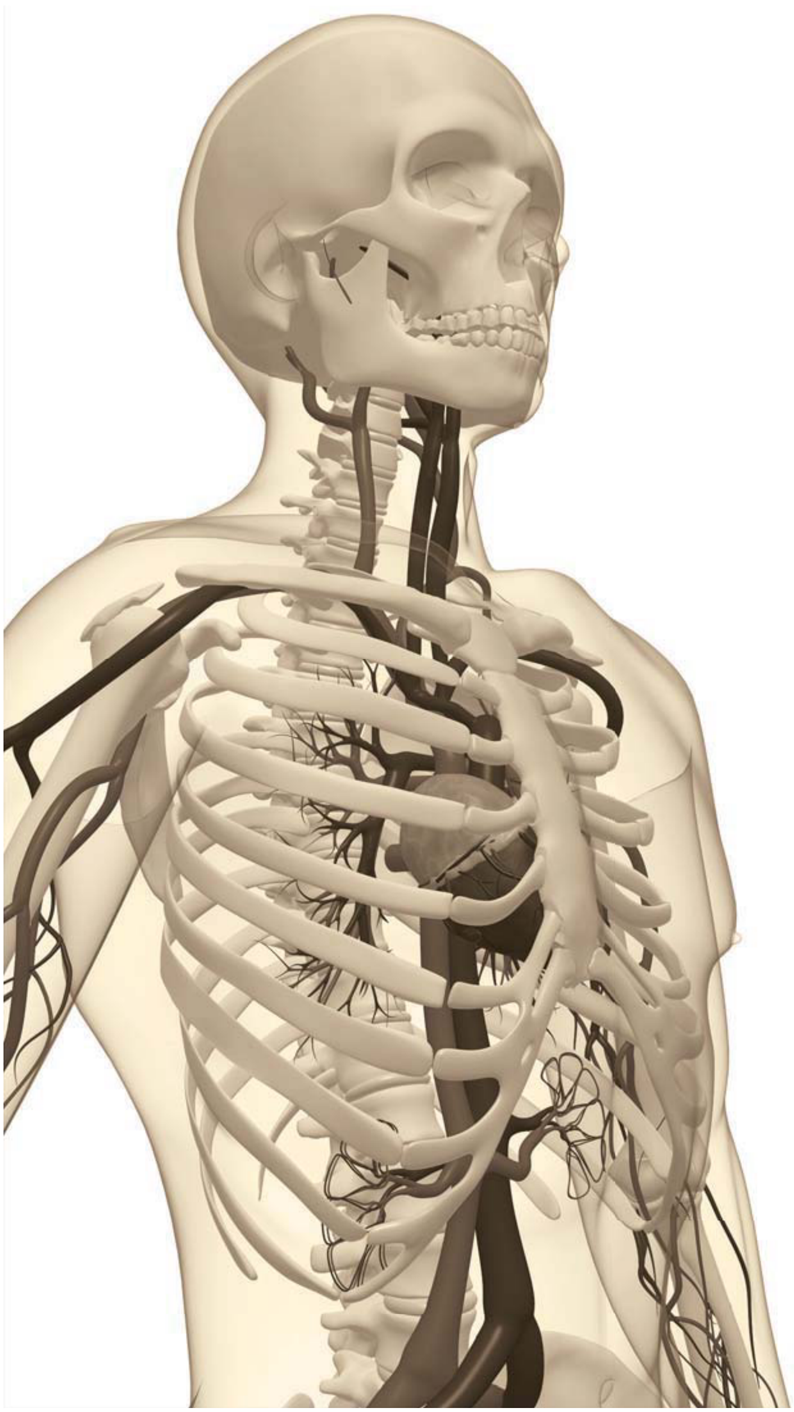
Human Physiological Anatomy
Laboratory Manual



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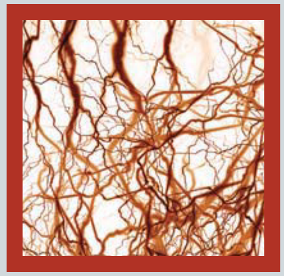

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Introduction

Welcome to Human Physiological Anatomy. This course is designed for students in the Health and Human Services programs. It is an intensive lecture/laboratory course emphasizing the basic concepts and principles of human anatomy and physiology. The purpose of this manual is to assist the student in meeting the laboratory objectives for this course. The laboratory objectives can be found in the course objective handbook available in the bookstore.

This manual is divided into four units that correspond to the four lab practical exams in this course. Your laboratory objectives identify the structures that you are responsible for on each lab practical. You should cross-reference the objectives with the information in each unit of this manual.

This laboratory manual should be used as a guide to help you study the models, charts, and dissected organs in the lab. It is only meant to guide you in your studies.

Each structure in the figures is identified by a number or letter. There is a key for each figure that matches the number or letter to the structure. This design was chosen to allow you to cover the key and test yourself on each figure.

Student Code of Conduct

Students are expected to behave in the following manner in the anatomy lab:

- Students must behave in a mature and responsible manner at all times in the laboratory. All inappropriate behavior is prohibited.
- Students must report any injuries or breakages to the instructor immediately.
- At no time will biological tissue or anatomical models be removed from the laboratory.
- At no time will food or drink be permitted in the laboratory.
- All cell phones and/or pagers must be turned off in the laboratory.
- Using a pen or pencil to point out structures on a model or a chart is strictly prohibited. Writing or circling structures on any charts is strictly prohibited.
- Students must return models to tables if moved during the laboratory session.
- Any keys to models or charts must not be removed from the laboratory. If a student would like a copy of any key, he/she may request one from the instructor.
- All biological tissue will be placed in the appropriate biological waste receptacle. At no time will any other material (e.g., paper products) be placed in this receptacle.
- Students are responsible for cleaning their table after dissections. Students must clean their instruments and dissecting pans. All equipment must be returned to the appropriate area in the laboratory.
- All paper and disposable gloves must be disposed of in the metal trash containers. Do not place paper in the biological tissue containers. Do not use the table sinks as trash receptacles.
- Women who are pregnant or who may become pregnant should discuss the potential risk of dissection and exposure to preservatives with their obstetrician. Material safety data sheets (MSDS) are available.
- Models or displays must not be removed from any practice lab practical. Models from the tables should not be moved and placed into the practice lab practical setup.
- During lab practical exams, students must not touch the models or displays.

I have read and understood the Student Code of Conduct

Student Signature *Date* *Section*

UNIT 1

Fundamentals, Integument, Skeleton, and Muscles

PART 1

Introduction and Fundamentals

To be successful in any field or discipline it is necessary to speak the language. Before learning about tissues, organs and organ systems, it is necessary to learn the correct terminology to adequately describe the structures you will be learning. Trying to discuss anatomy without understanding anatomical terms would be impossible. As you enter the medical field you need to convey information accurately and precisely in terms everyone else in the field can understand.

There are specific terms used to describe direction, parts of the body, cavities of the body, and areas within the cavities. The next sections will help you develop your terminology so you can begin to "talk the talk."

Directional Terms

Directional terms are used to accurately describe the location of a structure or organ. The terms used to describe anatomical directions can usually be paired as opposites.

These directional terms are only meaningful if they are applied consistently. In order to have the terms used the same way by everyone they must be used when the body is in a specific position. This is known as **anatomical position**. Anatomical position is an individual facing forward, feet facing forward, arms at side with palms facing forward.

Table 1.1: Directional Terms

TERM	DEFINITION	EXAMPLE
Anterior	The front, in front of (equivalent to ventral)	The stomach is anterior to the kidney
Distal	Away from or farthest from the point of attachment or origin	The wrist is distal to the shoulder
Dorsal	The back, behind (equivalent to posterior)	The dorsal root ganglion
Inferior	Below or towards the feet	The liver is inferior to the diaphragm
Lateral	At or towards the side	The lungs are lateral to the heart
Medial	Towards the body's midline	The heart is medial to the lungs
Posterior	The back or behind (equivalent to dorsal)	The kidneys are posterior to the liver
Proximal	Towards or closest to the point of attachment or origin	The elbow is proximal to the wrist
Superior	Above or toward the head	The lungs are superior to the diaphragm
Ventral	The abdominal side, in humans the front (equivalent to anterior)	The ventral nerve roots

Body Planes

There are ways to dissect the body in order to observe all structures and organs from different aspects. A body or structure can be dissected to divide it into right and left sides. This is a **sagittal** (SAJ-it-ahl) section. If the division is directly in the midline it may be referred to as a **midsagittal** section. It is possible to dissect a body or a structure to divide it into front and back sections. This is a **frontal** section. The last plane that can be used to divide a body or a structure is to dissect it into top and bottom portions. This is a **transverse** section.

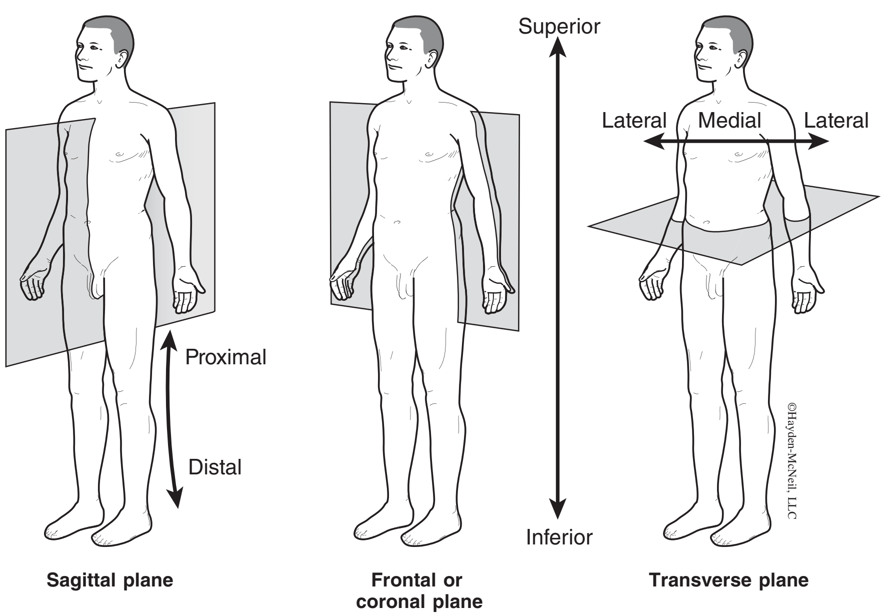


Figure 1.1. Planes of the Body

Regional Terms

Terms that refer to different regions of the body will help you understand where to find structures and organs.

Table 1.2: Regional Terms

TERM	LOCATION	TERM	LOCATION
Abdominal	Abdomen	Gluteal	Buttocks
Antebrachial	Forearm	Inguinal	Groin
Antecubital	Anterior elbow	Lumbar	Lower back
Axillary	Armpit	Palmar	Palm of hand
Brachial	Arm	Patellar	Anterior knee
Buccal	Cheek	Pectoral	Chest
Carpal	Wrist	Pedal	Foot
Caudal	Lower body	Pelvic	Pelvis
Cephalic	Head	Plantar	Sole of foot
Cervical	Neck	Popliteal	Posterior knee
Costal	Ribs	Tarsal	Ankle
Cubital	Posterior elbow	Thoracic	Chest
Femoral	Thigh	Visceral	Organ or viscera

Abdominal Regions

To try and localize areas in the abdomen the abdominal region can be divided into 4 quadrants or 9 regions. The quadrants are referred to as right and left and upper and lower. The four quadrants would be: right upper quadrant, right lower quadrant, left upper quadrant, and left lower quadrant.

The nine regions can be defined by drawing 2 horizontal lines about halfway between the midline and the side of the body and 2 vertical lines, one near the bottom of the ribs and the second near the top of the ribs. The regions down the center of the abdomen have unique names: epigastric (top center region); umbilical (middle center region); and hypogastric (lower center region). The regions on either side of the abdomen have the same names that are differentiated as right and left. These regions are the right and left hypochondriac regions, just below the ribs; the right and left lumbar regions, on either side of the umbilical region; and the right and left iliac or inguinal regions, at the lower boundary of the abdomen. Table 1.3 identifies the regions and the organs or structures that can be found in each region.

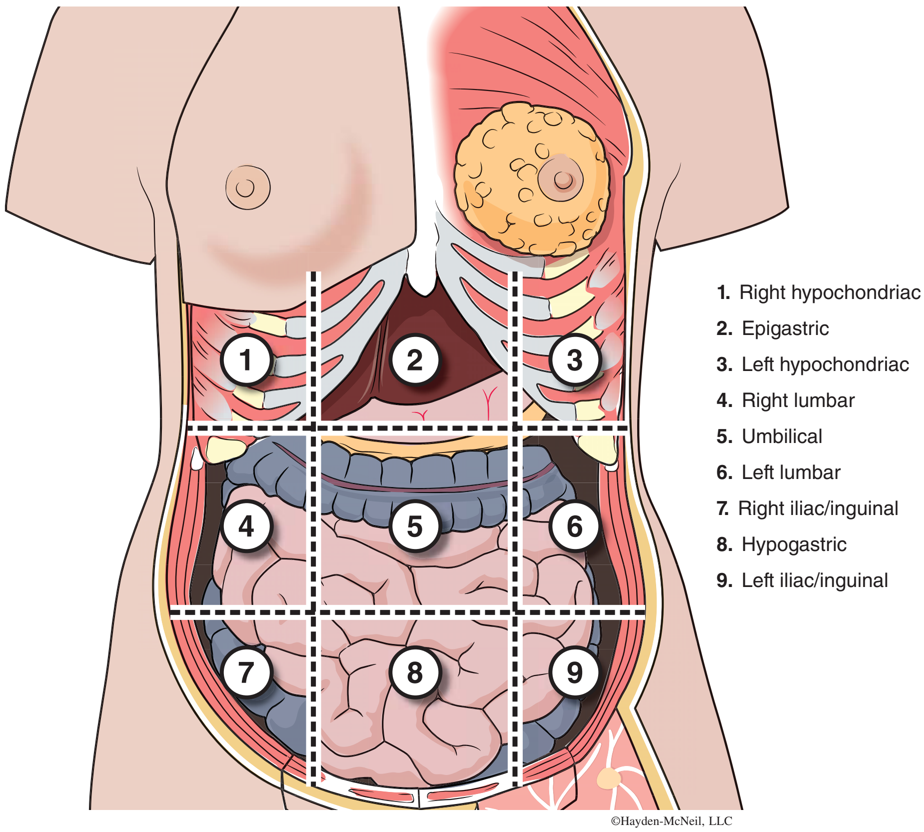


Figure 1.2. Abdominal Regions

Table 1.3: Regions and Their Structures

RIGHT HYPOCHONDRIAC (1)	EPIGASTRIC (2)	LEFT HYPOCHONDRIAC (3)
Right lobe of liver	Pyloric end of stomach	Stomach
Gallbladder	Duodenum/Left lobe of liver	Spleen
Right adrenal gland	Pancreas	Left adrenal gland
RIGHT LUMBAR (4)	UMBILICAL (5)	LEFT LUMBAR (6)
Ascending colon	Omentum	Descending colon
Right kidney	Mesentery	Left kidney
Portion of small intestine	Small intestine	Portion of small intestine
RIGHT ILIAC/INGUINAL (7)	HYPOGASTRIC (8)	LEFT ILIAC/INGUINAL (9)
Cecum of large intestines	Ileum	Sigmoid colon
Appendix	Bladder	Left ureter
Right ovary	Uterus	Left ovary

Body Cavities

All the internal body organs, also known as the **viscera** (VIS-er-ah), are located in cavities. These cavities are usually lined with membranes. There are 2 major cavities: the **dorsal cavity**, which contains the cranial and spinal cavities; and the **ventral cavity**, which contains the **thoracic** (tho-RAS-ik) and **abdominopelvic** (ab-DOM-eh-no-PEL-vik) cavities.

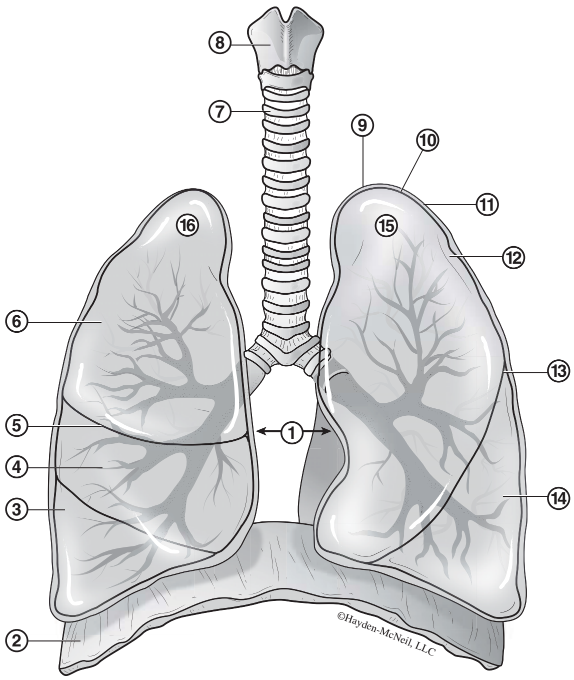
The **cranial cavity** contains the brain and the **spinal cavity** contains the spinal cord. Both of these structures are covered by three membranes known as the meninges.

The **thoracic cavity**, commonly referred to as the chest cavity, is found in the anterior portion of the body. This cavity is in the ventral cavity superior to the diaphragm. The main structures in the thoracic cavity are the lungs and the heart.

Each lung is covered by a double membrane known as the **pleura** (PLOO-ra). The pleura that is closest to the lung is the **visceral** (VIS-er-ahl) **pleura**, while the pleura that lines the rib cage is the **parietal** (pah-RYE-ah-tahl) **pleura** and the fluid-filled virtual space between them is the **pleural cavity**. So each lung is in the pleural cavity within the thoracic cavity.

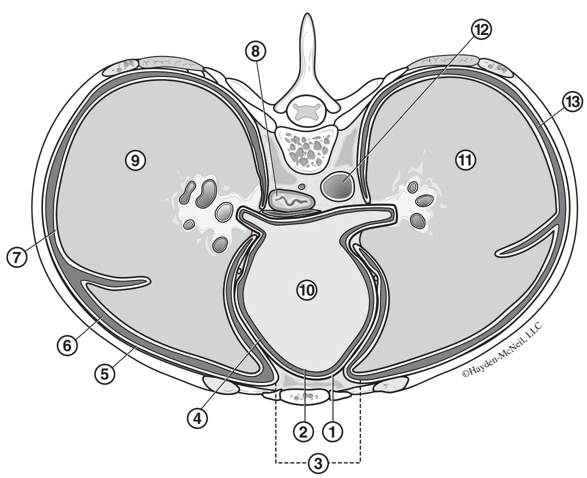
The heart is found between the two lungs in the area known as the **mediastinum** (me-de-ah-STY-num). The heart sits inside a sac called the fibrous pericardium. Lining this sac is a double membrane called the serous pericardium. The membrane closest to the heart is the **visceral pericardium** (PER-eh-KARD-eum), while the membrane lining the pericardial sac is the **parietal pericardium**. As with the lungs the fluid-filled virtual space between the two pericardial membranes is the **pericardial cavity**.

The abdominopelvic cavity is the portion of the ventral cavity that is inferior to the diaphragm. It can be further subdivided into the upper portion, the abdominal cavity, and the lower portion, the pelvic cavity. The abdominal cavity extends from the diaphragm to the area of the bony pelvis. The pelvic cavity is enclosed by the pelvic bones or the **os coxae** (OS COX-ee). The abdominal cavity contains the liver, stomach, spleen, pancreas, gallbladder, and small and large intestines. The pelvic cavity contains the urinary bladder, the sigmoid colon, rectum, and reproductive organs. The double membrane that covers most but not all the organs in the abdominopelvic cavity is the **peritoneum** (per-eh-toe-NEE-um). Just like in the thoracic cavity the membrane closest to the organs is the **visceral peritoneum**, the membrane closer to the abdominal wall is the **parietal peritoneum**, and the virtual space between them is the **peritoneal cavity**. There are abdominal organs that are not covered by the peritoneum. They are located near the posterior wall of the abdominal cavity. The most notable organs are the kidneys. The area containing organs not covered by the peritoneum is the **retroperitoneal space** (RET-row-per-eh-toe-NEE-al).



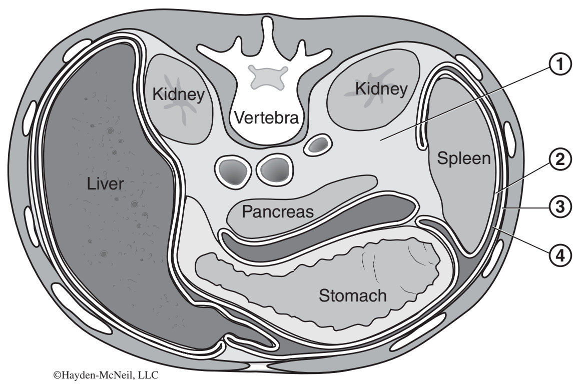
1. Mediastinum
2. Diaphragm
3. Right lower lobe
4. Right middle lobe
5. Horizontal fissure
6. Right upper lobe
7. Trachea
8. Larynx
9. Parietal pleura
10. Visceral pleura
11. Pleural cavity
12. Left upper lobe
13. Oblique fissure
14. Left inferior lobe
15. Left lung
16. Right lung

Figure 1.3. Frontal View of Thorax



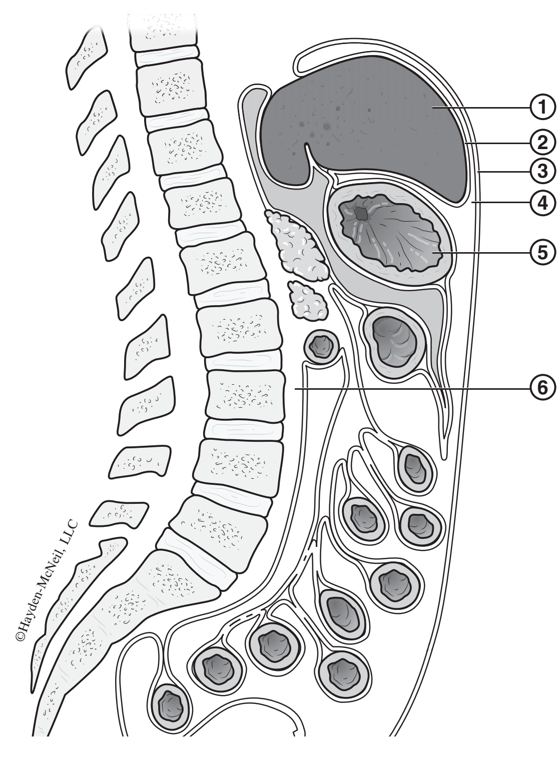
1. Parietal pericardium
2. Visceral pericardium
3. Mediastinum
4. Pericardial cavity
5. Parietal pleura
6. Right pleural cavity
7. Visceral pleura
8. Esophagus
9. Right lung
10. Heart
11. Left lung
12. Descending aorta
13. Left pleural cavity

Figure 1.4. Transverse View of Thorax



1. Retroperitoneal space
2. Visceral peritoneum
3. Parietal peritoneum
4. Peritoneal cavity

Figure 1.5. Transverse View of Abdomen



1. Liver
2. Visceral peritoneum
3. Parietal peritoneum
4. Peritoneal cavity
5. Stomach
6. Retroperitoneal space

Figure 1.6. Sagittal View of Abdomen

Transport Mechanisms

Cells must have an ability to move materials in and out through the plasma membrane. Depending on the nature and size of the materials they may move passively by diffusion or osmosis.

Diffusion

Diffusion is the movement of materials from an area of high concentration to an area of low concentration. Diffusion does not require a cell membrane, it can occur in any medium. You can observe diffusion by adding a dye, methylene blue, to a container of water. Gradually the blue color will disperse through the whole container.

Another way to observe diffusion over a much longer period of time is to use a denser medium than water. Adding methylene blue to a test tube of gel will allow you to observe diffusion over a period of weeks. The gel is thicker than water so it will take much longer for the color to disperse.

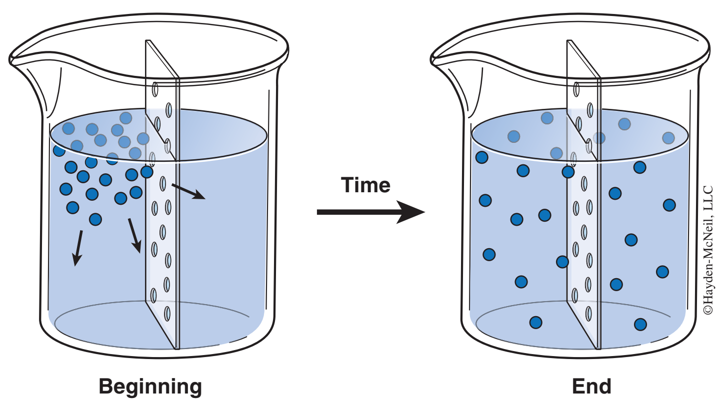


Figure 1.7. Process of Diffusion

Osmosis

Osmosis is a special type of diffusion. Osmosis is the diffusion of water through a selectively permeable membrane from an area of high concentration of water, low concentration of solute to an area of low concentration of water, high concentration of solute. The solute cannot move through the membrane. This can result in a change of volume of the cell.

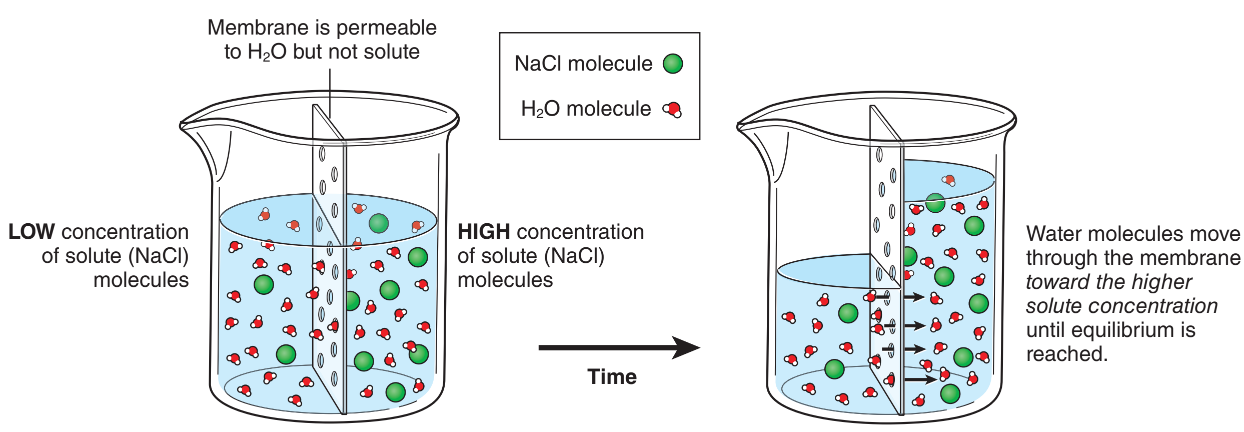


Figure 1.8. Process of Osmosis

The principle of osmosis can be observed using a thistle tube setup. A solution with a high concentration of sugar and low concentration of water is placed in the thistle tube and a selectively permeable membrane is placed across the bottom of the thistle tube. When the thistle tube is lowered into a container that contains water, water will move from the beaker (higher concentration of water) into the thistle tube (lower concentration of water). You will be able to observe this water movement by watching the upward movement of the solution in the thistle tube. The force that causes the increase in the solution volume in the thistle tube is osmotic pressure.

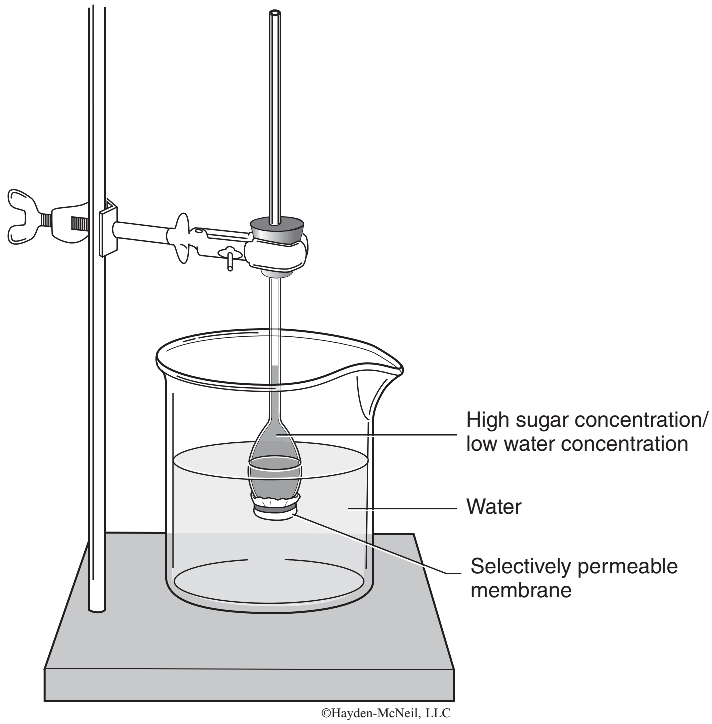


Figure 1.9. Osmometer

Part 2

The Integument

The **integument** (in-TEG-you-ment) is the skin. This is an important organ. It is the body's first line of defense. The skin consists of two distinct tissue layers. The superficial layer, the epidermis, consists of many thin layers of epithelial tissue, and the deeper layer, the dermis, is connective tissue.

The epidermis reproduces cells at the bottom layer and the cells move upward. As the cells progress through the layers of the epidermis they change and eventually die as they reach the surface. At this point they are shed.

The dermis is frequently referred to as the "true skin." In the dermis are all the structures that are frequently associated with skin. Structures found in the dermal layer include: hair follicles, sweat and sebaceous glands, blood vessels, and nervous tissue to name a few.

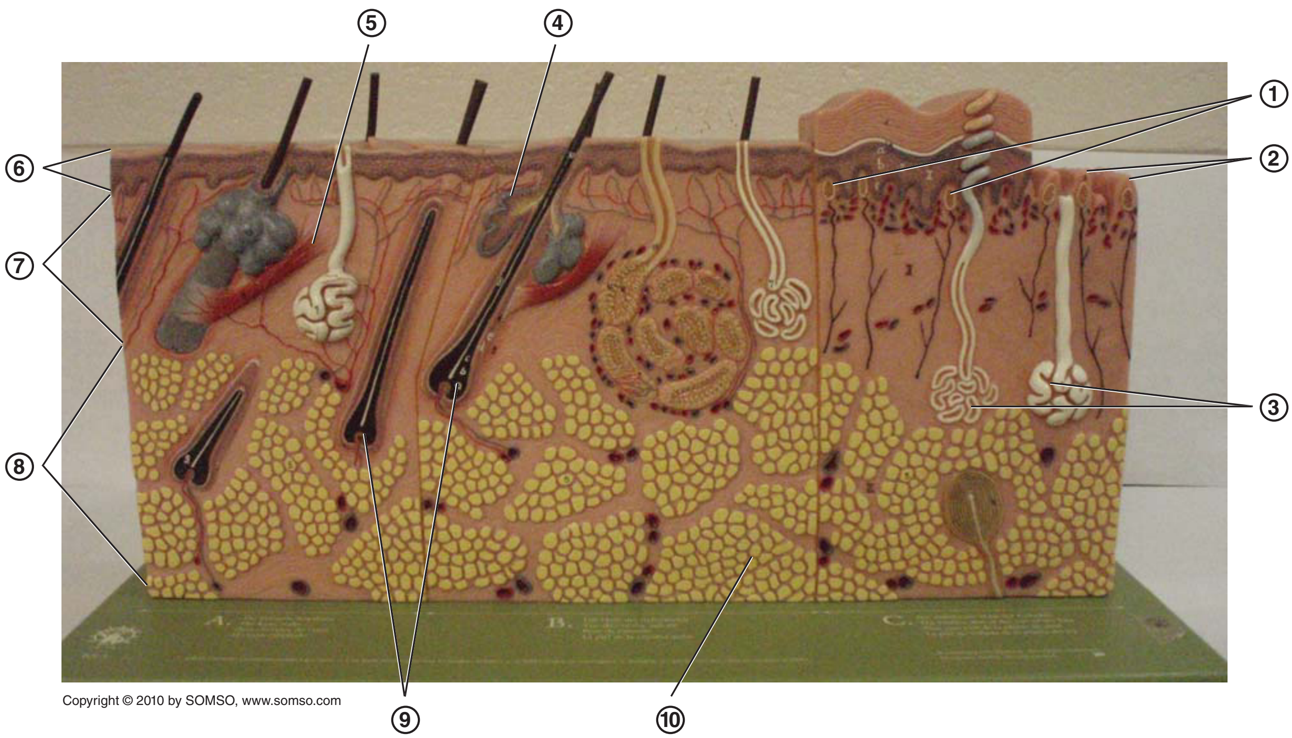
At the junction of the epidermis and dermis there are fingerlike projections: the dermal **papillae** (pah-PIL-ah). These papillae are responsible for ridges that are visible on the fingertips, palms, and soles. The patterns of the ridges are responsible for your fingerprints, palm prints, and footprints. They can be used for identification because the pattern is unique in each individual. However, the function is not identification. Dermal papillae function in grip. These ridges allow our hands and feet to grip surfaces and items.

The hair follicle consists of epidermal tissue that extends down into the dermis. Associated with the hair follicle is the arrector **pili** (PIE-lie) or (PILL-ee) muscle. When this muscle contracts it causes the hair to stand more upright and results in "goose pimples." Frequently associated with the hair follicles are the **sebaceous** (sah-BAY-shus) glands. These glands produce **sebum** (SEE-bum), an oily secretion that helps keep the hair and skin pliable and contributes to the waterproof nature of the skin. In some areas sebaceous glands may open directly to the skin.

Sweat or **sudoriferous** (sood-ah-RIF-ah-rahus) glands are found in the dermis. There are two types of sweat glands. **Eccrine** (EK-rahn) or (EK-ryne) sweat glands are found all over the body and respond to changes in body temperature. As the sweat evaporates from the skin the body is cooled. Eccrine sweat glands are active throughout life. **Apocrine** (AP-ah-crahn) or (AP-ah-cryne) sweat glands are only found in select sites in the body and become active at puberty. The secretion of these sweat glands is metabolized by skin bacteria.

Several different types of receptors are also present in the dermis. These receptors take many forms and are responsible for monitoring temperature, pressure, vibration, touch, pain, and other sensory input.

The layer below the dermis is known as the hypodermis or subcutaneous layer. This layer serves to attach the skin to the underlying structures. In the subcutaneous layer there are major blood vessels that supply the skin and adipose tissue, which provides the body with insulation. There is not a distinct border between the dermis and the subcutaneous layer.



1. **Receptors (nervous tissue)**
2. **Dermal papillae**
3. **Sweat (sudoriferous) glands**
4. **Sebaceous gland**
5. **Arrector pili muscle**
6. **Epidermis**
7. **Dermis**
8. **Hypodermis (subcutaneous tissue)**
9. **Hair follicles**
10. **Adipose tissue**

Figure 1.10. Skin Model

Part 3

The Skeleton

This section will look at bone tissue, the structure of the long bone, and the skeleton. It is necessary to be able to identify the bones and their markings before moving on to the muscles. Since muscle names may include bones or markings it is helpful in identifying the muscle if a student is familiar with the skeleton first.

Section A – Bone Tissue and Long Bone Structure

Bone Tissue

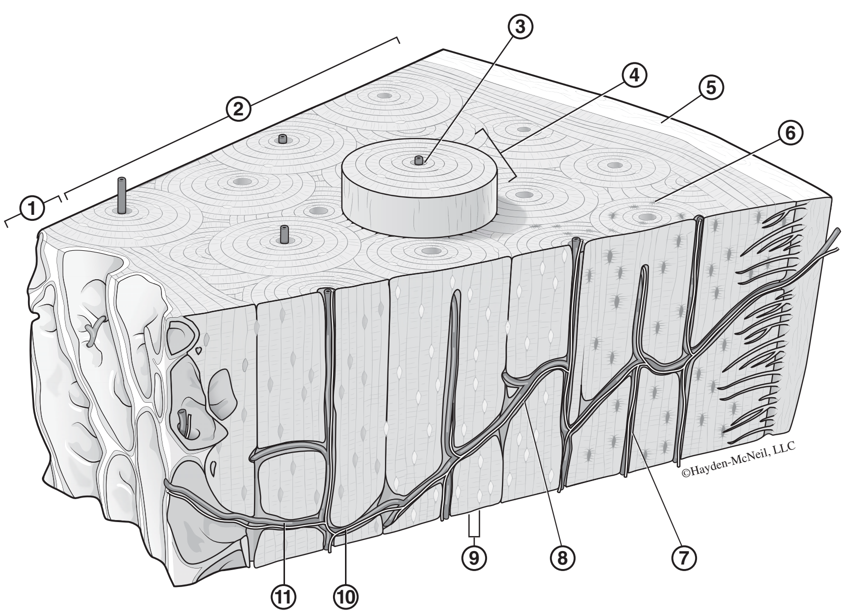
Bone is a connective tissue, which means it contains matrix. Matrix is the extracellular material in the tissue. There are two types of bone based on structure: compact bone and **cancellous** (KAN-silahs) or spongy bone.

Compact bone is found on the surface of all bones and is the bone tissue in the shafts of long bone. It has a very regular pattern of **osteons** (os-TEE-on), the fundamental unit of compact bone. The structures of the osteon include the central or osteonic canal, lamellae, osteocytes, lacuna, canaliculi, and perforating canals.

The **central** or **osteonic canal** contains blood vessels and lymphatics. The **lamellae** (lah-MEL-ah) are the concentric rings of matrix. The **osteocytes** (OS-te-o-sites) are bone cells sitting in **lacunae** (lah-KU-nah), which are depressions in the matrix. The osteocytes are responsible for maintaining the matrix. The **canaliculi** (KAN-AHLIK-yahlie) are small channels that allow extensions of the osteocytes to make contact with each other. The **perforating canal** allows communication between the central canals of osteons.

Cancellous bone, also known as spongy bone, is found on the interior of all short, flat, and irregular bones as well as in the ends of long bones. Spongy bone is not composed of osteons. This bone tissue has spike-like structures known as **trabeculae** (trah-BEK-u-lah).

The compact bone tissue may be seen under the microscope. In the laboratory a microscopic demonstration of the osteon will be available for all students.



1. Spongy bone
2. Compact bone
3. Osteonic canal (central canal) containing vessels and nerves
4. Osteon
5. Periosteum
6. Osteocyte in lacuna
7. Osteonic canal
8. Perforating canal (Volkmann's canal)
9. Lamella (matrix)
10. Nerve
11. Blood vessel

Figure 1.11. Compact Bone Tissue

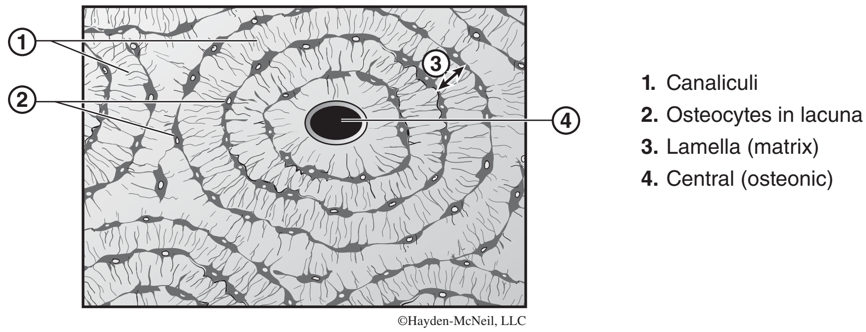


Figure 1.12. Structure of Osteon

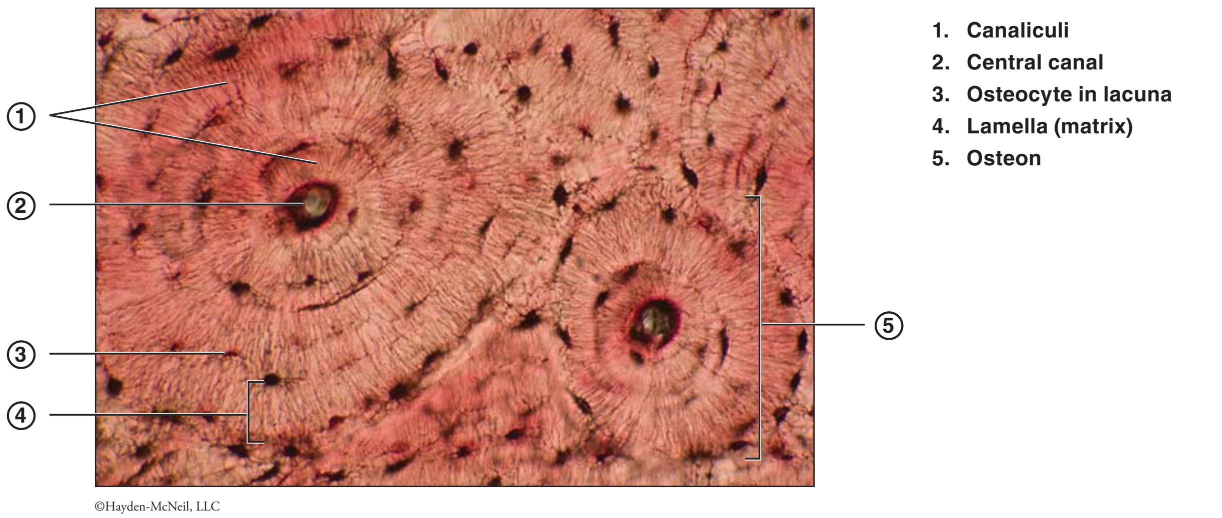


Figure 1.13. Compact Bone Slide

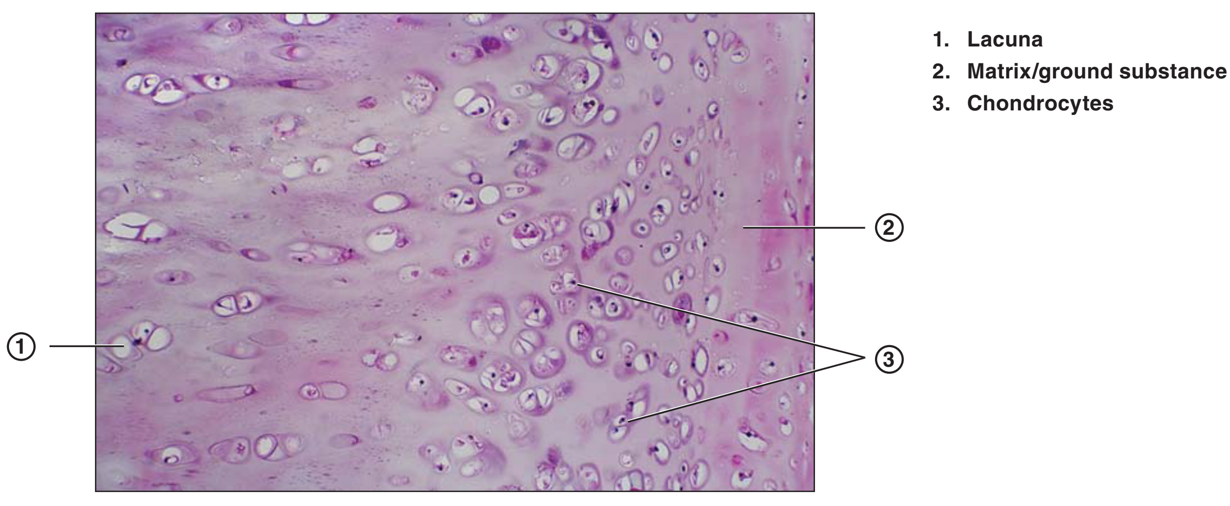


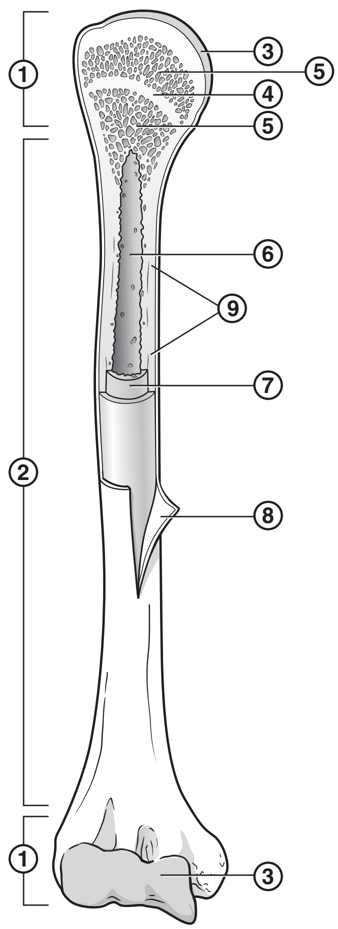
Figure 1.14. Hyaline Cartilage Slide

Structure of Long Bone

Long bones have a shaft called the **diaphysis** (die-AF-ah-sis). The shaft and the covering of the bone is compact bone. At each end of the shaft there is an enlarged portion called the **epiphyses** (ah-PIF-uh-seez). While children are growing there is a layer of cartilage between the diaphysis and the epiphyses, this is called the **epiphyseal plate** (epi-FIZZ-ee-ul). As children reach their adult height the cartilage is replaced by bone tissue and becomes the epiphyseal line. The outer surface of the ends is compact bone but inside these enlarged ends is cancellous bone. Covering the end of each epiphysis in living bone is an **articular cartilage** because these ends form articulations or joints with other bones.

Inside the diaphysis is a **medullary cavity** (MED-ular-ee KAV-ah-te) which contains marrow. In adults this marrow is yellow because it is not actively producing blood cells; in children it is red because it is producing blood cells. Lining the medullary cavity in living bone is the **endosteum** (end-OS-tee-um), a thin membrane. This membrane contains osteoblasts and osteoclasts. It also covers the surface of trabeculae in spongy bone. Covering the outside of living bone is a tough, fibrous **periosteum** (PER-ee-OS-tee-um). The periosteum assists in the formation and repair of bone tissue and contains osteoblasts as well as osteoclasts.

Bones have many grooves, depressions, and other types of bone markings where muscles attach or joints form. It is helpful to know the terminology before starting to look for these markings.



1. Epiphysis
2. Diaphysis
3. Articular cartilage
4. Epiphyseal line
5. Cancellous (spongy) bone
6. Medullary cavity
7. Endosteum
8. Periosteum
9. Compact bone

Figure 1.15. Structure of Long Bone

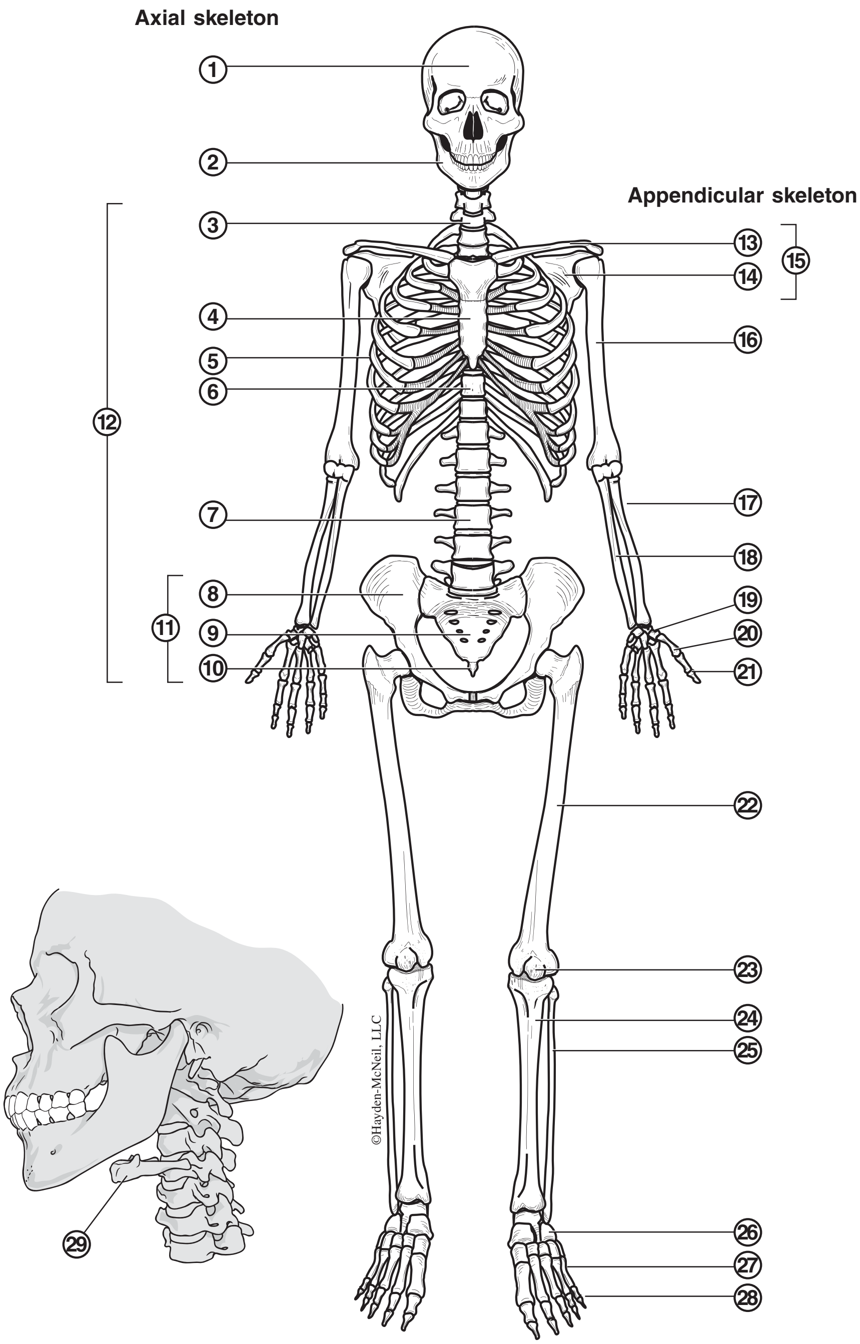
Table 1.4: Bone Markings

Term	Description	Example
Condyle	Rounded articular projection	Condyles of femur
Crest	Narrow ridge of bone; usually prominent	Iliac crest
Epicondyle	Raised area on or above a condyle	Medial epicondyle of humerus
Facet	Smooth, nearly flat articular surface	Vertebral facet
Fissure	Narrow, slit-like opening	Inferior orbital fissure
Foramen pl. foramina	Round or oval opening through a bone	Foramen magnum of occipital bone
Fossa	Shallow, basin-like depression in a bone, often serving as an articular surface	Mandibular fossa of temporal bone
Groove	Furrow	Intertubercular groove
Head	Bony expansion carried on a narrow neck	Head of femur
Line	Narrow ridge of bone; less prominent than a crest	Ileopectineal line
Meatus	Canal-like passage	External auditory meatus
Process	Prominence or projection	Zygomatic process
Ramus	Arm-like bar of bone	Mandibular ramus
Sinus	Space within a bone, filled with air & lined with mucous membrane	Frontal sinus
Spine	Sharp, slender, often pointed projection	Anterior superior spine of ilium
Trochanter	Very large, blunt, irregularly shaped process	Greater trochanter of femur
Tubercle	Small rounded projection or process	Greater tubercle of humerus
Tuberosity	Large rounded projection; may be roughened	Ischial tuberosity

Section B – Appendicular Skeleton - Upper Limb

When discussing the skeleton it can be divided into two main groups: the **axial** (AK-se-al) skeleton and the **appendicular** (ap-en-DIK-u-lar) skeleton. The axial skeleton is made up of the bones that are found down the center of the skeleton. The appendicular skeleton is made up of the bones that are involved in the appendages or the arms and legs.

Before studying individual bones it is helpful to learn the position of each bone in the skeleton. After learning where each bone is located then move on to the bones of the appendicular skeleton.



1. Skull
2. Mandible
3. Cervical vertebra
4. Sternum
5. Ribs
6. Thoracic vertebra
7. Lumbar vertebra
8. Pelvis (os coxae)
9. Sacrum
10. Coccyx
11. Pelvic girdle
12. Vertebral column
13. Clavicle
14. Scapula
15. Pectoral girdle
16. Humerus
17. Radius
18. Ulna
19. Carpals
20. Metacarpals
21. Phalanges
22. Femur
23. Patella
24. Tibia
25. Fibula
26. Tarsals
27. Metatarsals
28. Phalanges
29. Hyoid

Figure 1.16. Skeleton

The appendicular skeleton consists of the bones associated with the limbs. In the upper limb this would include the bones of the arm, forearm, wrist, hand, as well as the bones that make up the pectoral girdle—the scapula and the **clavicle**.

The **scapula** (SKAP-u-la) is also known as the shoulder blade. It is held in place by muscles so the scapula is not normally fractured. It articulates with the clavicle to form the pectoral girdle.

On the upper lateral edge is the **glenoid** (GLEE-noyd) **cavity**. This is the articulation point for the head of the humerus. On the posterior surface is a ridge called the **spine** of the scapula. The spine runs from the medial or vertebral margin to the acromion process at the lateral end. There is a depression above the spine that is called the **supraspinous fossa**, and a depression below the spine that is called the **infraspinous fossa**.

The edge of the scapula nearest the vertebral column is known as the **medial** or **vertebral margin**. The edge of the scapula opposite the medial margin is known as the **lateral** or **axillary** (AK-sahler-ee) **margin**.

The **acromion** (ah-CRO-me-on) process is a broad, flat process at the end of the scapular spine. It articulates with the clavicle. On the anterior surface of the scapula, projecting anterior to the glenoid cavity is the **coracoid** (COR-uh-coyd) process which is an attachment point for some of the muscles of the arm.

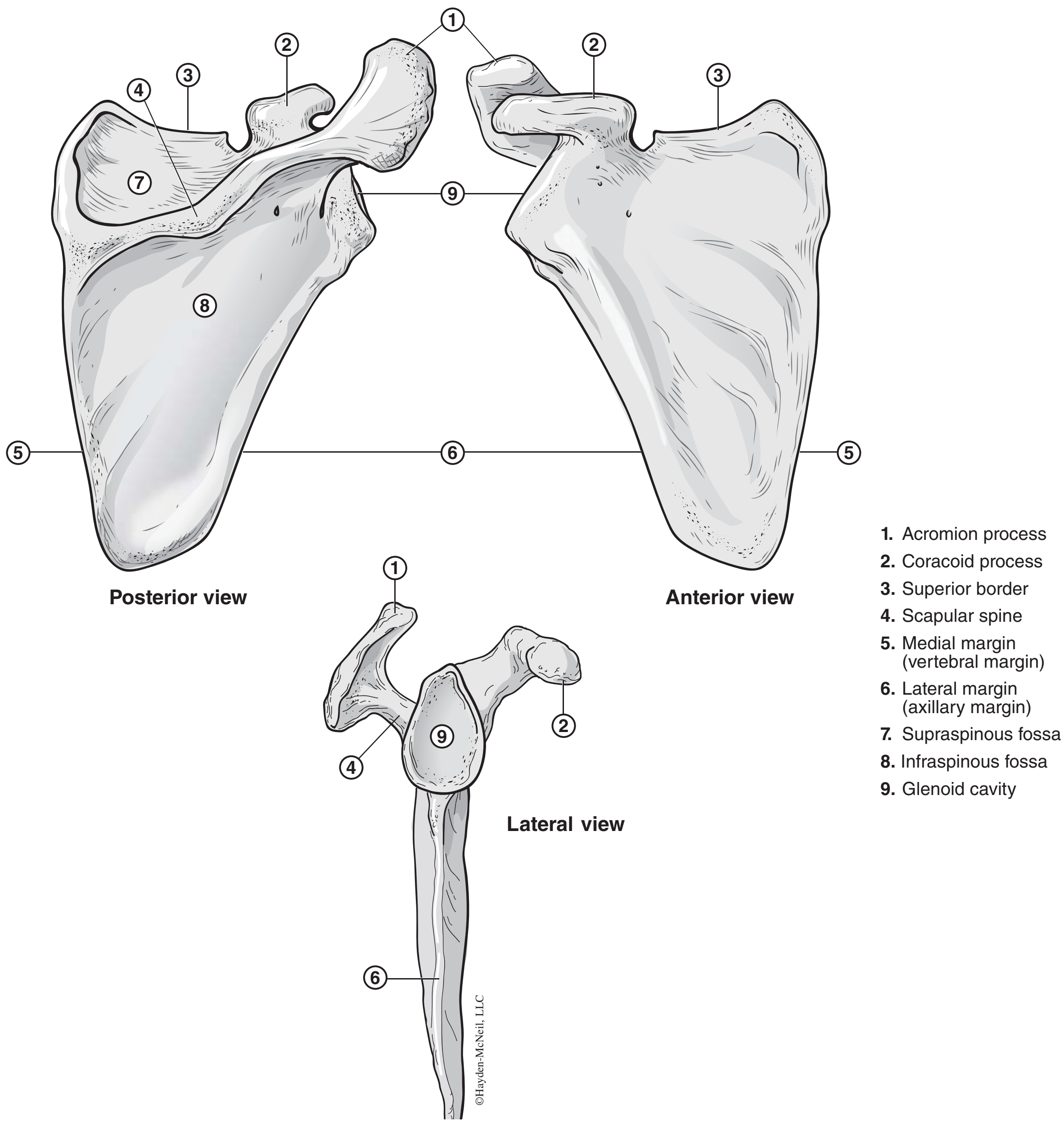


Figure 1.17. Posterior, Anterior, and Lateral Scapula

The **clavicle** is an "S" shaped bone that is also known as the collarbone. It articulates with the manubrium of the sternum on the medial end and with the acromion process of the scapula on the lateral end.

The **humerus** is the bone of the upper arm. The **head** of the humerus is a smooth, rounded end that articulates with the glenoid cavity of the scapula to form the shoulder joint. Just below the articular surface of the head is the **anatomical neck** of the humerus. The **surgical neck** is the site where fractures frequently happen. It is located inferior to the greater and lesser tubercles.

There are two projections on the proximal end of the humerus that serve as attachment sites for the muscles of the rotator cuff. The larger projection is called the **greater tubercle** (TOO-burk-ul). It is found on the proximal lateral surface of the humerus. The smaller projection is called the **lesser tubercle**. It is found on the proximal anterior surface of the humerus. A roughened process on the lateral surface about mid-shaft of the humerus is the **deltoid tuberosity** (TOO-ber-os-ity), which is so named because it is the insertion site of the deltoid muscle.

On the distal end of the humerus there are several processes and a couple depressions that either act as attachment sites for muscles or serve as articulation points in the elbow. On the medial distal surface there is the grooved process called the **trochlea** (TROW-klee-ah) that articulates with the ulna. Above the trochlea is a knob-like projection that is known as the **medial epicondyle** (EP-IKON-dahl). Several flexor muscles of the forearm attach here. The tendons of these muscles can become inflamed and can be one of the causes of "tennis elbow" which can also be called epicondylitis.

On the lateral distal surface of the humerus is a rounded process called the **capitulum** (KAHPICH-uhlum). This process articulates with the head of the radius. Above the capitulum is a knob-like projection similar to the one above the trochlea. This is the **lateral epicondyle**. Several extensor muscles of the forearm attach to this epicondyle. The tendons of these muscles can become inflamed just like the tendons of the flexor muscles. This could also be a cause of "tennis elbow."

On the anterior surface of the humerus, superior to the trochlea, there is a depression called the **coronoid** (CAW-rahnoyd) **fossa** (FOS-ah). When the arm is flexed the coronoid process of the ulna fits into this fossa of the humerus.

On the posterior distal surface of the humerus there is another depression known as the **olecranon** (uh-LEC-rah-non) **fossa**. When the arm is extended the olecranon process of the ulna fits into this depression.

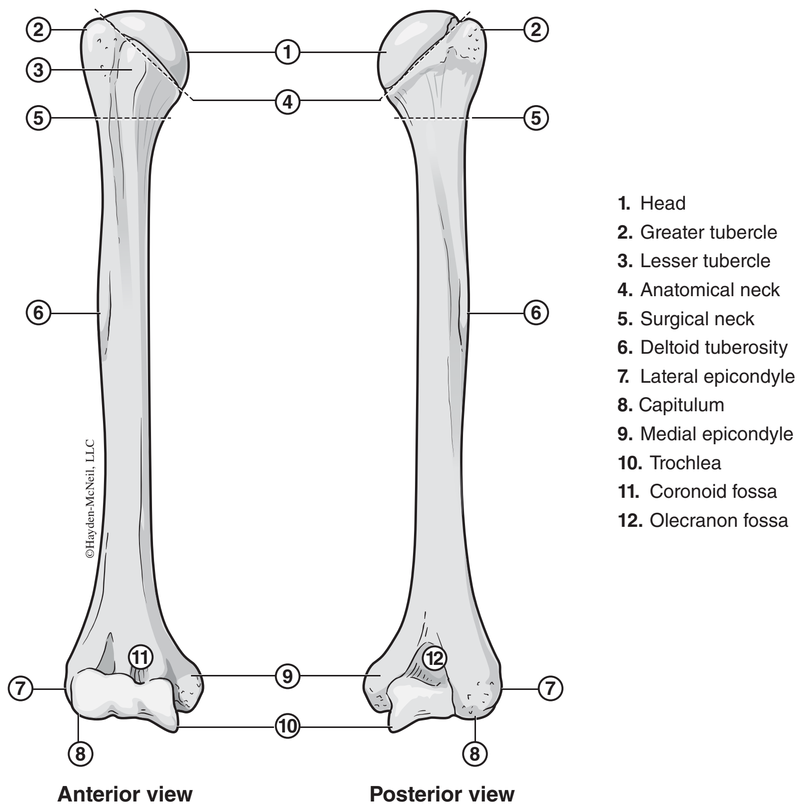


Figure 1.18. Anterior and Posterior Humerus

The **ulna** is the medial bone in the forearm when the arm is in anatomical position. It articulates proximally with the trochlea of the humerus and the head of the radius and distally with the ulnar notch of the radius.

On the posterior proximal end of the ulna is the **olecranon process**. This process is the insertion site for the triceps brachii. The olecranon process fits into the olecranon fossa of the humerus when the forearm is extended. Below the olecranon process is the **trochlear** or **semilunar notch** which articulates with the trochlea of the humerus.

On the anterior proximal end of the ulna is the **coronoid process**. This process is the insertion site for the brachialis muscle. The coronoid process fits into the coronoid fossa of the humerus when the forearm is flexed.

On the lateral proximal end of the ulna is the **radial notch**. This depression allows the head of the radius to rest against the ulna. This articulation allows the radius to rotate and cross over the ulna. This movement is necessary for pronation of the hand.

On the distal end is the **head** of the ulna. This is a rounded structure that articulates with the radius. On the medial distal end of the ulna is the **stylus** or **styloid process**, a small pointed projection. This is the bump that can be palpated on the medial surface of the wrist.

The **radius** is the bone on the lateral side of the forearm when in anatomical position. The rounded proximal end of the radius that articulates with the ulna is the **head** of the radius. The **neck** of the radius is the constricted area distal to the head.

On the anteromedial surface of the radius there is a roughened area called the **radial tuberosity** (TOO-BAHROS-itee). This is the insertion point of the biceps brachii muscle.

On the lateral surface of the distal end of the radius there is a pointed projection known as the **stylus** or **styloid** (STY-loyd) **process** of the radius. This is the bump felt on the lateral surface of the wrist.

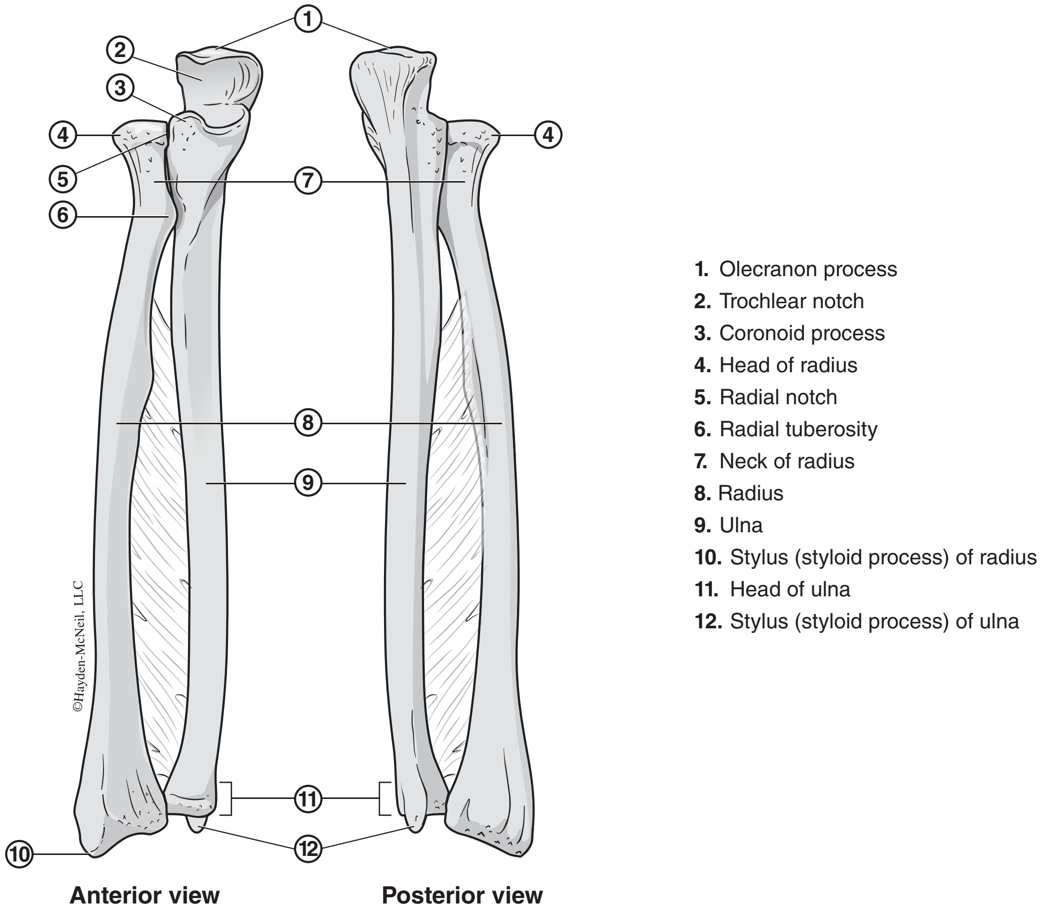


Figure 1.19. Anterior and Posterior Radius and Ulna

The bones of the wrist are known as the **carpal bones**. There are 8 of these bones arranged in two rows. Proximally these bones articulate with the ulna and radius. Distally they articulate with the metacarpals. The bones of the palm of the hand are called the **metacarpal** (MET-ah-KAR-pahl) **bones**. There are 5 of these bones. These articulate distally with the **phalanges** (fah-LAN-jeez), the bones of the fingers. There are a total of 14 phalanges in each hand. The thumb has two phalanges and each finger has three phalanges.

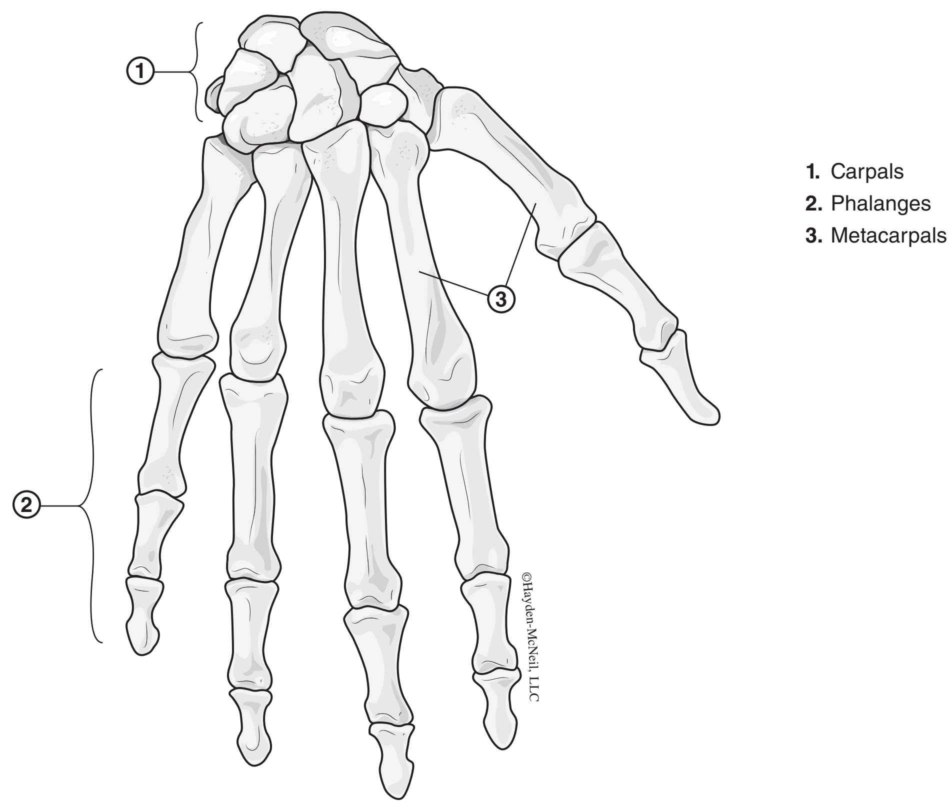


Figure 1.20. Bones of Hand

Section C – Appendicular Skeleton - Lower Limb

The appendicular skeleton of the lower limb includes the bones of the thigh, leg, ankle, foot, as well as the bones that make up the pelvis—the os coxae (OS COX-ee).

Each **os coxa**, or the hip bone, is formed by the fusion of three bones, the **ilium** (ILL-ee-um), **ischium** (ISS-kee-um) and **pubis** (PYOU-bis). The two os coxae are fused posterior to the sacrum and coccyx. This forms the **pelvic girdle**.

The ilium is the largest and most superior of the three bones. The pubis is the anterior portion of the os coxa and the ischium is the lowest portion of the os coxa. The three bones come together to form a cup-like structure known as the **acetabulum** (ASS-AHTAB-yahlum). This depression or cup on the lateral surface of the os coxa holds the ball-shaped head of the femur to form the hip joint.

The superior margin of the ilium is called the **iliac crest**. When placing the hands on the hips they rest on the iliac crests. On the posterior surface of the ilium it articulates with the sacrum at the **sacroiliac** (SAK-ro-IL-ee-ak) **joint**.

On the lateral surface of each ilium there are two projections. The uppermost, which is at the lateral end of the iliac crest, is called the **anterior superior iliac spine**. This is the attachment of the origin of the sartorius muscle. Below this the next projection is called the **anterior inferior iliac spine**. The projection ends just above the superior edge of the acetabulum. It is an attachment point for the rectus femoris.

On the posterior medial surface of each ilium, at the medial end of the iliac crest, there is a projection known as the **posterior superior iliac spine**. Below this projection is another projection called the **posterior inferior iliac spine**. Both these spines are on the posterior surface of the sacroiliac articulating surface.

Just below the posterior inferior iliac spine is the **greater sciatic** (sye-AT-ik) **notch**. This is a point of passage for a number of nerves and blood vessels.

The pubis is the anterior part of the pelvis on both sides. The pubic bones of each side meet anteriorly at a cartilaginous joint called the **symphysis pubis** (SIM-fie-sis PYOU-bis). The pubis has superior and inferior branches or rami that fuse with two rami of the ischium to form the **obturator foramen** (FORAY-mahn).

The ischium is the posterior, inferior portion of the pelvis. Rami of the ischium fuse with the pubis, as mentioned above. There is a rough projection on the lower portion of the ischium known as the **ischial tuberosity**. It is this projection that the body rests on when sitting. It is also the point of origin for the hamstring muscles of the thigh. Above the ischial tuberosity is a pointed projection called the **ischial spine**. It is just above the lesser sciatic notch.

Table 1.5: Differences between Female and Male Pelvis

Name of Bone	Female	Male
Obturator foramen	Oval	Round
Sacrum	Wider, shorter, accentuated sacral curve	Narrow, longer
Coccyx	More movable, straighter	Less movable, curves ventrally
Pelvic inlet	Wider, oval	Narrower, heart shaped
Pelvic outlet	Wider, ischial tuberosity shorter and farther apart	Narrower, ischial tuberosity longer, sharper, and point medially

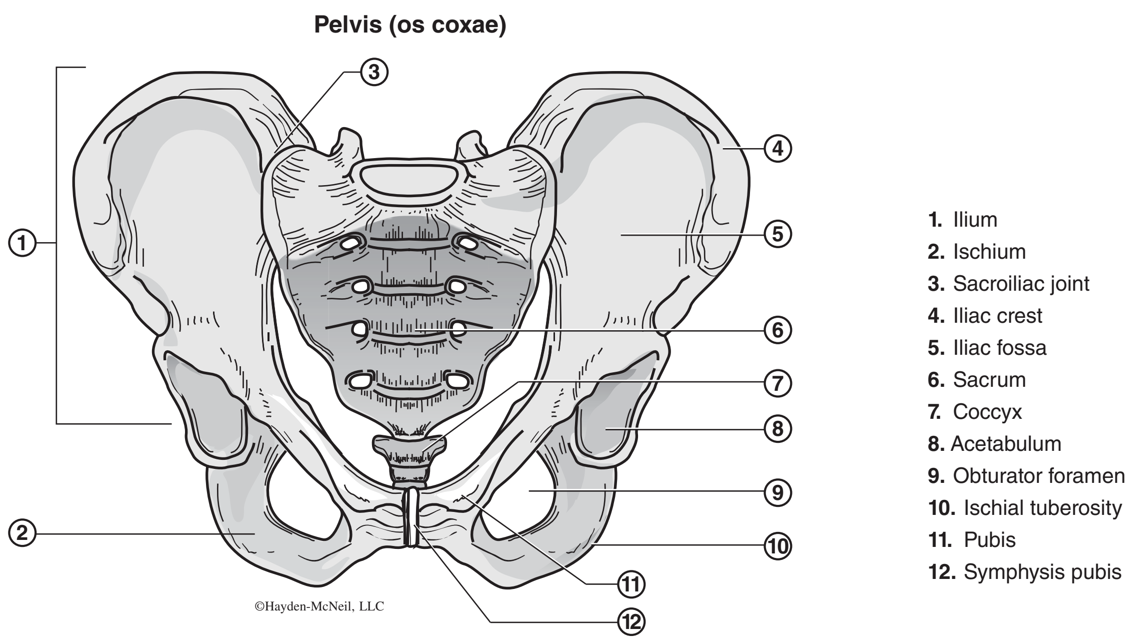


Figure 1.21. Anterior View of Pelvis

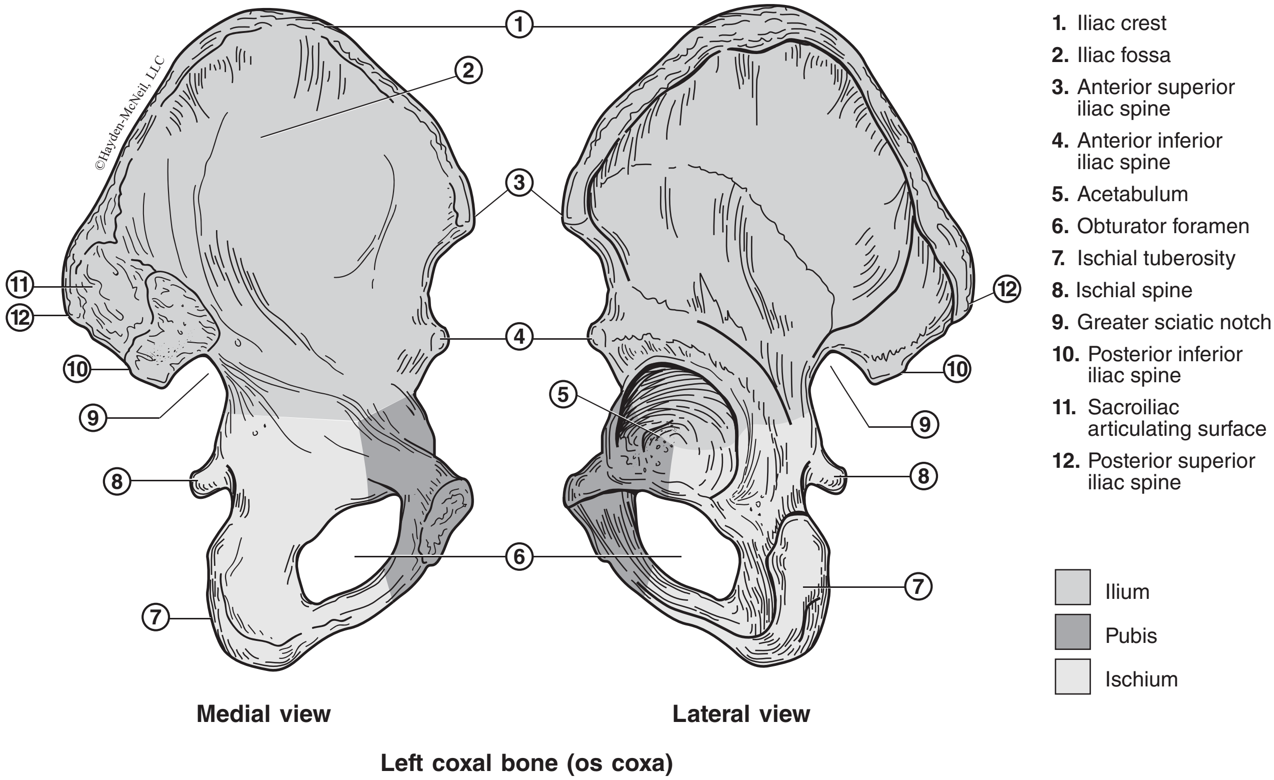


Figure 1.22. Medial and Lateral View of Left Coxal Bone

The **femur** is the longest, heaviest, and strongest bone in the body. It is the bone of the thigh. It has a rounded ball-like **head** that articulates with the acetabulum of the pelvis. Extending laterally from the head is the **neck** of the femur. This connects the head with the shaft. This neck is the weakest part of the femur and is the most common site of a "broken hip."

The **greater trochanter** (TRO-kan-tur) is a large process that projects superiorly from the junction of the neck and shaft of the femur. It is on the lateral surface of the bone. It is an insertion site for some of the muscles of the pelvis and buttocks. On the medial surface of the femur is a smaller projection known as the **lesser trochanter**. This is the insertion site of the psoas major and iliacus muscles. There is a roughened ridge on the lateral surface extending from the base of the greater trochanter, this is the **gluteal** (GLUE-tee-ul) **tuberosity**. This is an insertion site for the gluteus maximus.

On the distal end of the femur are two large rounded processes. On the medial surface is the **medial condyle** and on the lateral surface is the **lateral condyle**. These condyles articulate with the condyles of the tibia. Superior to the condyles are the **medial epicondyle** and **lateral epicondyle**. These are attachment points for ligaments and muscles.

On the anterior distal end there is a smooth **patellar surface** where the femur articulates with the patella or the kneecap.

The **patella** (PAH-tell-ah) is the bone that forms the kneecap. This bone is embedded in the tendon of the quadriceps femoris muscle. As a result of being embedded in the tendon it is classified as a **sesamoid** (SES-ah-moyd) bone. The patella protects the knee joint anteriorly. It also improves the leverage of the thigh muscles that extend across the knee joint.

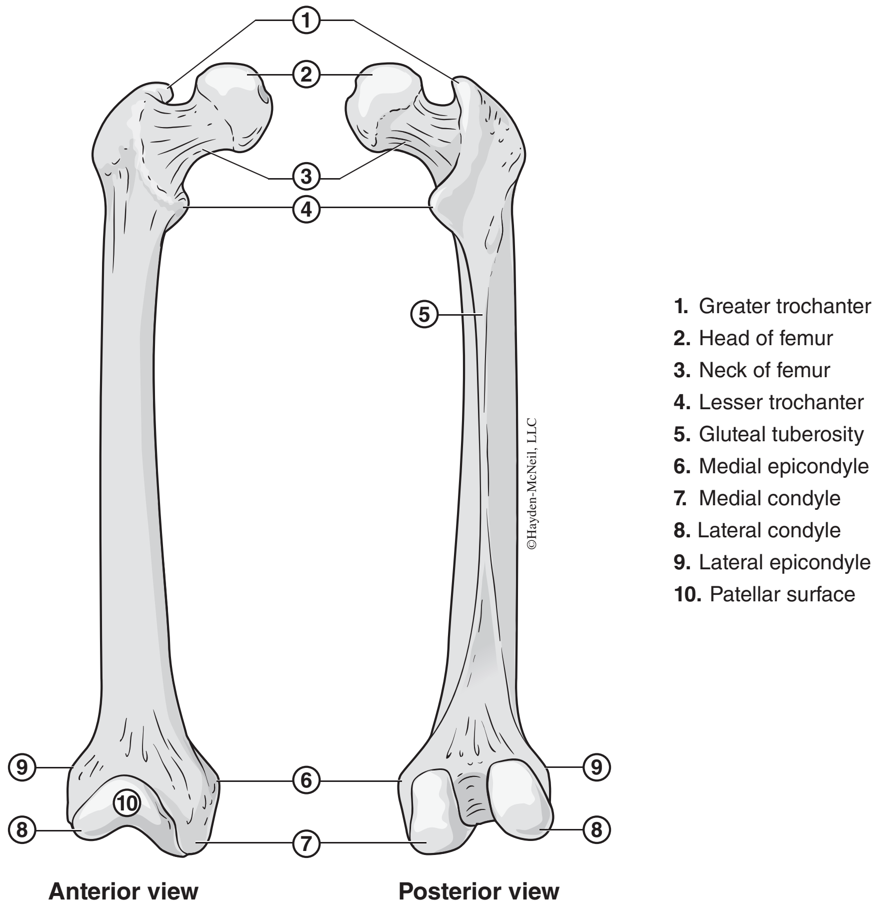


Figure 1.23. Anterior and Posterior Femur

The larger bone on the medial side of the leg is the **tibia** (TIB-ee-ah). It is known as the shinbone. It is the weight-bearing bone of the leg. On the proximal end there are two large processes: the **medial condyle** which articulates with the medial condyle of the femur and the **lateral condyle** which articulates with the lateral condyle of the femur and the head of the fibula.

Just below the condyles on the anterior surface of the tibia there is a roughened protrusion called the **tibial tuberosity**. This is the site where the patellar ligament attaches.

On the medial surface of the distal end of the tibia there is a large bony prominence known as the **medial malleolus** (mah-LEE-oh-lus). This is the bump found on the medial surface of the ankle. The malleolus articulates with the medial surface of the talus, which is one of the tarsal bones of the foot.

The smaller bone on the lateral side of the leg is the **fibula** (FIB-yah-lah). It is not a weight-bearing bone in the leg. The proximal end has an enlargement known as the **head**. This head articulates superiorly with the lateral condyle of the tibia. The fibula does not articulate with the femur.

On the lateral surface of the distal end of the fibula there is a bony projection called the **lateral malleolus**. This is the bump found on the lateral surface of the ankle. This malleolus articulates with the lateral surface of the talus.

The ankle consists of seven bones known as the **tarsals** (TAHR-sahls). The weight of the body is concentrated in two of these bones. The heel bone, which is the largest of the tarsals is the **calcaneus** (kal-KAY-nee-us). This bone helps support the weight and serves as an insertion point for the gastrocnemius and soleus muscles. The large bone on the top of the foot is the **talus** (TA-lus). This bone articulates with both the medial and the lateral malleoli to form the ankle joint.

The instep of the foot consists of five **metatarsal** (MET-ah-TAHR-sahl) bones. The distal heads of these bones form the ball of the foot. The toes of the foot consist of fourteen **phalanges**. The great toe contains two phalanges and all other toes contain three. These phalanges are shorter but otherwise similar to the phalanges of the fingers.

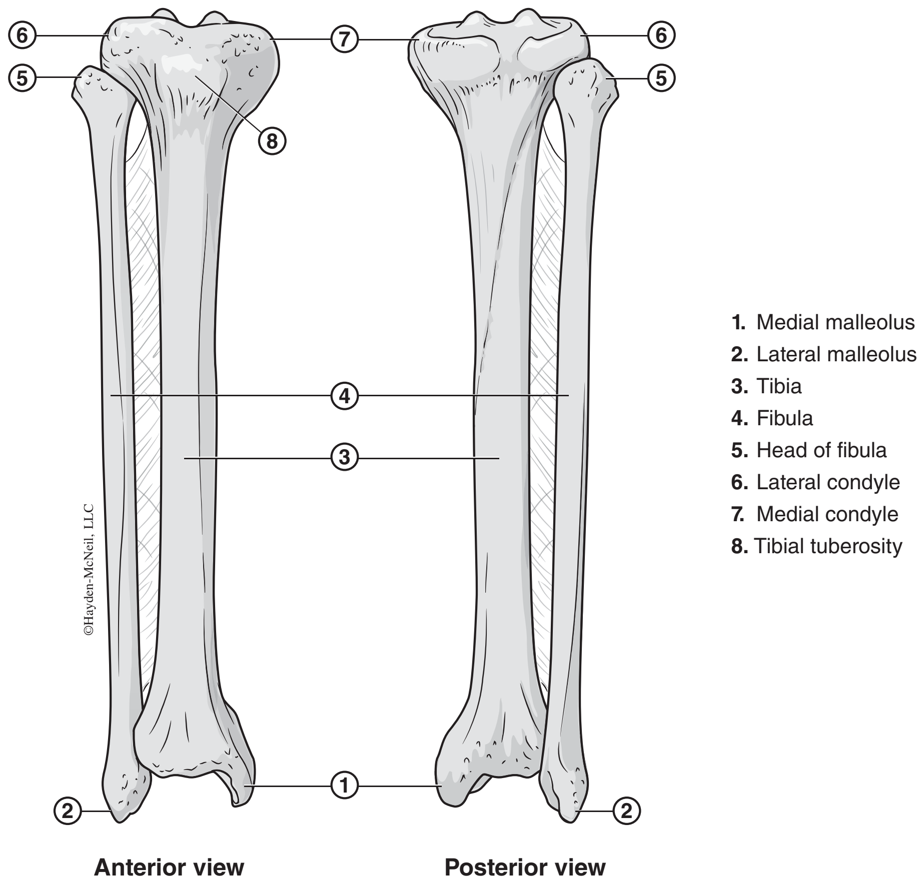


Figure 1.24. Anterior and Posterior Tibia and Fibula

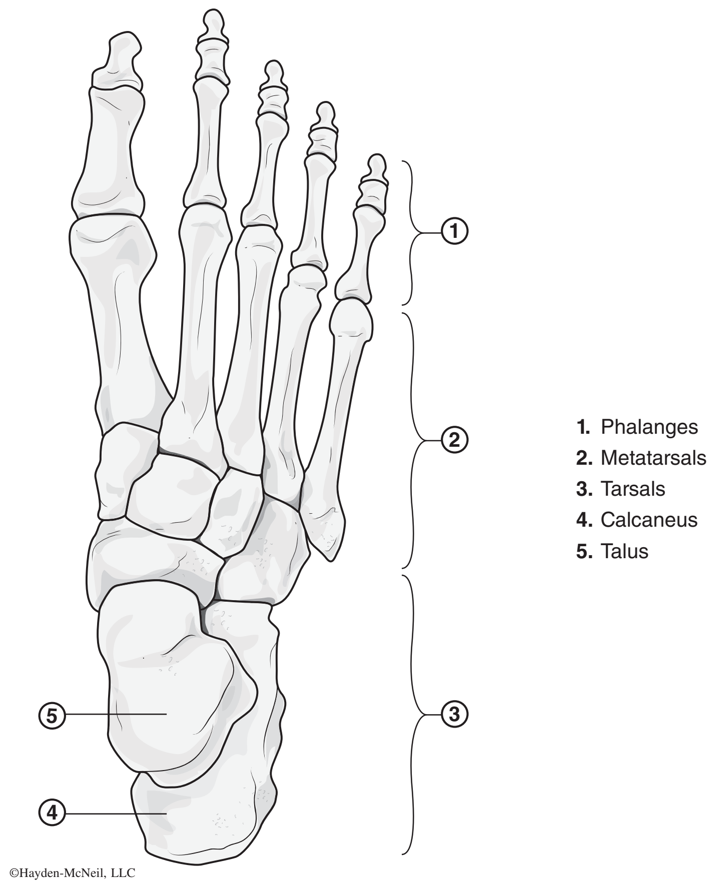


Figure 1.25. Bones of the Foot

Section D – Axial Skeleton - Vertebral Column

The axial skeleton is made up of the bones that are found down the center of the skeleton. This consists of the skull, vertebral column, and the rib cage.

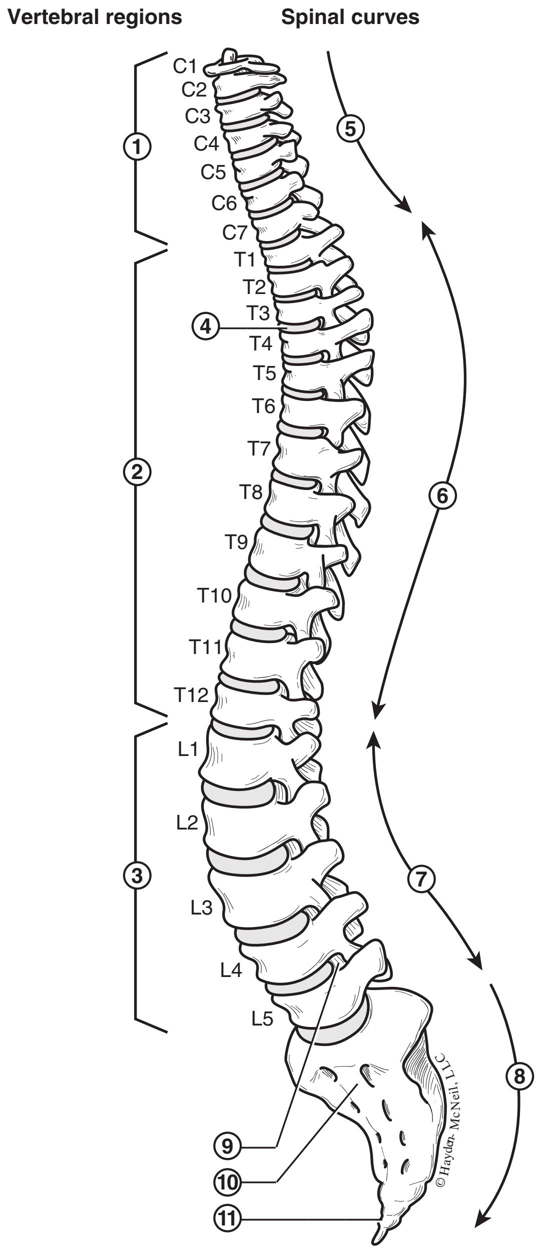
The vertebral column extends from the skull to the pelvis. It is the major support of the axial skeleton. It protects the spinal cord but allows the nerves to leave. There are four curvatures to the vertebral column: cervical, thoracic, lumbar, and sacral. The cervical and lumbar curvatures are convex, while the thoracic and sacral curvatures are concave.

Vertebra (VER-tah-brah) (pl. vertebrae)

The vertebrae are the bones that form the spine. There are a total of thirty-three (33) vertebrae: seven (7) cervical, twelve (12) thoracic, five (5) lumbar, five (5) fused to form the sacrum, and four (4) fused to form the coccyx.

There are several parts to each vertebra. The **body** is the largest part of the vertebra. Between each body there is an **intervertebral** (IN-TAHVER-tahbral) **disk** of cartilage. This is a disk of fibrocartilage that serves to cushion and act as a shock absorber. There is no intervertebral disk between the atlas and axis, and between the sacrum and coccyx. The **vertebral** or **neural arch** is the curve of bone formed by the pedicle and lamina of the vertebra. It is responsible for the protection of the spinal cord.

The **pedicle** (PED-ik-cul) is a bony projection that extends posteriorly from each side of the vertebral body. It connects the body with the transverse process. Each pedicle has superior and inferior vertebral notches which form the intervertebral foramen.



1. Cervical vertebrae
2. Thoracic vertebrae
3. Lumbar vertebrae
4. Intervertebral disk
5. Cervical curvature
6. Thoracic curvature
7. Lumbar curvature
8. Sacral curvature
9. Intervertebral foramen
10. Sacrum
11. Coccyx

Figure 1.26. Vertebral Column

The **lamina** (LAM-in-uh) is a plate of bone that is an extension of the pedicle. It is located between the transverse process and the spinous process of the vertebra. The laminae actually meet in the midline to form the spinous process.

The **transverse process** is a lateral process that extends from the junction of the pedicle and the lamina of the vertebra. It is a site for muscle attachment. On the transverse process of the thoracic vertebrae, there is an articular surface for the ribs.

The **spinous process** is a posterior process of the vertebrae that protrudes midline and projects inferiorly. It is an important site of muscle attachment. The spinous process takes on different appearances depending on the region of the vertebral column. For example, the spinous processes of cervical vertebrae 2–6 are split in two.

The **intervertebral foramen** is an opening between the pedicles of adjacent vertebrae. It is formed by adjacent inferior and superior intervertebral notches. This opening is for the passage of the spinal nerves and blood vessels.

The **superior** and **inferior articulating surfaces** are projections from the vertebral arch of each vertebra. Each articulating surface is covered with an articular cartilage. This is a joint between adjacent vertebrae.

The **vertebral** or **spinal foramen** is the opening formed by the body and the vertebral arch of the cervical, thoracic, and lumbar vertebrae. It contains the spinal cord, the meninges, epidural fat, and blood vessels.

Cervical vertebrae special features

Cervical vertebrae have **transverse foramina** (fah-RAM-ah-nah). These are openings in each transverse process. They allow for the passage of the vertebral arteries. The spinous processes on cervical vertebrae 2–6 are forked.

The first cervical vertebra is the **atlas**. The name is from the Greek Titan, Atlas. He was the Titan who carried the world on his shoulders. The first cervical vertebra carries the skull on its articular facets. The atlas has no vertebral body. It articulates superiorly with the occipital condyles of the skull and inferiorly with the odontoid process (dens) of the axis, the second cervical vertebra.

The second cervical vertebra is the **axis**. It has a process that extends superiorly from the vertebral body. This is the **odontoid** (O-DONT-oyd) **process** which is also known as the **dens**. This process articulates with the anterior vertebral arch of the atlas. The atlas and axis function as a unit. This articulation allows the head to rotate from side to side.

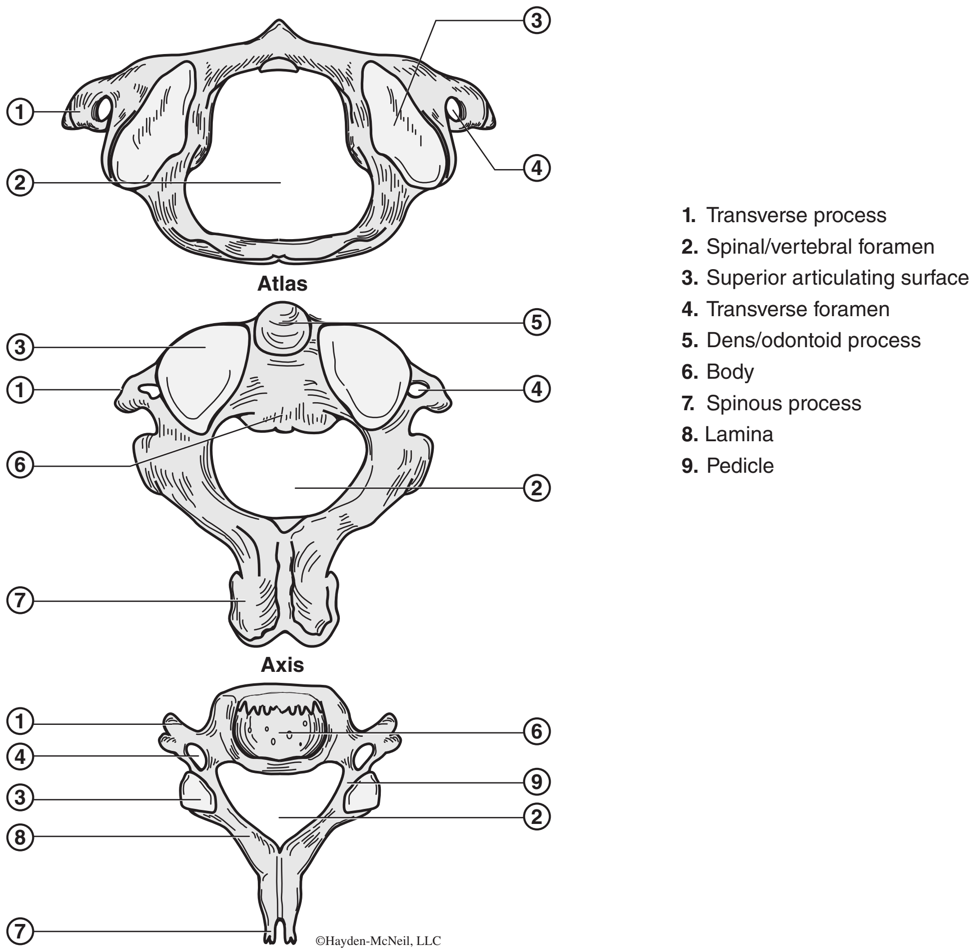


Figure 1.27. Cervical Vertebrae, Atlas, and Axis

Thoracic vertebrae special features

Thoracic vertebrae are characterized by spinous processes that are long and slender and project inferiorly. These vertebrae also have costal facets between the body and pedicle and on the transverse processes to articulate with the ribs.

Lumbar vertebrae special features

Lumbar vertebrae have short, blunt spinous processes that project posteriorly. These processes do not overlap the lumbar region. This allows for the insertion of a needle to perform a spinal tap.

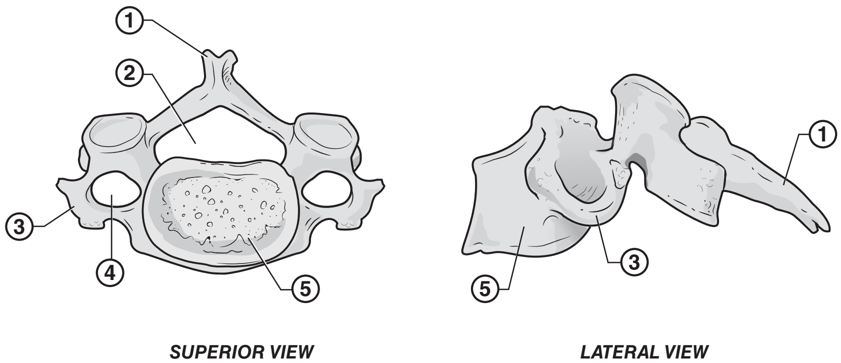
Sacrum

The **sacrum** is a triangular bone that is formed by 5 fused vertebrae. This vertebra and the two os coxae form the pelvis. The sacrum articulates with these bones at the sacroiliac joints. It forms the posterior part of the pelvis.

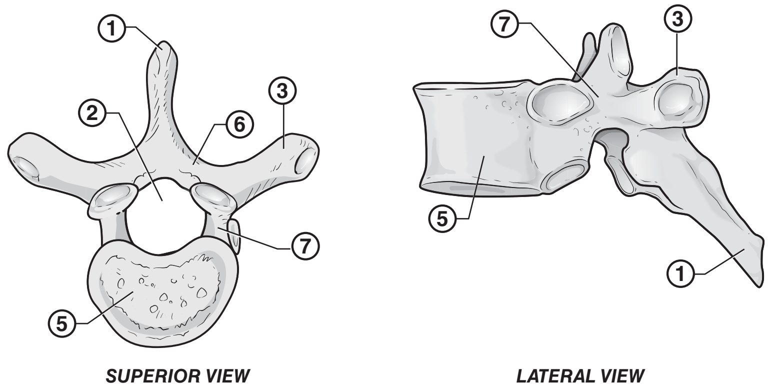
Coccyx

The **coccyx** is the most inferior portion of the vertebral column. It is formed by the fusion of the four coccygeal (KOKSIJ-ee-ul) vertebrae. It articulates superiorly with the sacrum. The coccygeal vertebrae are simple; they do not have pedicles, laminae, or spinous processes. This portion of the vertebral column is known as the tailbone.

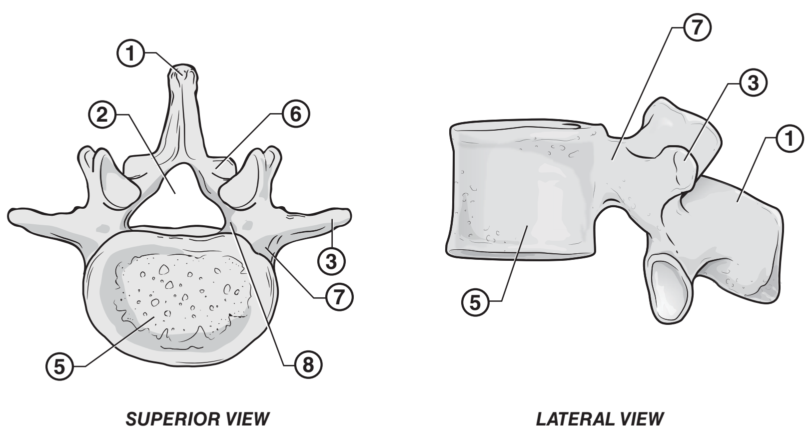
Cervical vertebrae



Thoracic vertebrae



Lumbar vertebrae



1. Spinous process
2. Spinal/vertebral foramen
3. Transverse process
4. Transverse foramen
5. Body
6. Lamina
7. Pedicle
8. Neural (vertebral) arch

Figure 1.28. Typical Cervical, Thoracic, and Lumbar Vertebrae

Section E – Axial Skeleton—Rib Cage

The rib cage consists of the sternum, twelve pairs of ribs, and the thoracic vertebrae. The thoracic vertebrae were discussed in the previous section so this section will only address the sternum and the ribs. This is a cone-shaped structure that protects the lungs and the heart.

The broad flat bone in the middle of the anterior thoracic wall is the **sternum** (STUR-num) or the breastbone. It is formed by three fused bones. The first seven pairs of ribs are attached to the sternum directly via costal cartilages.

The superior portion of the sternum is called the **manubrium** (MAHNOO-BREE-um). It articulates with the clavicles laterally. The first pair of ribs also articulate with the manubrium. It is one of the sites of attachment for the sternocleidomastoid muscle.

The middle part of the sternum is known as the **body**. It makes up most of the sternum, and ribs 2–7 articulate laterally with it. This portion of the sternum is the site of hand placement during CPR.

The articulation between the manubrium and the body form the **sternal angle**. These two bones meet at a slight angle at the level of the second rib. It is used as a reference point for locating the second intercostal space for listening to heart valve sounds. The inferior portion of the sternum is the **xiphoid** (ZYEF-oyd) process. It projects inferiorly over the abdominal cavity. It can be broken with incorrect hand placement during CPR.

There are twelve pairs of ribs. They all articulate posteriorly with the thoracic vertebrae. They curve downward and forward toward the anterior chest. The first seven pairs of ribs are called **true ribs** or **vertebrosternal ribs** because they attach directly to the sternum by means of a **costal cartilage**. The next five pairs of ribs are called **false ribs** because they either do not attach directly to the sternum or don't attach to the sternum at all. Rib pairs 8 though 10 attach to the rib above via a costal cartilage, so they are also called **vertebrochondral ribs**. Rib pairs 11 and 12 do not attach to any other rib or to the sternum. These two pairs of ribs are also called **floating ribs** or **vertebral ribs**.

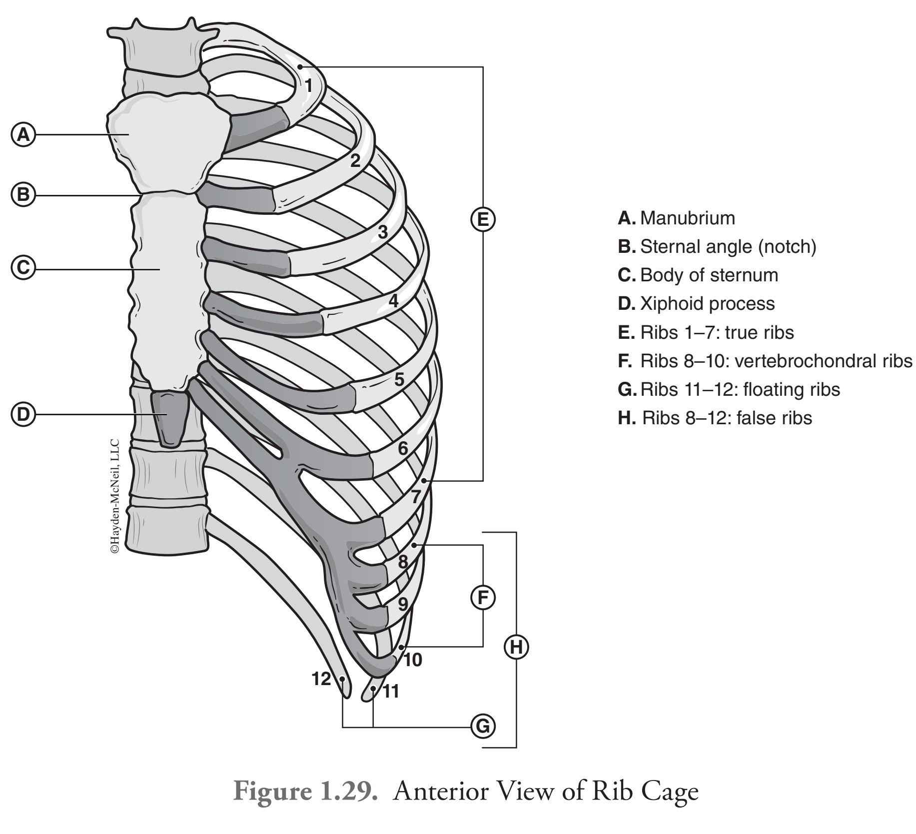


Figure 1.29. Anterior View of Rib Cage

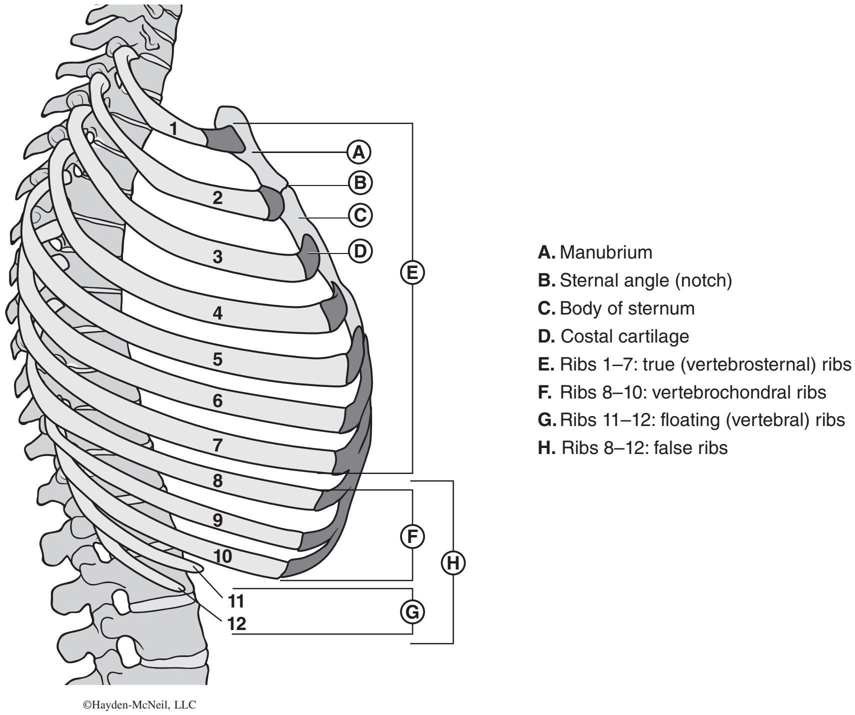


Figure 1.30. Lateral View of Rib Cage

Section F – Axial Skeleton - Skull

The skull consists of two sets of bones: the bones that make up the cranium, which encloses and protects the brain, and the facial bones. There are eight cranial bones and fourteen facial bones.

Table 1.6: Cranial and Facial Bones

Cranial Bones	Facial Bones
Frontal bone – 1	Maxilla – 2
Parietal bones – 2	Palatine bones – 2
Occipital bone – 1	Zygomatic bones – 2
Temporal bones – 2	Lacrimal bones – 2
Sphenoid bone – 1	Nasal bones – 2
Ethmoid bone – 1	Vomer – 1
	Inferior Nasal Conchae – 2
	Mandible – 1

Cranial Bones

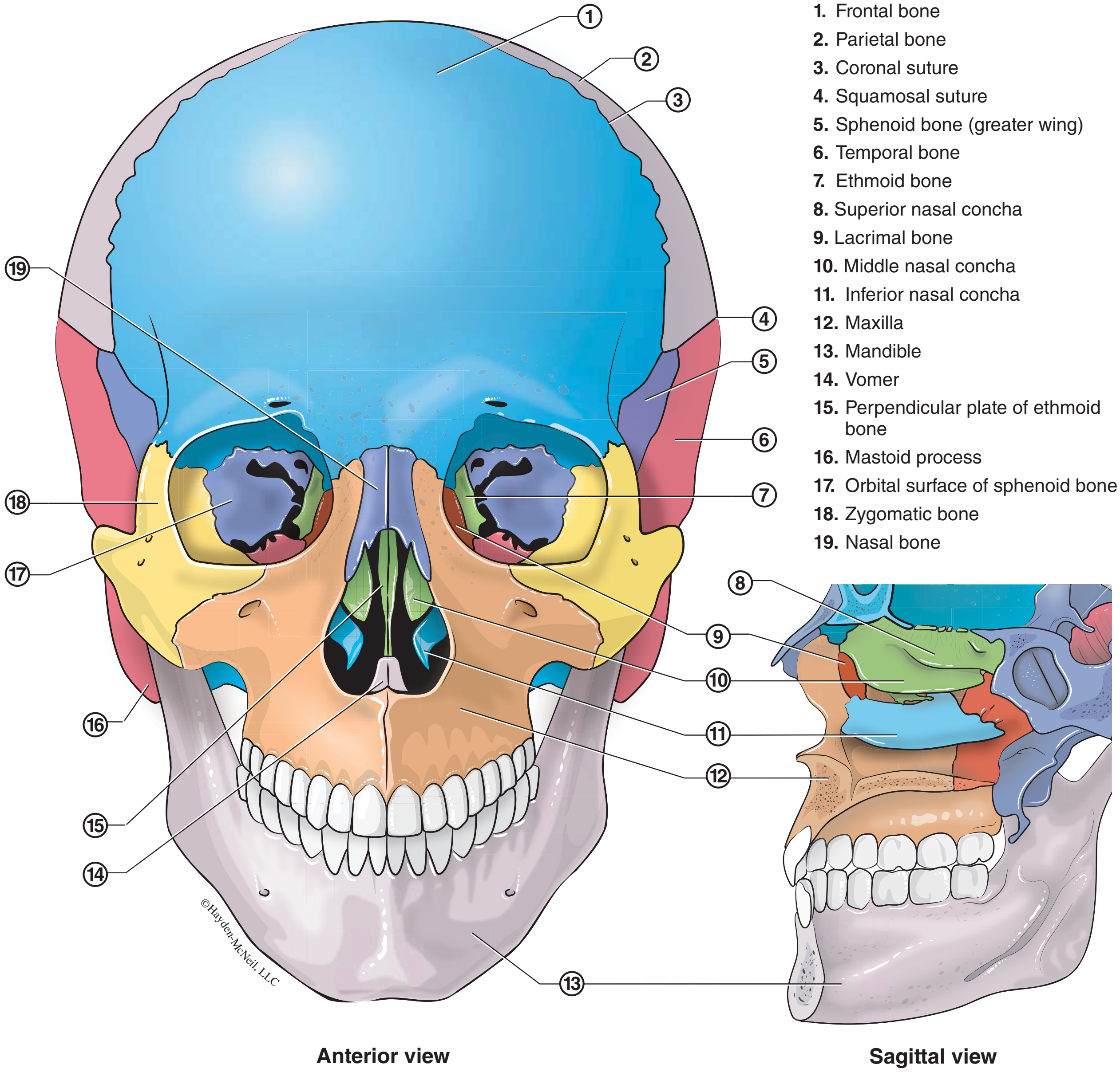
The anterior bone of the skull is the **frontal bone**. In the skull the articulations between the bones are immovable joints called sutures. The frontal bone articulates posteriorly with the two parietal bones at the **coronal suture**. It also articulates inferiorly with the ethmoid, sphenoid, and zygomatic bones. Anteriorly there are articulations with the maxilla, nasal, and lacrimal bones.

The superior lateral walls of the cranium are formed by the two **parietal bones**. These two bones articulate with each other in the midline at the **sagittal suture**. As mentioned above, the parietal bones also articulate anteriorly with the frontal bone at the coronal suture. Posteriorly it articulates with the occipital bone at the **lambdoidal** (LAMDOI-dahl) **suture**. The parietal bone articulates inferiorly with the greater wing of the sphenoid and with the temporal bone at the **squamosal** (SKWA-mow-sul) **suture**.

The inferior lateral walls of the cranium are formed by the **temporal bones**. There are several important markings on the temporal bones. The **zygomatic** (ZEYEGO-MAT-ik) **process** is a bridge-like projection off the temporal bone that joins the zygomatic bone anteriorly to form the **zygomatic arch** or the cheekbone.

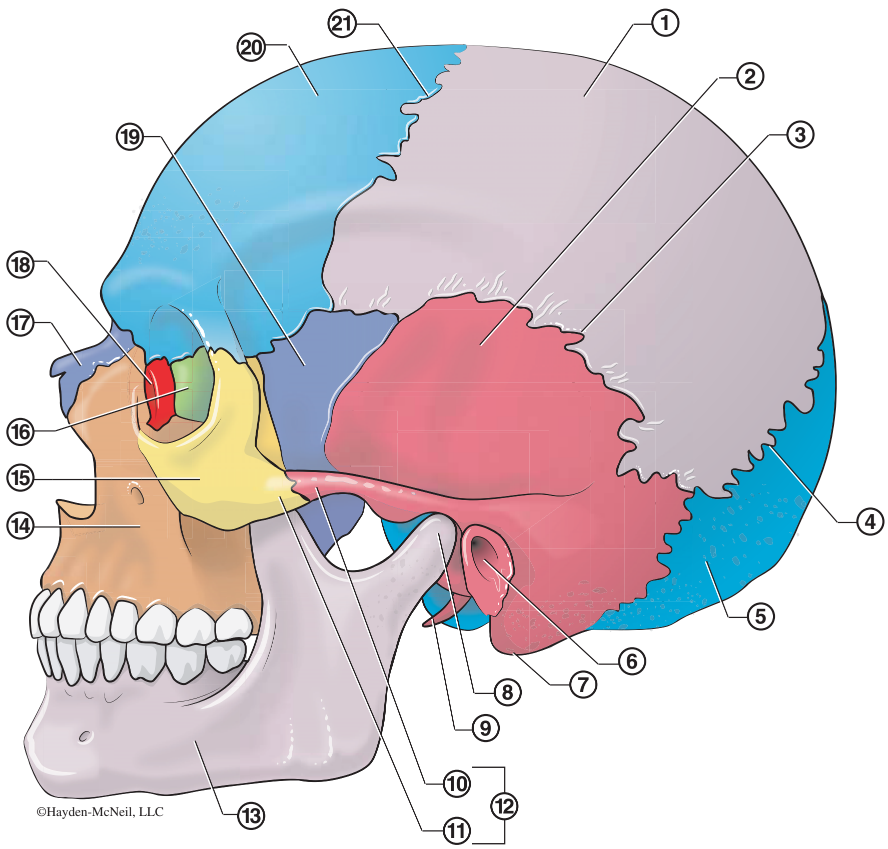
On the inferior surface of the zygomatic process is a depression known as the **mandibular** or **glenoid fossa** which articulates with the mandibular condyle of the mandible to form the temporomandibular joint.

Below the zygomatic process on the lateral surface of the temporal bone is the **external auditory** or **acoustic meatus** (ME-A-tus). This is the canal that leads to the middle ear. It allows sound to reach the tympanic membrane or eardrum.



1. Frontal bone
2. Parietal bone
3. Coronal suture
4. Squamosal suture
5. Sphenoid bone (greater wing)
6. Temporal bone
7. Ethmoid bone
8. Superior nasal concha
9. Lacrimal bone
10. Middle nasal concha
11. Inferior nasal concha
12. Maxilla
13. Mandible
14. Vomer
15. Perpendicular plate of ethmoid bone
16. Mastoid process
17. Orbital surface of sphenoid bone
18. Zygomatic bone
19. Nasal bone

Figure 1.31. Anterior and Sagittal View of Skull

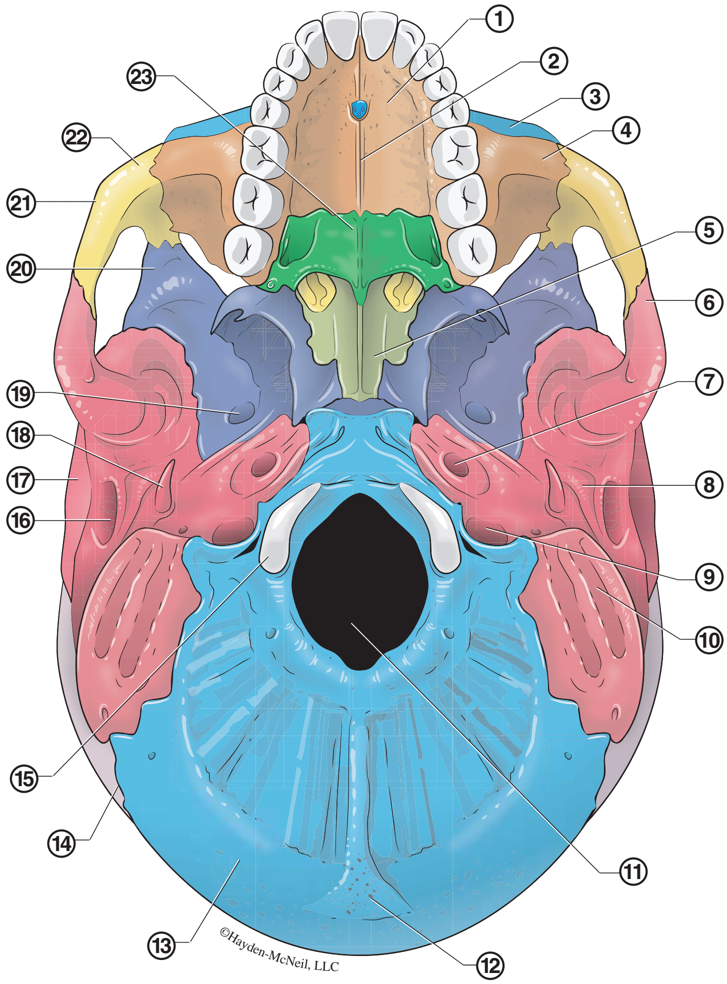


1. Parietal bone
2. Temporal bone
3. Squamosal suture
4. Lambdoidal suture
5. Occipital bone
6. External acoustic meatus
7. Mastoid process of temporal bone
8. Mandibular condyle
9. Styloid process of temporal bone
10. Zygomatic process of temporal bone
11. Temporal process of zygomatic bone
12. Zygomatic arch
13. Mandible
14. Maxilla
15. Zygomatic bone
16. Ethmoid bone
17. Nasal bone
18. Lacrimal bone
19. Greater wing of sphenoid bone
20. Frontal bone
21. Coronal suture

Figure 1.32. Lateral View of Skull

On the inferior surface of the temporal bone there are two important processes. The first is a rough rounded projection posterior and inferior to the external auditory meatus. This is the **mastoid** (MAS-toyd) **process**. This is an attachment point for muscles including the sternocleidomastoid muscle. The second projection is a needlelike structure known as the **styloid process**. It is found inferior to the external auditory meatus. It too is an attachment point for muscles and ligaments. In the laboratory this process is frequently missing or broken on the skull since it is a rather delicate process.

Also on the inferior surface of the temporal bone there is the **carotid** (KAHROT-id) **canal**, an opening for the passage of the internal carotid artery into the cranial cavity. This opening can be found medial to the styloid process. The **jugular foramen** is an opening between the temporal bone and the occipital bone that allows the passage of the internal jugular vein and cranial nerves IX, X, and XI. It can also be found medial to the styloid process.



1. Palatine process of maxilla
2. Median palatine suture
3. Frontal bone
4. Maxilla
5. Vomer
6. Zygomatic process of temporal bone
7. Carotid canal
8. Mandibular/glenoid fossa
9. Jugular foramen
10. Mastoid process
11. Foramen magnum
12. External occipital protuberance
13. Occipital bone
14. Lambdoidal suture
15. Occipital condyle
16. External acoustic meatus
17. Temporal bone
18. Styloid process
19. Foramen ovale
20. Sphenoid bone
21. Zygomatic arch
22. Zygomatic bone
23. Palatine bone

Figure 1.33. Inferior View of Skull

The back and floor of the skull is formed by the **occipital** (OKSIP-it-ahl) **bone**. It articulates with the parietal bones at the lambdoidal suture. The occipital bone also articulates with the temporal and sphenoid bones.

On the inferior surface of the occipital bone there is a large opening called the **foramen** (FORAY-mahn) **magnum**. The spinal cord and the vertebral arteries enter the cranium through this opening. Rounded projections lateral to the foramen magnum are the **occipital condyles**. These projections articulate with facets on the first cervical vertebra, the atlas.

The **sphenoid** (SFE-noyd) **bone** is a bat-shaped bone that spans the center portion of the skull. It is described as having a body, two greater wings, and two lesser wings. It articulates anteriorly with the zygomatic bone, superiorly with the frontal and parietal bones, and posteriorly with the temporal bone.

The **greater wings** of the sphenoid are on the exterior of the skull, anterior to the temporal bone. The greater wings form part of the outer wall of the orbits for the eyes and part of the internal lateral wall of the orbits.

The sphenoid bone is best observed looking into the floor of the cranium or looking at the inferior surface of the skull. Observing the sphenoid on the cranial floor there is a saddle-shaped region in the midline called the **sella turcica** (SEL-ah TUR-sikah) which means the Turkish saddle. The seat of the saddle is the **hypophyseal fossa** (HIPO-FIZE-ahl FOS-ah). The pituitary gland sits in this depression. The horns on the back of the saddle are the **dorsum sellae**.

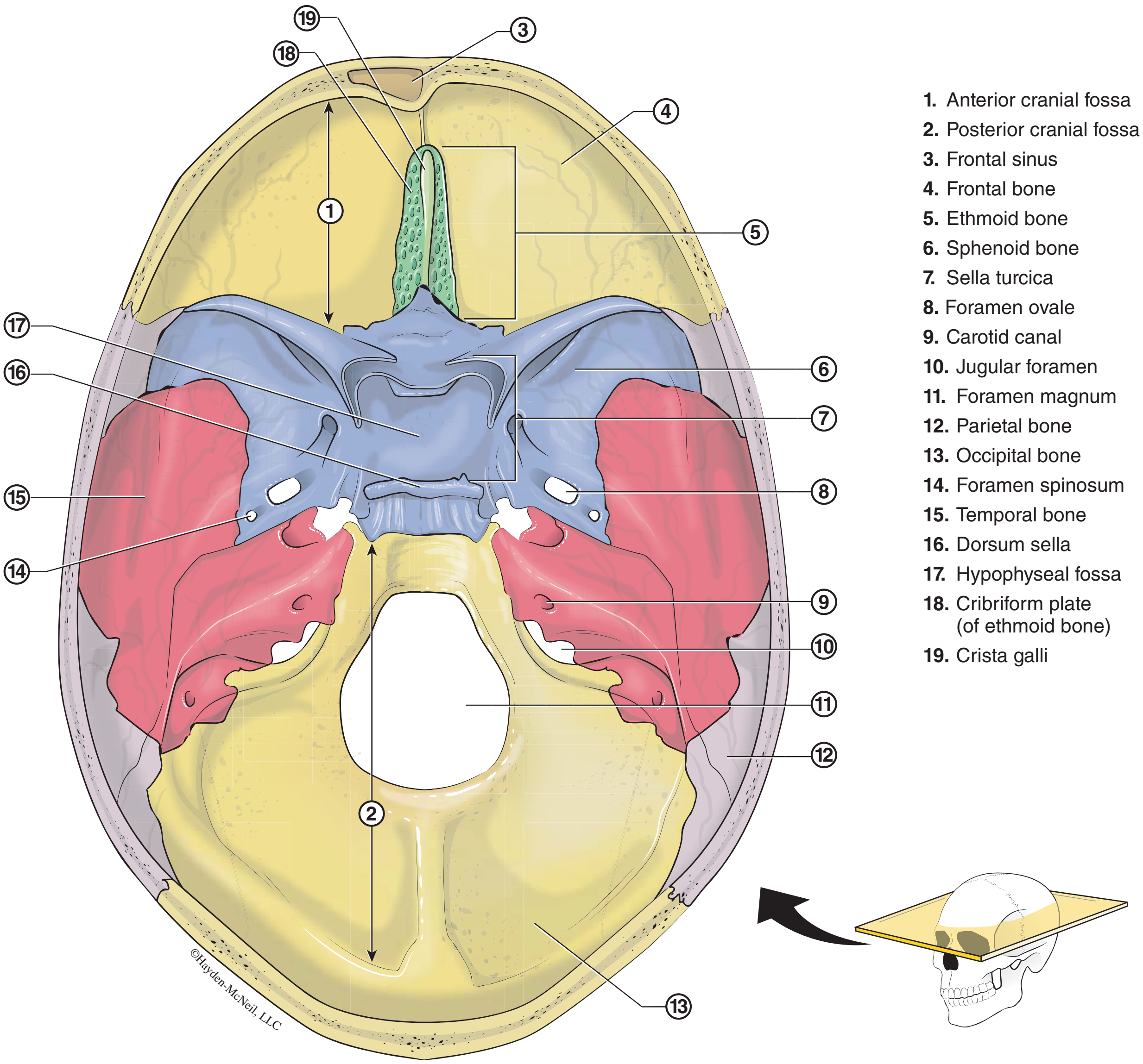


Figure 1.34. Cranial Floor

Openings in the base of the lesser wings are the **optic canals**. These openings allow the optic nerves to leave the eyes and approach the optic chiasm or chiasma.

Looking into the cranial floor there are three depressions: anterior cranial fossa, middle cranial fossa, and posterior cranial fossa. The **anterior cranial fossa** is formed by the orbital plates of the frontal, the cribriform plate of the ethmoid, and the small wings and front part of the body of the sphenoid. This is the region in the anterior portion of the cranial floor where the front lobes of the brain sit. The **middle cranial fossa** is formed mainly by the body of the sphenoid bone posterior to the lesser wing and the petrous portion of the temporal bone. This is the region where the temporal lobes and the hypothalamus are located. The **posterior cranial fossa** is located between the foramen magnum and tentorium cerebelli. This is the region in the posterior portion of the cranial floor where the cerebellum, pons, and medulla oblongata sit.

One of the hardest bones for students to identify is the **ethmoid** (ETH-moyd) **bone**. This is an irregular bone that is fused into the center of the skull. It forms the roof of the nasal cavity, the upper nasal septum, and part of the medial walls of the orbits.

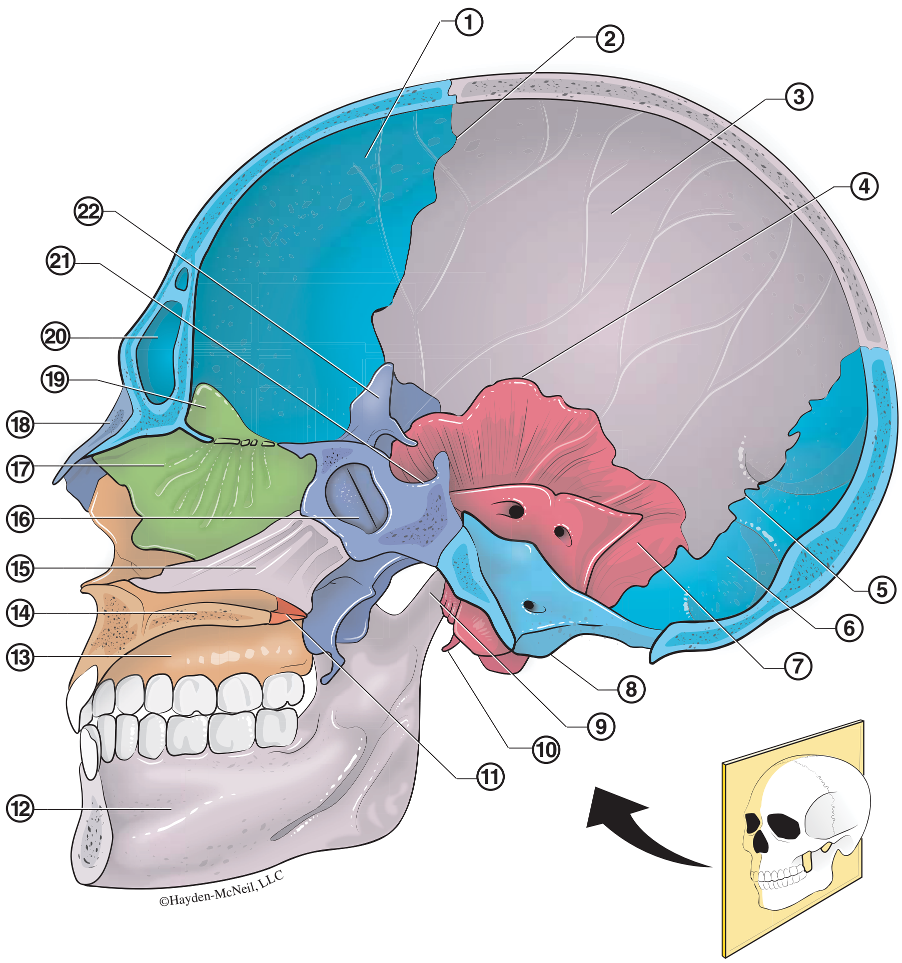
The ethmoid bone extends superiorly into the floor of the cranium. The upper extension of this bone forms a vertical projection called the **crista galli** (KRIS-tah GAL-lee). This structure provides an attachment point for the dura mater, which helps secure the brain within the skull. On either side of the crista galli there are **cribriform** (KRIB-ri-FORM) **plates**. These plates contain many small foramina that allow the olfactory nerves to pass from the nose to the brain.

An inferior projection of the ethmoid bone forms the superior portion of the nasal septum; this is the **perpendicular plate** of the ethmoid. There are masses on either side of the perpendicular plate. Projections from these masses extend medially into the nasal cavities. These are the **superior concha** (KONG-kah) and **middle concha**. These structures increase the surface area in the nasal cavity to increase the ability of the nasal mucosa to adequately warm and humidify inhaled air.

Facial Bones

The lower jaw bone is the **mandible**, a U-shaped bone. It articulates with the mandibular fossa on the temporal bone to form the only freely moving joint in the skull. The horizontal portion of this bone that forms the chin is the **body**. The vertical projection of either side of the body is the **ramus** (RAY-mahs). The anterior portion of the ramus is the **coronoid process**. It serves as a site of the temporalis muscle attachment. The posterior rounded projection is the **mandibular condyle** which fits into the mandibular fossa on the temporal bone to form the temporomandibular joint (TMJ).

The upper jaw is the **maxilla** (MAKSIL-ah). Two bones fuse to form the upper jaw, and all bones except for the mandible articulate with the maxilla. So the maxillae can be considered major bones of the face. Projecting posteriorly from the maxilla are the **palatine processes**. These processes join together at the **median palatine suture**. The fused palatine process along with the palatine bone forms the roof of the mouth, which is the hard palate. The palatine process also forms the floor of the nasal cavity.



1. Frontal bone
2. Coronal suture
3. Parietal bone
4. Squamosal suture
5. Lambdoidal suture
6. Occipital bone
7. Temporal bone
8. Mastoid process
9. Mandibular condyle
10. Styloid process of temporal bone
11. Palatine bone
12. Mandible
13. Maxilla
14. Palatine process of maxilla
15. Vomer
16. Sphenoidal sinus (right)
17. Perpendicular plate of ethmoid bone
18. Nasal bone
19. Crista galli
20. Frontal sinus
21. Hypophyseal fossa of sella turcica
22. Sphenoid bone

Figure 1.35. Sagittal View of Skull

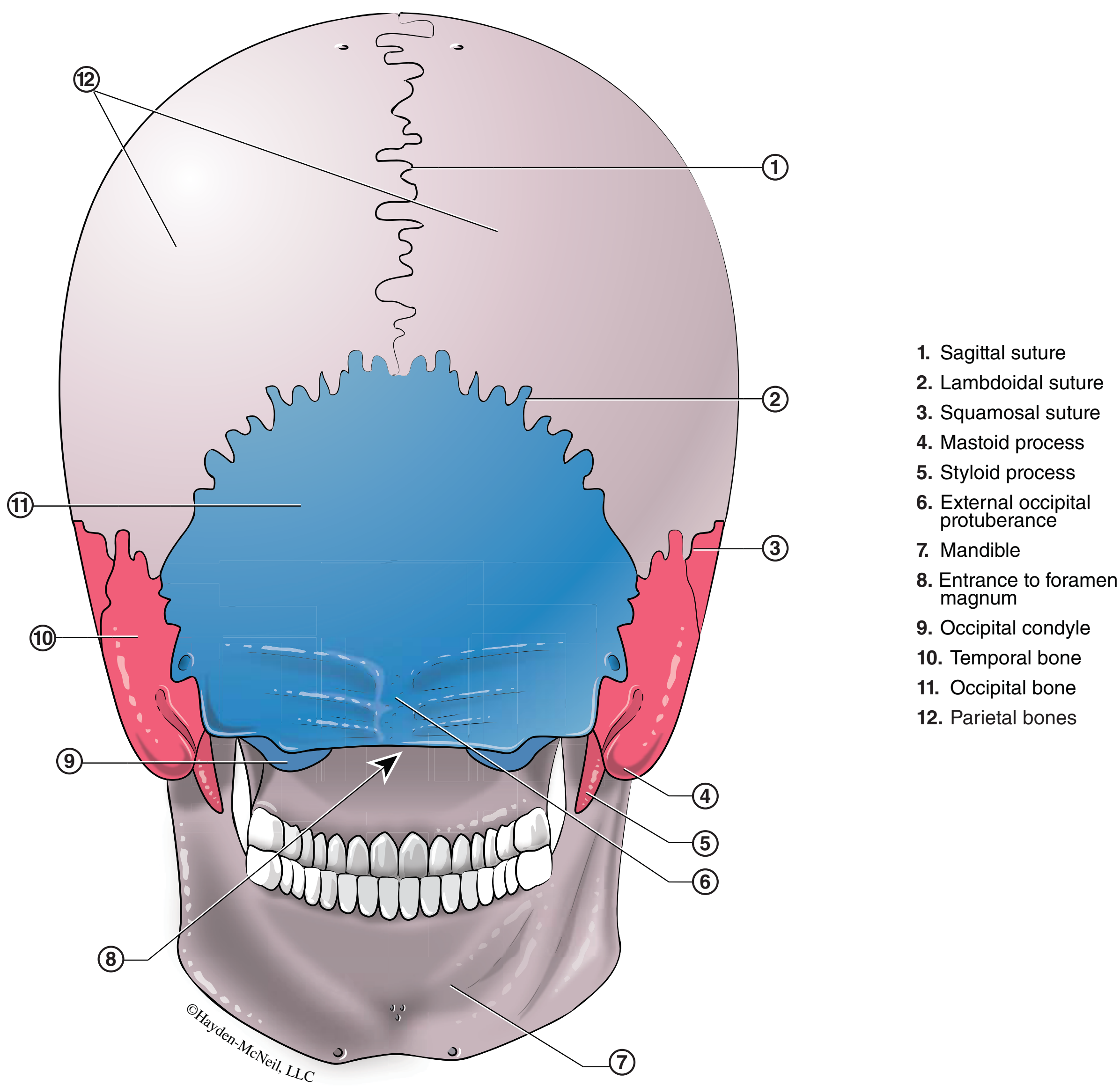


Figure 1.36. Posterior View of Skull

The posterior portion of the hard palate is formed by the **palatine bones**. When these bones fail to fuse during development it leads to a cleft palate. The palatine bones articulate anteriorly with the palatine processes of the maxilla. Perpendicular portions of these bones help form the lateral walls of the nasal cavity.

The bones that form the bridge of the nose are the two **nasal bones**. These bones articulate with the frontal bone superiorly and the frontal process of the maxilla laterally.

Small rectangular bones that form the anterior portion of the orbit wall between the maxilla and the ethmoid are the **lacrimal** (LAK-rimul) **bones**. Each lacrimal bone has an opening, the **lacrimal fossa**, which serves as a passageway for the nasolacrimal duct which carries the tears from the eye to the nasal passage.

Separate bones on the lateral walls of the nasal cavity are the **inferior nasal conchae**. These serve the same purpose as the superior and middle conchae which are projections of the ethmoid bone.

Lateral to the maxilla is the **zygomatic bone** which forms part of the cheekbone. It articulates anteriorly with the maxilla, superiorly with the frontal bone, and posteriorly with the zygomatic process of the temporal bone. Together the zygomatic process and the zygomatic bone form the zygomatic arch, which is commonly called the cheekbone.

A thin bone that forms the posteroinferior part of the nasal septum is the **vomer**. It articulates superiorly with the perpendicular plate of the ethmoid bone and the body of the sphenoid bone; articulates inferiorly with the palatine processes of the maxilla and the horizontal plate of the palatine bone. This is another bone that is fused interiorly on the skull making it difficult to isolate.

Paranasal Sinuses

In four of the skull bones there are mucous-lined air cavities called sinuses. These cavities serve to lighten the bones and may act as resonance chambers. They lead into the nasal passages. The sinuses are located in the frontal, maxilla, sphenoid, and ethmoid bones. An inflammation of any of these cavities is sinusitis.

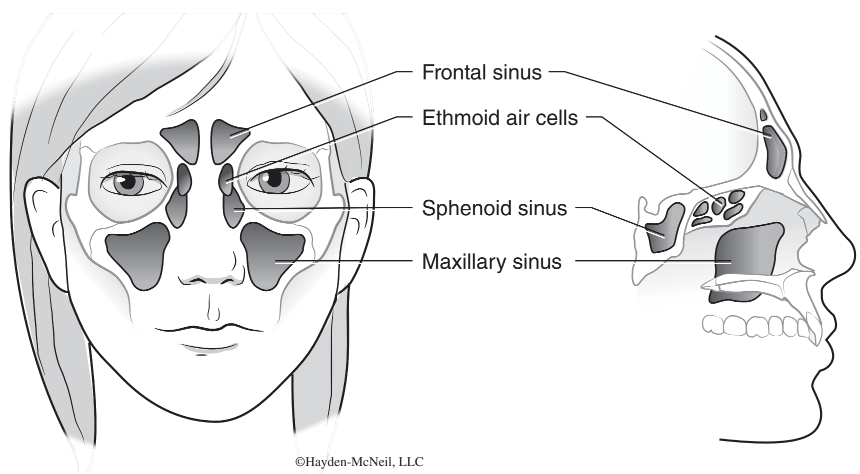


Figure 1.37. Paranasal Sinuses

Hyoid Bone

The hyoid bone is not part of the skull but it also doesn't fit well into any of the other categories. It is a "U" shaped bone that is located in the neck superior to the larynx. It does not articulate with any other bones. It serves as a point of attachment for muscles of the tongue and neck.

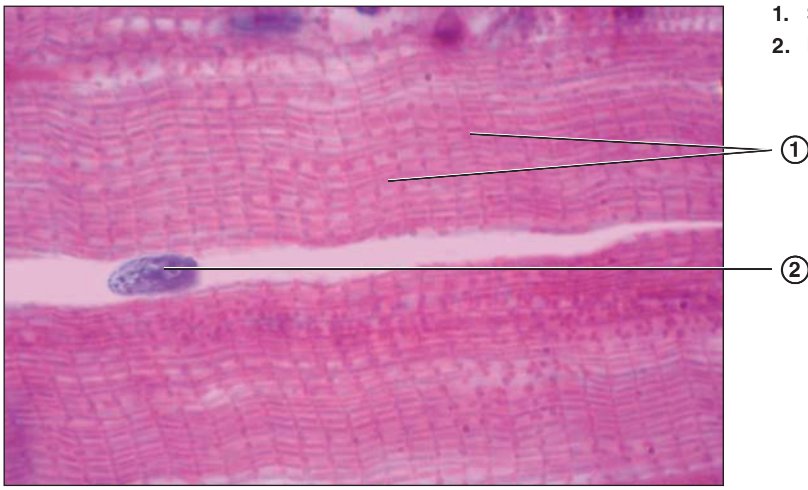
Part 4

Muscles

This section will focus on muscle tissue and some common skeletal muscles.

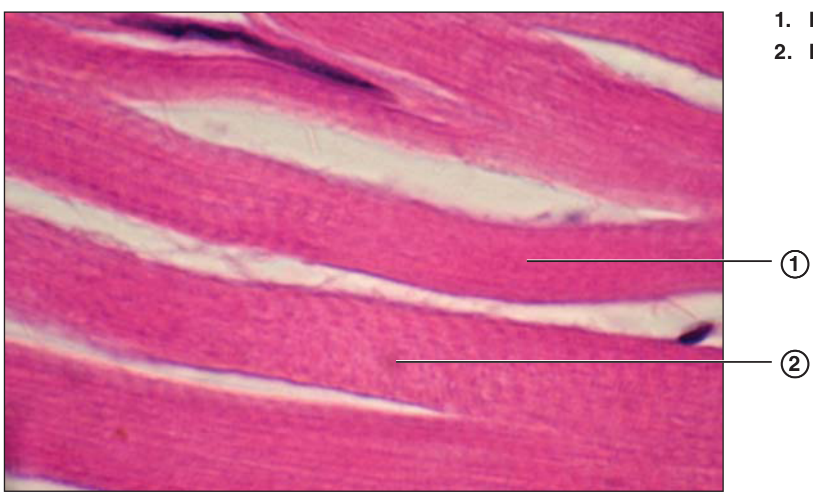
Section A – Muscle Tissue

There are three types of muscle tissue: skeletal muscle, smooth muscle, and cardiac muscle.



1. **Striations**
2. **Nucleus of muscle cell**

Figure 1.38. Skeletal Muscle Slide



1. **Muscle fiber**
2. **Nucleus of muscle fiber**

Figure 1.39. Cardiac Muscle Slide

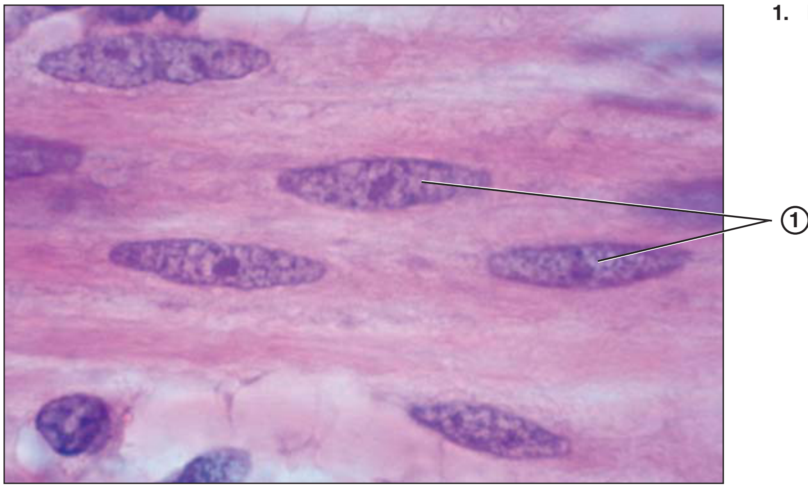


Figure 1.40. Smooth Muscle Slide

Skeletal muscle is striated muscle under voluntary control. These muscle fibers extend the length of the muscle and are multinucleated, i.e., they have more than one nucleus. Skeletal muscles are attached to bone by tendons. They span joints, also known as articulations, and as a result are responsible for movement as well as joint stabilization. The origin of a muscle is the end attached to the bone that doesn't move, while the insertion of a muscle is the end that is attached to the bone that moves. For example, the origin of the biceps brachii muscle is on the scapula because this muscle does not move the scapula. The insertion of the biceps is on the radius because when the muscle contracts it pulls on the radius and results in the flexion of the forearm.

Cardiac muscle is only found in the walls of the heart. It is an involuntary muscle that is striated when observed under the microscope. The function of cardiac muscle is to pump blood through the body. Cardiac muscle will be addressed in Unit 3 when learning about the heart.

Smooth muscle is called smooth because it lacks striations. It is involuntary muscle that is located in the walls of hollow organs. This is the type of muscle found in blood vessels, airways, digestive organs, urinary bladder, and uterus to name a few. This type of muscle is found in structures in Unit 3 and 4.

Section B – Muscles of the Face and Neck

There are several muscles found in the face, some are involved in facial expression, others are involved in mastication or chewing. Two of the muscles that are responsible for mastication are the temporalis and the masseter. The muscles in the neck are responsible for moving the head and the vertebral column.

Muscles of the Face and Head

Temporalis (TEM-pur-alis)

The temporalis can be found on the surface of the temporal bone, above and in front of the ear. It is a muscle active in chewing. Tensing of this muscle is associated with the temporomandibular joint syndrome. This muscle can be felt in front of the ear when clenching the teeth.

Masseter (MASS-ih-tur)

This is a thick, flattened muscle just in front of the ear. It spans the jaw. It is the primary chewing muscle. This muscle can be felt in front of the ear when clenching the teeth.

Buccinator (BUK-se-NAY-tur)

This is a thin, flat muscle found under the masseter that forms the wall of the cheek. It functions to compress the cheek during chewing and pull the corner of the mouth laterally.

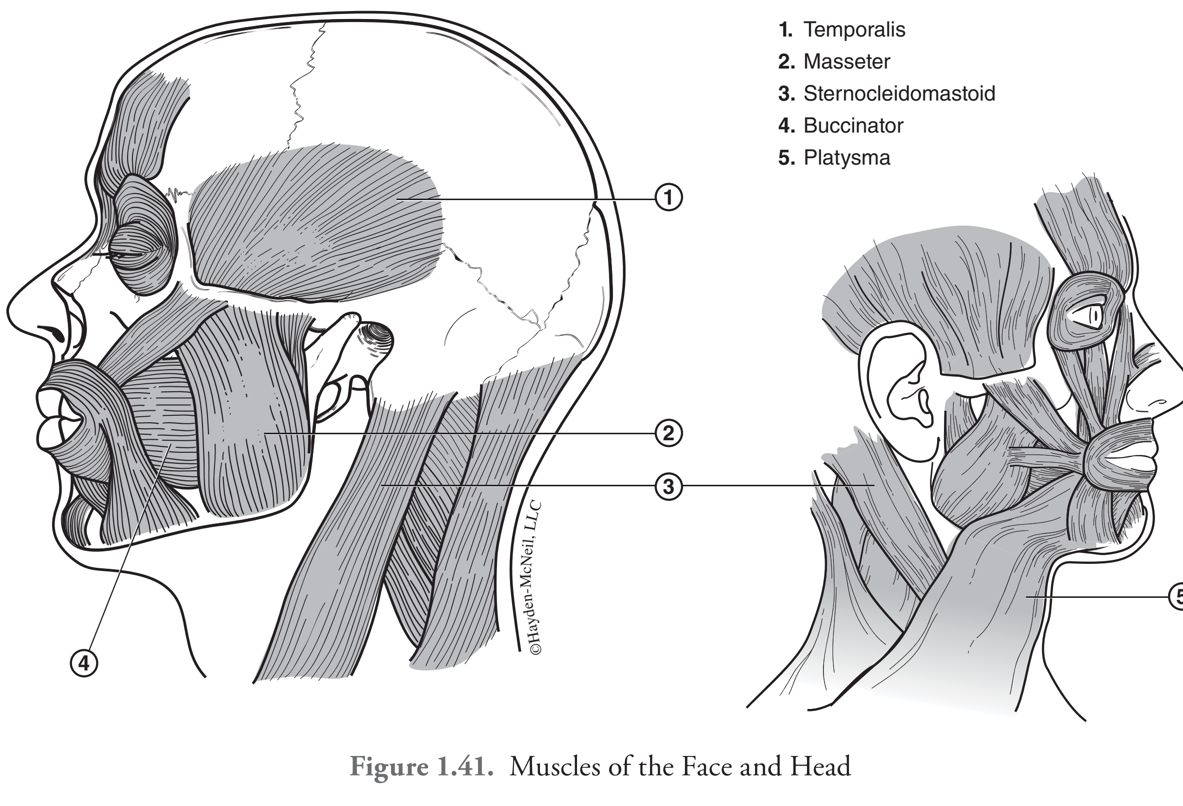


Figure 1.41. Muscles of the Face and Head

Muscles of the Neck

Sternocleidomastoid (STUR-no-KLEYE-doe-MAS-toyd)

This muscle is found on either side of the neck, extending on the diagonal from the chest to the mastoid process of the skull. When only one of the sternocleidomastoid muscles contracts it rotates the head towards the opposite side. When both muscles work together they flex the neck towards the chest. The sternocleidomastoid can raise the sternum and help with inhalation if the head is stabilized by other muscles.

Platysma (plah-TIZ-mah)

This is the surface muscle of the neck. This muscle is responsible for depressing the mandible and lower lip. It also tenses the skin over the lower neck. It is superficial to the sternocleidomastoid.

Table 1.7: Muscles of the Head, Face, and Neck

Muscle	Origin	Insert	Action
Face			
Temporalis	Temporal fossa	Coronoid process of mandible	Closes jaw; elevates and retracts mandible
Masseter	Zygomatic arch and maxilla	Angle and ramus of mandible	Closes jaw; elevates and protracts mandible
Buccinator	External alveolar margins of maxilla	Decussates at modiolus of mouth and interdigitates with opposite side	Aids mastication, tenses cheeks in blowing and whistling, aids closure of mouth
Neck			
Sternocleidomastoid	Manubrium of sternum; medial portion of clavicle	Mastoid process of temporal bone and superior nuchal line of occipital bone	Abducts, rotates, and flexes head
Platysma	Skin over lower neck and upper lateral chest	Inferior border of mandible and skin over lower face and mouth	Depresses and wrinkles skin of lower face and mouth. Aids forced depression of mandible

Section C – Muscles of the Trunk

The muscles of the trunk would include muscles found on the chest, shoulder, back, and abdomen. These muscles are separated according to the area of the torso where they are found.

Muscles of the Chest

The muscles found on the chest can be involved in moving the arm, pectoral girdle, or the rib cage. The superficial muscles of the chest include the pectoralis major and the serratus anterior. These are involved in moving the arm and pectoral girdle. The deeper muscles of the chest include the external and internal intercostals which are involved in moving the rib cage.

Pectoralis major (PECK-tur-AL-is)

This is a large muscle that makes up the majority of the upper chest. It is fan-shaped and extends from the armpit to the middle of the thorax. The pectoralis major moves the arm. It is a target of most bodybuilders.

Serratus anterior (SER-RAT-us)

The muscle is found on the upper lateral aspect of the chest. It's origin on the ribs appears to give the muscle the look of the serrated edge of a knife. It is responsible for moving the pectoral girdle. It is the muscle that is used if the shoulder is moved forward when pushing something.

External intercostals (IN-ter-KOS-tahl)

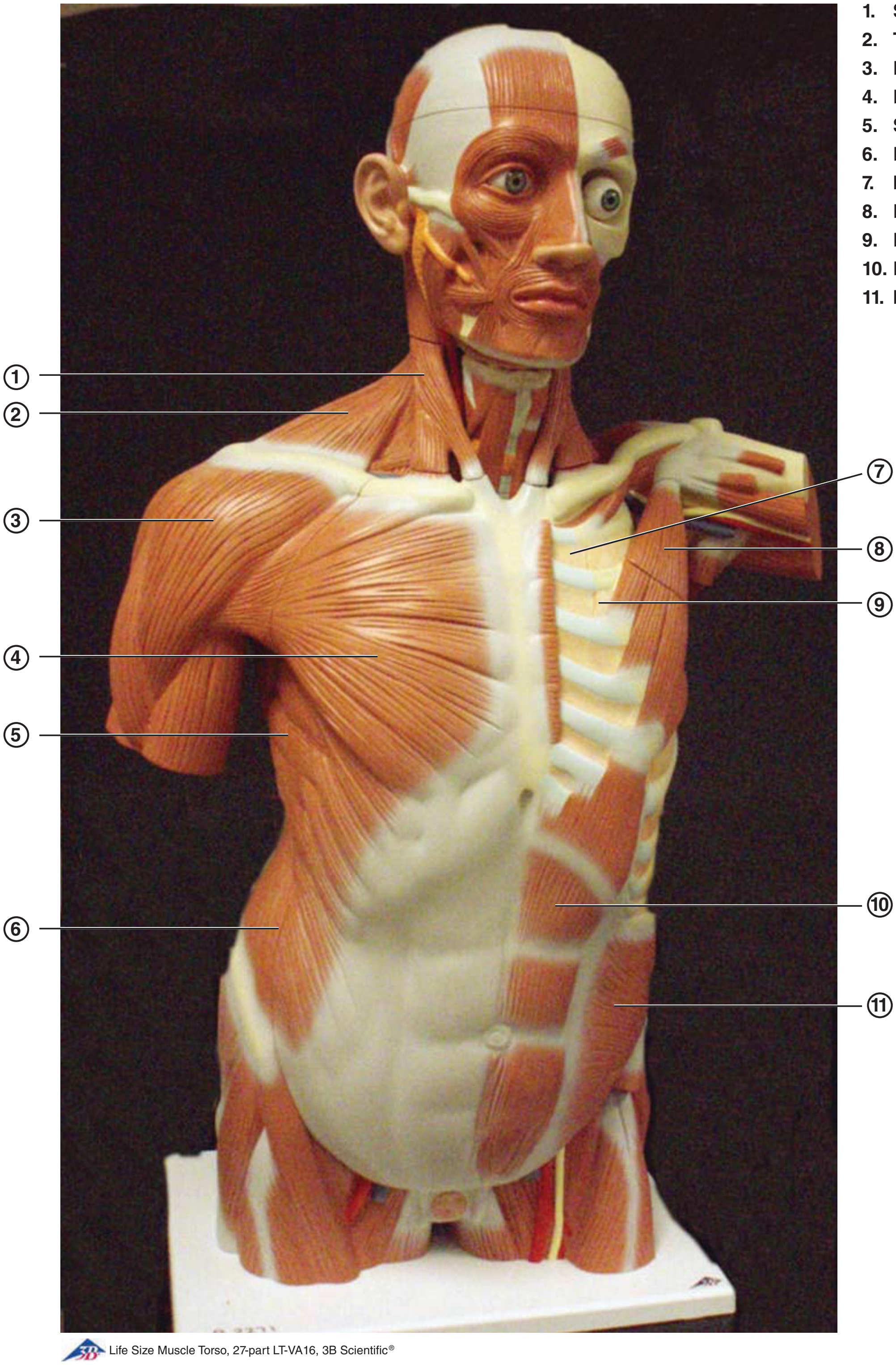
These muscles are found between the ribs. The external intercostals are closer to the surface than the internal intercostals. The fibers of these muscles run obliquely downward and forward toward the sternum. These muscles are used to assist in inhalation.

Internal intercostals

These muscles are also found between the ribs. The internal intercostals are under the external intercostals. The fibers of these muscles run in the opposite direction of the external intercostals. These muscles are used in forceful exhalation as when blowing out the candles on the birthday cake.

Table 1.8: Muscles of the Chest

Muscle	Origin	Insert	Action
Face			
Pectoralis major	Clavicle, sternum, cartilage of ribs 1–7	Crest of greater tubercle	Flexes, adducts and medial rotates arm
Serratus anterior	Lateral aspect of ribs 1–8	Vertebral border of anterior surface of scapula	Laterally rotates and protracts scapula
External intercostals	Inferior border of rib above	Superior border of rib below	Elevates ribs; aids in inspiration
Internal intercostals	Superior border of rib below	Inferior border of rib above	Depresses ribs; aids in forced expiration



1. **Sternocleidomastoid**
2. **Trapezius**
3. **Deltoid**
4. **Pectoralis major**
5. **Serratus anterior**
6. **External oblique**
7. **Internal intercostal**
8. **Pectoralis minor**
9. **External intercostal**
10. **Rectus abdominis**
11. **Internal oblique**

Figure 1.42. Muscles of the Chest and Abdomen

Muscles of the Abdomen

The abdominal muscles in the anterior and lateral wall are layers of broad flattened muscles. Most muscles are directly supported by bone, but these muscles are not. They connect the ribs and the vertebral column to the pelvic girdle. There is a band of connective tissue that extends from the xiphoid process to the symphysis pubis which serves as an attachment point for some of the abdominal muscles. This connective tissue is known as the **linea alba** (LIN-ee-ah AL-bah).

When the abdominal muscles contract they decrease the volume of the abdominal cavity and increase the pressure inside. They can be used during forceful exhalation, and to assist in defecation, childbirth, and urination.

These muscles include the rectus abdominis and external obliques which are superficial muscles and the internal obliques and the transverse abdominis which are deeper muscles.

Rectus abdominis (REK-tahs AB-dom-in-us)

These are two muscles that are long straight muscles on the surface of the abdomen. They can be found on each side of the linea alba. These are the muscles individuals are referring to when they talk about "six-pack abs."

External oblique (ik-STUR-nahl ah-BLEEK)

This muscle is on the lateral surface of the abdomen. The fibers run downward and medially. The fibers run as if one is putting the hands in the pants pockets.

Internal oblique (in-TUR-nahl ah-BLEEK)

This muscle is on the lateral surface of the abdomen beneath the external oblique. The fibers run at a right angle to the external oblique.

Transverse abdominis (trans-VURS AB-dom-in-us)

This is the deepest muscle of the abdominal wall. These muscles run across the abdomen from each side to the linea alba.

Table 1.9: Muscles of the Abdomen

Muscle	Origin	Insert	Action
Rectus abdominis	Pubic crest and symphysis	Xiphoid process and costal cartilages of ribs 5–7	Flexes vertebral column, compresses abdomen
External oblique	Ribs 5–12	Linea alba, pubic crest, and tubercles and iliac crest	Compresses abdomen, laterally rotates trunk
Internal oblique	Lumbar fascia, iliac crest, inguinal ligament	Linea alba, pubic crest, and costal cartilages of last 3 ribs	Compresses abdomen, laterally rotates trunk
Transverse abdominis	Inguinal ligament, iliac crest, cartilages of last 5–6 ribs and lumbar fascia	Linea alba and pubic crest	Compresses abdomen, laterally rotates trunk

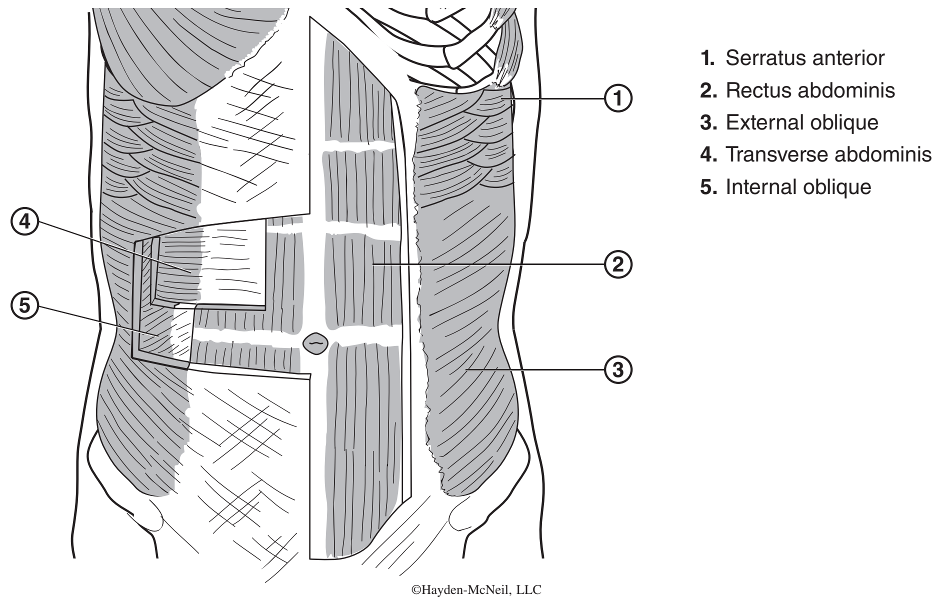


Figure 1.43. Abdominal Muscles

Muscles of the Shoulder and Back

The muscles of the shoulder and back are responsible for moving the pectoral girdle and the arm. Most of the muscles discussed here are superficial; a couple, the supraspinatus and subscapularis, are deeper muscles. Four of these muscles are known as the rotator cuff: the subscapularis, supraspinatus, infraspinatus, and teres minor. The rotator cuff muscles are responsible for holding the humerus in the shoulder joint. When there is a shoulder injury these muscles are frequently involved.

Trapezius (trah-PEE-zee-us)

This is a diamond shaped surface muscle found in the upper back. This is the muscle used when shrugging the shoulder. It can also be used to hyperextend the neck.

Latissimus dorsi (lah-TISS-ih-mus DOR-sigh)

This is a large muscle in the lumbar region of the back. It arises in the back but inserts on the humerus so it is responsible for movement of the shoulder. This is the muscle that is used when swimming, climbing, and rowing.

Teres major (TARE-eez)

This is the most inferior muscle on the posterior surface of the scapula. It connects the scapula to the humerus.

Teres minor

This muscle is found on the posterior surface of the scapula between the teres major and the infraspinatus. This muscle and the infraspinatus rotate the arm laterally.

Infraspinatus (IN-fra-spin-AT-us)

The infraspinatus is found on the posterior surface of the scapula, inferior to the scapular spine.

Supraspinatus (SOUP-rah-spin-AT-us)

This muscle is found on the posterior surface of the scapula, superior to the scapular spine. It is found under the trapezius muscle.

Subscapularis (SUB-skap-you-LAR-is)

This muscle covers the anterior surface of the scapula. The subscapularis rotates the arm medially.

Deltoid (DEL-toyd)

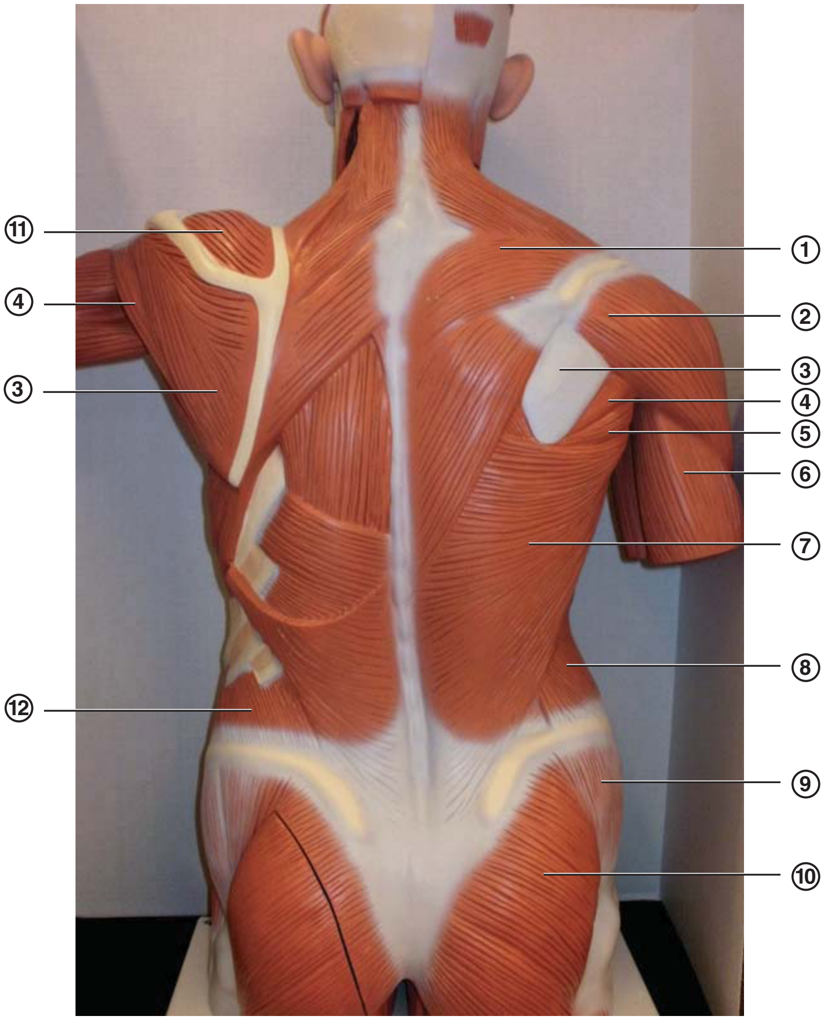
This muscle is responsible for the roundness of the shoulder. It is the muscle mass that is the site of intramuscular injections.

Coracobrachialis (core-AK-oh-BRAY-key-AL-is)

This muscle arises on the coracoid process of the scapula. It can be found by looking in the axillary region and the medial surface of the humerus.

Table 1.10: Muscles of the Shoulder and Back

Muscle	Origin	Insert	Action
Trapezius	Posterior occipital bone, ligamentum nuchae, spines of C7–T12	Acromion and spinous process of scapula; lateral 1/3 of clavicle	Extends and adducts head, rotates, adducts, and fixes scapula
Latissmus dorsi	T7–12, L1–5, S1–5, crest of ilium, ribs 10–12	Tubercular groove of humerus	Extension, adduct and medially rotate arm, depresses the shoulder
Teres major	Posterior surface at inferior angle of scapula	Crest of lesser tubercle of humerus	Extends, medially rotates and adducts arm
Teres minor	Lateral margin of scapula	Greater tubercle of humerus	Extends, laterally rotates and adducts arm; stabilizes shoulder joint
Infraspinatus	Infraspinous fossa	Greater tubercle of humerus	Extension, lateral rotation of arm; stabilizes shoulder joint
Supraspinatus	Supraspinous fossa of scapula	Greater tubercle of humerus	Abduction of arm; stabilizes shoulder joint
Subscapularis	Subscapular fossa of scapula	Lesser tubercle of humerus	Medially rotate arm; stabilizes shoulder joint
Deltoid	Lateral 1/3 of clavicle, acromion and spine of scapula	Deltoid tuberosity of humerus	Adducts arms, flexes, extends, medially and laterally rotates arm
Coracobrachialis	Coracoid process of scapula	Midmedial shaft of humerus	Flexes and adducts arm



Life Size Muscle Torso, 27-part LT-VA16, 3B Scientific®

1. **Trapezius**
2. **Deltoid**
3. **Infraspinatus**
4. **Teres minor**
5. **Teres major**
6. **Triceps brachii**
7. **Latissimus dorsi**
8. **External oblique**
9. **Gluteus medius**
10. **Gluteus maximus**
11. **Supraspinatus**
12. **Internal oblique**

Figure 1.44. Muscles of the Back and Shoulder

Section D – Muscles of the Upper Limb

Muscles of the upper limb are responsible for the movement of the forearm and the wrist. These will be muscles that extend from the humerus across the elbow to the ulna and/or the radius.

Triceps brachii (TRY-ceps BRAY-key-eye)

This is the only muscle on the posterior surface of the arm.

Biceps brachii

This is the most familiar muscle on the arm. It is found on the anterior surface of the arm. It is frequently a target of bodybuilders and is usually reasonably well-defined on most individuals.

Brachialis (BRAY-key-AL-us)

The brachialis can be found under the biceps brachii on the anterior surface of the humerus.

Brachioradialis (BRAY-key-oh-RAY-dee-AL-us)

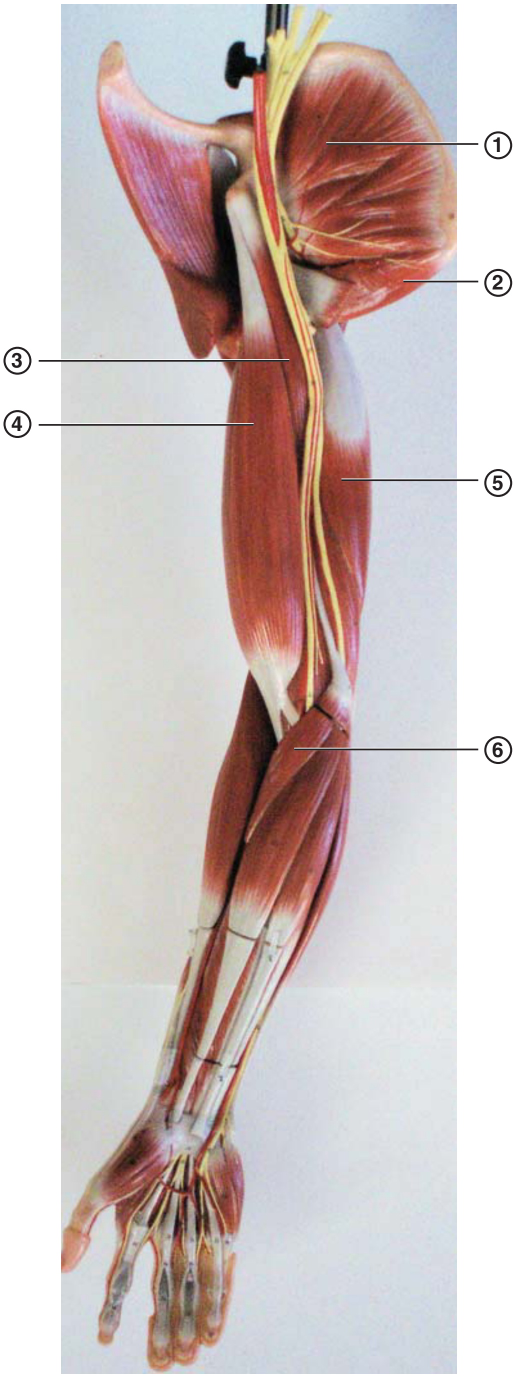
This muscle is found on the lateral surface of the upper arm and extends across the elbow to insert on the radius.

Pronator teres (pro-NAY-tor TARE-eez)

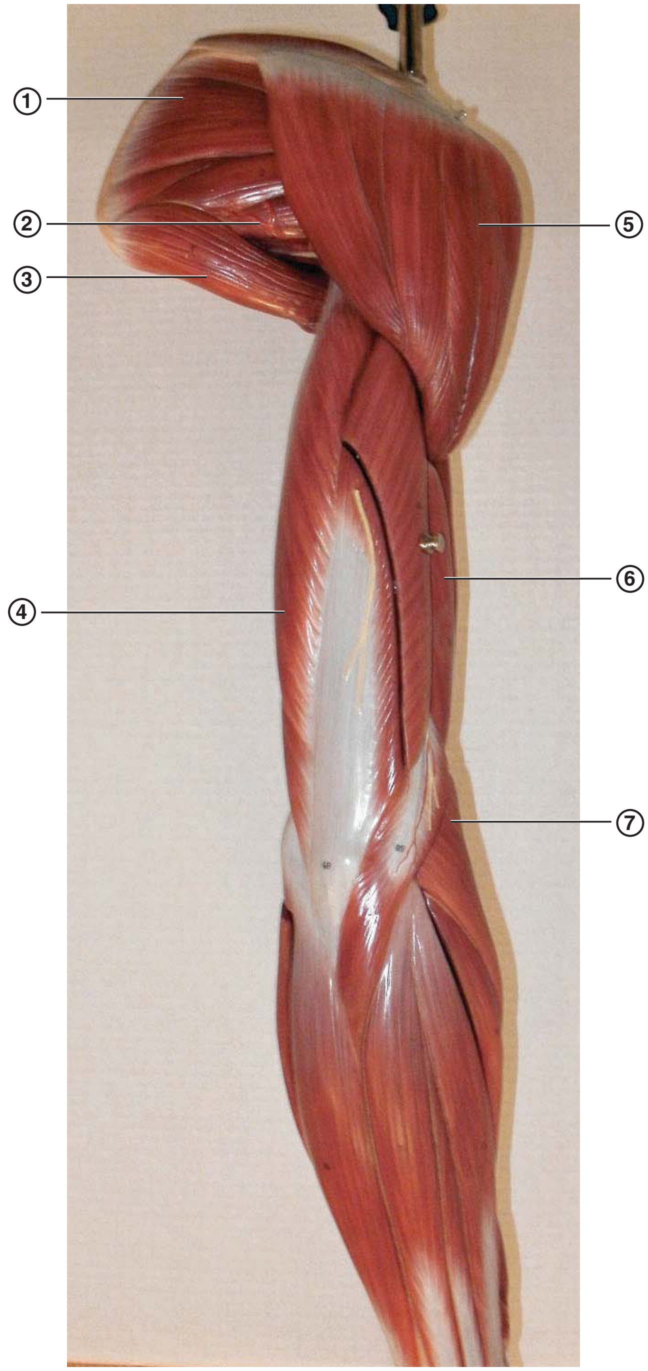
This is a short muscle that runs from the humerus and ulna to the radius. It can be found opposite the brachioradialis at the elbow.

Table 1.11: Muscles of the Upper Limb

Muscle	Origin	Insert	Action
Triceps brachii	Long head – inferior margin of glenoid cavity; lateral head – posterior humerus; medial head – distal radial groove on posterior humerus	Olecranon process of ulna	Extends arm; adducts arm; extends forearm
Biceps brachii	Short head – coracoid process; Long head – superior margin of glenoid fossa	Radial tuberosity	Flexes arm; flexion of forearm; supination of hands
Brachialis	Distal portion of anterior humerus	Coronoid process of ulna	Flexion of forearm
Brachioradialis	Lateral ridge at distal end of humerus	Base of styloid process of radius	Flexion of forearm
Pronator teres	Medial epicondyle of humerus and coronoid process of ulna	Midshaft of radius	Pronate hand; flexes forearm



1. **Subscapularis**
2. **Teres major**
3. **Coracobrachialis**
4. **Biceps brachii**
5. **Triceps brachii**
6. **Pronator teres**



1. **Infraspinatus**
2. **Teres minor**
3. **Teres major**
4. **Brachioradialis**
5. **Brachialis**
6. **Deltoid**
7. **Triceps brachii**

Figure 1.45. Anterior and Posterior Muscles of the Upper Limb

Section E – Muscles of the Pelvis, Buttocks, and Lower Limb

The muscles of the pelvis, buttocks, and lower limb are responsible for movement of the thigh, leg, and foot.

Muscles of the Pelvis

Iliopsoas (ILL-ee-oh-SO-az), **Iliacus** (ILL-ee-AK-us), **Psoas major** (SO-az MAY-jor)

These muscles are the primary flexors of the thigh. They move the leg forward when walking. The iliacus and psoas major are found in the pelvic cavity and the iliopsoas is found in the proximal thigh, near the ramus of the pubis. In the upper thigh the iliacus and psoas major are essentially inseparable so they are referred to jointly as the iliopsoas.

Muscles of the Buttocks

Gluteus maximus (GLOO-te-us MAK-si-mus)

This is the largest muscle in the body. It is a surface muscle that covers a large part of the buttocks. The gluteus maximus helps straighten the leg when walking, running, and climbing stairs. It also assists in standing up from a seated position.

Gluteus medius

This muscle originates superior to, but is partially covered by, the gluteus maximus. It assists with balance during walking.

Muscles of the Thigh

Adductor magnus

This is a large triangular muscle found on the medial surface of the surface of the thigh. It can be found posterior to the gracilis.

Adductor longus

This is a triangular muscle found on the medial surface of the thigh, anterior to the gracilis.

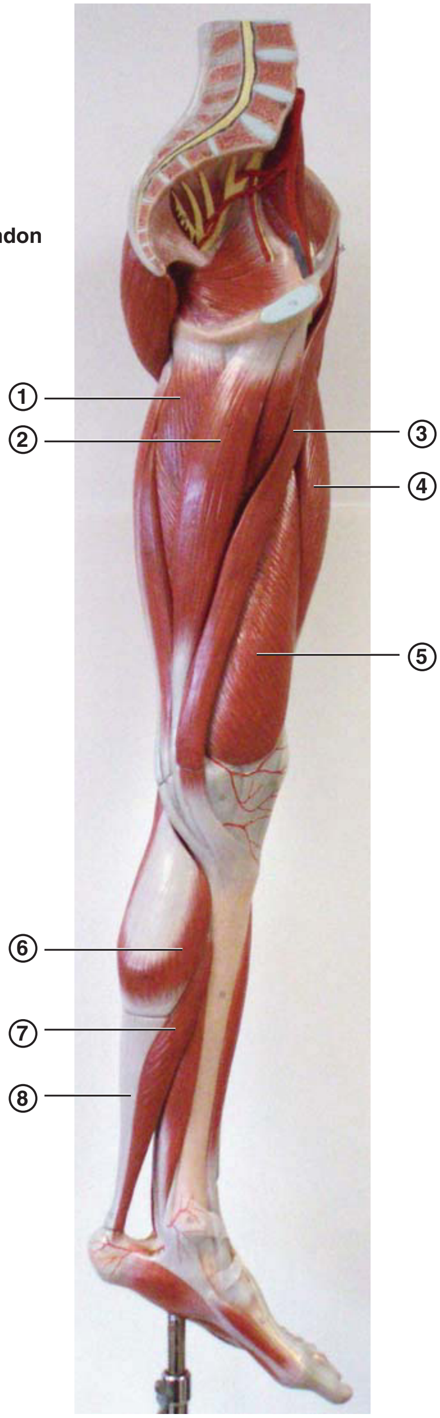
Gracilis (grah-SIL-us)

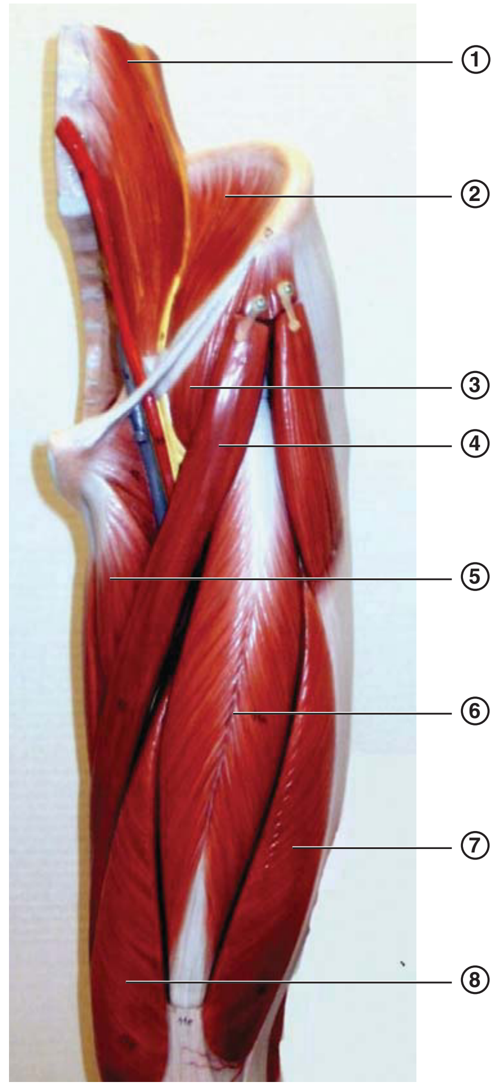
This is a thin, straight muscle found on the medial surface of the thigh.

Sartorius (sar-TOR-ee-us)

This long narrow muscle runs obliquely across the anterior surface of the thigh.

1. **Adductor magnus**
2. **Gracilis**
3. **Sartorius**
4. **Rectus femoris**
5. **Vastus medialis**
6. **Gastrocnemius**
7. **Soleus**
8. **Calcaneal (Achilles) tendon**





1. **Psoas major**
2. **Iliacus**
3. **Iliopsoas**
4. **Sartorius**
5. **Adductor longus**
6. **Rectus femoris**
7. **Vastus lateralis**
8. **Vastus medialis**

Figure 1.46. Muscles of the Medial Lower Limb (left), and Muscles of the Pelvis and Upper thigh (right)

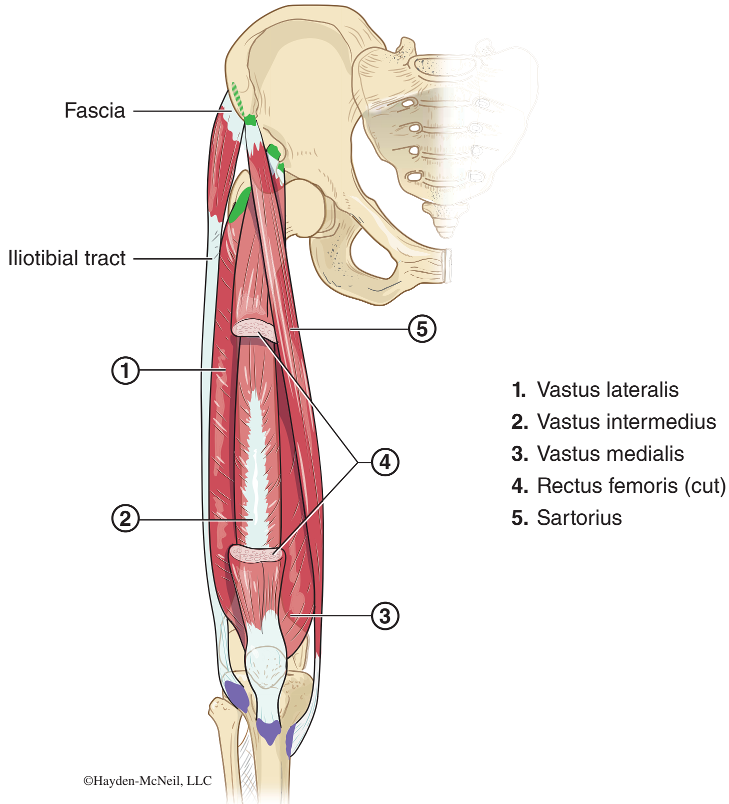


Figure 1.47. **Thigh Muscle**

Rectus femoris (REK-tus FEE-mor-us)

This is a long straight muscle found in the center of the anterior thigh. The rectus femoris, along with the vastus lateralis, vastus medialis, and vastus intermedius are known as the quadriceps muscle. All four muscles have a common ligament, the patellar ligament, which inserts on the tibial tuberosity. However, the rectus femoris is the only one of the four that originates in the pelvis and therefore moves the thigh as well as the leg.

Vastus lateralis

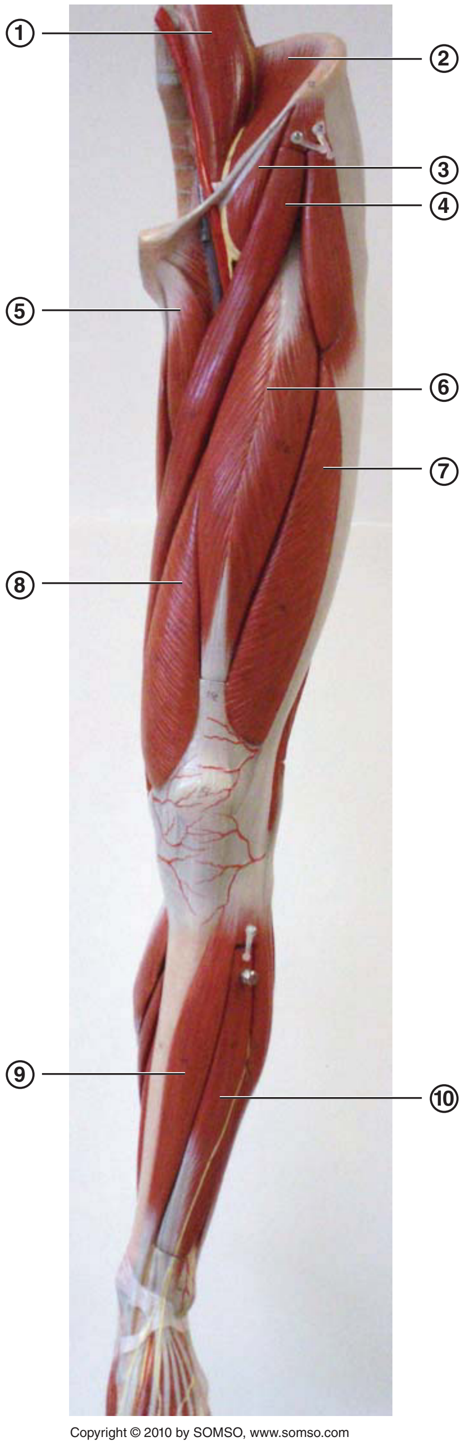
This muscle is found lateral to the rectus femoris on the anterior thigh.

Vastus medialis

This muscle is found medial to the rectus femoris on the anterior thigh.

Vastus intermedius

This muscle is found beneath the rectus femoris on the anterior thigh. It is not a surface muscle.



1. Psoas major
2. Iliacus
3. Iliopsoas
4. Sartorius
5. Adductor longus
6. Rectus femoris
7. Vastus lateralis
8. Vastus medialis
9. Tibialis anterior
10. Extensor digitorum longus

Figure 1.48. Muscles of the Anterior Lower Limb

Biceps femoris (BY-ceps FEE-mor-us)

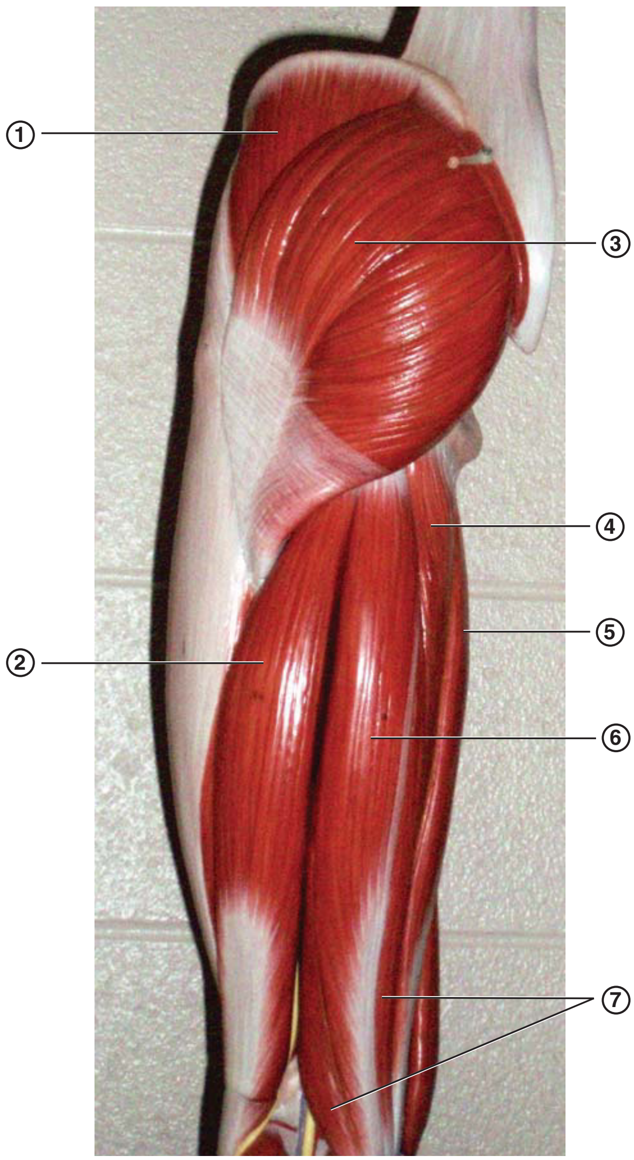
This muscle is found on the lateral surface of the posterior thigh. As its name indicates it has two heads. The tendon of the biceps femoris (the hamstring) can be felt as a lateral ridge behind the knee. The biceps femoris along with the semitendinosus and the semimembranosus are known as the hamstrings.

Semitendinosus

This is a narrow muscle found on the medial surface of the posterior thigh.

Semimembranosus

This is a muscle found on the medial surface of the posterior thigh. It is wider and underneath the semitendinosus.



1. Gluteus medius
2. Biceps femoris
3. Gluteus maximus
4. Adductor magnus
5. Gracilis
6. Semitendinosus
7. Semimembranosus

Figure 1.49. Muscles of the Posterior Lower Limb

Muscles of the Leg

Tibialis anterior

This muscle can be found on the anterior surface of the leg. It runs parallel to the anterior margin of the tibia.

Extensor digitorum longus

This is a muscle found on the anterior surface of the leg. It is lateral to the tibialis anterior. Its main function is the extension of all the toes except the great toe.

Gastrocnemius (gas-TROW-NE-me-us)

This muscle has two prominent bellies on the posterior surface of the leg. This is the most superficial calf muscle. The gastrocnemius helps push the body forward when walking or running.

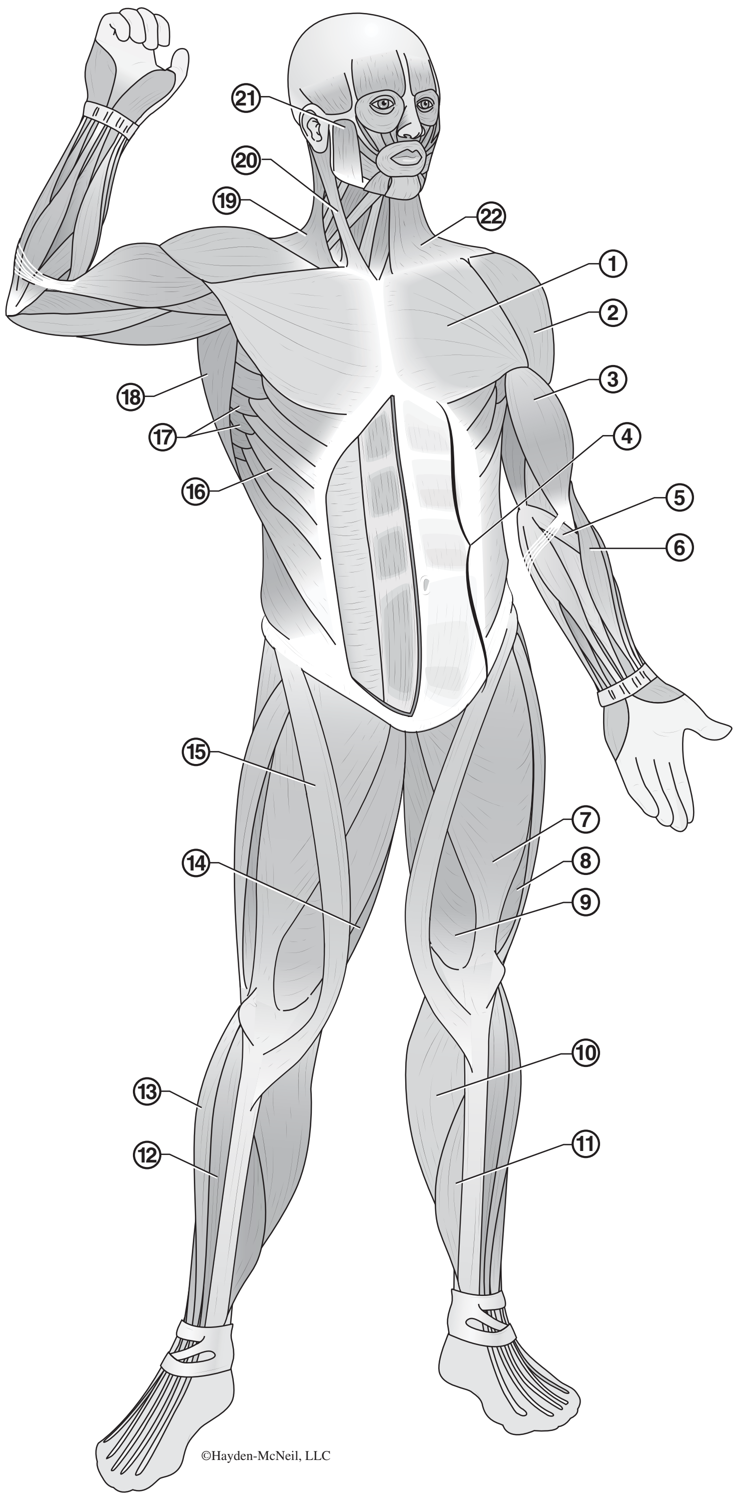
Soleus (SOW-lee-us)

This muscle is below the gastrocnemius on the posterior surface of the leg. Both the gastrocnemius and the soleus insert on the heel (calcaneus) via the calcaneal tendon, which is also known as the Achilles tendon.

Table 1.12: Muscles of Pelvis and Lower Limb

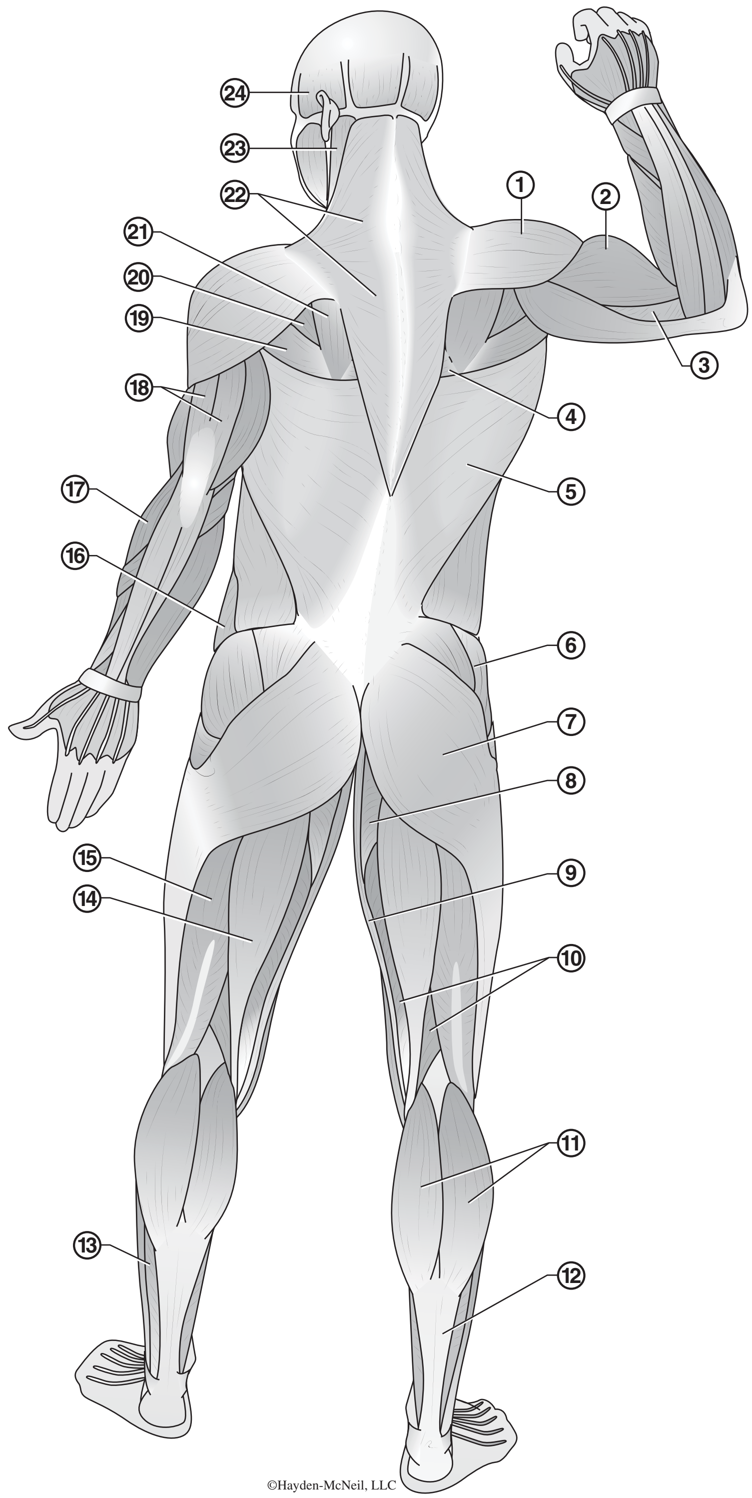
Muscle	Origin	Insert	Action
Pelvis			
Iliospoas; Iliacus; Psoas major	Iliacus – iliac fossa and crest; lateral sacrum Psoas major – transverse processes, bodies, and discs of T12 and lumbar vertebrae	On and just below lesser trochanter of femur	Flexes lumbar vertebrae; flexes thigh
Buttocks			
Gluteus maximus	Dorsal ilium, sacrum, and coccyx	Gluteal tuberosity of femur and iliotibial tract	Extends, adducts, and laterally rotates thigh; braces knee
Gluteus medius	Upper lateral surface of ilium	Greater trochanter of femur	Abducts and medially rotates thigh
Medial Thigh			
Adductor magnus	Ischial and pubic rami and ischial tuberosity	Linea aspera and adductor tubercle of femur, gluteal tuberosity	Adduct, laterally rotate, flex and extend thigh
Adductor longus	Pubis near pubic symphysis	Linea aspera and middle portion of femur	Adduct, laterally rotates and flexes thigh
Gracilis	Symphysis pubis	Medial surface of tibia just inferior to medial condyle	Adducts thigh, flexes and medially rotates leg

Muscle	Origin	Insert	Action
Anterior Thigh			
Sartorius	Anterior superior iliac spine	Medial aspect of proximal tibia	Flexes and laterally rotates thigh, flexes leg
Rectus femoris	Anterior inferior iliac spine and superior margin of acetabulum	Tibial tuberosity and patella	Extends leg; flexes thigh
Vastus lateralis	Greater trochanter, intertrochanteric line and linea aspera	Tibial tuberosity and patella	Extends leg and stabilizes knee joint
Vastus medialis	Intertrochanteric line and linea aspera	Tibial tuberosity and patella	Extends leg and stabilizes knee joint
Vastus intermedius	Anterior and lateral surface of femur	Tibial tuberosity and patella	Extends leg
Posterior Thigh			
Biceps femoris	Long head – ischial tuberosity; short head – linea aspera and distal femur	Head of fibula and lateral condyle of tibia	Extends thigh; flexes leg
Semitendinosus	Ischial tuberosity	Medial aspect of upper fibula shaft	Extends thigh; flexes leg
Semimembranosus	Ischial tuberosity	Medial condyle of tibia; lateral condyle of femur	Extends thigh; flexes leg
Leg			
Tibialis anterior	Lateral condyle and upper 2/3 of tibia; interosseous membrane	Inferior surface of first cuneiform and metatarsal 1	Dorsiflexion, inverts foot
Extensor digitorum longus	Upper 2/3 of anterior shaft of fibula; interosseous membrane	Lateral four toes	Extends all toes except great toe and extends foot at ankle
Gastrocnemius	Medial and lateral condyles of femur	Calcaneus via calcaneal tendon	Flexes leg; plantarflexion foot
Soleus	Proximal portion of tibia and fibula; interosseous membrane	Calcaneus via calcaneal tendon	Plantarflexion foot



1. Pectoralis major
2. Deltoid
3. Biceps brachii
4. Rectus abdominis
5. Pronator teres
6. Brachioradialis
7. Rectus femoris
8. Vastus lateralis
9. Vastus medialis
10. Gastrocnemius
11. Soleus
12. Tibialis anterior
13. Extensor digitorum longus
14. Gracilis
15. Sartorius
16. External oblique
17. Serratus anterior
18. Latissimus dorsi
19. Trapezius
20. Sternocleidomastoid
21. Masseter
22. Platysma

Figure 1.50. Muscles of the Anterior Body



1. Deltoid
2. Biceps brachii
3. Brachialis
4. Rhomboideus
5. Latissimus dorsi
6. Gluteus medius
7. Gluteus maximus
8. Adductor magnus
9. Gracilis
10. Semimembranosus
11. Gastrocnemius
12. Calcaneal tendon
13. Soleus
14. Semitendinosus
15. Biceps femoris
16. External oblique
17. Brachioradialis
18. Triceps brachii
19. Teres major
20. Teres minor
21. Infraspinatus
22. Trapezius
23. Sternocleidomastoid
24. Temporalis

Figure 1.51. Muscles of the Posterior Body

UNIT 2

Nervous Tissue, Central Nervous System, Special Senses, and Endocrine System

PART 1

This unit will be covering the systems that allow communication in the body—the nervous system and the endocrine system. We will begin with the nervous system, then explore the ear and eye, and end this unit with the endocrine system.

Nervous Tissue and the Neuron

Nervous tissue is one of the four types of tissues found in the human body. The primary characteristic of nervous tissue is conductivity. This tissue is capable of transmitting an impulse. This tissue is also described as irritable which means it can be stimulated. When it is stimulated it then conducts the impulse.

The fundamental unit of the nervous system is the **neuron**. This is the cell that is stimulated and responsible for transmitting nervous impulses. There are about 20 billion neurons in the cerebrum and a total of 100 billion neurons in the brain. In the spinal cord there are about 1 billion neurons. The other type of cell found in nervous tissue is the **neuroglia** or glial cells. For every neuron there are 10 to 50 glial cells. These cells serve many functions in the nervous system including support, nourishment, and protection. In the lab the only glial cell studied is the **Schwann cell** (SHWAHN) also known as a **neurolemmocyte** (NU-rah-LEM-mah-site) which is the glial cell found in the peripheral nervous system.

There are three important parts to every neuron: the **cell body**; the **dendrites** (DEN-drytes); and the **axon**. First, let's look at the cell body. This is the control center for the neuron. If the cell body dies, the neuron will die. The cell body may be called the **soma** (so-MAH) or the **perikaryon** (PER-IKER-ee-on). In the neuron you will find the same organelles as in most other cells. Neurons have a nucleus, ribosomes, Golgi bodies, mitochondria, and all the other organelles necessary for cellular function.

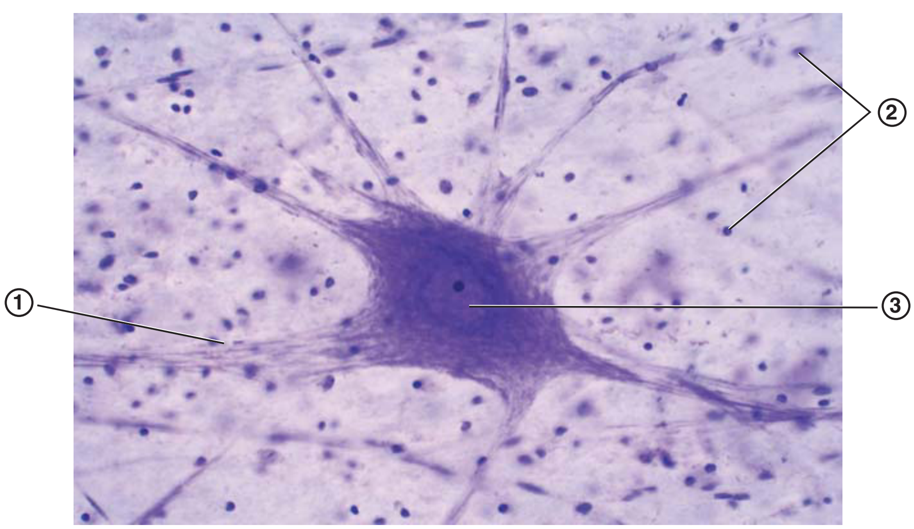
There are a few unique features in the cell body of a neuron that need to be addressed. Scattered throughout the cytoplasm of the neuron there are dark structures called **Nissl bodies** (NIS-ahl). These structures are mainly rough endoplasmic reticulum that are responsible for protein synthesis. The neuron has a well developed cytoskeleton that functions in support and intracellular transport. The microtubules are important in intracellular transport. There are **neurofibrils** (NU-rah-FYE-brils); very thin threads that extend into the axon to support it.

The dendrites are processes of the neuron that receive information from other cells or stimuli and transmit the message to the cell body. Depending on the neuron, the dendrites can take on several different appearances. These processes allow neurons to receive communications from other cells as well as monitoring the environment, internal and external.

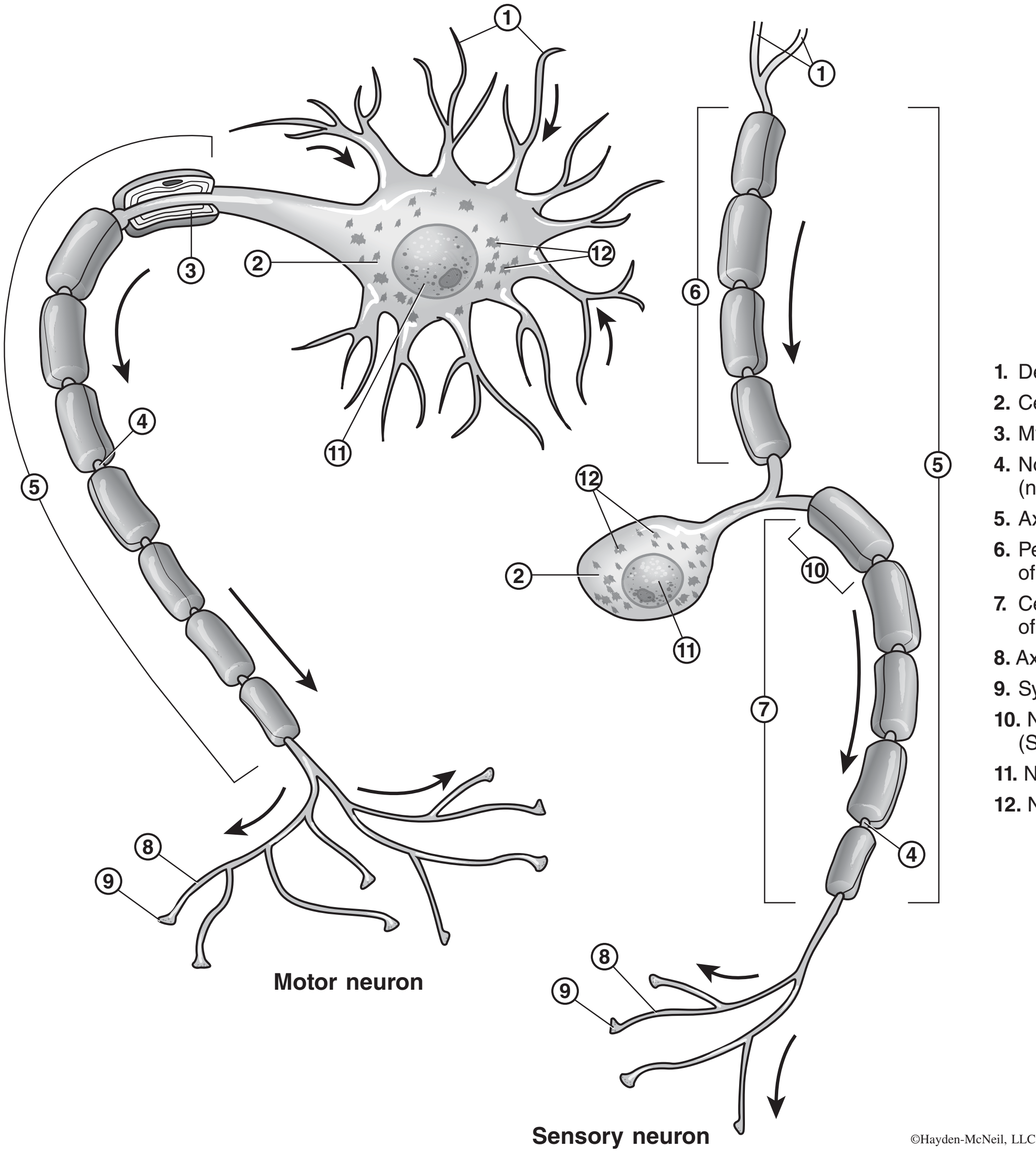
The axon is a process that conducts the message away from the cell body toward other cells. A bundle of axons is known as a **nerve** in the peripheral nervous system, and a **tract** in the central nervous system. There is only one axon leaving a cell body, however, that axon can then branch into collaterals. At the end of the axon there are many small branches that each have a specialized **axon terminal** that ends in the **synaptic knob** (SINAP-tik). The synaptic knob contains the chemical neurotransmitter that will be released to carry the electrical message from the neuron to the next cell. The synaptic knob does not actually touch the next cell, there is a very small gap known as the **synaptic cleft**. A **synapse** is the area that encompasses the synaptic knob, synaptic cleft, and the postsynaptic membrane. Each "typical" neuron is part of a thousand to ten thousand synapses. As a result, there are about a quadrillion synapses in the brain and 60 trillion of those are just in the cerebral cortex.

Axons in the peripheral nervous system may be covered by a **myelin sheath** (MY-ah-lin) formed by neurolemmocytes (Schwann cells). Myelin is a fatty material that serves as insulation on the axon. It is also responsible for the white color of white matter in the nervous system. The neurolemmocytes are wrapped around the axon and the myelin is found between this cell and the axon of the neuron. The nucleus and organelles of the neurolemmocyte are found just beneath the neurilemma. The membranous sheath of the neurolemmocyte around the axon is the **neurilemma** (alternate spelling: neurolemma). There are several neurolemmocytes (Schwann cells) covering each axon and the gaps between these cells are the **nodes of Ranvier** (RON-vee-ay), or **neurofibril nodes**.

Neurons can be classified according to their functions. **Sensory** or **afferent neurons** transmit impulses from sensory receptors to the central nervous system. **Motor** or **efferent neurons** transmit impulses from the central nervous system to the muscles or glands. **Interneurons** are found only in the central nervous system where they connect neuron to neuron.



1. **Process**
2. **Glia**
3. **Cell body**



1. Dendrites
2. Cell body
3. Myelin sheath
4. Node of Ranvier (neurofibril node)
5. Axon
6. Peripheral process of axon
7. Central process of axon
8. Axon terminal
9. Synaptic knob
10. Neurolemmocyte (Schwann cell)
11. Nucleus of neuron
12. Nissl bodies

Figure 2.1. Motor and Sensory Neuron

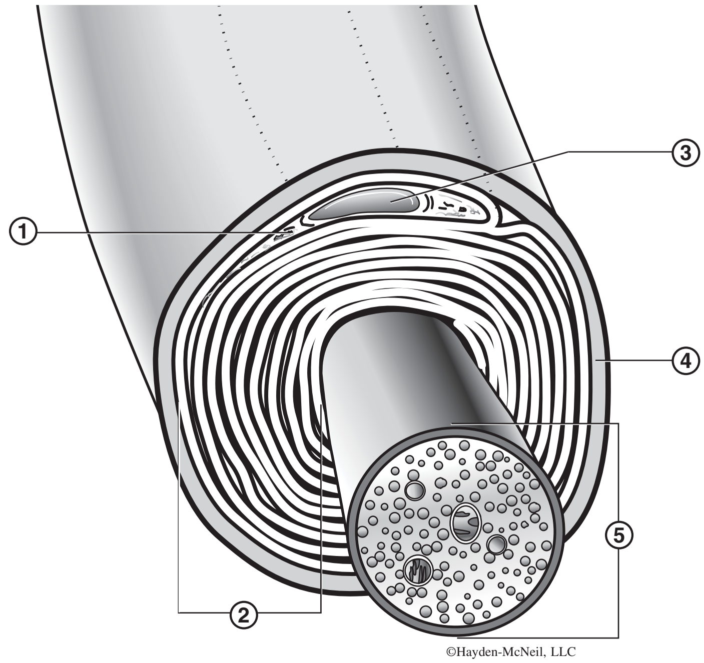


Figure 2.2. Axon with Myelin Sheath

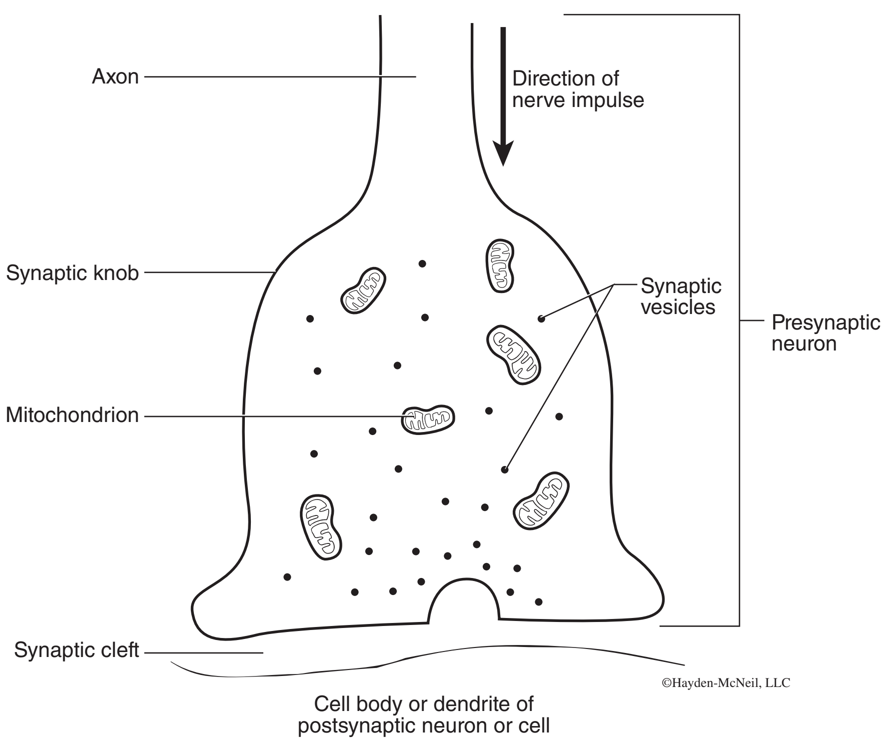


Figure 2.3. Synaptic Knob

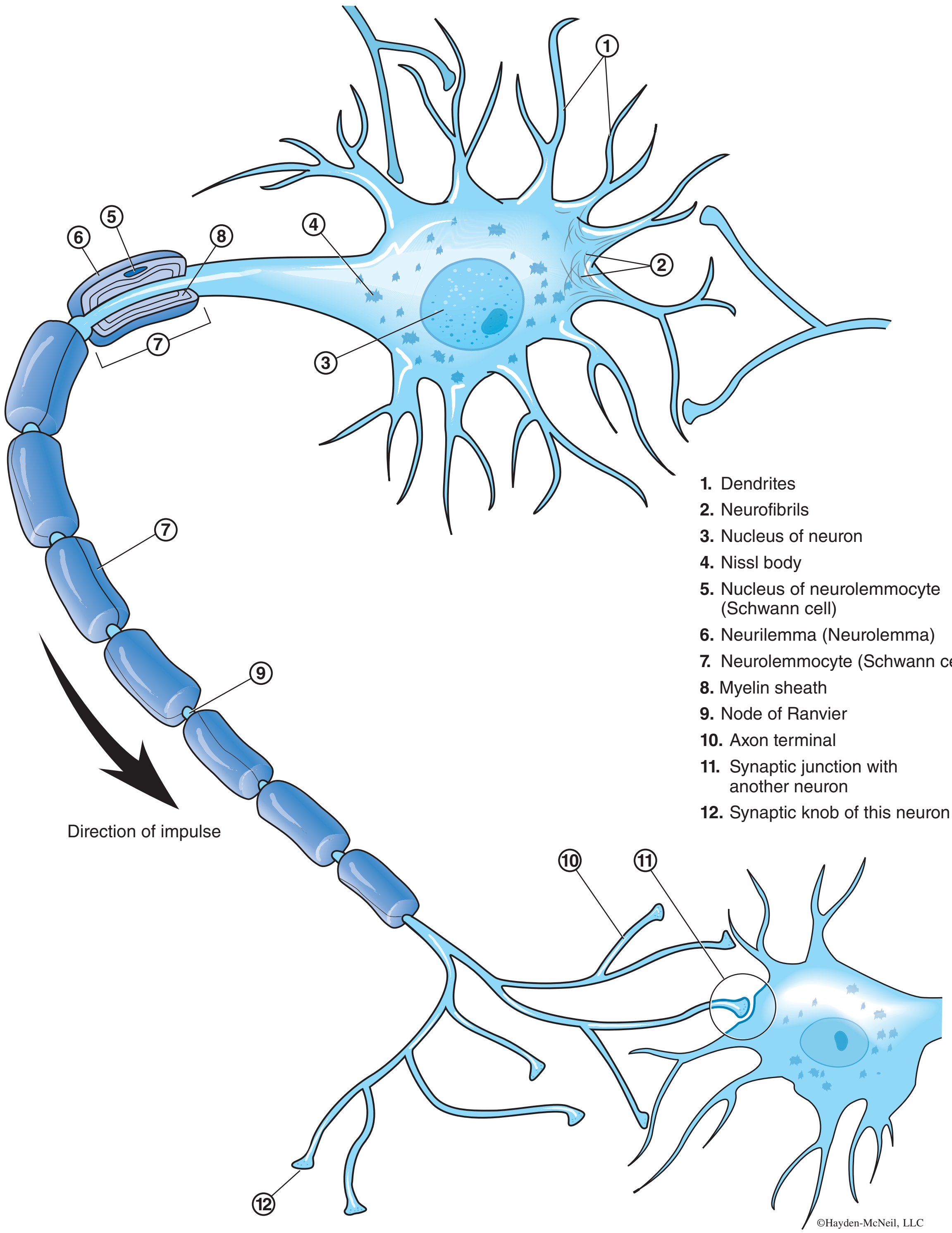


Figure 2.4. Motor Neuron with Synapse

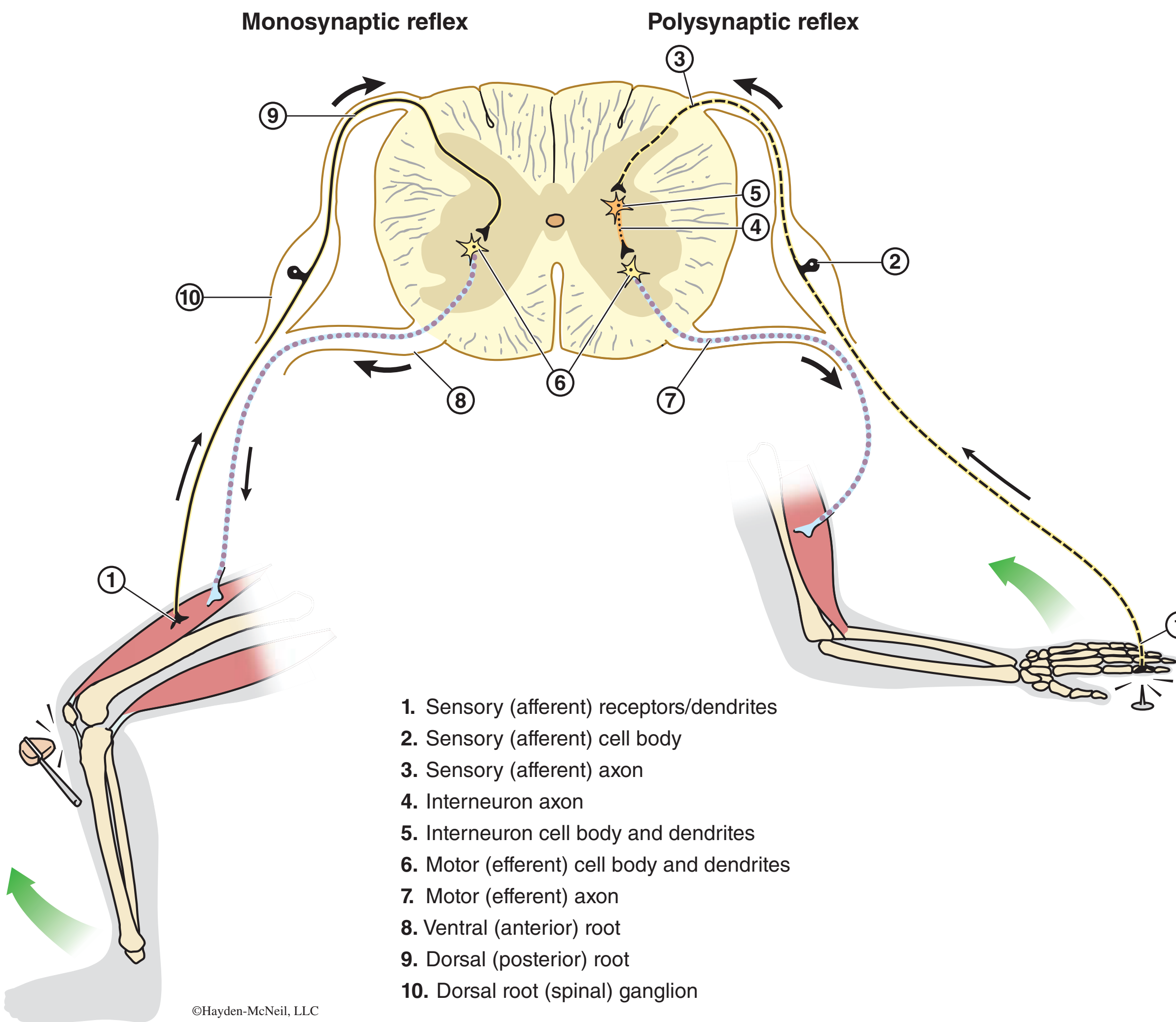


Figure 2.5. Spinal Cross Section with Neurons

Part 2

The Brain

The central nervous system consists of the brain and the spinal cord. You will first examine the brain and then in the next part you will examine the spinal cord.

The human brain weighs about three pounds and is located inside the skull or cranium which protects it from harm. The brain is made of white and gray matter. White matter refers to the presence of myelin and gray matter refers to the absence of myelin. When observing actual brain tissue it does not actually appear gray and white. All brain tissue appears beige with the gray matter referring to the darker beige tissue and the white matter referring to the lighter beige tissue.

In the cerebrum and cerebellum the gray matter is a thin layer on the exterior surface and is referred to as the cortex. The white matter is located in the interior. The thalamus and hypothalamus are mainly gray matter. In the brainstem gray matter is scattered within the white matter and is associated with the reflex centers.

The brain has four main divisions: the **cerebrum** (SER-e-brum), the **diencephalon** (DYE-en-SEF-ah-lon), the **cerebellum** (ser-e-BELL-um), and the **brainstem**. The brainstem is the most inferior part of the brain and it consists of the **medulla oblongata** (mah-DUL-ah OB-long-GAH-tah), **pons** (PONZ), and **midbrain**. The brainstem is the structure that connects the brain with the spinal cord. Attached posteriorly to the pons and midbrain is the cerebellum. Superior to the brainstem is the diencephalon, and the largest division of the brain is the cerebrum.

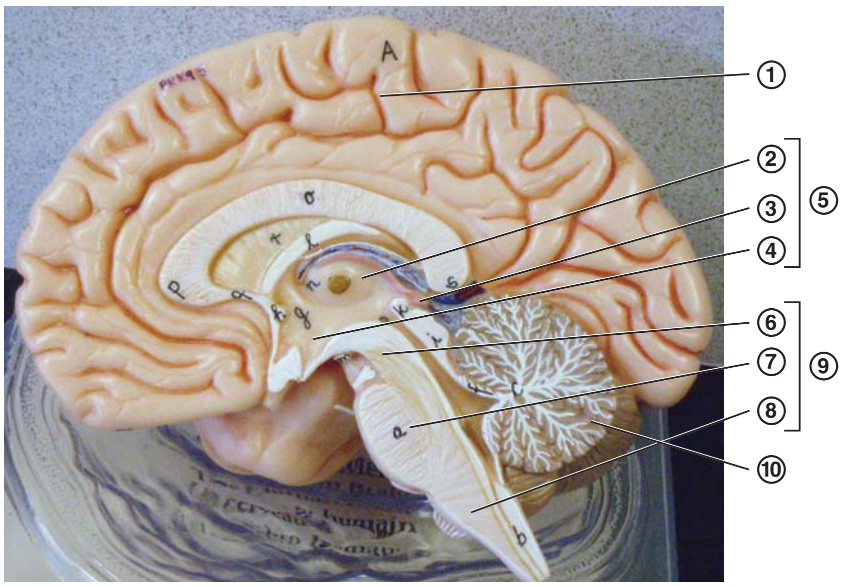


Figure 2.6. Divisions of the Brain

Cerebrum

The **cerebrum** has two hemispheres that superficially appear the same. The surface of the cerebrum has many ridges and grooves. The ridges are the **gyri** (JI-rye) [singular, gyrus (JI-rahs)] and the grooves are the **sulci** (SUL-key) [singular, sulcus (SUL-kus)]. Deep grooves are called **fissures**. The fissures, sulci, and gyri are used as markers to identify locations or separate areas of the brain.

Each hemisphere consists of five lobes. However, only four of the lobes are visible on the surface of the brain. The frontal lobe is located beneath the frontal bone; the parietal lobe is beneath the parietal bone; the temporal lobe below the temporal bone, and the occipital lobe below the occipital bone. The fifth lobe is located by separating the lateral fissure between the frontal lobe and temporal lobe. This is the insula and is not visible anywhere in the laboratory.

The **frontal lobe** is located anterior to the **central sulcus**. The somatic motor cortex is found in the **precentral gyrus** of this lobe. The prefrontal areas are involved in emotions, motivation, and personality.

The **parietal lobe** is located posterior to the central sulcus. The **postcentral gyrus** in this lobe is the location of the somatic sensory cortex. The area behind the postcentral gyrus is involved in visual-spatial relationships and proprioception, which is the awareness of the position of body parts in space.

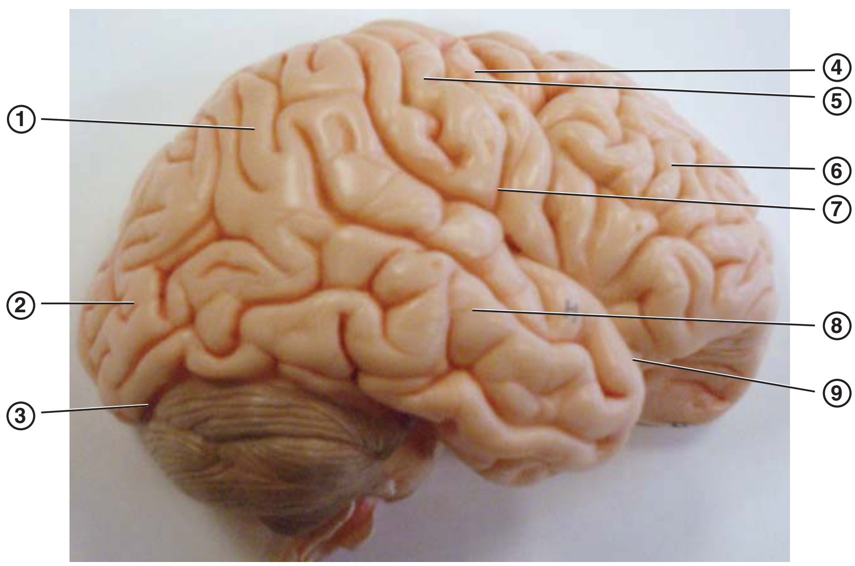
The **temporal lobe** is separated from the frontal lobe by the **lateral fissure**. This lobe contains the auditory cortex which is concerned with hearing. It also plays an important role in memory, language, and speech.

The **occipital lobe** is located in the posterior region of the brain. This lobe is primarily concerned with vision as it is the location of the visual cortex.

The **insula** is located under the lateral fissure of the brain and is not visible in lab. This lobe plays a role in some language functions as well as processes certain sensory input such as pain, temperature sensation, and possibly taste. It also integrates sensory and autonomic information from the viscera.

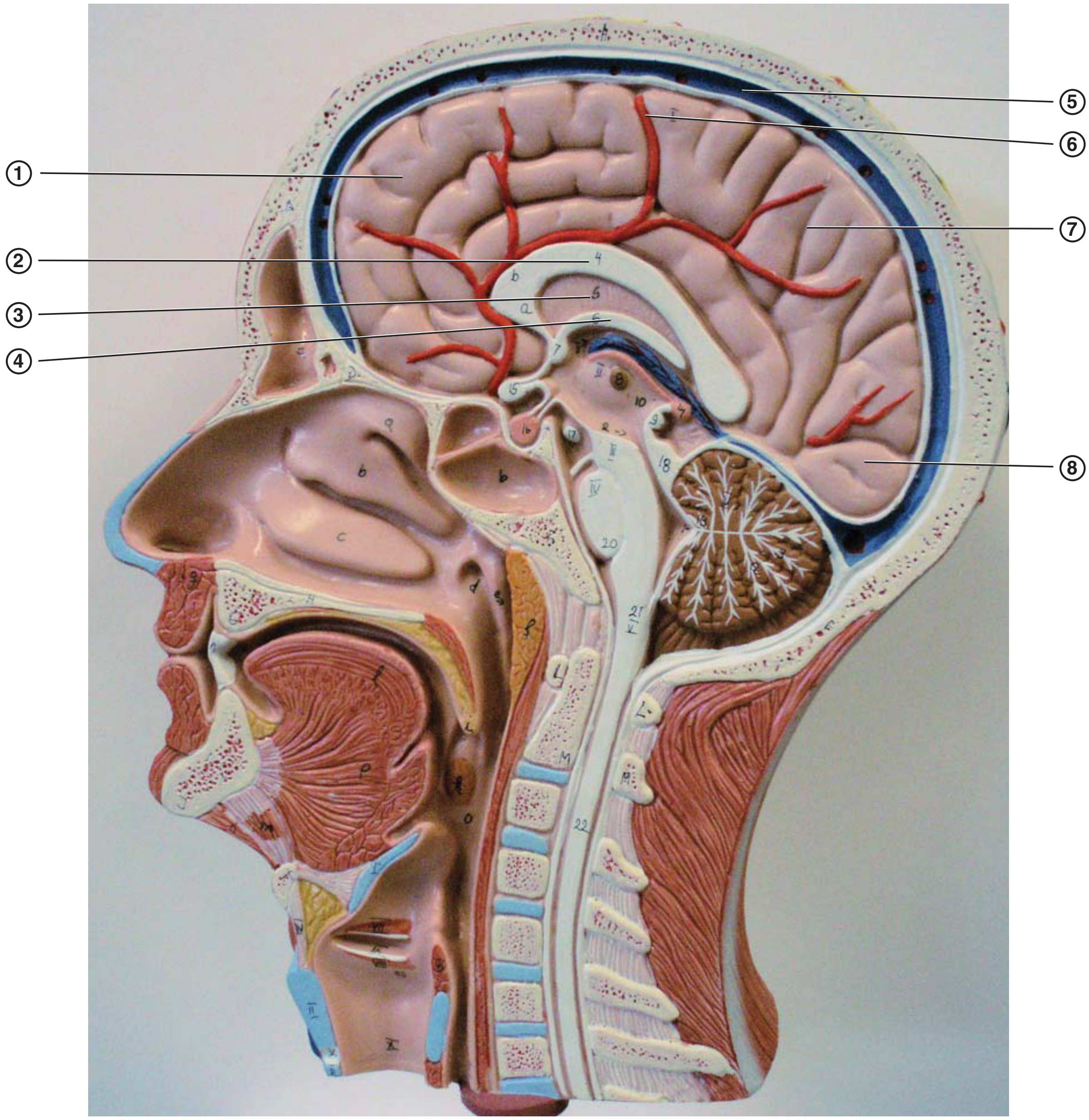
The crevice between the two hemispheres is the **longitudinal fissure**. The crevice between the cerebrum and the cerebellum is the **transverse fissure**. The **central sulcus** is the groove that separates the frontal and parietal lobes. The **lateral fissure** is the crevice between the frontal and temporal lobes.

Most structures that must be identified in the brain can be located by viewing the sagittal or inferior view. On the sagittal section there is a wide curved band of white fibrous tissue; this is the **corpus callosum** (KOR-pus kah-LO-sum). It is a band of commissural fibers that allows communication between the two hemispheres. This structure actually contains about 250 million fibers. When you dissect the sheep's brain you will be cutting through this structure.



1. **Parietal lobe**
2. **Occipital lobe**
3. **Transverse fissure**
4. **Precentral gyrus**
5. **Postcentral gyrus**
6. **Frontal lobe**
7. **Central sulcus**
8. **Temporal lobe**
9. **Lateral fissure**

Figure 2.7. Lobes, Gyri, and Fissures of the Cerebrum



Median Section of the Head LT-C12, 3B Scientific®

1. **Frontal lobe**
2. **Corpus callosum**
3. **Septum pellucidum**
4. **Fornix**
5. **Superior sagittal sinus**
6. **Central sulcus**
7. **Parietal lobe**
8. **Occipital lobe**

Figure 2.8. Structures of the Cerebrum

Below and attached to the corpus callosum is the **septum pellucidum** (SEP-tum pah-LOO-si-dum). This is a membrane that separates the lateral ventricles of the brain. Below this structure is another band of nerve fibers known as the **fornix** (FOR-niks). This connects the hippocampus, part of the limbic system, to the mamillary bodies of the hypothalamus.

Surrounding the outer perimeter of the cerebrum is a large vein-like structure called the **superior sagittal sinus**. This venous vessel collects the blood from the veins that drain the cerebral hemispheres. This is just one of a number of venous vessels known as the dural sinuses that drain the brain. Ultimately they drain into the internal jugular vein to return oxygen poor blood to the heart. The superior sagittal sinus is the location of the arachnoid granulations that return cerebrospinal fluid to the venous blood.

On the inferior surface of the cerebrum are the **olfactory bulbs** and **olfactory tracts**. These structures carry the sense of smell from the olfactory nerves in the roof of the nose to the brain.

Diencephalon

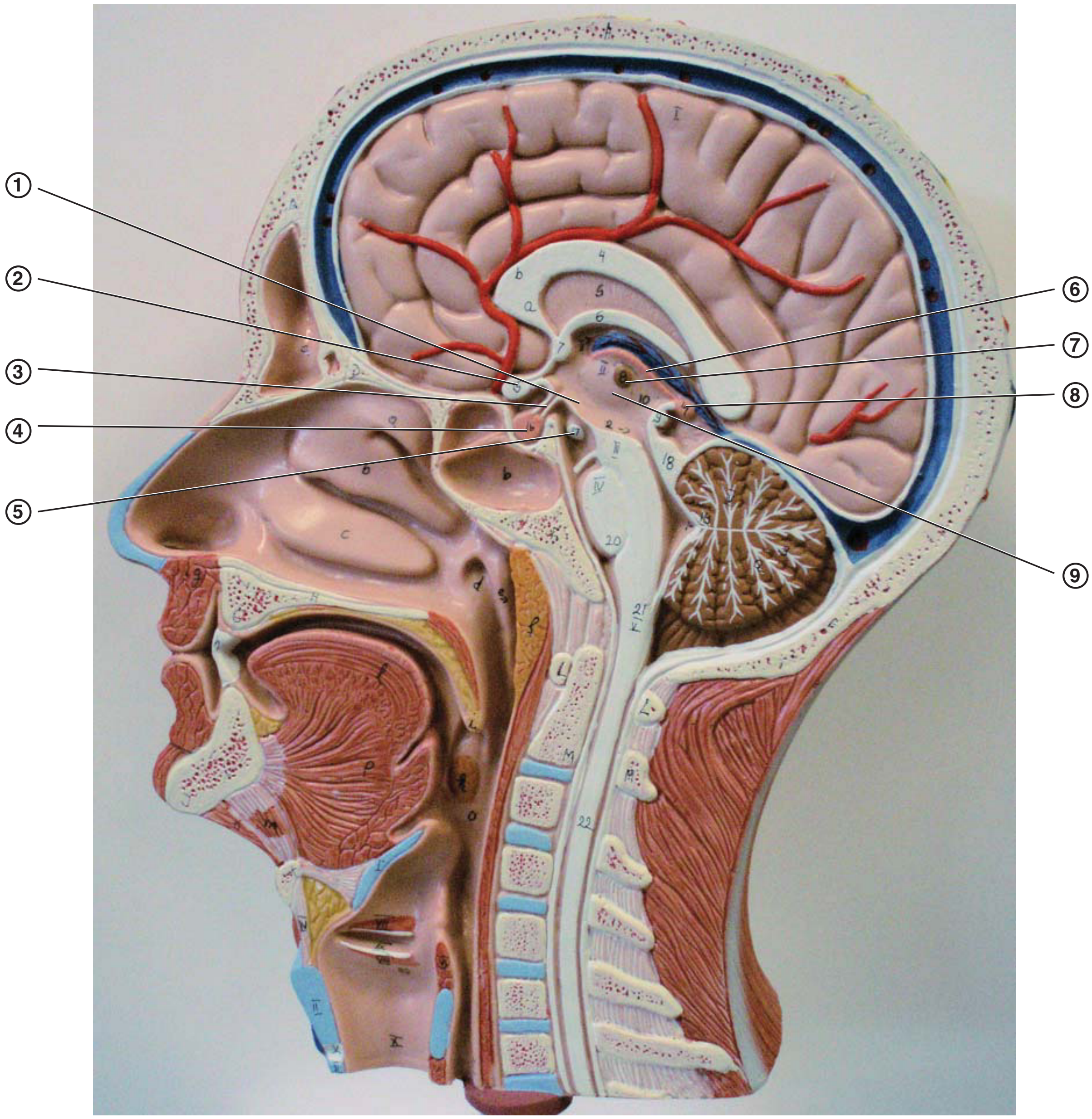
Located inferior to the cerebrum is the diencephalon. The thalamus, hypothalamus, optic chiasma, pituitary gland, and the pineal gland are all located in this division of the brain.

The **thalamus** (THAL-ah-mus) is located just below the fornix. The tissue of the thalamus makes up the walls of the third ventricle. In the center of this area there is the **intermediate mass of the thalamus**, which connects the two lobes of the thalamus. This area of the brain serves as a sensory relay station.

The **hypothalamus** (HY-po-TAL-ah-mus) is located below the thalamus and the tissue makes up the floor of the third ventricle. This area of the brain has an immense impact on life. It essentially regulates homeostasis. It controls the pituitary gland and actually produces two of the hormones released by the posterior pituitary gland.

The **hypophysis** (hi-POF-i-sis), which is also known as the **pituitary gland**, is situated below the hypothalamus and connected to it by the **infundibulum** (in-fun-DIB-u-lum). The infundibulum is a hollow stalk that serves as a passageway for hormones and regulatory factors. Two projections off the hypothalamus just posterior to the hypophysis are the **mamillary bodies** (MAM-ah-LAR-e). These serve as olfactory relay stations. Anterior to the hypophysis is the **optic chiasma** (OP-tik ki-AZ-mah). This is the point where optic nerve fibers from the nasal portion of each retina cross over to the opposite side of the brain. The **optic nerves** are anterior to the optic chiasma while the **optic tracts** are posterior. Chiasma means to cross over or form an X. When observed on the inferior brain the optic chiasma does have the appearance of an X. On the sagittal section, all that is visible is the center of the X so it appears as an oval structure.

The **pineal gland** (PIN-e-al) or body and the **choroid plexus** (KO-roid PLEK-sus) **of third ventricle** are structures of the epithalamus, which forms the roof of the third ventricle. The pineal gland is a neuroendocrine structure. It is stimulated by the nervous system and releases a hormone, melatonin. This gland can be found at the end of the choroid plexus of the third ventricle and slightly superior and posterior to the corpora quadrigemina of the midbrain. The choroid plexus is a structure found in the roof of every ventricle and is composed of a capillary bed, pia mater, and ependymal cells. It produces the cerebrospinal fluid (CSF) that is found in the ventricles of the brain, the subarachnoid space, and central canal of the spinal cord.



Median Section of the Head LT-C12, 3B Scientific®

1. **Hypothalamus**
2. **Optic Chiasma**
3. **Infundibulum**
4. **Pituitary gland (hypophysis)**
5. **Mamillary body**
6. **Choroid plexus of 3rd ventricle**
7. **Intermediate mass of thalamus**
8. **Pineal gland (body)**
9. **Thalamus (tissue) 3rd ventricle (space)**

Figure 2.9. Structures of the Diencephalon

Cerebellum and Brainstem

The most inferior divisions of the brain are the cerebellum and the brainstem. The **cerebellum** is located on the dorsal aspect of the brain inferior to the occipital lobe of the cerebrum and posterior to the pons and midbrain. It is responsible for muscle coordination, posture, and balance. It consists of two hemispheres with gyri and sulci on the surface.

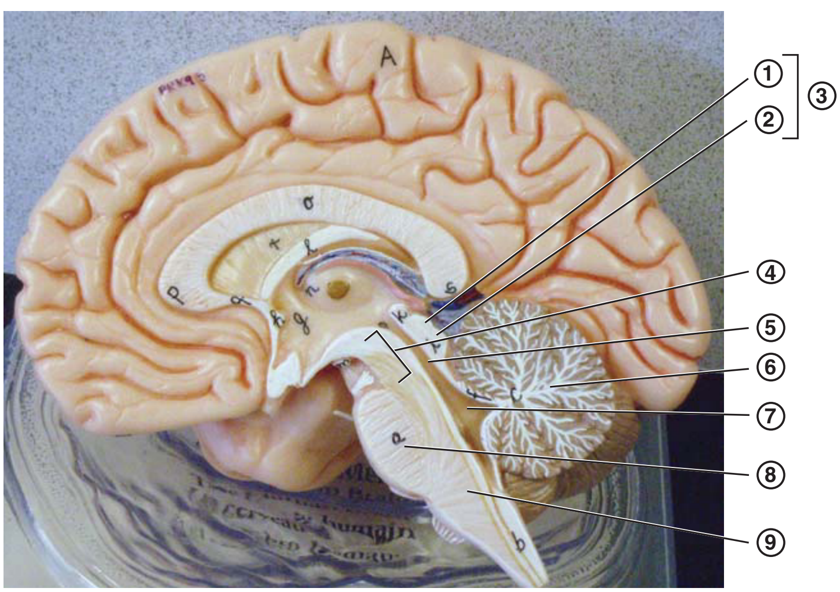
Anterior to the cerebellum is the **brainstem**. The most superior division of the brainstem is the **midbrain** or the **mesencephalon** (mez-en-SEF-a-lon). Below the midbrain is the **pons** and the most inferior portion is the **medulla oblongata**. As the nervous tissue from the medulla oblongata narrows and passes through the foramen magnum of the skull it becomes the spinal cord.

The midbrain contains a couple of important structures. On the sagittal section of the brainstem, it appears that the midbrain is dissected by a canal. This is the **cerebral aqueduct** (SUREE-bral AH-kwah-duct) or the **cerebral aqueduct of Sylvius** that connects the third ventricle with the **fourth ventricle**.

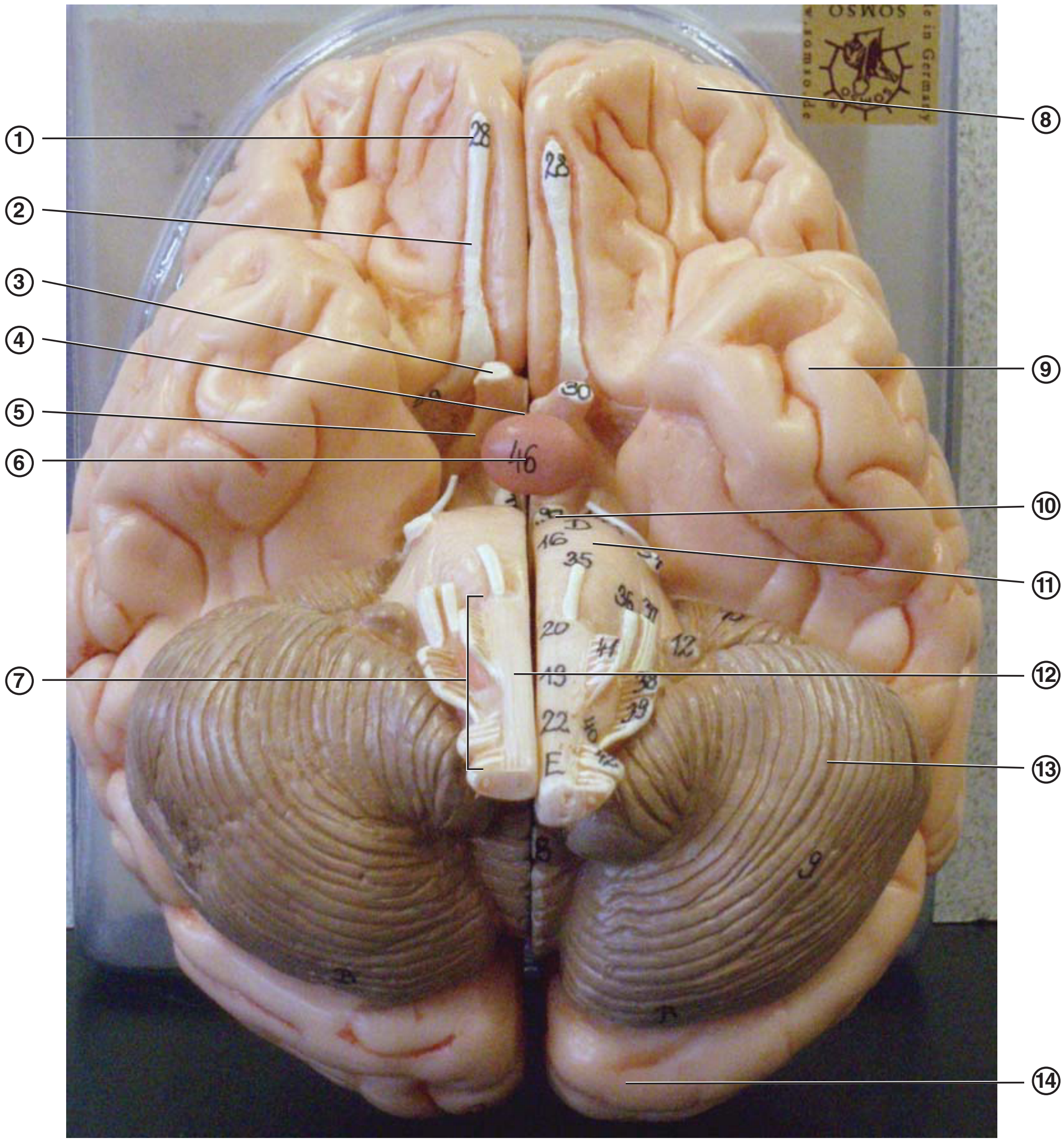
Posterior to the cerebral aqueduct there are two pairs of rounded processes. These four masses are known as the **corpora quadrigemina** (KOR-pour-ah KWAH-dri-JEM-i-nah). The two superior masses are the **superior colliculi** (ko-LIK-you-lye) (singular: colliculus) which are involved in visual reflexes. The two inferior masses are the **inferior colliculi** which are involved in auditory reflexes.

The **pons** is the rounded bulge of the brainstem below the midbrain. It serves to relay impulses between the medulla and the cerebrum as well as between the cerebrum and the cerebellum. It also contains reflex centers involved in inspiration (inhalation). Between the pons and the cerebellum there is a triangular cavity known as the fourth ventricle.

Between the pons and the foramen magnum is the **medulla oblongata**. It is a slightly enlarged continuation of the spinal cord. It contains several reflex centers, most importantly the reflex centers for heart rate, blood pressure, and respiration. The dorsal surface forms the floor of the fourth ventricle. The **pyramids** are a pair of elevations on the anterior surface of the medulla. Tracts entering and leaving the brain may pass through these structures and will be called pyramidal tracts. If the tracts pass around the pyramids they are extrapyramidal tracts.



1. **Superior colliculus**
2. **Inferior colliculus**
3. **Corpora quadrigemina**
4. **Midbrain**
5. **Cerebral aqueduct (of Sylvius)**
6. **Cerebellum**
7. **Fourth (4th) ventricle**
8. **Pons**
9. **Medulla**



1. **Olfactory bulb**
2. **Olfactory tract**
3. **Optic nerve**
4. **Optic chiasma**
5. **Optic tract**
6. **Pituitary gland (hypophysis)**
7. **Medulla oblongata**
8. **Frontal lobe**
9. **Temporal lobe**
10. **Mamillary body**
11. **Pons**
12. **Pyramid**
13. **Cerebellum**
14. **Occipital lobe**

Figure 2.10. Inferior Brain

Meninges

It is apparent that the brain and spinal cord are important. They are also delicate tissue. The skull provides a rigid protective case for the brain, and the vertebral column provides protection for the spinal cord. However, there are additional structures that are involved in the protection of the brain and spinal cord. Both the meninges and the cerebrospinal fluid aid in the protection of the brain. The meninges will be discussed first.

The **meninges** (meh-NIN-jes) are three layers of tissue that cover the brain and spinal cord—**dura mater** (DOO-rah MAY-ter), **arachnoid mater** (ah-RAK-noyd), and **pia mater** (PI-ah). The dura mater is the outermost layer. It is tough, white, dense connective tissue that contains blood vessels and nerves. It is the most durable of the meninges. In the skull it is attached to the inner surface of the bones and forms the internal periosteum, so there is no space between the dura mater and the skull bones.

Between the hemispheres of the cerebrum and cerebellum as well as between the cerebrum and cerebellum it extends inward to form partitions known as the **falx cerebri** (FALKS SER-ah-bri), **falx cerebelli** (ser-ah-BELL-i), and **tentorium cerebelli** (ten-TOE-ree-um). In some areas there are canals in the dura mater that contain venous blood, these are the dural sinuses.

The dura mater continues to cover the spinal cord. However, in the vertebral column it is not fused with the bones. This results in the space containing blood vessels and adipose tissue between the dura mater and the periosteum of the vertebrae. This space is the **epidural space**. The name refers to the fact that the space is on or above the dura mater. It is only present in the spinal cord, not in the brain. This space has a purpose in anesthesia. It can be used to administer anesthetics to block pain sensations.

The dura mater covering the spinal cord continues to the level of the second sacral vertebra, well beyond the end of the spinal cord. The dura mater and the pia mater continue beyond this point as a filament to secure the spinal cord at the end of the spinal canal. This is the **filum terminale** (FI-lum TER-min-NAL-ee). The pia mater and the dura mater also fuse together in places along the length of the spinal cord to form the **denticulate ligament** (den-TIK-you-late) which secures the spinal cord in the center of the spinal canal.

The second layer of the meninges is the arachnoid mater or sometimes known simply as the arachnoid. This is a thin membrane that has the appearance of a spider web, hence the name. It is located between the dura mater and pia mater. It does not follow the contour of the brain and spinal cord but it does have thin strands that extend from it and attaches to the pia mater. There are also projections of the arachnoid mater through the dura mater into the dural sinuses. These projections are the **arachnoid granulations** that consist of a number of arachnoid villi. These structures function to return cerebrospinal fluid to the venous blood.

Normally the arachnoid mater is pressed against the inner surface of the dura mater by cerebrospinal fluid pressure in the subarachnoid space. However, there is the potential for fluid to collect in the space between these two layers. This potential space is the **subdural space**, referring to the fact it would be located below the dura mater. In normal individuals there is no space, however, if there is damage to the dural sinuses it is possible for blood to collect in this space to cause a subdural hematoma.

The pia mater is the innermost meninges. It is a very thin membrane that contains blood vessels and nerves. It lies on the surface of the brain and spinal cord, following the contours. As mentioned earlier the pia mater along with the dura mater forms the denticulate ligament and the filum terminale.

Between the arachnoid mater and the pia mater there is a fluid-filled space that is the **subarachnoid space**. The fluid is the cerebrospinal fluid (CSF).

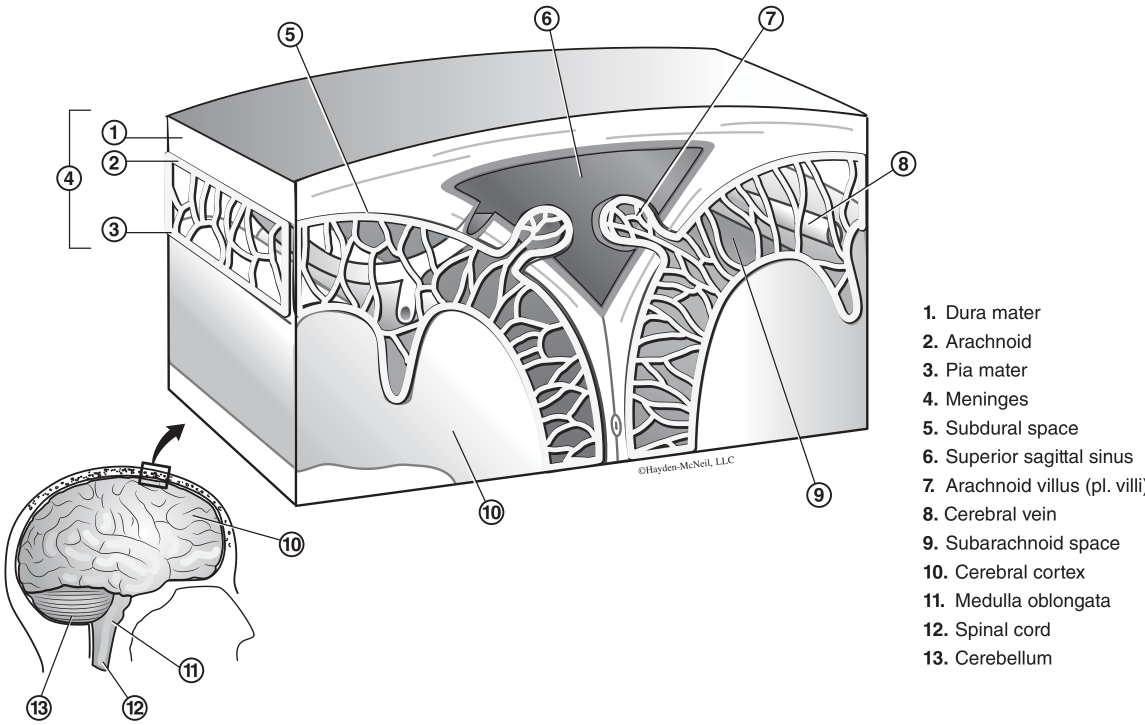


Figure 2.11. Meninges of the Brain

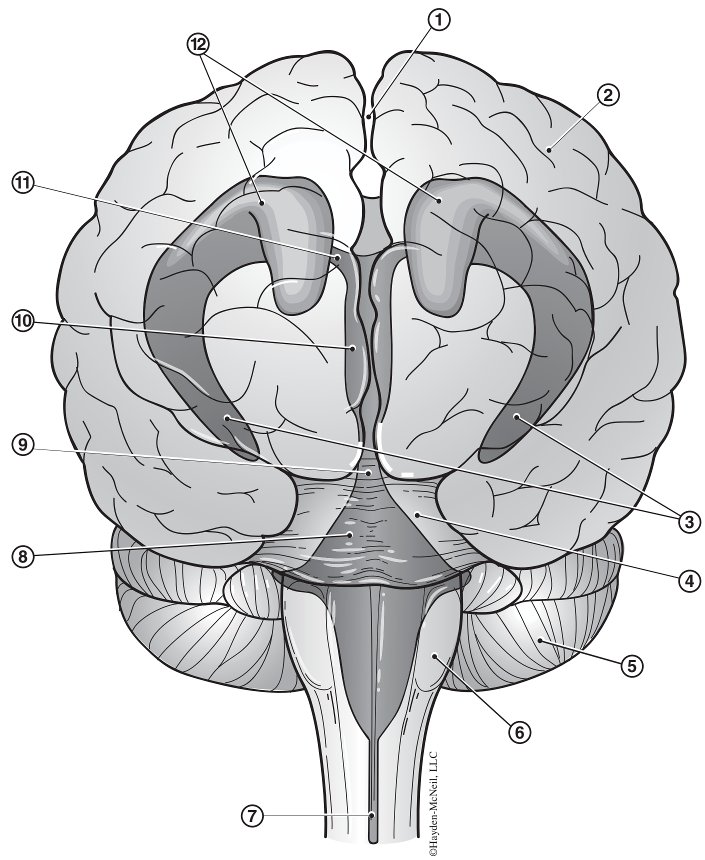
Ventricles

The **ventricles** are four fluid-filled cavities located in the cerebrum, diencephalon, and brainstem. The fluid found in the ventricles is cerebrospinal fluid (CSF). In the cerebrum there are two **lateral ventricles**, one in each hemisphere. These ventricles are connected by way of the **interventricular foramina** with the **third ventricle**, which can be found in the midline region of the diencephalon, between the two hemispheres. The thalamus makes up the walls of the third ventricle, while the floor is made up of the hypothalamus, and the epithalamus makes up the roof. The third ventricle is connected to the **fourth ventricle** by way of the cerebral aqueduct.

The cerebrospinal fluid is formed in the choroid plexuses of the ventricles. A choroid plexus is a specialized capillary bed located in the roof of each ventricle. Each plexus secretes CSF; however, the majority of the fluid is produced in the lateral ventricles.

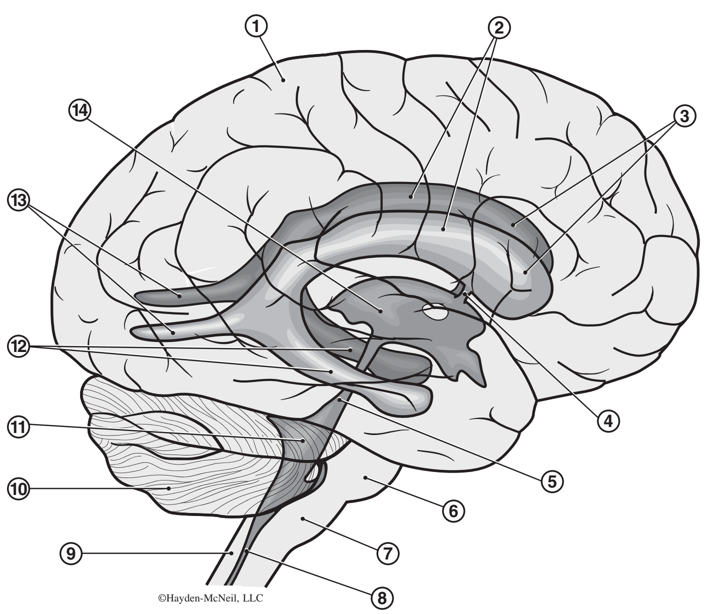
Cerebrospinal Fluid

Cerebrospinal fluid is another protective factor for the central nervous system. The fluid serves as a shock absorber as well as a method for the brain to monitor conditions within the body. After the CSF is formed in the choroid plexuses it flows through the ventricles. The fluid in lateral ventricles flows through the interventricular foramina into the third ventricle. The fluid then flows through the cerebral aqueduct to the fourth ventricle. From the fourth ventricle the fluid flows into the central canal of the spinal cord which is continuous with the fourth ventricle. The CSF also enters the subarachnoid space through the 2 lateral aperatures in the walls and the single medial aperature in the roof of the fourth ventricle. After passing through the subarachnoid space the CSF is reabsorbed into the blood by way of the **arachnoid granulations**, which penetrate the dura mater into the superior sagittal sinus. This allows the cerebrospinal fluid to be replaced on a regular basis, usually about every 8 hours. There is 125 to 150 mL of CSF in the central nervous system. The body produces about 400–500 mL each day. The CSF also produces a pressure that can be measured during a lumbar puncture or by way of an intracranial pressure transducer. The normal pressure of the CSF is 70–180 mm H_2O.



1. Longitudinal fissure
2. Cerebrum
3. Inferior horns of lateral ventricle
4. Pons
5. Cerebellum
6. Medulla oblongata
7. Central canal of spinal cord
8. Fourth ventricle
9. Cerebral aqueduct (aqueduct of Sylvius)
10. Third ventricle
11. Interventricular foramen
12. Lateral ventricles

Figure 2.12. Frontal View of Ventricles



1. Cerebral hemisphere
2. Lateral ventricles
3. Anterior horns of lateral ventricles
4. Interventricular foramen
5. Cerebral aqueduct (aqueduct of Sylvius)
6. Pons
7. Medulla oblongata
8. Central canal of spinal cord
9. Spinal cord
10. Cerebellum
11. Fourth ventricle
12. Inferior horns of lateral ventricles
13. Posterior horns of lateral ventricles
14. Third ventricle

Figure 2.13. Lateral View of Ventricles

Sheep Brain Dissection

To assist in your understanding of the brain you will be dissecting a sheep's brain. You will need a preserved sheep's brain with the dura mater, a dissecting tray, a scalpel, scissors, and a probe. Remove the brain from the container. It will be covered with the dura mater. Carefully look over the brain and identify the pituitary gland on the inferior surface. You will note that the dura mater covers this structure. When you remove the dura mater you want to cut it around the pituitary so that you do not remove it with the dura mater.

Carefully remove the dura mater. Note how strong and durable it is. Fused with the dura mater is the arachnoid mater, and therefore, you will not be able to see it. You will note that the dura and arachnoid mater are not attached to the surface of the brain; this is due to the presence of the subarachnoid space. The pia mater adheres to the surface of the brain and will give the brain a glistening appearance. Carefully remove the falx cerebri and the tentorium cerebelli.

Before you perform a sagittal section on the brain, if you gently pull down on the cerebellum you will be able to visualize the corpora quadrigemina. Slightly superior to this structure you should be able to visualize the pineal gland. Turn the brain over and find the olfactory bulbs. Compare the sizes of the sheep's and the human's olfactory bulb.

You will now perform a sagittal section on the sheep's brain. Using the scalpel cut down from the superior surface through the longitudinal fissure. Cut the brain completely in half. You should now be able to identify the major structures of the sheep's brain that are visible on sagittal section. Your lab objectives have a list of structures you should be able to identify on the sheep's brain.

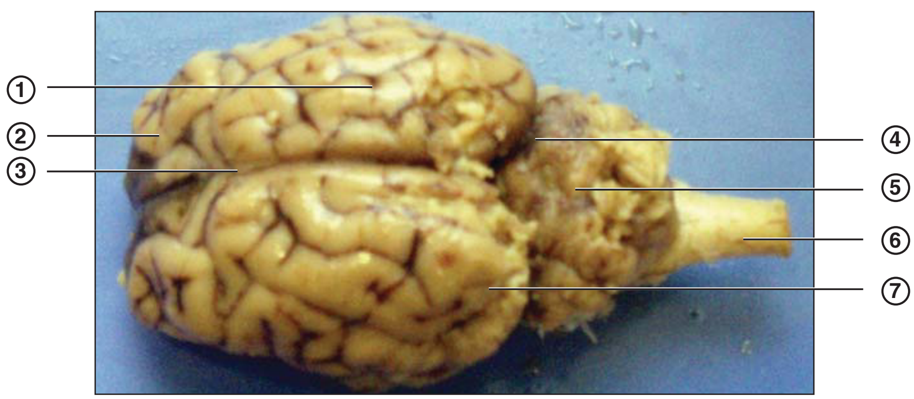


Figure 2.14. Superior View of Sheep's Brain

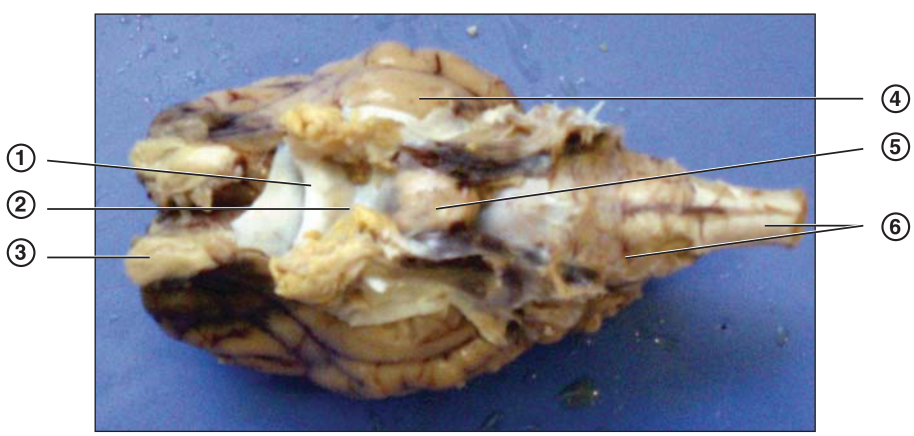
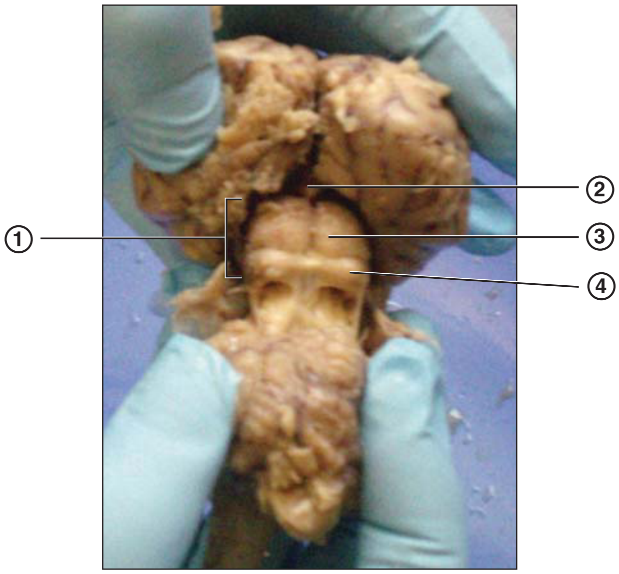
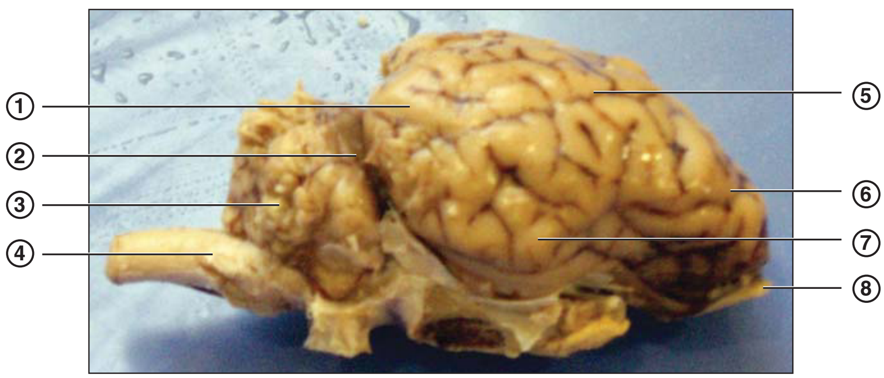


Figure 2.15. Inferior View of Sheep's Brain



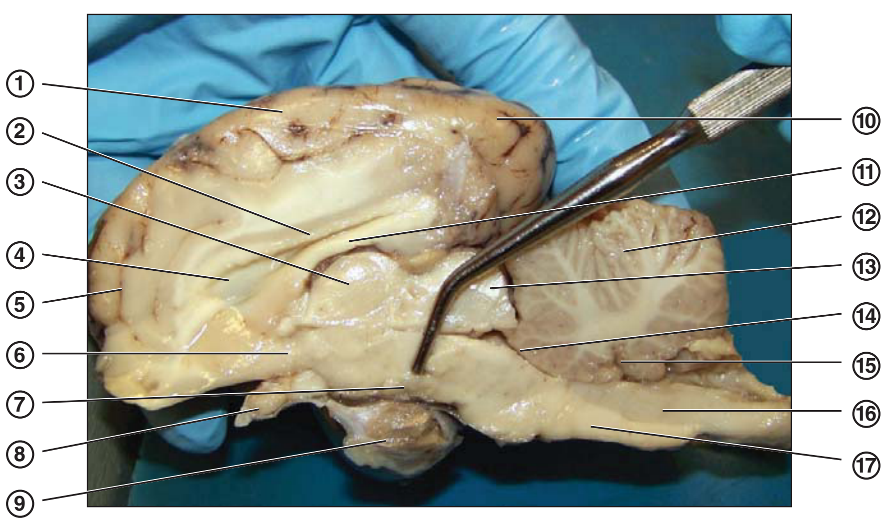
1. Corpora quadrigemina
2. Pineal gland/body
3. Superior colliculus
4. Inferior colliculus

Figure 2.16. Posterior View of Sheep's Brain



1. Occipital lobe
2. Transverse fissure
3. Cerebellum
4. Brainstem
5. Parietal lobe
6. Frontal lobe
7. Temporal lobe
8. Olfactory bulb

Figure 2.17. Lateral View of Sheep's Brain



1. Parietal lobe
2. Corpus callosum
3. Space—3rd ventricle
   Tissue—thalamus
4. Septum pellucidum
5. Frontal lobe
6. Hypothalamus
7. Mamillary body
8. Optic chiasma
9. Pituitary/hypophysis
10. Occipital lobe
11. Fornix
12. Cerebellum
13. Corpora quadrigemina
14. Cerebral aqueduct
15. 4th ventricle
16. Medulla
17. Pons

Figure 2.18. Mid-Sagittal View of Sheep's Brain

Part 3

The Spinal Cord, Somatic Reflex Arc, Visceral Reflex Arc

The central nervous system continues outside the cranium as the spinal cord. This structure weighs about 1.25 ounces, has a diameter at its widest point of about 1.5 inches and has a length of about 17–18 inches. It is not a very large structure, but it serves as a conduit between the brain and the body. The spinal cord extends from the foramen magnum to between the first and second lumbar vertebrae. It does not fill the entire vertebral column, which measures about 27.5 inches. After the spinal cord terminates at the **conus medullaris** the nerves exit the cord and stay within the spinal foramen of the vertebral column until they exit at the appropriate level. This mass of nerves within the vertebral column is the **cauda equina** (KAW-do ee-KWAY-nah).

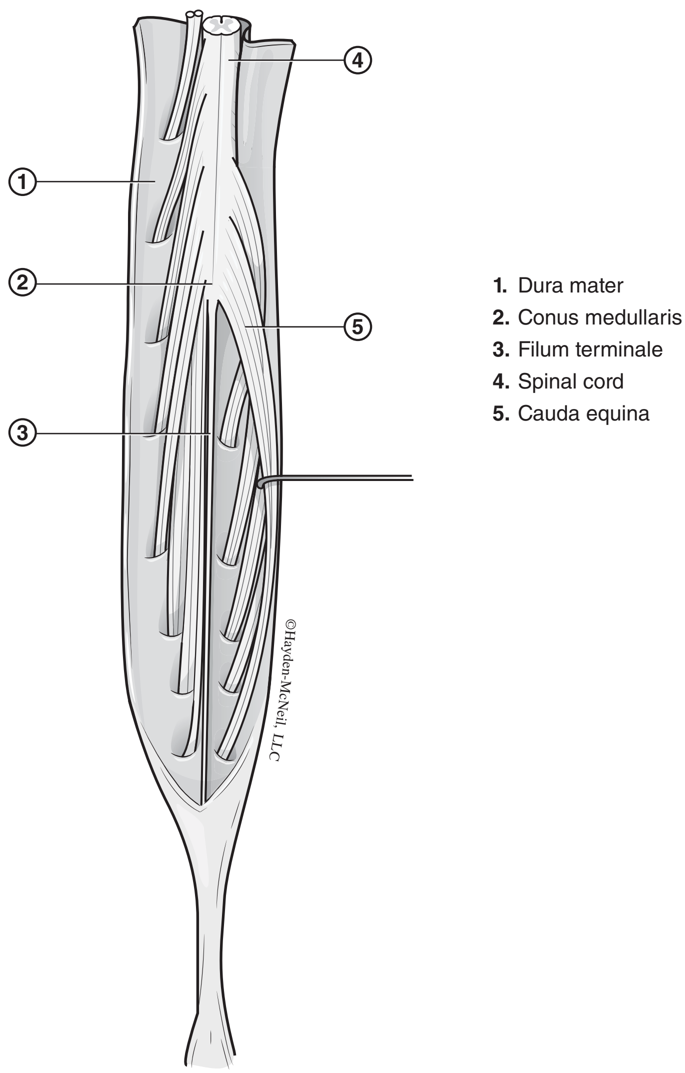


Figure 2.19. Cauda Equina and Filum Terminale

The spinal cord is protected by a bony covering, the vertebral column, a membranous covering, the meninges, and is surrounded by fluid, the cerebrospinal fluid, just like the brain. It is important to protect the delicate spinal cord just as the brain is protected. The spinal cord is also secured within the spinal canal by extensions of the dura mater and pia mater. The spinal cord is secured to the bottom of the spinal canal by the **filum terminale** and is secured at the sides by the **denticulate ligament**.

The spinal cord is covered by the three layers of meninges like the brain. However, in the spinal cord there is a space between the dura mater and the periosteum of the vertebrae, so in the spinal column there is an **epidural space**, unlike the brain.

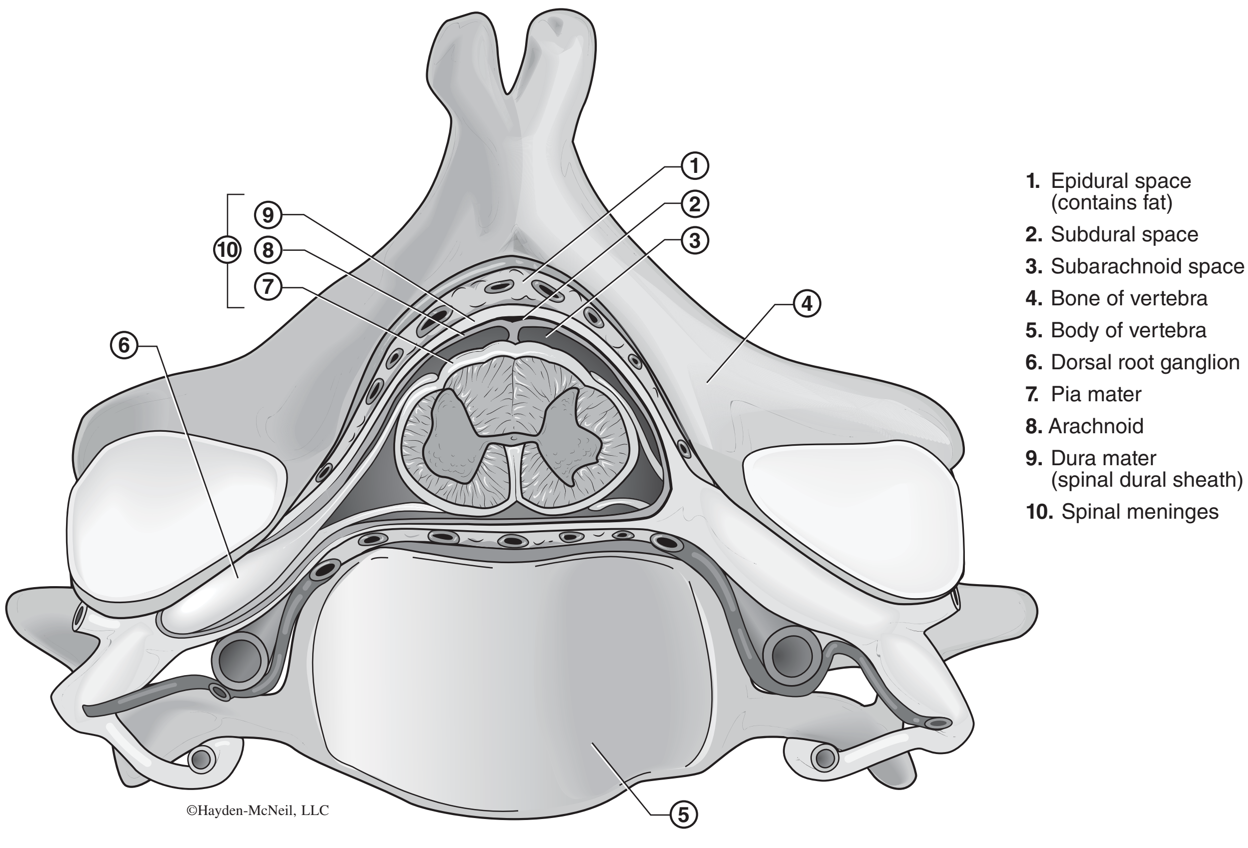


Figure 2.20. Meninges of the Spinal Cord

White myelinated fibers and gray cell bodies are found in the spinal cord. In this structure the white fibers, or nerve tracts, are on the exterior and the gray matter, or the cell bodies, are in the center of the spinal cord. The pattern the gray matter creates is described as a butterfly or an H-shape. In the midline it is divided by an **anterior median fissure** and a **posterior median sulcus**. The anterior fissure is deeper than the posterior sulcus so this characteristic can be used to determine the orientation of the spinal cord.

In the center of the spinal cord is the **central canal**. This is an extension of the fourth ventricle and contains cerebrospinal fluid. This fluid returns to the brain via the subarachnoid space between the arachnoid mater and pia mater in the spinal meninges.