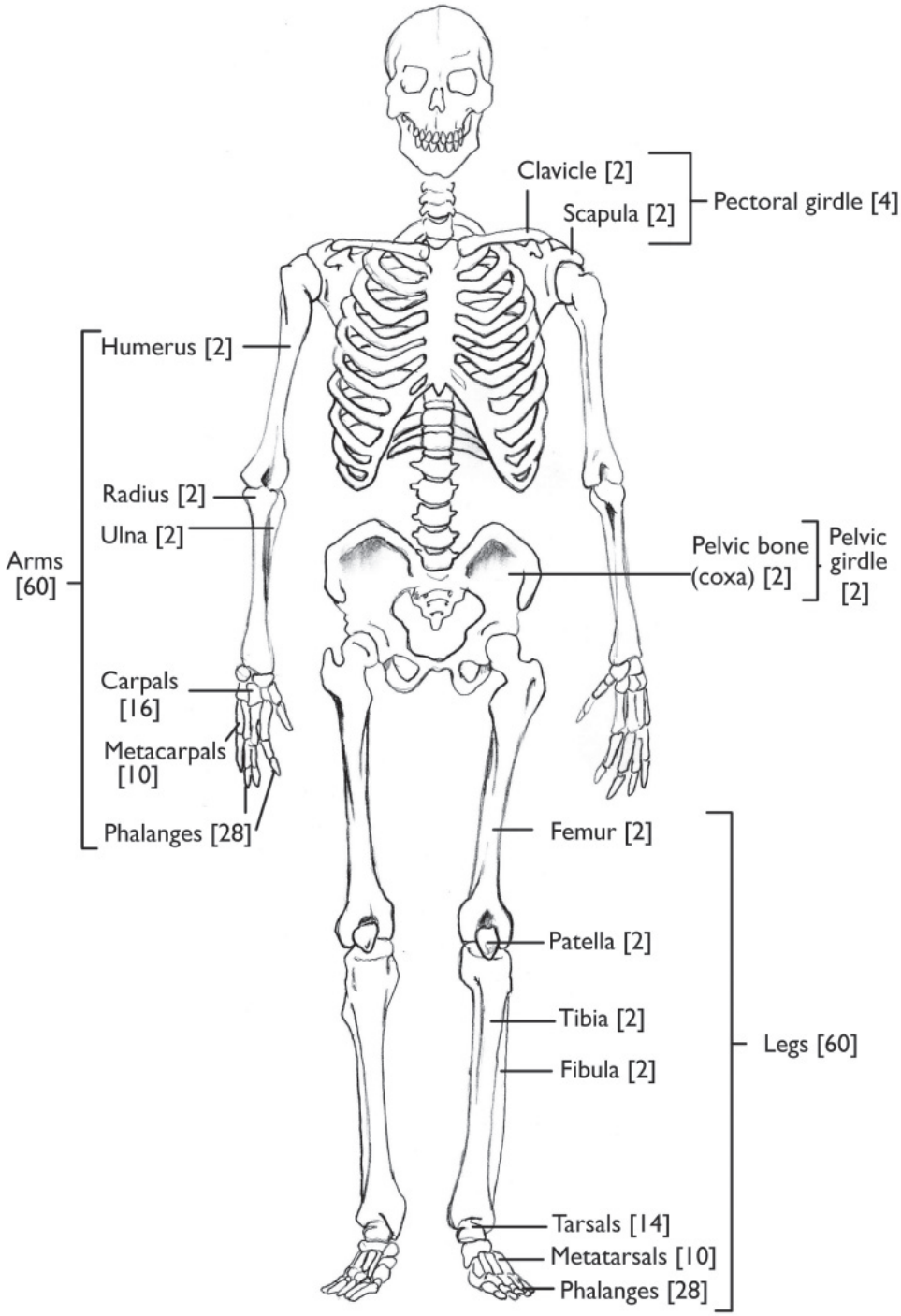


Figure 6.b: Appendicular Skeleton



Bone

Bone, although strong, is a constantly changing tissue that has several functions. Bones serve as rigid structures to the body and as shields to protect delicate internal organs. They provide housing for the bone marrow, where the blood cells are formed. Bones also maintain the body's reservoir of calcium. In children, some bones have areas called growth plates. Bones lengthen in these areas until the child reaches full height, at which time the growth plates close. Thereafter, bones grow in thickness rather than in length, based on the body's need for additional bone strength in certain areas.

Figure 6.c

Classifications of Bone

Bones have five primary shapes:

1) Long – such as thigh bones and arm bones
2) Short – such as carpal and tarsal bones, which are cube shaped
3) Flat – such as the plates in the skull.
4) Irregular – such as vertebrae
5) Sesamoid – such as the patella and those developed in tendons.

All bones have essentially the same structure. The hard outer part (cortical bone) consists largely of proteins, such as collagen, and a substance called hydroxyapatite, which is composed mainly of calcium and other minerals. **Hydroxyapatite** is largely responsible for the strength and density of bones. The inner part of bones (trabecular bone) is softer and less dense than the hard outer part. Bone marrow is the tissue that fills the spaces in the trabecular bone. Bone marrow contains specialized cells (including stem cells) that produce blood cells. Blood vessels supply blood to the bone, and nerves innervate the bone.

Axial Skeletal System

Eighty bones make up the axial skeleton; also known as the central axis, or trunk, of the human body. It is the principal supportive structure of the body. It includes the skull, vertebrae, sternum, ribs, and hyoid bone. Most of the mobility of the torso can be attributed to the joints within this system (See Figure 6.a).

Bones of the Skull

There are two major regions of the skull: the **cranium** and the **facial** region. Most bones of the cranium are flat and tightly fused to one another. The facial bones support several of the sensory organs of the head including the eyes, ears, and nose.

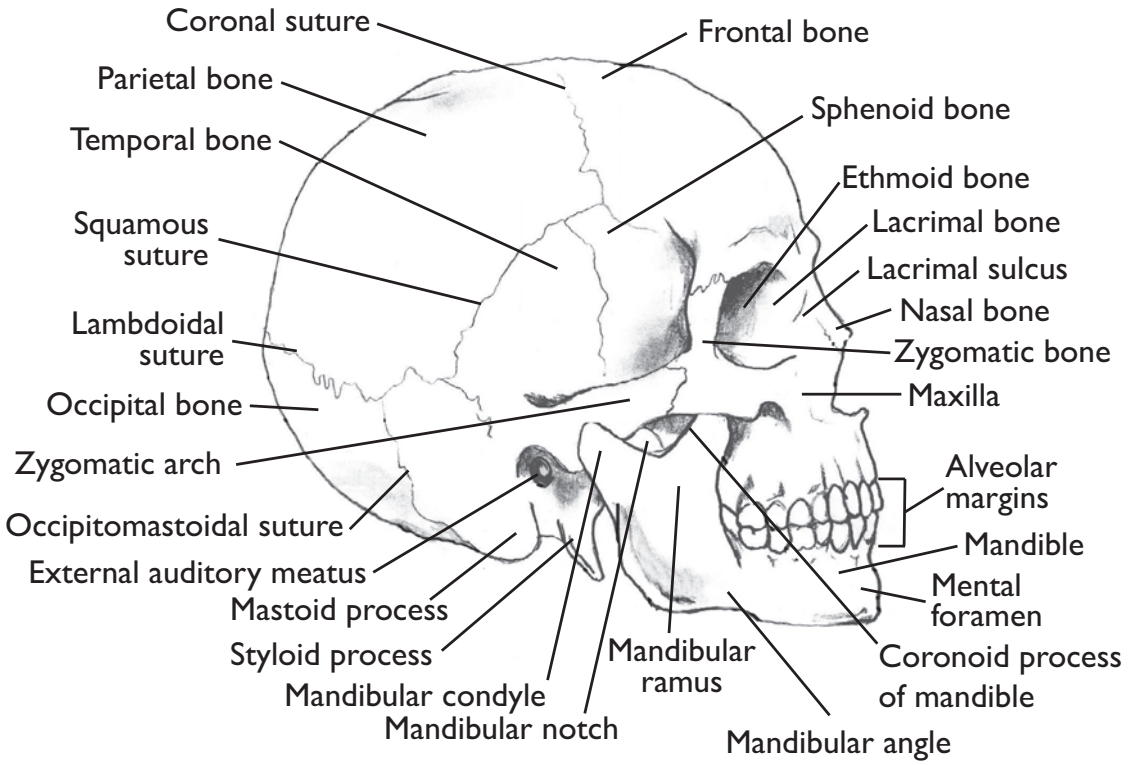
Cranium – The cranium consists of eight bones, which are fused together at rough immovable joints. The amount shown within the parentheses provides the number of parts to make up the bone listed.

Occipital (1)
Parietal (2)
Frontal (1)
Temporal (2)
Ethmoid (1)
Sphenoid (1)

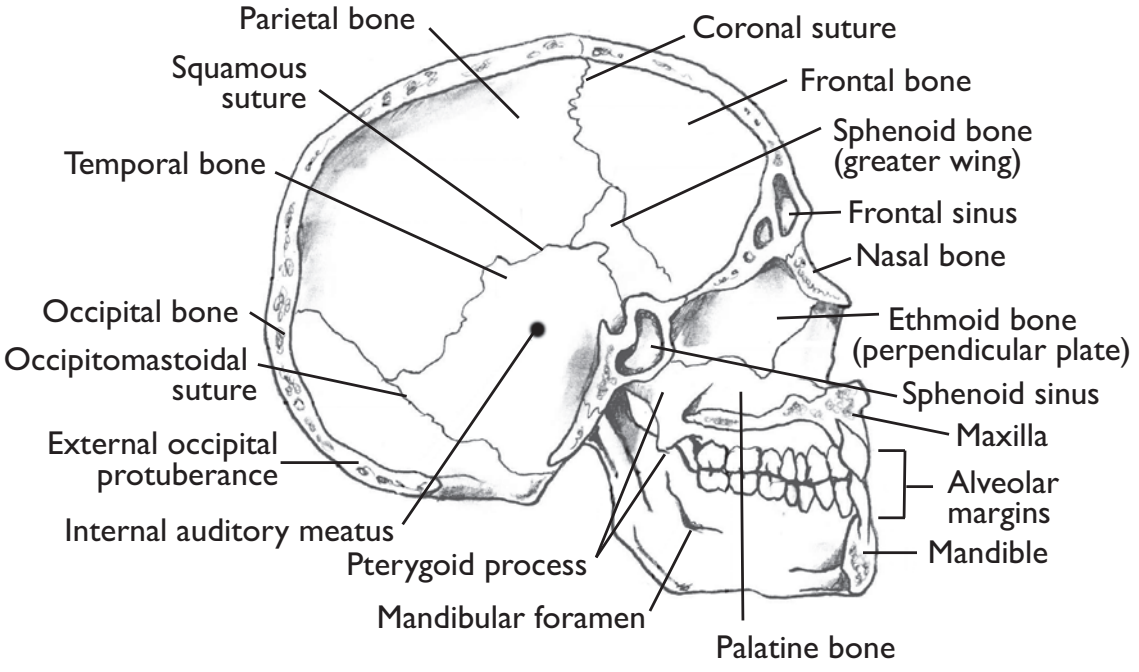
Facial Bones – The face is formed by 14 bones. These provide attachments for chewing muscles and support head and facial muscles.

Nasal (2)
Vomer (1)
Lacrimal (2)
Zygomatic (2)
Palatine (2)
Maxilla (2)
Mandible (1)
Inferior Nasal Concha (2)

Figure 6.d: Bones of the Skull (outer view)



Transection (inner) View



The Vertebral Column *(Spine)*

The vertebral column (also called spine or backbone) extends from the base of the skull and downwards. The 26 bones of the vertebral column form a flexible structure supporting the head, thorax, abdomen and upper extremities. A series of vertebral foramina (openings) form a canal for the spinal cord and nerves to pass through, providing protection and a safe passageway. The vertebrae include:

Cervical Spine (7)

The Cervical Spine has 7 vertebrae. This flexible group of spinal segments supports the skull and neck. Holding the head erect develops and maintains its curvature. Two cervical vertebrae are important to note. The first, the **atlas**, balances and supports the head. Its two processes called **facets** articulate with the occipital condyles of the skull. The second vertebra is the **axis**. The **odontoid** process of this bone projects upward into the ring of the atlas. The head rotates on this joint, which is responsible for the majority of neck rotation. These are the only named vertebrae. The 7th cervical vertebra is unique with its prominent spinous process. The foramina in the transverse processes of C1-C6 transmit the vertebral arteries to the base of the brain (See Figure 6.e).

Figure 6.e: Cervical vertebrae

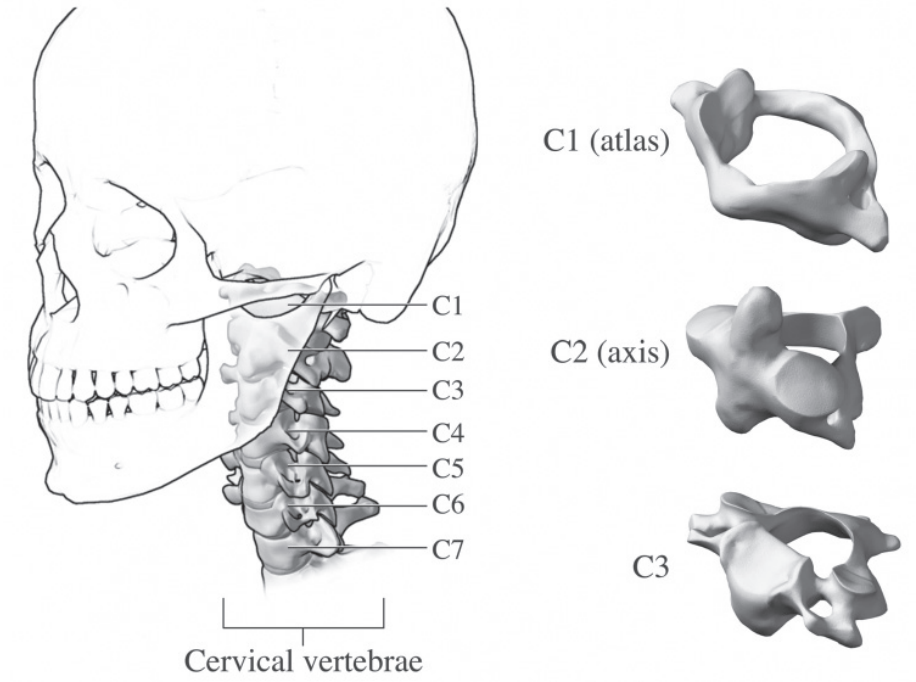


Figure 6.f: Spinal Column

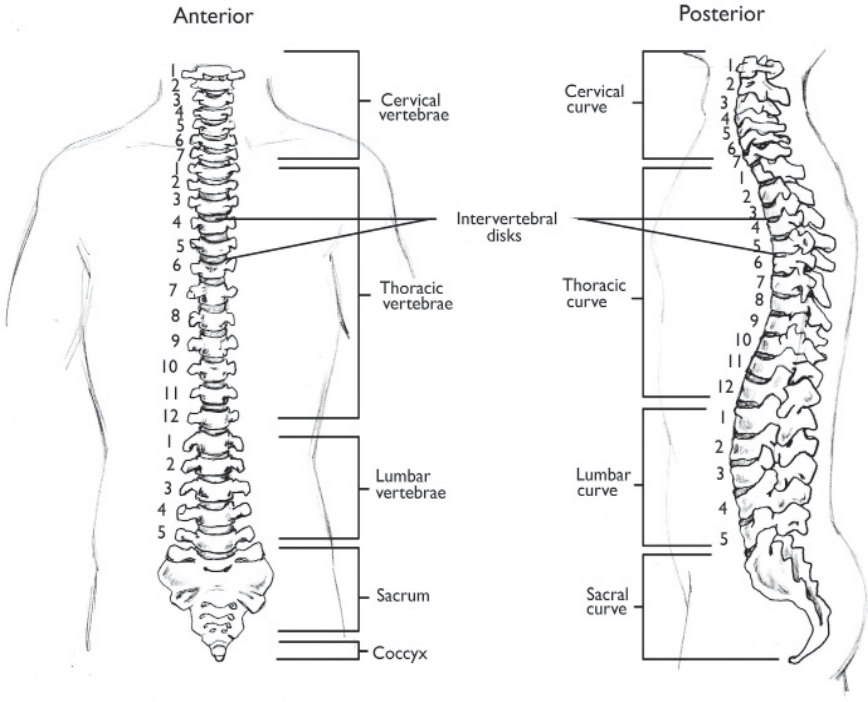
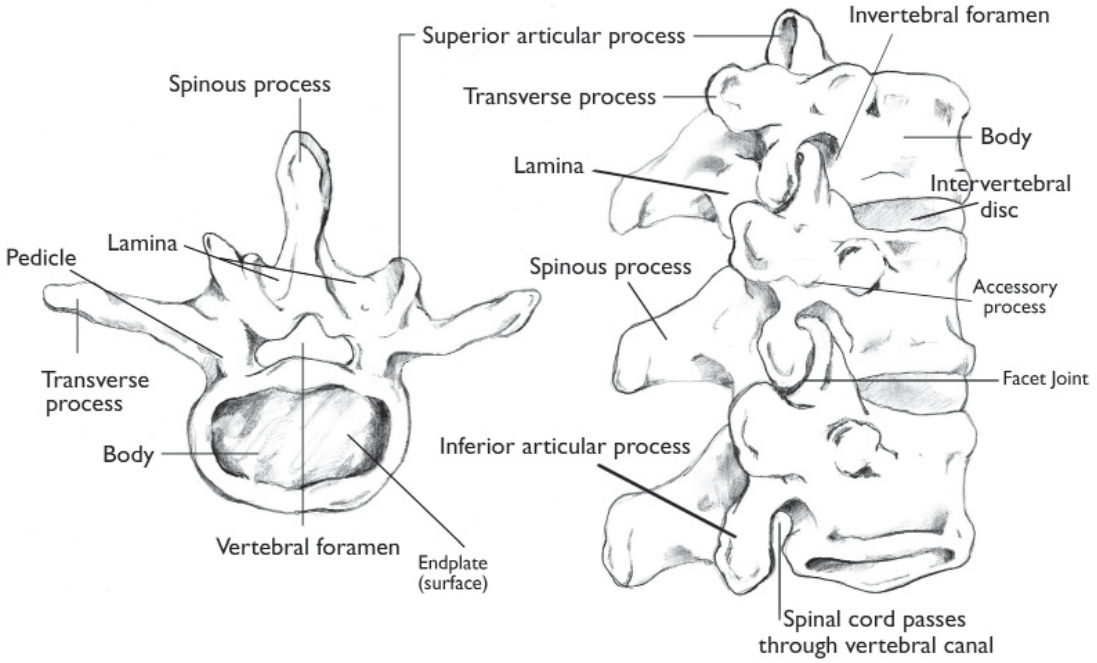


Figure 6.g: Vertebra



Thoracic Spine (12)
The thoracic vertebrae and the 24 ribs with which they articulate support the thorax. Its prominent curvature, called kyphosis, is developed in fetal life. Thoracic vertebrae are characterized by long slender spinous processes, heart shaped bodies, and facets for rib articulation.

Lumbar Spine (5)
These strong lumbar vertebrae, the most massive of the column, carry a large share of the body weight, balancing the torso on the sacrum. The lumbar curvature results from walking, crawling, and standing erect. This group of vertebrae allows for significant mobility of the trunk and withstands great loads of pressure when bending and twisting. Over time or with trauma, the discs between the lumbar vertebrae can become weakened and may bulge toward the spinal cord or nerves, leading to pain and dysfunction.

Sacrum (1)
Five sacral vertebrae fuse to form this single bone. It transmits the body weight to the hip joints via its articulation with the pelvic girdle, which is called the sacroiliac joint.

Coccyx (1)
Consisting of 2 to 4 fused, small segments, the coccyx is the attachment point for essential ligaments and muscles that lend support to the pelvic floor.

The movable vertebral segments are separated from one another by **intervertebral discs**. These discs are made up of fibrous cartilage, with a soft inner core, which allows them to absorb shock and permit flexibility. Excessive strain can cause the discs to bulge out of shape which is known as a herniated disc or protruded disk. A **herniated disc** can be extremely painful causing irritation or compression on the surrounding spinal cord or spinal nerve, bringing about weakness, numbness, or pain.

Each vertebra has a **body** that performs as a weight-bearing cylinder between the discs. Individual vertebrae vary in size and shape. Healthy vertebral bodies are able to withstand the compressions exerted by movement.

The vertebral column, if viewed from the side, has four normal curves.

These curves add strength and flexibility. The **cervical curve** (neck) and **lumbar curve** (low back) are concave or lordotic; i.e., curving inward. The **thoracic** (mid spine) and **sacral curves** are convex or kyphotic; i.e., curving outward. An abnormal sideways spinal curve is called **scoliosis**. An exaggeration of the thoracic curve is known as **hyper-kyphosis** (hunchback). An exaggerated curve of the lumbar area is called hyper **lordosis** (swayback).

Thoracic Cage (Thorax)

The thoracic cage is made up of the **sternum** (breastbone) and ribs to contain and protect the heart, lungs, and related structures of respiration and circulation. There are three main parts of the sternum: the **manubrium**, which has the shape of a protective shield and is at the highest point; the **body,** located in the center and shaped more like a sword; and the **xiphoid process**, which is located at the base of the sternum. The sternum and the ribs form the chest wall, which undulates with respiration and muscular motion.

Twelve pairs of ribs are found in the typical adult. The first seven pairs of ribs are known as **true ribs.** This is because they link directly to the sternum by strips of cartilage called **hyaline costal cartilages**. These attachments offer flexibility to the ribs and absorb shock that may occur to the chest wall.

The next five pairs of ribs are known as **false ribs** because they do not attach to the sternum directly. The seventh rib has costal cartilages that merge with ribs 8 to 10. Ribs 11 and 12 do not have any cartilage and do not attach to the sternum, which is why they are known as **floating ribs**.

The **hyoid bone** (lingual bone) is a bone in the human neck. It is the only bone in the skeleton system not touching any other bone. It is supported by the muscles of the neck and in turn, supports the root of the tongue. The hyoid bone is shaped like a horseshoe, and is suspended from the tips of the styloid process of the temporal bones by the stylohyoid ligaments.

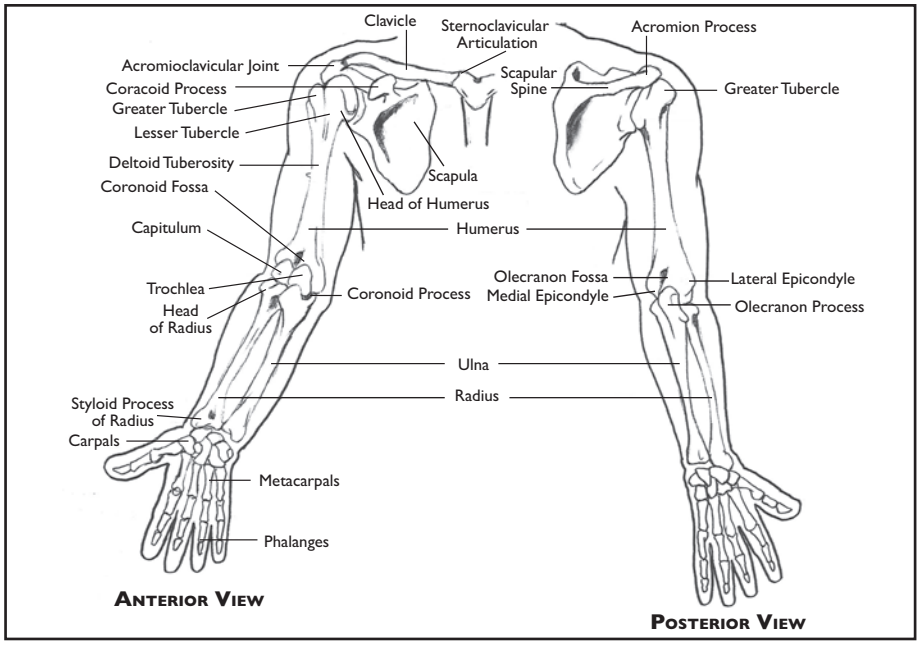
Appendicular Skeletal System

The **appendicular skeleton** is comprised of 126 bones and appendages that connect to the axial skeleton. The connecting bone system is known as a **girdle.** There are two girdles: the **pectoral girdle** connects the bones of the arm to the rib cage; and the **pelvic girdle** connects the leg bones to the sacrum. The joints of the appendicular skeleton make possible a considerable degree of freedom for the upper and lower limbs. Fractures and dislocations are more common in this part of the skeleton, however, more serious injuries tend to occur in the axial skeleton (See Figure 6.a).

Pectoral (shoulder) Girdle

The **pectoral girdle** is comprised of the clavicle and scapula. The **clavicle** (collarbone) is a rod-shaped bone that acts as a brace between the scapula and the top of the sternum. The **scapula** is a large triangular bone. The clavicle stabilizes the scapula backward and outward, creating the shoulder. Muscles of the chest and upper back make it possible for the arm to connect to the axial skeleton. The clavicle is subject to break with its role as a pivoting structure, unlike the scapula, which is flat and packed in muscle so breaks are not as common. Fractures of the scapula tend to occur in race car drivers because of their form fitting seat and arm position.

Figure 6.h: Shoulder Girdle

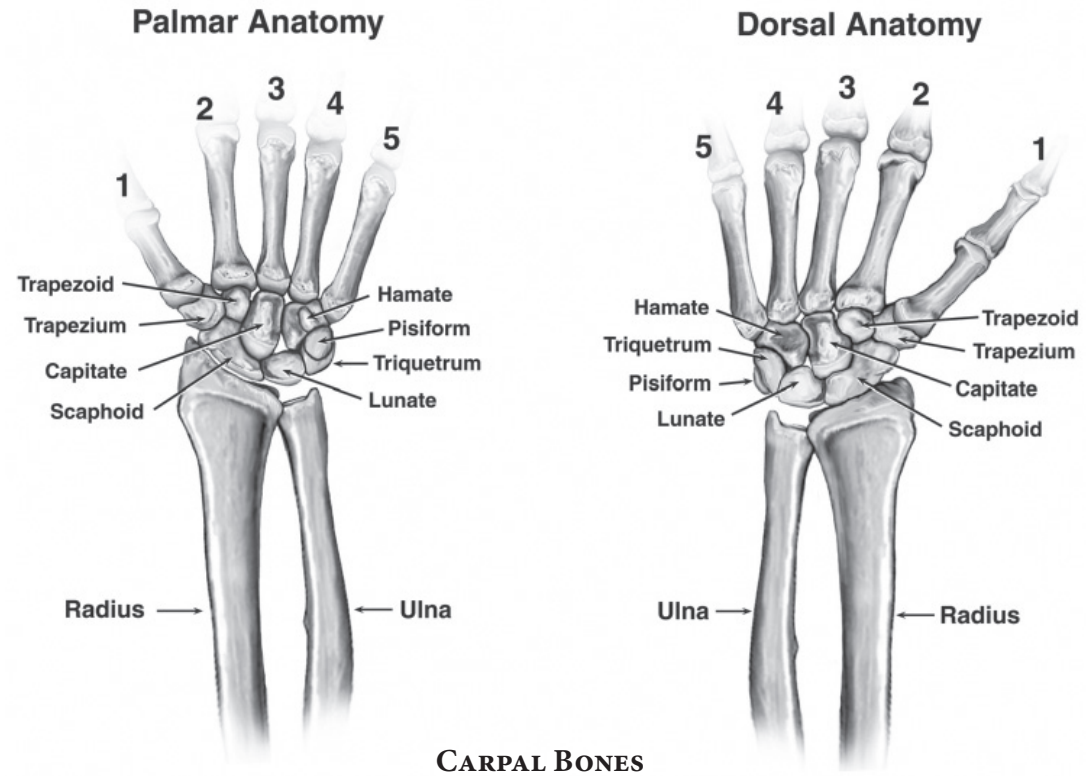


Bones of the Upper Limb

The upper arm bone that extends from the shoulder to the elbow is called the **humerus.** The humerus is not tightly bound in its joint with the scapula, allowing its mobility. If a fracture occurs to the humerus it will most likely break at mid-shaft.

The radius and ulna are the bones of the forearm. The **ulna** forms a major part of the elbow joint with the humerus. The **radius** forms the lateral part of the wrist joint. The radius is free to pivot about the ulna, and the hand moves with it, due to its joint at the wrist. The ulna cannot rotate at all because the nature of the joint at the elbow will not allow it. As the radius rotates in one direction, it crosses the ulna. You can try it yourself by holding your hand in front of your face and rotating your palm so that it faces away from you — this rotation movement is **pronation**. Rotate your palm so that it faces you — this rotary movement is **supination**. Note that as the radius moves, so does the thumb. This is because the radius attaches to the hand on the thumb side.

Figure 6.1



Carpal Bones

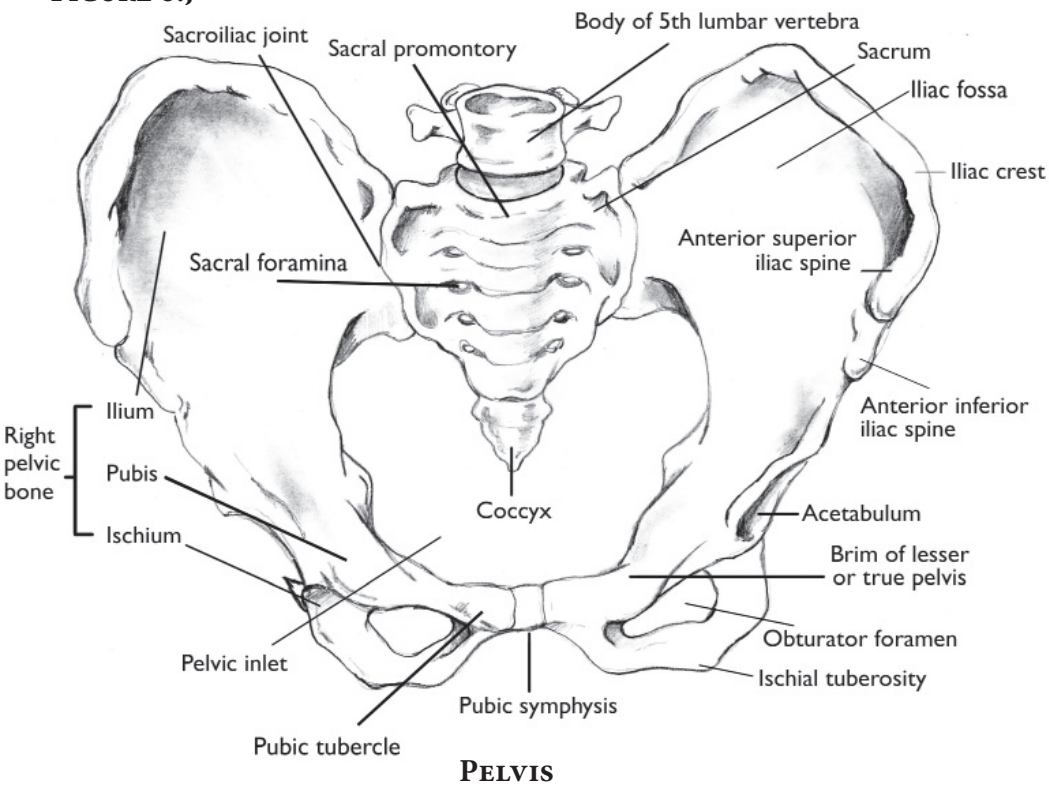
The radius and ulna articulate at the distal end with a series of wrist bones called **carpals**. There are eight carpal bones in two rows of four each. The carpals are named the **pisiform**, **lunate**, **triangular**, **hamate**, **capitate**, **scaphoid**, **trapezoid**, and **trapezium**. Their small size and joint connections permit great flexibility in the wrist.

The carpal bones articulate with **metacarpals**, the five bones (numbered 1-5) in the thick portion of the hand. The metacarpals, in turn, articulate with finger bones called **phalanges** (singular, phalanx). The thumb has two phalanges, and each of the remaining fingers have three phalanges (See Figure 6.1).

Pelvic Girdle

The pelvic girdle is formed from two pelvic bones. They join one another at the pubic joint and provide articulation for the lower limbs. Each pelvic bone is formed by fusion of three bones: the ilium, ischium, and the pubis. The **ilium** is the shallow bowl like upper region of the pelvis

Figure 6.j



Pelvis

and forms the iliac crests, which are often used as important landmarks of the body. The **ischium** is the lower, posterior portion on which we sit. The **pubis** is the anterior portion of the hip. The cup shape of the **acetabulum** fits the head of the femur to form the hip joint. The male and female pelvis differs considerably; principally, the female cavity is rounder and wider in all dimensions to accommodate child bearing (See Figure 6.j).

Bones of the Lower Limb

The upper leg (thigh bone) is called the **femur**. The femur joins the pelvic girdle and is the longest and strongest bone in the body. It has a large head, a neck, and two large protrusions called the greater trochanter and lesser trochanter. Muscles of the legs and buttocks attach here. The femur meets the lower leg bones at the kneecap, or patella. The **patella** is oval in shape and protects the front of the knee joint. It is a unique type of bone embedded within the patellar tendon that extends from the powerful quadricep muscles of the thigh.

The lower leg bones are the tibia and the fibula. The **tibia** (shin bone is the larger bone and is found on the medial side of the leg. It supports body weight and joins with the femur at the knee joint. The projection at the lower end is the **medial malleolus** (the inner ankle bone)**.** On the anterior surface of the tibia is the **tibial tuberosity**, which is the attachment site for the patellar ligament. The **fibula**, lateral leg bone, articulates with the tibia at its distal and proximal ends but not with the femur. This bone is considered a non-weight bearing bone.The projection at the distal end of the fibula is the **lateral malleolus** (the outer ankle bone).

The skeleton of the foot is made up of tarsals, metatarsals, and phalanges. The ankle is formed by a series of seven **tarsals**. The names of the tarsals are the **talus, calcaneus, navicular, cuboid, lateral cuneiform, medial cuneiform, and intermediate cuneiform**. The talus is the largest ankle bone, and the calcaneus is known as the heel bone. The instep is formed by the **metatarsals**. Together, the tarsals and metatarsals form the arch of the foot. The metatarsals (number 1-5) join with the toe bones called **phalanges**. There are two phalanges in the large toe and three phalanges in each of the other toes. The phalanges of the toes are similar to the finger bones, but do not have the importance to the foot that the fingers have to the hands, in that they are more for stability than for dexterity.

Tendons and Bursae

Tendons are tough bands of connective tissue made up mostly of a rigid protein called collagen. Tendons firmly attach each end of a muscle to a bone. They are often located within sheaths, which are lubricated to allow the tendons to move without friction. Their white appearance is due to their limited blood supply compared to the adjacent tissue, the muscle belly, which has a large blood supply giving its red appearance. **Bursas** are small fluid-filled sacs that lie under or around a tendon, cushioning the tendon and protecting it from injury. Bursas also provide extra cushioning to adjacent structures that otherwise might rub against each other, causing wear and tear.

Ligaments

Ligaments are tough fibrous cords composed of connective tissue that contains both collagen and elastic fibers. The elastic fibers allow the ligaments to stretch to some extent. Ligaments surround joints and bind them together. They help strengthen and stabilize joints, permitting movement only in certain directions. Ligaments also connect one bone to another (such as the ACL and PCL ligaments). Ligaments do not have a large blood supply.

Articulations (Joints)

Joints, or **articulations**, are the connection between two or more bones. Joints are classified into three categories and by the degree of movement they permit, **immovable** (synarthroses), **semi-movable** (amphiarthroses), and **freely movable** (diarthroses). Some joints, like those found in adults, of the sacral and coccygeal segments, move only slightly. Other joints allow a large and more complex range of motion. The design of a joint determines the degree and direction of possible motion. For example, the shoulder joints, which have a ball-and-socket design, allow internal and external rotation as well as forward, backward, and sideways motion of the arms. Hinge joints of the knees, fingers, and toes allow only bending (flexion) and straightening (extension).

The workings of joints provide stability and reduce the risk of damage from constant use. In a joint, the ends of the bones are covered with **cartilage**—a smooth, tough, resilient, and protective tissue (synovial

cartilage) that reduces friction as joints move. Joints also have a fibrous lining that encloses them to form the joint capsule. Cells in the tissue produce a small amount of clear fluid (synovial fluid), which provides nourishment to the cartilage and further reduces friction while facilitating movement.

Key Joints of the Body

Spinal Joints

Due to the irregular bone shape of vertebrae, spinal joints have numerous functions and positions that allow for coupled motion. Coupled motion is the combined motion of the spinal column, in which the spine allows itself to be the axis from which the numerous structures of the body pull. Costal and demifacet joints allow for the attachment of ribs. Facet joints sit on the posterior portion of a vertebra and articulate with the same joints on the adjacent verbetrae to allow forward, backward, rotational and lateral bending (See Figure 6.f and 6.g).

Atlantooccipital

The **atlantooccipital joint** is one of a pair of condyloid joints formed by the articulation of the atlas of the vertebral column with the occipital bone of the skull.

Atlantoaxial

The **atlantoaxial joint** is the articulation of the atlas with the axis. The alignment and function of the occiput, atlas and axis is of special concern to chiropractic physicians because of their relationship to the brainstem. This joint is responsible for over 80% of neck rotation.

Temporomandibular

The **temporomandibular joint** (TMJ) is a small joint located in front of the ear where the skull and lower jaw meet. It permits the lower jaw (mandible) to move and function. TMJ disorders are not uncommon and have a variety of symptoms, such as: earaches, headaches, and limited ability to open the mouth (See Figure 6.d).

Figure 6.k: Types of Joints and Their Movements

Diarthrosis	***Description***	***Movement***	***Examples***
Ball and Socket	Ball-shaped head fits into concave socket	Widest range of all joints	Shoulder joint and hip joint
Hinge	Spool-shaped surface fits into concave surface	In one plane about single axis, like hinged door movement	Elbow, knee, ankle, and interphalangeal joints
Pivot	Arch-shaped surface rotates about rounded or peg like pivot	Rotation	Between axis and atlas
Gliding	Articulating surfaces, usually flat	Gliding, a non-axial movement	Between carpal bones; between sacrum and ilium (sacroiliac joints)
Saddle	Saddle-shaped bone fits into socket that is curved in opposite direction	Same kinds of movement as condyloid joint but freer; resembles rider in saddle	Thumb, between first metacarpal and carpal (trapezium)
Condyloid (ellipsoidal)	Oval-shaped condyle; fits into elliptical cavity	In two planes at right angles to each other	Wrist joint (between radius and carpals)

Acromioclavicular

The **acromioclavicular joint** (AC joint), is a joint at the top of the shoulder. It is the junction between the acromion (part of the scapula that forms the highest point of the shoulder) and the clavicle. The AC joint allows the ability to raise the arm above the head. When this joint pulls apart it is usually termed a shoulder separation (See Figure 6.h).

Glenohumeral

The **glenohumeral joint** is a ball-and-socket joint that allows for the arm to move in a circular rotation as well as to move towards and away from the body. The motion that the glenohumeral joint provides is flexion, extension, abduction, adduction, internal rotation and external rotation. When this joint is pulled apart it is usually called a dislocation.

Costosternal Articulations

The **costosternal articulations** are the articulations of the cartilages of the true ribs with the sternum.

Costochondral

The **costochondral joints** are the articulations between the false ribs and costal cartilage.

Sacroiliac

The **sacroiliac joint** (SI) is a significant load-bearing articulation. The sacroiliac joints are located between the sacrum and the ilium. There is one on either side of the sacrum. The sacroiliac joints help make up the rear part of the pelvic girdle. These joints can often get stuck, or in some cases one half of the pelvis can glide forwards or backwards, which is often referred to as a twisted pelvis. When this occurs it often irritates the iliolumbar ligament which results in inflammation. This is usually indicated by tenderness around the bony lumps (PSIS or posterior superior iliac spine) which you can feel if you place your thumbs on either side of your lower back (See Figure 6.j).

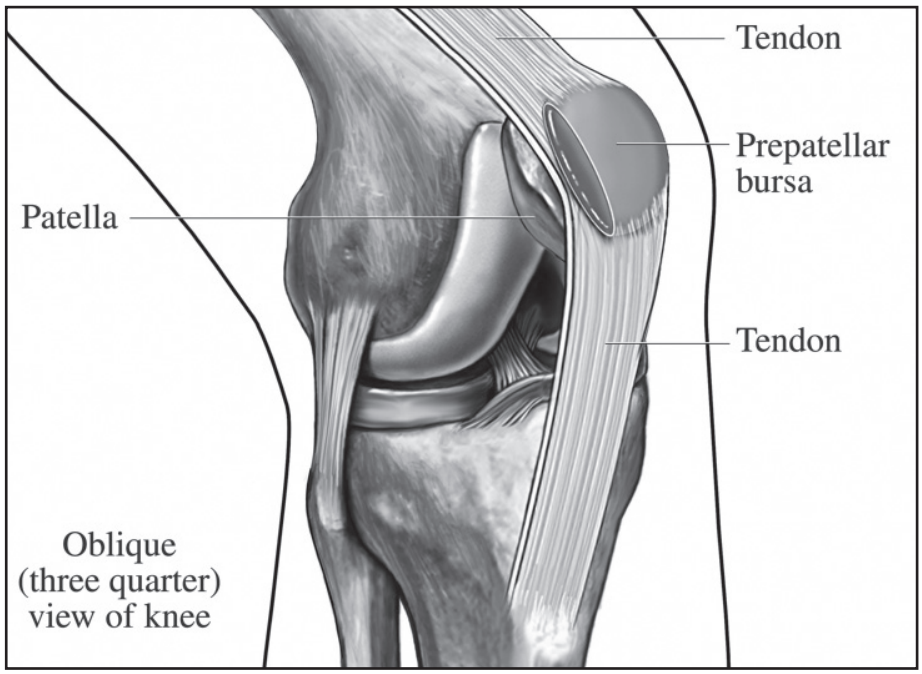
Hip

The **hip joint**, although similar in structure to the shoulder joint, is far more secure with its deep socket and strong ligaments. For these reasons, movements at the hip are somewhat more restricted than those of the shoulder.

Knee

The **knee** is designed for its own protection. It is completely surrounded by a joint capsule that is flexible enough to allow movement, but strong enough to hold the joint together. The capsule is lined with synovial tissue, which secretes synovial fluid to lubricate the joint. Wear-resistant cartilage covering the ends of the femur (thighbone) and tibia (shinbone) helps reduce friction during movement. Pads of cartilage (menisci) act as cushions between the two bones and help distribute body weight in the joint. Bursas (fluid-filled sacs) provide cushioning between structures such as the tibia and the patellar tendon (attached to the kneecap). Five ligaments along the sides and the back of the knee reinforce the joint capsule, adding stability. The patella (kneecap) protects the front of the joint (See Figure 6.l).

Figure 6.l

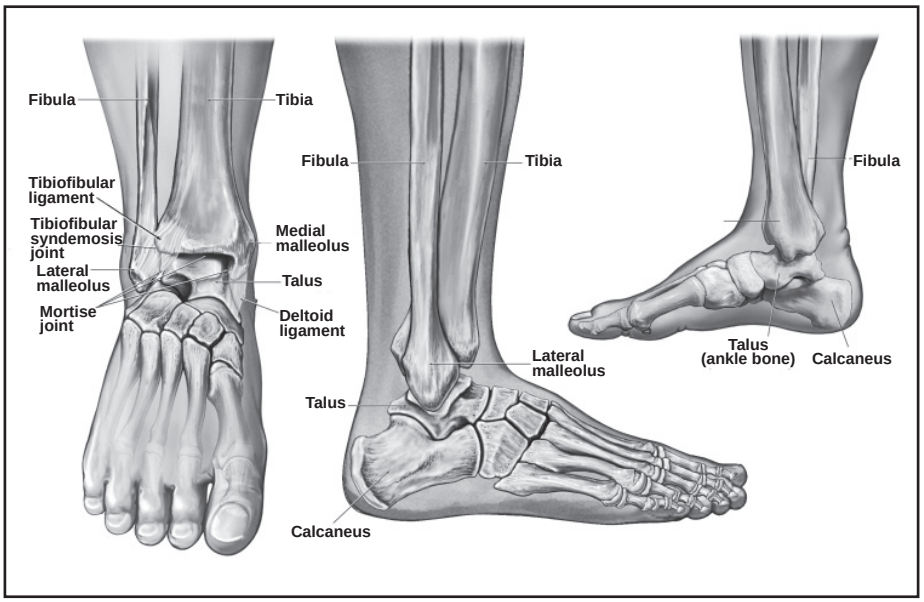


Knee Detail

Ankle

The foot is a mobile, weight-bearing structure. The **ankle joint** is responsible for dorsiflexion (moving the toes up as when standing only on the heels) and plantar flexion of the foot (moving the toes down, as when standing on the toes), and allows for the greatest movement of all the joints in the foot. With excessive rotation, inversion or reversion of this joint, characteristic fractures and torn ligaments occur (See Figure 6.m).

Figure 6.m



Ankle Detail

Musculoskeletal System

Muscular System

You may have heard the term Musculoskeletal System. This is a general term which is defined as **relating to muscles and the skeleton.** Thus, the musculoskeletal system entails the:

- **Muscles**
- **Bones**
- **Joints** (the place of union between two or more bones)

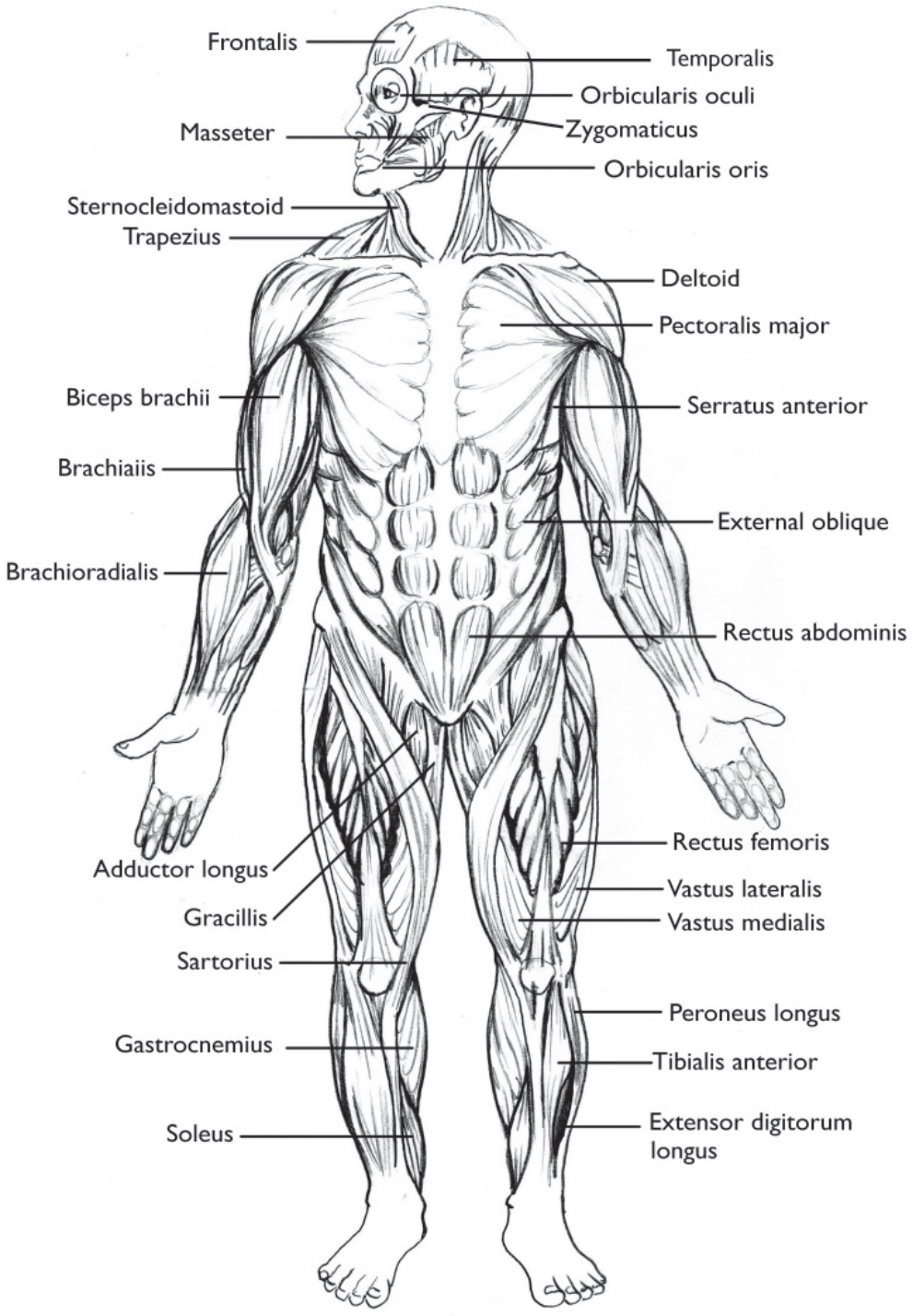
- **Bursa** (fluid sacs between the muscles and bones that form in areas of friction)
- **Ligaments** (fibrous bands of tissue connecting bones)
- **Tendons** (fibrous bands of tissue connecting muscle with bone)

The human body contains more than 650 individual muscles which are attached to the skeleton and provide the pulling power for humans to move around. The **muscles** are the specialized tissues that facilitate body movement and make up about 40% of body weight. There are three types of muscles: **smooth, skeletal** and **cardiac** (heart). Each of these different tissues has the ability to contract, which then allows for body movements and tissue function. Two of these kinds—skeletal and smooth—are part of the musculoskeletal system.

Smooth Muscles control specific bodily functions that are not under a person's control. Smooth muscle surrounds many arteries and contracts to adjust blood flow. It surrounds the intestines and contracts to move food along the digestive tract (peristalsis). Smooth muscle is controlled by the brain, but not voluntarily. The triggers for contracting and relaxing smooth muscles are controlled by the body's needs; so, smooth muscles are considered involuntary muscles, because they operate without a person's awareness.

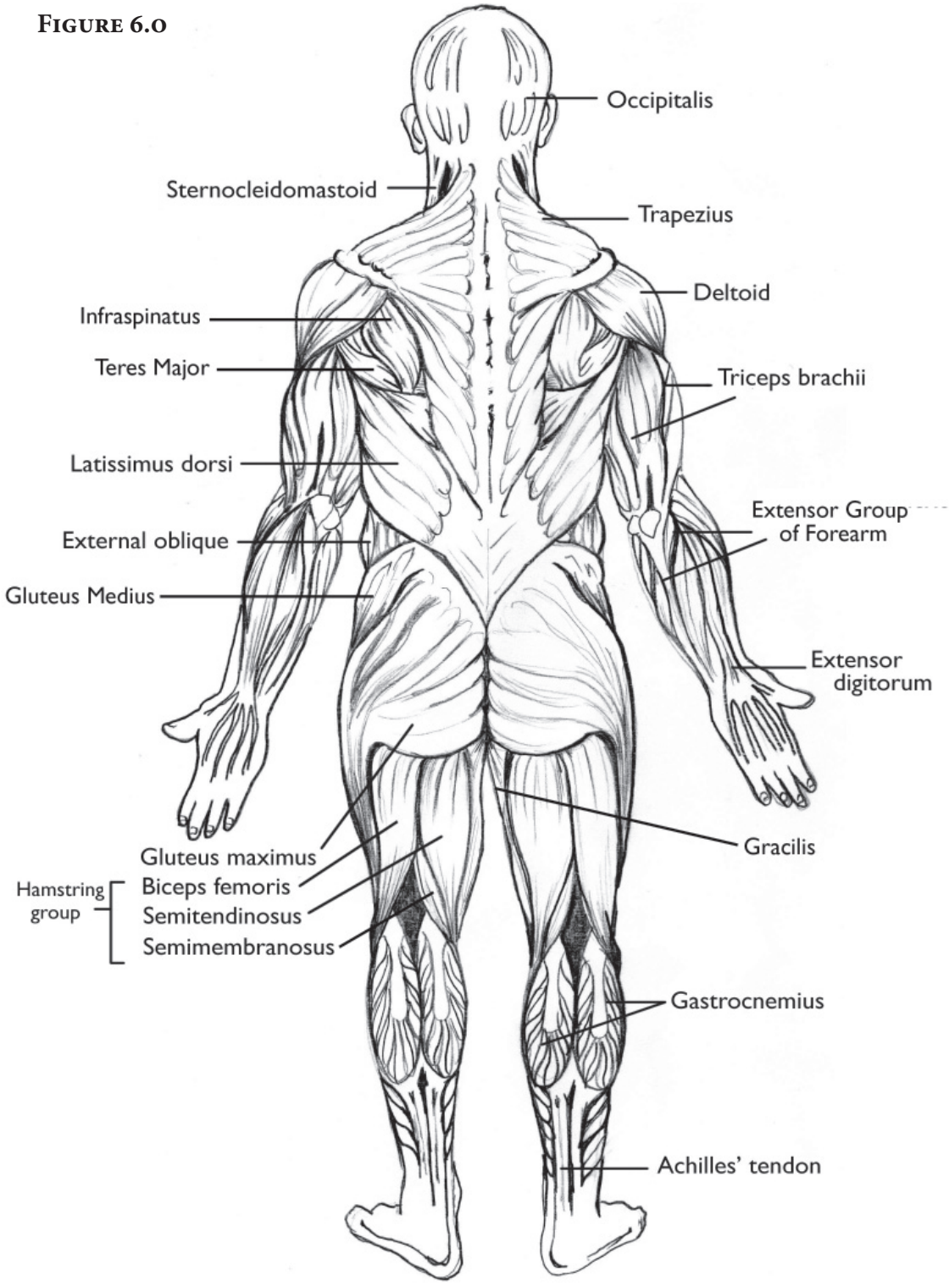
Skeletal Muscles are considered voluntary muscles because they operate with a person's awareness. Skeletal muscles demand large amounts of oxygen and nutrients to sustain themselves, and will spasm or atrophy in their absence. The size and strength of skeletal muscles are maintained or increased by regular exercise. Skeletal muscle is what most people think of as muscle, the type that can be contracted to move the various parts of the body. Skeletal muscles are bundles of contractile fibers that are organized in a regular pattern, so that under a microscope they appear as stripes. (They are also called striped or striated muscles.) Skeletal muscles vary in their speeds of contraction. Skeletal muscles, which are responsible for posture and movement, are attached to bones and arranged in opposing groups around joints. For example, muscles that bend the elbow (biceps) are countered by muscles that straighten it (triceps). These countering movements are balanced. The balance makes movements smooth, which helps prevent damage to the musculoskeletal system.

Figure 6.n



Muscular System (Anterior View)

Figure 6.0



Muscular System (Posterior View)

Cardiac Muscle forms the heart and is not part of the musculoskeletal system. Like skeletal muscle, cardiac muscle has a regular pattern of fibers that also appears as stripes under a microscope. However, similar to smooth muscle, cardiac muscle contracts and relaxes rhythmically and without a person's awareness or direct control.

Do you know?

You use 17 muscles when you smile.
You use 43 muscles when you frown.

Muscle Groups of the Body

The muscles of the extremities join the arms and legs to the body trunk and regulate the movement of all parts of the extremities. To assist you in your learning process, they have been divided into groups.

Muscles of the Neck and Back (See Figure 6.n and 6.o)

The **suboccipital muscles** – located at the base of the skull, control movement of the head especially, in extension of the neck. Tension in these muscles is a major cause of headaches in patients.

The **latissimus dorsi** muscles are the largest muscles of the back. Being large, fan-shaped muscles, they are able to provide force in a wide range of body positions, e.g. leaning back, to straight vertical, and all points in between. They are attached to the upper end of the humerus with fibers running in a fan shape along the **vertebral column** to the **pelvic girdle**. The function of the latissimus dorsi is to pull the arm down towards the pelvis. They also function to stabilize the torso during many daily movements.

The **trapezius** muscle is a long, trapezoid-shaped muscle that runs down the upper section of the spinal column, originating at the base of the skull and attaching at the shoulder and down in the middle to lower back. The angles of the trapezius fibers provide pull in three different directions: up, down and in towards the centerline of the body. The functions of the trapezius muscle include scapular elevation (shrugging

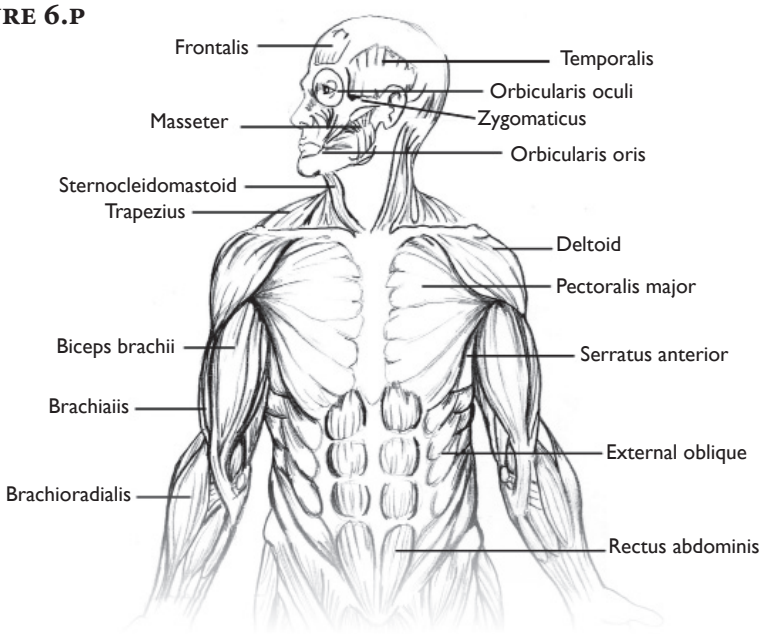
up), scapular adduction (drawing the shoulder blades together) scapular depression (pulling the shoulder blades down), and aids neck rotation.

The **pectoralis major** ("pecs") muscles are located on the front of the rib cage. They attach to the humerus near the shoulder joint and originate on the breastbone in the center of the chest. The fibers of the pectoralis muscles run like a fan across the chest. The fan-like structure allows the humerus to move in a variety of planes across the body. The **pectoralis minor** muscle is located underneath the pectoralis major muscle, attaching to the **coracoid process** of the scapula and originating on the middle ribs. The function of the pectoralis major is to bring the humerus across the chest. The pectoralis minor serves to move the shoulder area forward. This can be seen by shrugging your shoulder forward.

Muscles of the Abdomen

The **abdominals** are composed of several muscles: the rectus abdominus, transverse abdominus, and the external and internal obliques. The abdominal muscles sit on the front and sides of the lower half of the torso, originating along the rib cage and attaching along the pelvis. The **rectus abdominus** muscle is commonly known as the "six-pack" muscle of the abs. Thin bands of connective tissue give it that appearance. The **transverse abdominus** is the deepest muscle. It wraps laterally around the abdominal area. The fibers of **external and internal obliques** run diagonally on the body, allowing for angled movement.

Figure 6.p



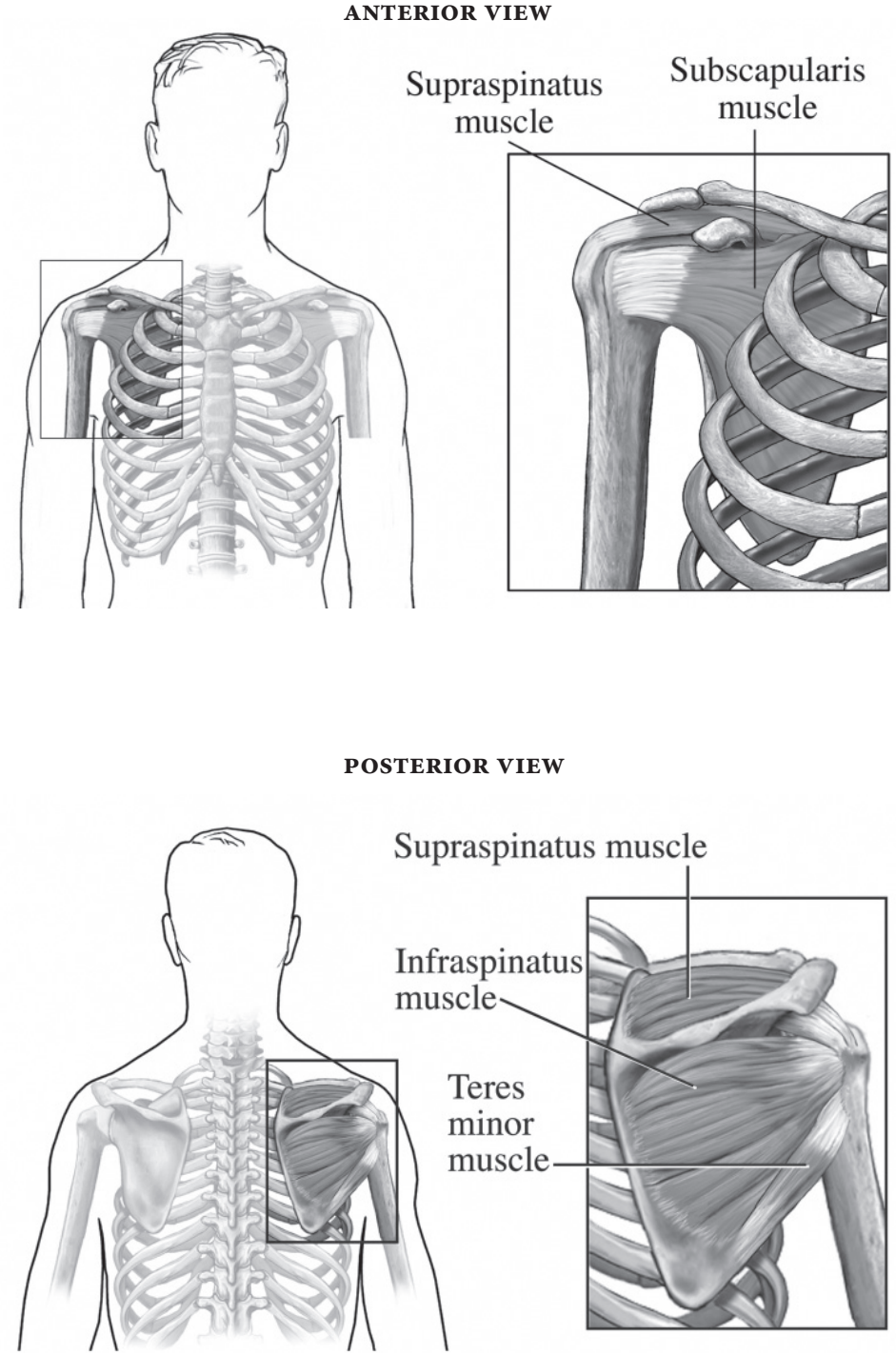
Muscular System (Anterior View)

Muscles of the Upper Extremity (See Figure 6.p)

The musculature of the upper extremity has many actions and demands placed on it. The **deltoid** is a three-headed muscle (**anterior, lateral, and posterior**) that caps the shoulder. All three deltoid heads attach to the humerus. The anterior and lateral heads originate on the collar bone, while the posterior head originates on the scapula. The function of the deltoid muscle is essentially to move the arm away from the body (abduction). The **anterior** head raises it away to the front, the **lateral** head raises up and away to the side, and the **posterior** head raises away and to the rear.

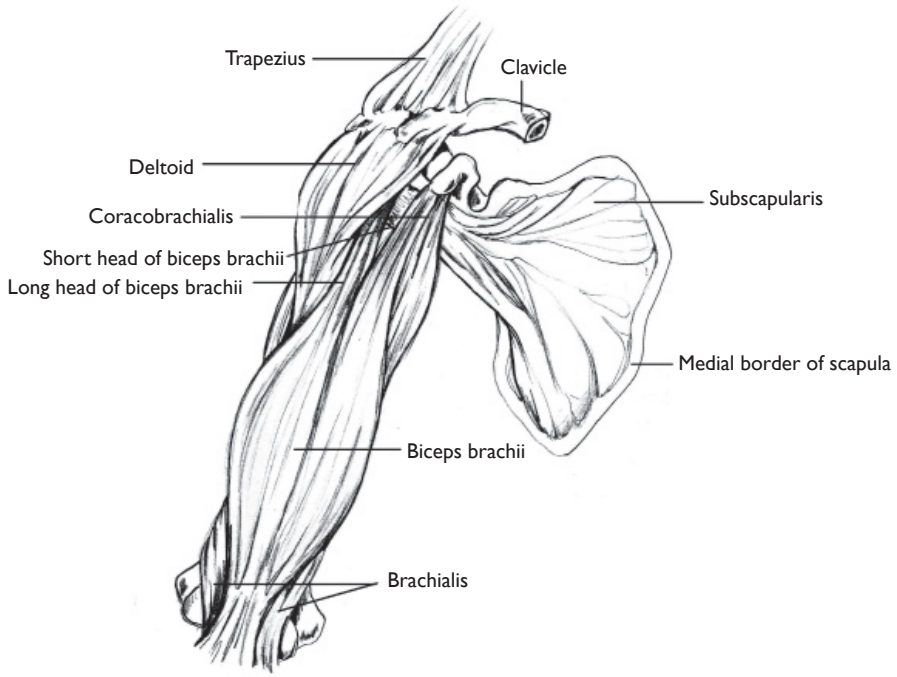
The **rotator cuff** (See Figure 6.q) is a group of muscles that work in the shoulder joint to keep the humerus in tact, which makes the rotator cuff critical for shoulder stability. There are four muscles (S.I.T.S.) in the rotator cuff: the **supraspinatus**, the **infraspinatus**, the **teres minor** and the **subscapularis**. The rotator cuff is one of the primary areas of shoulder trauma; i.e., when someone has a shoulder injury, chances are good that it is related to injury in the rotator cuff. The main functions of the rotator cuff are shoulder joint stabilization and external rotation of the humerus (rotating the arm to the rear).

Figure 6.q Rotator Cuff



The **biceps brachii** (See Figure 6.r) is attached to the forearm bone called the radius and originates at the scapula in two places. The bicep gets its name from these two heads, called the short head and the long head. The bicep runs down the anterior or front side of the humerus and makes up approximately 1/3 of the muscle mass of the upper arm. The primary function of the bicep muscle is to move the forearm towards the shoulder (elbow flexion). The secondary function of the bicep is supination of the forearm. This means turning the hand from a palms-down position to a palms-up position.

Figure 6.r Biceps brachii

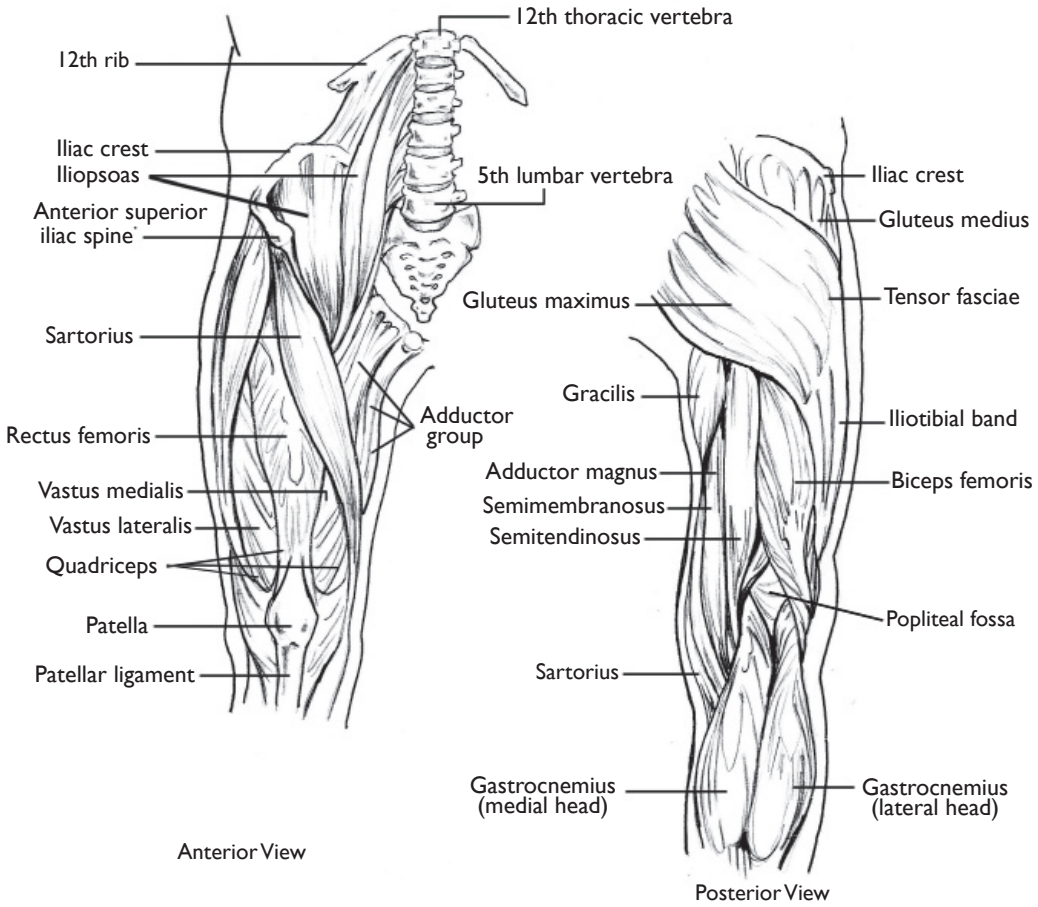


The **triceps brachii** has three heads which connect the **humerus** and **scapula** to the forearm bone called the **ulna**. These heads are known as the lateral, medial, and long heads. The lateral head is located on the outward facing side of the humerus. The medial head is located towards the midline of the body. The long head, along the bottom side of the humerus is the largest of the three heads. The primary function of the tricep is to extend the elbow (straightening the arm). The secondary function is bringing the arm down towards the body (adduction). This is made possible only by the long head of the muscle. The tricep shares this function with the latissimus dorsi.

Muscles of the Lower Extremity (See Figure 6.s)

The **iliopsoas** consists of two muscles: the iliacus and the psoas major. The **iliacus** originates on the pelvic crest and attaches on the femur. The **psoas major**, the longer of the two muscles, originates on the lumbar vertebrae and attaches to the femur. The **rectus femoris** is one of the four quadriceps muscles and the only one that crosses the hip joint. This crossing of the hip joint enables it to operate as a hip flexor, as well as a **knee extensor** (straightening the knee). Over-developed and tight hip flexors can contribute to lower back pain by causing the pelvis to tilt forward. The function of the iliopsoas is hip flexion, which means bringing the thigh up towards the abdomen.

Figure 6.s



Lower Extremity Muscles

The **gluteus maximus** is one of the largest and strongest muscles in the body. The **gluteus medius** and **minimus** lie directly underneath the gluteus maximus. The gluteus maximus originates along the pelvic bone crests and attaches to the rear of the femur. The gluteus medius and minimus originate in the same spot as the maximus, but attach to the side of the femur. The **iliotibial band** is made only of connective tissue. This band serves to transfer the force of abduction (moving the leg away from the centerline of the body) to the leg. The primary function of the gluteus maximus is hip extension (moving the thigh to the rear). The gluteus medius and minimus serve to abduct (move away from the centerline of the body) the leg.

The quadriceps are a group of four muscles that sit on the anterior or front aspect of the thigh. They are the **vastus medialis, vastus intermedius, vastus lateralis** and the **rectus femoris**. The quadriceps attach to the front of the tibia and originate at the top of the femur. The exception to this rule is the rectus femoris, which actually crosses the hip joint and originates on the pelvis. The function of the quadriceps overall is to extend the knee. The rectus femoris functions to extend the knee, but also acts as a hip flexor because it crosses the hip joint.

The **adductors** are a group of muscles that include: the **adductor magnus**, **adductor longus**, **adductor brevis, gracilis** and the **pectineus**. The adductors originate on the pelvic bone and attach at intervals along the length of the femur. This interval attachment provides the most power and stability for the hip joint and the femur. The primary functions of the adductors are adduction (the movement of the leg in towards the centerline of the body). The adductors also serve to stabilize the hip joint.

The **hamstrings** are actually comprised of three separate muscles: the **biceps femoris**, **semitendinosus** and **semimembranosus**. These muscles originate just underneath the gluteus maximus on the pelvic bone and attach on the tibia. The primary functions of the hamstrings are knee flexion and hip extension.

The **gastrocnemius** is the calf muscle that is visible from the outside of the body. It attaches to the heel by the **achilles tendon** and originates behind the knee on the femur, crossing two joints. The gastrocnemius has two heads: **medial** and the **lateral**. When fully developed, these two heads appear to form a diamond shape. The **soleus** is not visible and lies underneath the gastrocnemius on the rear of the lower leg. The function

of the gastrocnemius is to elevate the heel (known as plantar flexion). The function of the soleus is exactly the same as the gastrocnemius: to raise the heel. The only difference is that it works in a different position – with the knee bent. The soleus aids in postural control as well.

The Nervous System

Basic Structure and Function (See Figure 6.1)

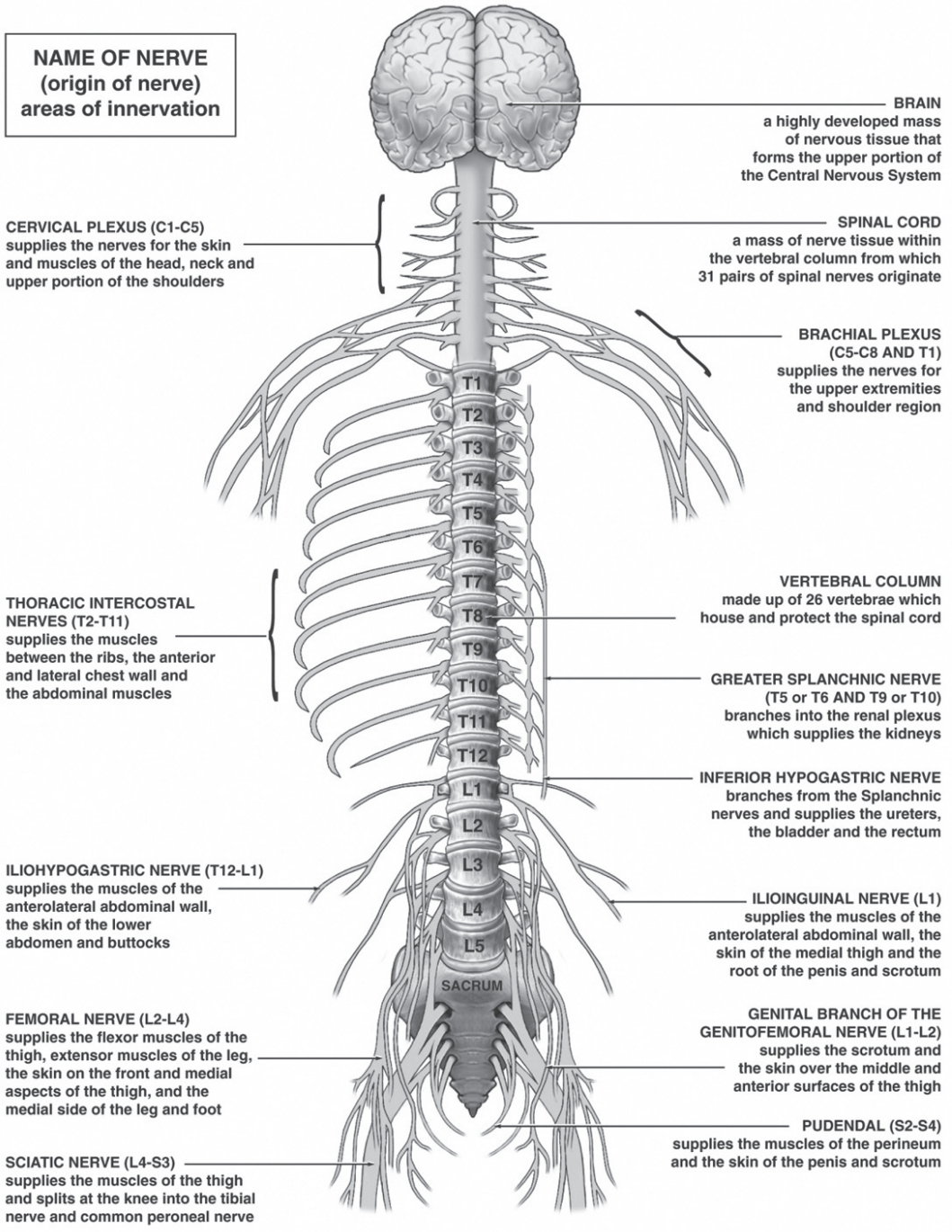
Conditions both within the body and in the environment are constantly changing. The **nervous system** directs the complex processes of the body's internal environment and also provides a link to the external world. This allows humans to respond to changes both from internal sources, as well as from external stimuli. Without the nervous system, there would be no regulation in the organ systems. They would act independently of one another without consideration to the body's needs.

The nervous system is organized into three basic functional and structural categories: the central nervous system, the peripheral nervous system, and the autonomic nervous system.

The **central nervous system** (**CNS**), which includes the **brain** and **spinal cord**, plays a vital role in body orientation, coordination of bodily movements, assimilation of experience, and playing out the behaviors driven by instinct. The central nervous system has a finely tuned, highly developed capacity for interpretation of stimulus, as well as the ability to sense, integrate, and control the motor response necessary. This ability allows the human body to function and remain remarkably safe while maintaining homeostasis of the body. **Homeostasis** is the body's ability to maintain stability within itself by coordinating responses of the organ systems to environmental stressors. The central nervous system is the primary nervous system with the largest communications network within the human body. Among its many functions, it tells the heart to beat and warn the body of danger by detecting pain or abnormal function. Without the central nervous system, the human body would not survive.

The four basic functions of the central nervous system (orientation, coordination, assimilation, and programming) require constant and vigilant monitoring of the body's internal and external stimuli, as well as a remembered and controlled response to the stimuli. Integration, which is the process of interpreting the changes in stimuli, usually produces a

Figure 6.1



Basic Nervous System

response requirement from the muscles or glands.

The **peripheral nervous system** (**PNS**), which includes all **nerves**, carries impulses to and from the brain and spinal cord. The peripheral nervous system is primarily responsible for centralized communication. The PNS includes sensory organs such as eyes and ears. It also includes the intricate web of nerves and tissues that facilitate the body's sense of taste, smell and touch, as well as the ability to feel pain.

The **autonomic nervous system** is the key to involuntary functions such as breathing and maintaining a heart rate. While the autonomic nervous system shares some responsibilities with the central nervous system, all three segmented nervous system categories are always working in constant continuity with each other.

Other Body Systems

Cardiovascular (See Figure 6.u)

The cardiovascular system consists of a four-chambered heart, arteries conducting blood to the tissues, capillaries through which nutrients, gases, and molecular material pass to and from the tissues, and veins returning blood from the tissues to the heart. Broadly characterized, the cardiovascular system includes the lymphatic system.

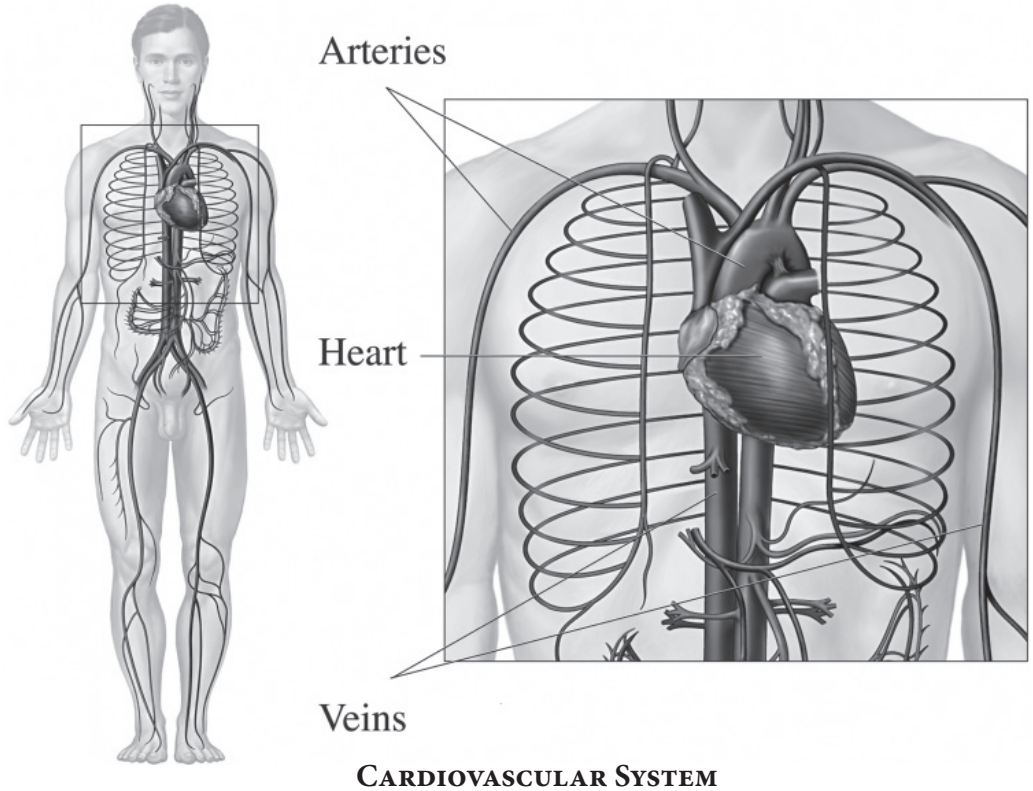
The Heart: A Four-Chambered Pump

- **Right Atrium** – receives blood from the body and sends it to the right ventricle
- **Right Ventricle** – pumps the blood to the lungs
- **Left Atrium** – receives the blood from the lungs and sends it to the left ventricle
- **Left Ventricle** – pumps the blood to the body

Types of Blood Vessels

- **Arteries** – carry blood away from the heart
- **Arterioles**
- **Capillaries** – where exchanges take place; smallest type of blood vessel
- **Venules**
- **Veins** – carry blood toward the heart

Figure 6.u



Cardiovascular System

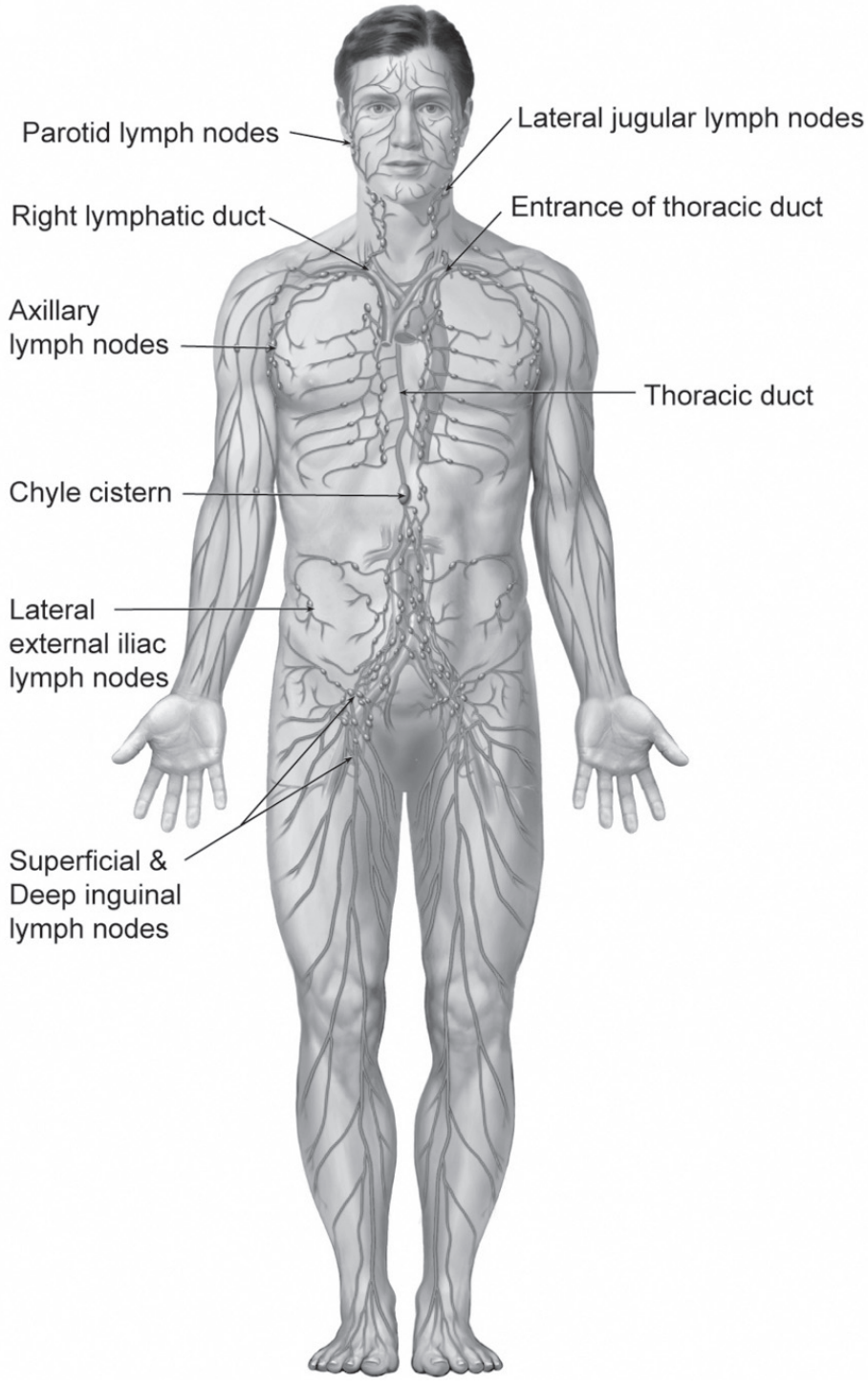
Blood Pressure
Systolic/Diastolic

- **Systole** – the point when the pressure in the arteries is at its highest
- **Diastole** – the point when the pressure in the arteries is at its lowest
- **Brachial artery** – normally used to check blood pressure
- **Radial artery** – normally used to check pulse

Lymphatic (See Figure 6.v)

The lymphatic system is a system of vessels assisting the veins in recovering the body's tissue fluids and returning them to the heart. The body is about 60% water, and the veins alone are generally incapable of meeting the demands of tissue drainage. Lymph nodes, which filter lymph, are located throughout the body and aid in containing and excreting foreign materials.

Figure 6.v



Lymph Nodes

Endocrine

The endocrine system consists of glands that secrete chemical agents (hormones) into the tissue fluids and blood, affecting the function of multiple areas of the body. Many of these glands are under some control by the brain (hypothalamus). Hormones help maintain balanced metabolic functions in many of the body's systems.

Common Functions:
- Ductless glands secrete directly into the blood system
- Secrete hormones
- Body regulation

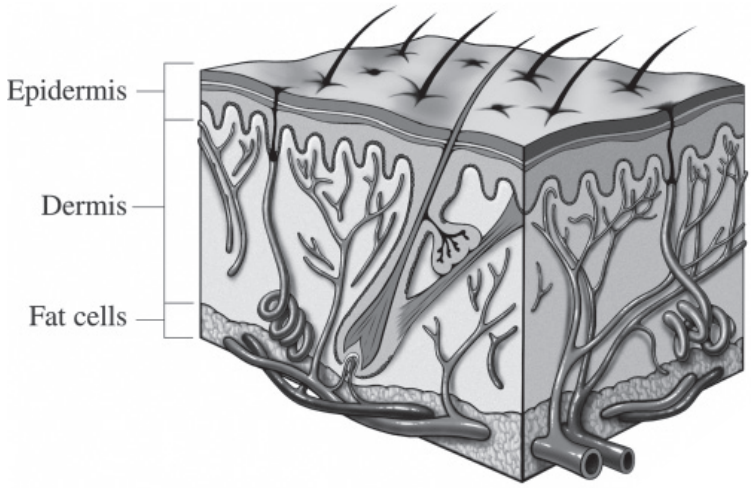
Glands of the Endocrine System are:
- Thyroid
- Parathyroid
- Adrenals
- Isles of the Pancreas
- Pituitary
- Testes and Ovaries

Integumentary

The integumentary system is the skin, replete with glands, sensory receptors, vessels, immune cells, and antibodies, and layers of cells and keratin that resist environmental factors harmful to the body.

Functions include:
- Protection
- Regulation of body temperature
- Sensory perception
- Excretion of body wastes

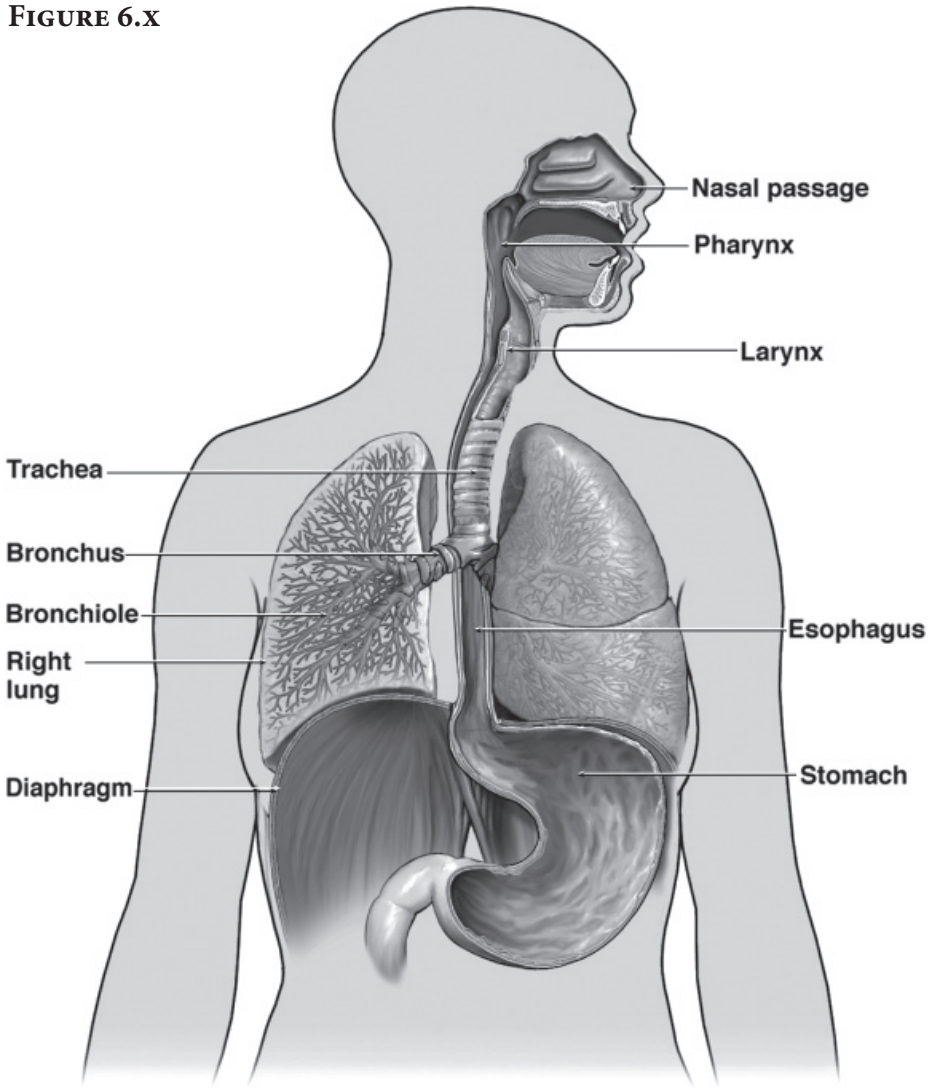
Figure 6.w: Layers of the Integumentary System



Respiratory (See Figure 6.x)

The respiratory system consists of the upper (nose through larynx) and lower respiratory tract (trachea through the air spaces of the lungs). Most of the tract is airway; only the air spaces (alveoli) and very small bronchioles exchange gases between alveoli and the lung capillaries. The respiratory system's primary function is to mediate the movement of air into and out of the body by way of the airways, the lungs, and the respiratory muscles.

Figure 6.x



Respiratory System

The Air Passageway
- **Nose**
- **Sinuses**
- **Pharynx**
- **Larynx** – voice box; epiglottis closes during swallowing
- **Trachea** – windpipe
- **Bronchi**
- **Lungs** – right 3 lobes; left 2 lobes
- **Alveoli** – where the gas exchange takes place

Respiration – the exchange of oxygen and carbon dioxide within the body, and between the body and the atmosphere

- **Breathing** – the cycle of inhalation and exhalation
- **Respiratory Rate** – number of breathing cycles per minute; normally between 16-20
- **Inhalation** – the process of bringing air into the lungs
- **Exhalation** – the process of taking air out of the lungs

Digestive (See Figure 6.y)

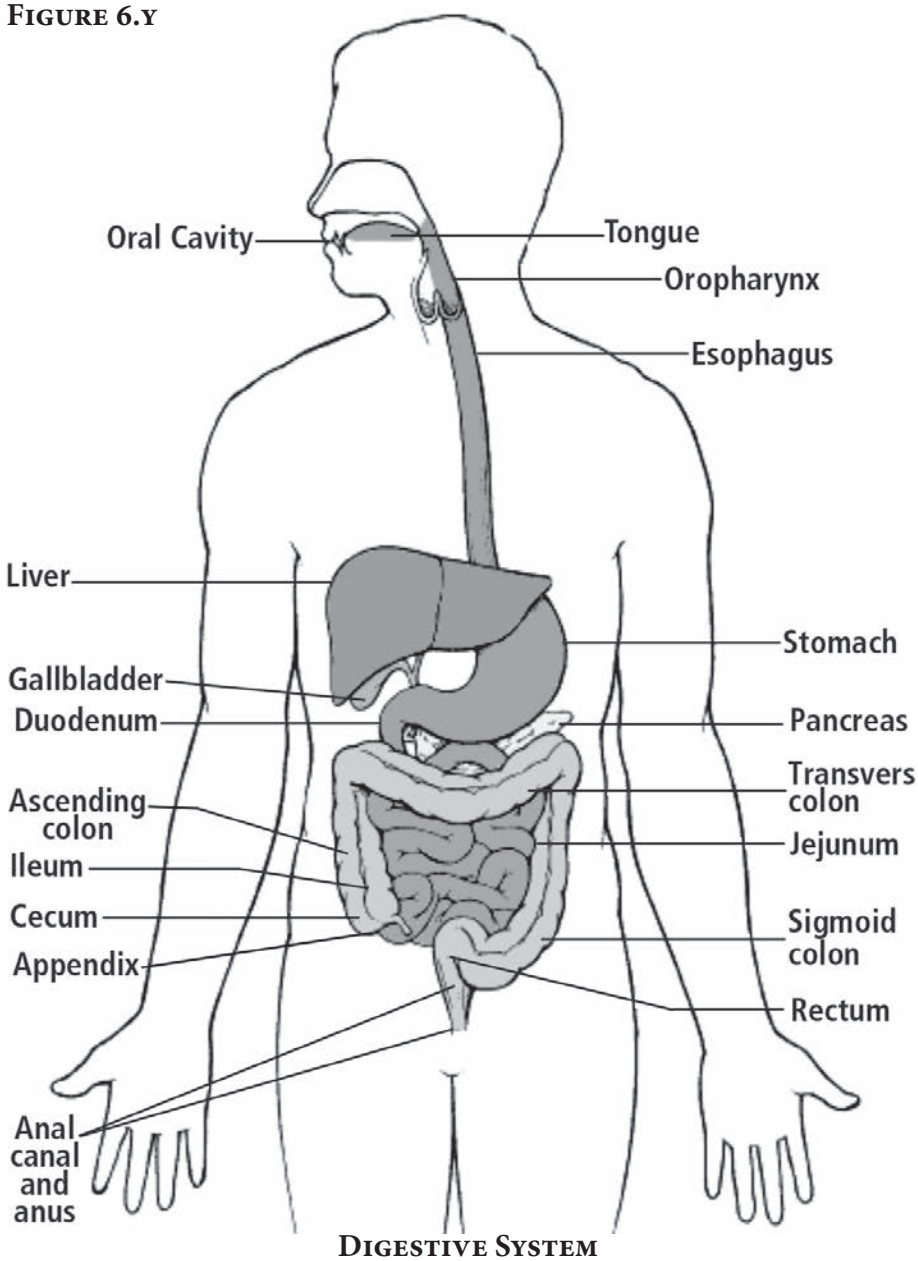
The digestive system is concerned with the breakdown, digestion, and assimilation of food, as well as excretion of the residual excrement. Its alimentary tract begins with the mouth and continues down to the abdomen, where it takes a complex course to open again at the anus. Associated glands include the liver, the pancreas, and the biliary system (gallbladder and related ducts).

Alimentary tract "food passageway" functions include:
- Ingest
- Transport
- Digest
- Absorb
- Eliminate

The alimentary tract is made up of the following:
- Teeth
- Tongue
- Pharynx
- Esophagus
- Stomach (primary storehouse of food)

- Small intestine: duodenum, jejunum, ileum (absorption of food)
- Large intestine (absorption of water)
- Rectum
- Anus

Figure 6.y



Digestive System

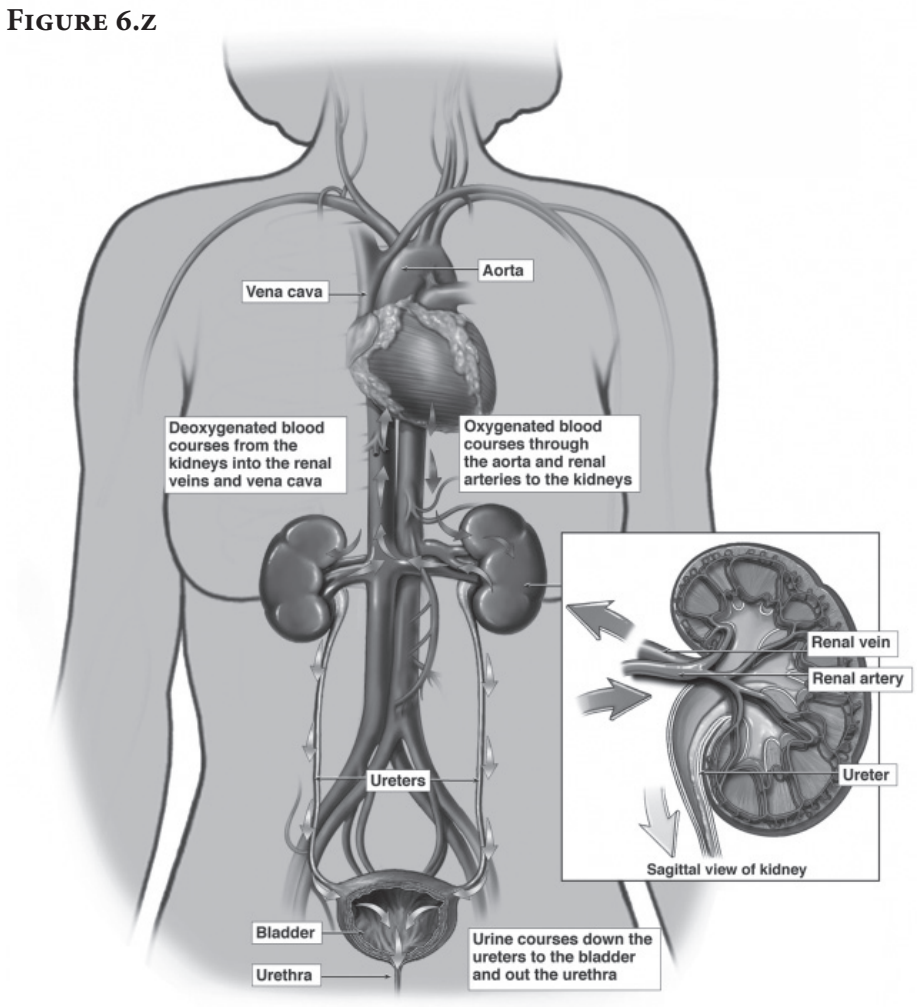
Accessory Organs

- Prepare food for absorption and use

The accessory organs include the following:

- **Salivary glands** – first accessory organs
- **Pancreas** – secretes a juice that acts on all kinds of foods
- **Liver** – other than skin, largest organ in body; secretes bile; storehouse for sugar, iron, and Vitamin B; detoxifies blood
- **Gallbladder** – stores and concentrates bile; and emulsifies fat.

Figure 6.z



Urinary System

Urinary (See figure 6.z)

The urinary system is the organ system that produces, stores, and eliminates urine. The kidneys are the main functionaries of this system; residual fluid (urine) is excreted through ureters to the urinary bladder for retention and discharged to the outside through the urethra.

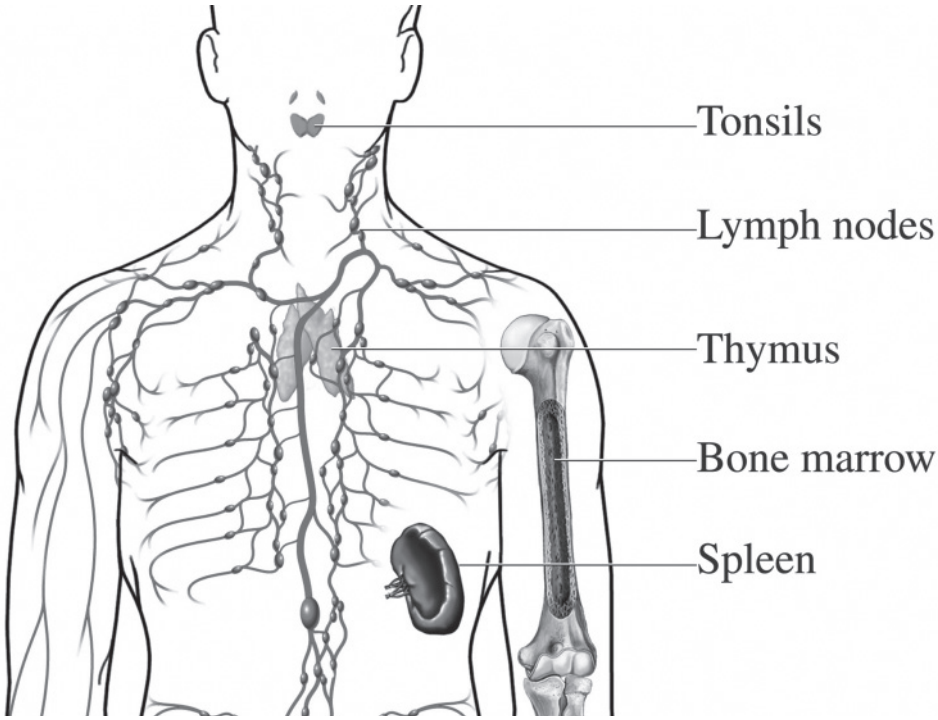
The Urinary System – filters and excretes waste materials from the blood. Its organs include the following:

- **Kidneys**
- **Ureters** – tubes carrying urine from the kidney to the bladder
- **Urinary bladder** – storage of urine
- **Urethra** – tube carrying urine from the bladder to the outside of body

Immune/Lymphoid (See figure 6.aa)

The lymphoid system consists of organs concerned with body defense: thymus, bone marrow, spleen, lymph nodes, tonsils, and smaller aggregates of lymphoid tissue. This system, including a diffuse

Figure 6.aa



Lymphoid System

arrangement of immune-related cells throughout the body, is concerned with resistance to invasive microorganisms and the removal of damaged or otherwise abnormal cells.

Reproductive

Female (See Figure 6.bb)

The female reproductive system is concerned with the secretion of sex hormones, production and transportation of germ cells (ova), receipt and transport of male germ cells to the fertilization site and maintenance of the developing embryo, fetus, and initial sustenance of the newborn.

The female reproductive system is made up of the following:

- Ovaries
- Fallopian tubes
- Uterus
- Vagina
- Mons Pubis
- Labia
- Clitoris
- Vestibule

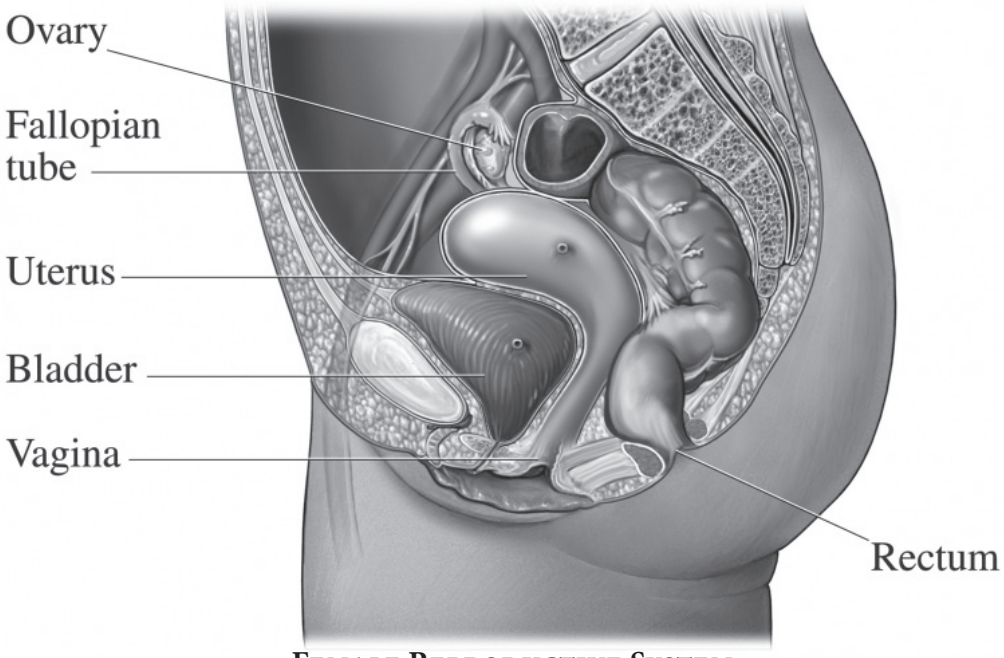
Male (See Figure 6.cc)

The male reproductive system is concerned with the secretion of male sex hormones, formation and maintenance of germ cells (sperm), and transport of germ cells to the female genital tract.

The male reproductive system is made up of the following:

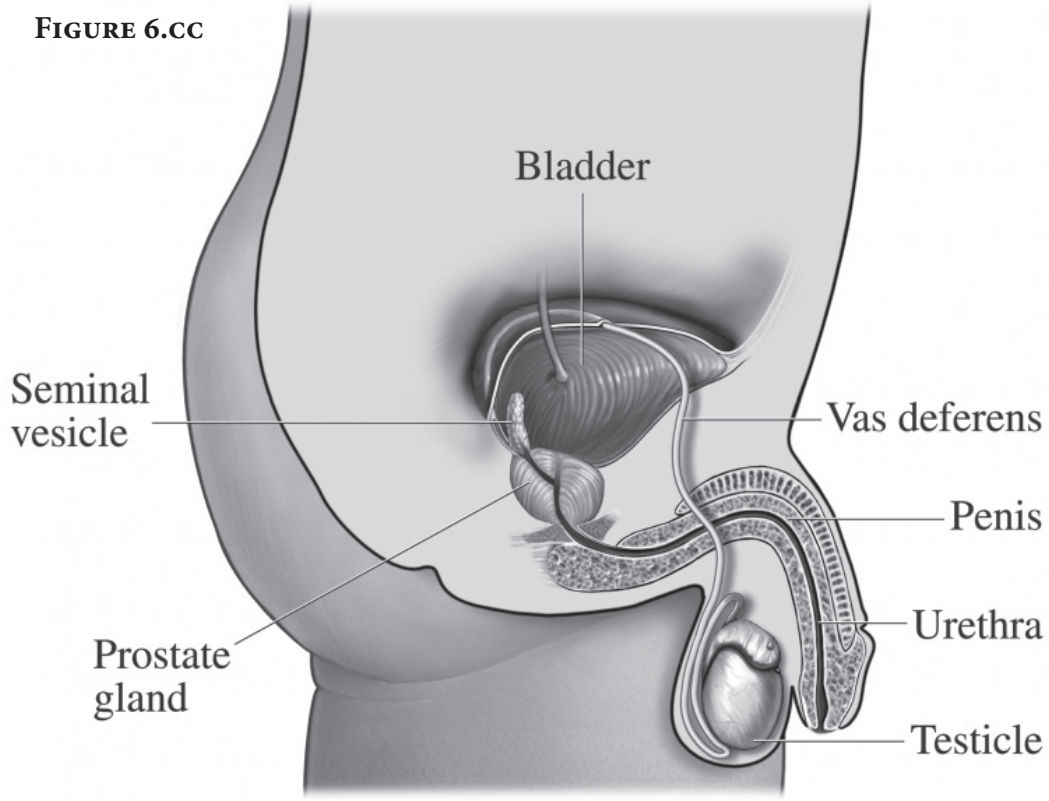
- Scrotum
- Testes
- Epididymis
- Ductus deferens
- Seminal vesicles
- Ejaculatory ducts
- Prostate gland
- Urethra
- Penis

Figure 6.bb



Female Reproductive System

Figure 6.cc



Male Reproductive System