MODULE 1: HISTOLOGY I

An Introduction to Histology; Begin Epithelial Tissue and Connective Tissue

Histology is the study of the microscopic anatomy of the cells and extracellular matrix that make up the tissues of the body. Using the physical appearance of cells and the matrix that surrounds them, the 10-100 trillion cells of the human body can be grouped into just four major tissue types: epithelial, connective, muscle and nervous tissues. In the Histology Modules of this course, you will learn to identify each of these tissue types as well as their subclasses and important structures.

Chemical fixatives are used to preserve tissues when they are harvested. These fixatives are important to preserve the tissue from degradation. These chemicals also destroy the biological function of the cells, so all of the cells in any micrograph images that you see are dead.

Biological tissue has little inherent color. In fact, in reality, the tissues that you study would look transparent or have various shades of gray for the most part. However, scientists use staining techniques to help highlight particular features of a tissue. As a student of histology, you should avoid the temptation to memorize tissues based on color. Since it is possible to stain the same tissue with a variety of different colors, you could be easily fooled if you trained yourself to recognize color as the major feature of tissues that you study. The wiser approach would be to carefully learn the shapes and physical characteristics other than color when studying histology. Students who memorize color as the main characteristic to trigger their memory will be disappointed when the exam does not maintain color schemes.
Why would anyone want to study tissues through a microscope? Well, it turns out that histology is an important tool in medicine. Accurate diagnosis of many diseases, including cancer, usually requires someone trained in histology. Physicians who are trained in this often work as “pathologists” and their skills are critical in the efforts to determine an appropriate treatment plan. Anyone working in the lab to discover the effects of almost any type of medical treatment will also need to be trained in histology so that they can assess the effects of their efforts on biological tissue at the cellular level.

In this course, we will provide a basic view of the four major tissues and their subcategories. Upon mastery of this module, you should have the basic skills required to go on to more advanced courses such as BIO 380 – Histology. You will also have the basic skill necessary to understand many histological characteristics of diseases that affect humans across a lifespan.

Epithelial Tissue

General Characteristics of Epithelial tissues

- Composed almost entirely of close-packed cells with very little extracellular material
- Usually form a barrier, therefore, the cells are arranged in a dense and closely packed fashion
- Have a free surface (apical surface) which is exposed to the body exterior (skin) or the cavity of an internal organ (body cavities, blood vessels, heart, digestive and respiratory system passageways, covering of internal organs, etc.)
- Have a basement membrane (composed of glycoprotein material plus collagen fibers) – The basement membrane anchors basal surface of epithelium to the underlying connective tissue
- Do not have blood vessels (avascular): the blood supply is in the underlying loose connective tissue
- Cells are held together by specialized contacts including tight junctions and desmosomes

General Functions of Epithelial tissues

- Protect underlying structures
- Act as a barrier to prevent movement of substances through the epithelial layer
- Permit movement of some substances through the epithelial layer such as oxygen and carbon dioxide
- Secretion of substances such as mucous, sweat, and digestive enzymes
- Absorption of substances such as nutrients in the digestive system

Simple Epithelium - single layer

A. Simple squamous epithelium: This tissue is composed of a single layer of flattened cells with nuclei that resemble flattened ovals. The cells are very thin and the nuclei are often thicker than the rest of the cell and bulge into the free space giving the tissue the appearance of a fried egg. This tissue forms the walls of capillaries in the cardiovascular system and alveoli in the lungs. It lines all blood vessels, lymphatic vessels and the chambers of the heart, and forms Bowman's capsule in the kidneys. Additionally, the serous membranes you learned about in lecture in chapter 1 are composed of simple squamous epithelium.

B. Simple cuboidal epithelium: This tissue is composed of a single layer of cells that have roughly the same height as width. The most distinguishing characteristic of simple cuboidal epithelium is their large round nuclei that are typically located near the center of the cell. This tissue often forms ducts or tubes. When viewed in cross-section, the round nuclei are lined up in a single row around the circumference of the tube while in longitudinal section the nuclei resemble a string of beads. Simple cuboidal epithelium is found forming the tubules of the kidneys, forming exocrine glands and their ducts, forming the choroid plexus of the brain and on the surfaces of the ovaries.

C. Simple columnar epithelium: Simple columnar epithelium is composed of a single layer of cells that are taller than they are wide. As a result, the nuclei reflect this shape by becoming elongated ovals that run perpendicular to the surface of the tissue. Typically the

nuclei are located closer to the basal surface than the apical surface, typically in the lower ½ of the cell. Another common feature of simple columnar epithelium is the presence of specialized, mucous-secreting cells known as **goblet cells**. These are easily identified as they frequently break the otherwise continuous arrangement of columnar nuclei and are much lighter in color. Under higher magnification, you will be able to see the presence of **microvilli (brush border)** on the apical surface of the columnar cells. Microvilli are finger-like projections of the plasma membrane that greatly increase the surface area of the apical surface. In addition, some simple columnar epithelium possess another cell surface modification on their apical surface known as **cilia**. Cilia are thread-like projections capable of wave-like motion and assist in propelling substances over the surface of the cells. Simple columnar epithelium is found throughout the digestive system, lining the chambers of the stomach, small intestines and large intestines. In addition, it is found lining the chambers of the uterus, uterine tubes, gall bladder and bile ducts.

D. Pseudostratified columnar epithelium: Although it looks like it is multi-layered, pseudostratified columnar epithelium is actually a single layer of cells. Each cell is connected to the basement membrane; however, not all cells project all the way to the free surface. The "shorter," basal cells are wedge shaped, with their nuclei near the basement membrane, while the nuclei of the "taller," apical cells are located higher in the tissue. The overall effect is that of several layers of nuclei giving it a stratified appearance. Like simple columnar epithelium, pseudostratified columnar epithelium typically contains **goblet cells** and **cilia**. This tissue is found lining the nasal cavity, the nasal sinuses, the auditory tubes, the trachea and the bronchi of the lungs.

Stratified Epithelium - multiple layers

A. Keratinized stratified squamous epithelium: As the name implies, this tissue is composed of squamous-type cells that are piled into a multi-layered tissue. However, stratified epithelia are named based on the shape of the cells on the apical surface. As you examine this tissue, you will see that at the basal surface the cells are actually columnar shaped and then transition as they move toward the surface to cuboidal and finally to squamous shaped cells. Keratinized stratified squamous epithelium is characterized by the presence of a keratinized layer at the apical surface composed of dead, squamous shaped cells that are filled with the tough protein keratin. Another distinct characteristic of stratified squamous is its wavy basement membrane. This formed by projections of the underlying dermis called papillae that protrude into the epithelium of the epidermis. Keratinized stratified squamous is found on the skin.

B. Non-keratinized stratified squamous epithelium: This tissue looks very much like the keratinized stratified squamous with the exception that it lacks the keratinized layer. One key feature of all stratified squamous epithelium is that the lowest layer of cells stains dark purple. Cells that are more superior become gradually lighter toward the apical surface. This tissue is found lining the mouth, the throat, the esophagus, the vagina, the anus and the cornea

C. Transitional epithelium: Although this is a stratified epithelium, we do not include the term stratified in the name. Transitional epithelium is found in the urinary bladder and some of the other structures of the urinary system. It can have two different appearances depending on the state of the organ so it is named transitional epithelium. For example, when the urinary bladder is in its empty or relaxed state, the epithelium will appear like stratified cuboidal epithelium. When it is filled or stretched, it will appear more like stratified squamous. All of the images you will see are of the tissue in the relaxed state.

In addition to stratification also look for the characteristic brick cells on the free surface that will cover 2-3 of the cells below them and often bulge into the lumen organ. Transitional epithelium is found lining the urinary bladder, the ureters and the superior urethra.

List of Terms

Spend as much time as you need reviewing Epithelial Tissues and structures. The most important thing will be for you to practice identifying all of the structures listed in the table below. Use your online resources, open lab, and any other tool that you have to become confident in your identification skills. Your exam will ask you to identify and then write in (Fill in the Blank) the correct term for your identification. The table below is a comprehensive list of all the terms from this section that we would consider asking you to identify on an exam.

List of Terms for Epithelial Tissue	
Simple squamous epithelium	**Apical (free) surface**
Simple cuboidal epithelium	**Basal surface**
Simple columnar epithelium	**Goblet cell**
Pseudostratified columnar epithelium	**Cilia**
Keratinized stratified squamous epithelium	**Microvilli (brush border)**
Non-keratinized stratified squamous epithelium	**Basement membrane**
Transitional epithelium	

Connective Tissue

General Characteristics of Connective Tissues

- Very few cells compared to other tissues
- Large amounts of extracellular (intercellular) substance called matrix (matrix = ground substance plus fibers)
- Contains various fibers
- Vascular, meaning blood vessels are present (exceptions are cartilage and dense connective tissue)

General Functions of Connective Tissues

- Connect and bind other tissues together
- Support and give structure to the body

- Protect and cushion organs
- Defense against disease (inflammation and immunity)
- Storage of energy and minerals
- Repair of damaged tissue
- Transportation of nutrients, gases and wastes

Loose Connective Tissues

A. Loose fibrous connective tissue (areolar connective tissue): This tissue is often lacy in appearance and is found in numerous fluid-filled spaces. It constitutes the loose packing material in many organs. Loose fibrous connective tissue connects the skin to underlying structures and is composed of **collagen fibers**, **elastic fibers** and a variety of cells including **fibroblasts** and **mast cells**. It can be found directly under all epithelial tissue where its appearance can be quite variable.

B. Adipose tissue*:* Adipose tissue is widely distributed throughout the body and has very typical characteristics. Unlike the other connective tissues, adipose tissue has very little extracellular matrix. This tissue is characterized by large, round, open spaces separated by very thin plasma membranes. Adipose cells (adipocytes) contain a large lipid droplet inside that is dissolved away during preparation of the slides making them appear clear and open. The lipid droplet pushes the nucleus and other organelles of the cell up against the plasma membrane. The nucleus is small, flattened, and is usually visible in most of the cells. These nuclei resemble the nuclei of simple squamous epithelium. This tissue is one of the easier tissues to identify in that it looks much like a hair net. Most of our adipose tissue is found in the subcutaneous areas. It can also be found in the mesenteries, renal pelvis, mammary glands, around the kidneys and attached to the surface of the colon.

Dense Connective Tissues

A. Dense regularly arranged fibrous connective tissue: This tissue is composed primarily of very large **collagen fibers** that are tightly packed in parallel bundles. Scattered among the parallel collagen fibers are the elongate, sliver-like nuclei of the **fibroblasts** that run parallel to the direction of the fibers. This tissue has a very poor blood supply; consequently, when it is damaged, it takes a long time to heal. Dense regularly arranged fibrous connective tissue is found forming tendons and ligaments.

B. Dense irregularly arranged fibrous connective tissue: Like regularly arranged connective tissue, irregularly arranged connective tissue is also composed of large **collagen fibers**. In this tissue, however, the fibers are not all parallel, but run in several different directions. In addition, nuclei of the **fibroblasts** are more oval shaped. This tissue is located in the dermis of the skin, the outer coverings of body tubes, and the fibrous capsules of organs and joints.

Cartilage

Although there are three distinct types of cartilage, all have similar characteristics. Among these characteristics are the presence of small open spaces **(lacunae)** within the matrix of the
cartilage and cartilage cells **(chondrocytes)** occupying these openings. Like denser regularly arranged fibrous connective tissue, cartilage has a poor blood supply and thus

heals slowly when damaged. We will learn to identify two of the three types, **hyaline** and **elastic cartilage**; we will not, however, ask you to identify **fibrocartilage**.

A. Hyaline cartilage*:* The matrix contains roughly equal amounts of collagen fibers and ground substance. Since the collagen fibers are evenly distributed throughout the matrix, it generally appears as a homogenous pink or blue material. **Lacunae**, small open spaces, are present throughout the cartilage matrix. **Chondrocytes** can be found within the lacunae. Notice the **perichondrium** along the edge of this tissue. This tissue will contain immature chondrocytes known as **chondroblasts** and is composed mainly of dense regularly arranged connective tissue. Once the chondroblasts become surrounded by matrix, they are called chondrocytes. Hyaline cartilage is found in the growth plates of growing long bones, the rings of the trachea and bronchi, the nose, articulating surfaces of joints and the embryonic skeleton.

B. ***Elastic cartilage****:* This tissue looks much like to the hyaline cartilage. The major identifying feature is that the matrix contains large amounts of elastic fibers which appear dark purple in the micrographs. Elastic cartilage is found in the ears and the epiglottis.

Solid Connective Tissue

Bone is classified as a connective tissue. Like all connective tissue, it has more matrix than cellular component. In this case, the matrix is a calcified solid material surrounding collagen fibers. Under the microscope, you will see many structures and openings within the solid matrix of the bone that are essential to allow the bone tissue to live.

A. Compact bone: Compact bone is composed of small units called **osteons or Haversian systems**. Under the microscope these systems have the appearance of targets with a large bull's eye in the center. The bull's eye is formed by the **central or Haversian canal**. In living bone, blood vessels pass through these canals. Surrounding the central canal are a series of concentric rings of matrix called **concentric lamellae** (*lamella*, singular). At the borders between the lamellae are **lacuanae** (*lacuna*, singular), and within the lacunae are the cells that maintain the matrix, the **osteocytes**. If you look closely under high magnification, you can observe small, crack-like structures radiating out from the lacunae and interconnecting the lacunae of the different lamellae. These small tubes, called **canaliculi**, allow nutrients and wastes to pass between the osteocytes and the blood. If the bone is cut just right, you can see structures that connect one Haversian canal to another; these are the **Volkmann canals**. Compact bone is found in all bones of the body.

Fluid Connective Tissue

A. Blood: Blood cells are found in a fluid matrix called plasma. Blood is a bit unusual among the connective tissues because it does flow and the matrix is a liquid. Cells in other connective tissues are more or less stationary and do not move around much. Cells in blood however move freely and rapidly. Many blood cells freely move in and out of the blood vessels.

List of Terms

Spend as much time as you need reviewing Connective Tissues and structures. The most important thing will be for you to practice identifying all of the structures listed in the table below. Use your online resources, open lab, and any other tool that you have to become confident in your identification skills. Your exam will ask you to identify and then write in (Fill in the Blank) the correct term for your identification. The table below is a comprehensive list of all the terms from this section we would consider asking about on an exam.

List of Terms for Connective Tissue	
Loose fibrous (areolar) connective tissue • **Fibroblasts** • **Mast cells**	**Bone (compact)** • **Periosteum** • **Endosteum** • **Osteon (Haversion system)** • **Haversian (central) canal**
Dense regularly arranged connective tissue • **Fibroblasts**	**Osteocyte** • **Lacuna** • **Canaliculi** • **Volkmann's canal** • **Concentric lamella** • **Interstitial lamella**
Dense irregularly arranged connective tissue • **Fibroblasts**	**Blood**
Adipose connective tissue	
Hyaline cartilage • **Chondrocyte** • **Lacuna** • **Perichondrium**	
Elastic cartilage • **Elastic fibers** • **Chondrocyte** • **Lacuna**	

MODULE 2: HISTOLOGY II

Muscle and Nervous Tissue

Muscle Tissue

General Characteristics of Muscle

- Elongated cells in direction of contraction
- Appearance depends on direction of cut (longitudinal or cross section)

General Functions of Muscle

- Contracts in response to a stimulus to generate movement
  - Movement of one part with respect to another
  - Movement of materials through the body
  - Movement of the body through space (locomotion)

Skeletal Muscle

A. Skeletal muscle makes up the majority of the tissue that we think of when we think of muscles. It is under voluntary control and is located throughout the body. Skeletal muscle is generally attached to bones by tendons and uses these bones as levers to accomplish work. However, not all skeletal muscle is anchored to bones. Some, like those in the face, are attached to fibrous connective tissue. Skeletal muscle occurs in bundles. Each skeletal muscle cell or fiber is elongated and has multiple nuclei that are located on the periphery of the cell. The cells are very large and can be several centimeters long, often running the entire length of the muscle (*note: when referring to muscles we use the terms cell and fiber interchangeably. This is not to be confused with the fibers found in the matrix of connective tissue*). Skeletal muscle is also striated with alternating light and dark bands running the entire length of the cell. These striations are caused by the regular overlapping arrangement of the muscle proteins, actin and myosin. The dark band is called the "**A Band**" and the light band is the "**I Band.**" If you look carefully, you will be able to identify a very thin, dark line running down the middle of the "I Band." This represents the backbone of the actin molecule and is called the "**Z-disk**".

When we look at skeletal muscle in cross section, we see that individual skeletal muscle fibers are surrounded by a thin layer of loose fibrous (areolar) connective tissue, the **endomysium**. Furthermore, we see that the muscle fibers are not uniformly distributed throughout the muscle; rather, they are grouped into bundles called **fasciculi** with each **fasciculus** likewise surrounded by "heavier" connective tissue, the **perimysium**. Finally,

the entire muscle is surrounded by a sheath of dense fibrous connective tissue, the **epimysium**. The large collagen fibers in the epimysium are continuous with those of the tendon that attaches the muscle to bone. Your biceps, for example, is composed of many fasciculi bundled together with each fasciculus being composed of many muscle fibers.

Smooth Muscle

A. Smooth muscle is an involuntary, non-striated muscle that is found in the walls of hollow organs like arteries, veins, the stomach, the small and large intestines, the uterus, uterine tubes, the urinary and the gall bladders just to name few. Smooth muscle cells are fusiform in shape (football shaped). Each muscle cell contains one centrally located, cigar-shaped nucleus. The cells are arranged side by side in sheet-like layers. The muscle cells are much smaller than skeletal muscle fibers and are woven together to form the sheet-like layers. Most of the digestive tract—with the exception of the stomach—has smooth muscle arranged in two layers: an **inner circular** and an **outer longitudinal** layer. The stomach has *three* layers of smooth muscle in its walls.

Cardiac Muscle

A. Cardiac muscle is found only in the heart. Like smooth muscle, cardiac muscle is involuntary; however, unlike smooth-muscle, cardiac muscle is striated. The muscle fibers resemble skeletal muscle, with the following exceptions: the cells are branched, they have a single, oval, centrally located nucleus and the striations are not as pronounced. Additionally, the muscle fibers are shorter and thus are connected end-to-end. At the points of connection there are specializations called **intercalated discs** that both hold the cells together with desmosomes and allow communication between the cells via gap junctions. Under the microscope, the intercalated discs look like very pronounced striations.

List of Terms

Spend as much time as you need reviewing Muscle Tissues and structures. The most important thing will be for you to practice identifying all of the structures listed in the table below. Use your online resources, open lab, and any other tool that you have to become confident in your identification skills. Your exam will ask you to identify and then write in (Fill in the Blank) the correct term for your identification. The table below is a comprehensive list of all the terms from this section that we would consider asking about on an exam.

List of Terms for Muscle Tissue

Skeletal Muscle - Longitudinal Section

Skeletal Muscle - Cross Section

- **Striations**
- **Sarcomere**
  - **A-band**
  - **I-band**
  - **Z disc**
- **Endomysium**
- **Perimysium**
  - **Fasciculi (F*asciculus*, singular)**
- **Epimysium**

Smooth Muscle - Longitudinal Section

Smooth Muscle - Cross Section

Cardiac Muscle - Longitudinal Section

- **Intercalated Discs**
- **Striations**

Cardiac Muscle - Cross Section

Nervous Tissue

General Characteristics and Functions of Nervous Tissue

- Composed of neurons and neuroglial cells
- Main function is to transmit and process information
- Divided into two major components
  - Central Nervous System: composed of the brain and spinal cord
  - Peripheral Nervous System: composed of nerves and ganglia

Overview of the Nervous System

The nervous system is uniquely designed for gathering, transmitting, processing and storing information. It controls voluntary as well as most involuntary functions. The nervous system is divided into two major components. The Central Nervous System (CNS) includes the brain and spinal cord and the Peripheral Nervous System (PNS) contains those structures outside of the brain and spinal cord, namely nerves and ganglia. Two classes of cells are found in the nervous system: neurons, which transmit the nerve impulses; and neuroglial cells, which carry out support functions in the nervous system. Most neurons have three parts: the soma, the axon and the dendrites. The soma (or neuron cell body) houses the nucleus of the cell and most of the other organelles**.** In the CNS, soma are usually found in gray matter, whereas in the PNS, they are located in discrete clusters called ganglia. In addition to the soma, neurons possess two types of processes: axons and dendrites. Dendrites are short, branched processes designed to transmit information toward the soma (incoming signals). Typical neurons have many dendrites which are found in the same locations as the soma. Axons are processes that carry information away from the soma (outgoing signals). A neuron typically has a single axon that, in some cases, can be as long as a meter. Axons in the CNS are located in the white matter; axons in the PNS are the principle component of nerves. Specialized neuroglial cells in the CNS (oligodendrocytes) and PNS (Schwann cells) wrap themselves around the axon producing a coating called the myelin sheath that can run the entire length of the axon. Each Schwann cell can produce a segment of myelin sheath that will cover about 1

millimeter of the axon. Between each segment of the myelin sheath is a small un-myelinated gap called a node of Ranvier.

Spinal Cord

A. In the spinal cord smear, we can see neuron cell bodies. In these slides, gray matter from the spinal cord is literally smeared across the microscope slide disrupting the normal histology of the gray matter. This process, however, allows us to see the large, multi-shaped **neuron cell bodies** or **soma**. **Axons** and **dendrites** can be observed attached to the cell body, but there is really no reliable way to determine which is an axon and which is a dendrite. In the background, you will see many small, dark nuclei. These are the nuclei of the various **neuroglial cells**.

B. Under low magnification the entire cross section of the spinal cord can be observed. It looks like a large circle with an "H" or butterfly shaped structure in its center**.** The "H" is the **gray matter** and, therefore, contains neuron cell bodies. The lighter colored tissue around the gray matter is the **white matter**, containing axons that run up and down the spinal cord. Two grooves divide the spinal cord into right and left sides. These are the **anterior median fissure** and the **posterior median sulcus**. In the very center of the spinal cord is a small, fluid filled open space called the **central canal**. The gray matter around the central canal is the **gray commissure** which connects the right and left sides. The rest of the gray matter is subdivided into three horns: the right and left **ventral, dorsal** and **lateral horns**. The white matter is subdivided into columns, the right and left **ventral, dorsal** and **lateral columns**. If you have a good preparation, you will be able to see a **dorsal root ganglion** which is actually a cluster of **soma** in the PNS**.** It can be seen just lateral to the spinal cord.

Higher magnification of the ventral horn of the gray matter will reveal the large neuron cell bodies of the motor neurons that originate in this tissue. White matter under high magnification reveals tissue composed of small, clear circles with dark dots in the center (kind of like a doughnut). The dark dots are **axons** and the clear area around the axon is the **myelin sheath**.

Peripheral Nerve

A. In longitudinal sections, a peripheral nerve has a unique appearance. At first it may look very nondescript, but on closer observation you will be able to see a **node of Ranvier**. It will look something like a "+" sign. The horizontal line is an axon and the vertical line is a node of Ranvier. Once you have located a node, you should be able to make out the myelin sheath on either side of the node. A nerve is composed entirely of axons surrounded by layers of connective tissue.

In cross section, nerves look somewhat like white matter of the spinal cord—that is, dark dots with light circles around them. Again, the dots are axons and the lighter circles are the myelin sheath. If we observe this tissue under low magnification, we see that nerves are arranged somewhat like skeletal muscle; that is, groups of axons are bundled into **fasciculi** and each nerve is composed of many fasciculi**.** Also, like skeletal muscle, these structures are surrounded by connective tissue layers. Individual axons are surrounded by the **endoneurium**, fasciculi are surrounded by **perineurium** and the entire nerve is surrounded by **epineurium**.

List of Terms

Spend as much time as you need reviewing Nerve Tissues and structures. The most important thing will be for you to practice identifying all of the structures listed in the table below. Use your online resources, open lab, and any other tool that you have to become confident in your identification skills. Your exam will ask you to identify and then write in (Fill in the Blank) the correct term for your identification. The table below is a comprehensive list of all the terms from this section that we would consider asking about on an exam.

List of Terms for Nerve Tissue

Neuron

- **Soma (Cell Body)**
- **Axon**
- **Dendrite**

Spinal Cord

- **Gray Matter**
- **White Matter**
- **Central Canal**
- **Ventral Horn**
- **Dorsal Horn**
- **Lateral Horn**
- **Gray Commissure**
- **Ventral Column**
- **Dorsal Column**
- **Lateral Column**
- **Anterior Median Fissure**
- **Posterior Median Sulcus**
- **Dorsal Root Ganglion**

Identify a Spinal Cord smear and each of the structures below in this smear:

- **Soma**
- **Neuroglial Cell Nuclei**
- **Axons And Dendrites**

Peripheral Nerve - Longitudinal Section

- **Node of Ranvier**
- **Axon**
- **Myelin Sheath**

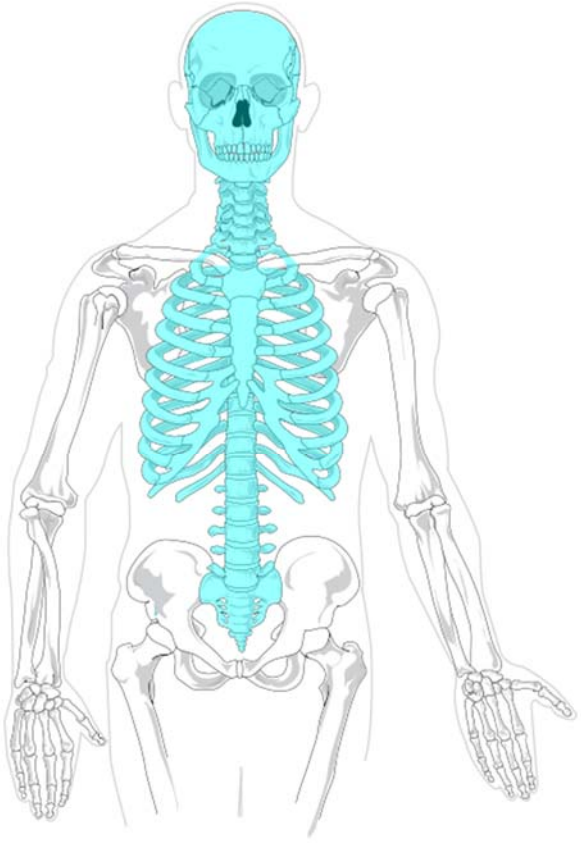
Peripheral Nerve - Cross Section

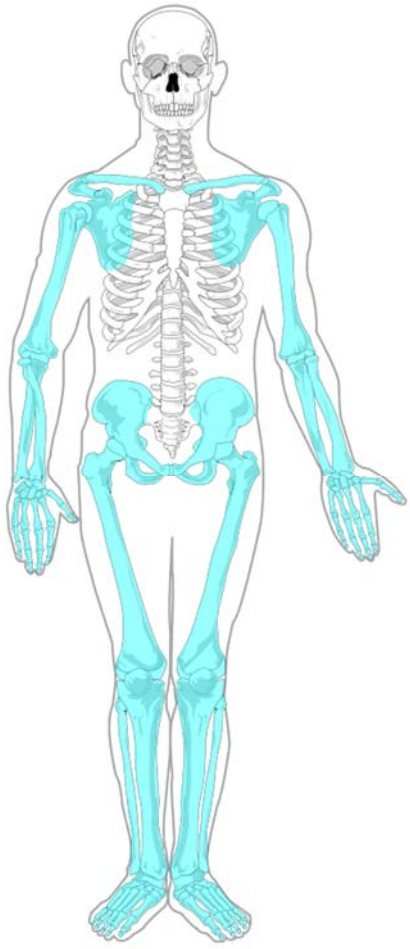
- **Endoneurium**
- **Perineurium**
- **Epineurium**

BIO 264L Anatomy & Physiology

Module 3 - The Skeletal System

Introduction to the Skeletal System and the Skull





Axial **Appendicular**

The skeletal system can be divided into two parts: the **axial skeleton** and the **appendicular skeleton**. The axial skeleton includes the skull, the vertebrae, the sacrum, the sternum and the ribs. The appendicular skeleton includes the bones of the appendages plus the bones of the girdles that attach the appendages, i.e. the scapula and clavicles for the upper limb and the coxal bones for the lower limbs (see figure 1).

For the skeletal system, we will divide all of the bones and bony landmarks that we want you to learn into modules. The first will cover the anatomy of the skull. The second will cover the anatomy of the trunk and arms. Finally, the third skeletal module will cover the bones of the pelvis and legs. The third skeletal module will also cover the types of joints in the skeletal system and the movements that occur at these joints.

As you use the online atlas to study images of these bones, please note a link towards the top of the menu for these bones. It is called "Anatomical Terms" and it lists common prefixes, suffixes and words that we find in our studies of the skeletal system. If you become well acquainted with these terms, you will have an easier time memorizing all the bones and bony landmarks.

The Skull

The skull is a bony structure that protects the brain and supports the structures of the face. There are about 22 bones in the skull. We say "about" because some anatomy textbooks can differ just a little bit on exactly how some of the bones are classified. All of the bones of the skull except the mandible are joined together by a type of immovable joint called a suture.

All of the muscles for facial expressions and chewing must associate with skull bones. Many nerves involved in sight, hearing, skin sensation, taste, smell and balance must negotiate through and around skull bones. A large number of blood vessels must negotiate through and around skull bones as well. For all of these reasons, the skull has a lot of angles, grooves, canals, raised areas and depressed areas. It also has sinuses and cavities. It will take an entire module to learn a good basic list of skull structures.

The skull has a lot of parts to learn and so we teach it first in the modules of the skeleton. This is so that you can review the skull through the other two skeletal modules and finally get a good handle on it before the skeletal exam. Don't underestimate how much time you should spend studying the skull bones and skull bone structures. There is a lot to learn.

List of Terms

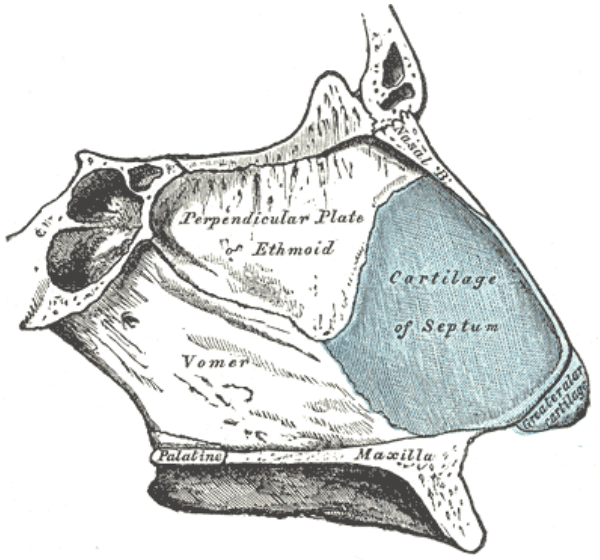
Spend as much time as you need reviewing the skull bones and skull bone structures. The most important thing will be for you to practice identifying all of the structures listed in the table below. Use your online resources, open lab, and any other tool that you have to become confident in your identification skills. Your exam will ask you to identify and then write in (Fill in the Blank) the correct term for your identification. The table below is a comprehensive list of all the terms from this section that we would consider asking about on an exam (The bolded terms).

LIST OF TERMS FOR THE BONES AND BONY LANKMARKS OF THE SKULL	
Ear Bones (bones of the middle ear) • **Malleus** • **Incus** • **Stapes**	The Malleus, Incus and Stapes are the three smallest bones of the human body. Together we call these bones **Ossicles**. They transmit sound from the air to the portion of our hearing apparatus called a cochlea
Ethmoid Bone • **Cribriform Plate** • **Crista Galli** • **Nasal Conchae** • **Perpendicular Plate**	The ethmoid bone is hard to see as it is buried deep to the face. The bulleted structures of this bone can be seen in the cranial cavity, the socket of the eye or the nasal cavity. This bones seperates the nasal cavity from the brain. It makes up the "roof" of the nose.
Fossas, Sinuses, and Sutures • **Anterior Cranial Fossa (floor of the cranial cavity)** • **Middle Cranial Fossa (floor of the cranial cavity)** • **Posterior Cranial Fossa (floor of the cranial cavity)** • **Mandibular Fossa (where jawbone connects)** • **Frontal Sinus** • **Maxillary Sinus** • **Sphenoid Sinus** • **Coronal Suture** • **Lambdoid Suture** • **Sagittal Suture** • **Squamous Suture**	A Fossa is a depression or hollow. A sinus is a cavity within a bone and a suture is a union between two bones that creates an immovable joint
Frontal Bone • **Glabella** • **Supraorbital Foramen** • **Supraorbital Margin** • **Zygomatic Process of the Frontal Bone**	Frontal comes from the Latin root "frons" which means forehead. The glabella is an area without clear boundaries but is generally considered to be a region between the eyebrows and above the nose. Supraorbital means "above the eye". Finally, note that the zygomatic process of the frontal bone refers to a process on the frontal bone that is "pointing" towards and actually makes a union with the zygomatic bone. It is NOT actually a part of the zygomatic bone. This happens other times in the skull, be on the lookout for this type of naming strategy.
Hyoid Bone	The hyoid bone is shaped like a horse show and is not actually connected to the skull. Some would say that this is not a skull bone, but we will list it here as one of the bones to learn in this module. This bone is actually found in the anterior midline of the neck between the chin and the "adams apple"

Lacrimal Bone • **Nasolacrimal Canal**	The lacrimal bone is the smallest bone of the face. It is found on the medial surface of the eye socket. Tears from the eye can move through a canal in this bone and enter the nasal cavity. This anatomical structure explains why a runny nose follows a good cry.
Mandible • **Alveolar Processes-Mandible** • **Angle of Mandible** • **Body of Mandible** • **Condylar Process of Mandible** • **Coronoid Process of Mandible** • **Mandibular Condyle** • **Mandibular Notch** • **Mandibular Symphysis** • **Mental Foramen** • **Ramus of Mandible**	The mandible is also known as the "jawbone". This bone forms a moveable joint with other bones of the skull and is important for containing the lower teeth and for most of the movement that occurs with chewing. There are several specific areas and structures that we learn on this bone.
Maxilla • **Alveolar Processes of the Maxilla** • **Anterior Nasal Spine** • **Frontal Process of the Maxilla** • **Infraorbital Foramen** • **Palatine Process** • **Zygomatic Process of the Maxilla**	The maxilla consists of the anterior part of the roof of the mouth. It is also known as the upper jaw. It contains the upper teeth. The maxilla is another bone that helps from the eye socket. Notice that similar to the frontal bone, there is a zygomatic process that refers to an area of the bone that "points" towards and actually forms a union with the zygomatic bone but is not part of the zygomatic bone. Also, this same technique for naming is found with the palatine process. This is a part of the maxilla that "points" to and joins with the palatine bone but is not part of the palatine bone.
Nasal Bone	There are actually two nasal bones. They are quite small and form the "bridge" of the nose. They can differ quite a bit in size and form between individuals.
Occipital Bone • **External Occipital Protuberance** • **Foramen Magnum** • **Hypoglossal Canal** • **Nuchal Lines** • **Occipital Condyles**	The occipital bone sits on the very back of the skull. It is kind of bowl shaped and makes up the floor of the cranial cavity on the very posterior side. Look for the foramen magnum in the center of the occipital bone.
Palatine Bone • **Horizontal Plate** • **Palatine Foramina**	The Palatine bone contributes to the posterior part of the roof of the mouth (just behind the maxilla). I also contributes to the floor and lateral walls of the nasal cavity. You generally have to turn the skull upside down, remove the mandible and look at the posterior nasal cavity to get a good glimpse of this bone.

Parietal Bone • **Temporal Lines**	Two parietal bones meet in the center and form much of the sides and roof of the skull. The latin root “pariet-“ means wall. The temporal lines can be hard to see sometimes. It depends on the skull. Generally the temporal lines are slightly raised ridges that mark the attachment of the temporalis muscle.
Sphenoid Bone • **Foramen Lacerum** • **Foramen Ovale** • **Foramen Rotundum** • **Foramen Spinosum** • **Greater Wing** • **Inferior Orbital Fissure** • **Lateral Pterygoid Plate** • **Lesser Wing** • **Medial Pterygoid Plate** • **Optic Canal** • **Sella Turcica** • **Superior Orbital Fissure**	The sphenoid bone kind of resembles a butterfly. It is situated towards the front of the skull, but much of it is hidden behind the face. It is another bone that helps make up the eye socket. This bone has quite a few important structures on it that we must learn.
Temporal Bone • **Carotid Canal** • **External Acoustic Meatus** • **Internal Acoustic Meatus** • **Jugular Foramen** • **Mastoid Process** • **Petrous Portion** • **Squamous Portion** • **Styloid Process** • **Stylomastoid Foramen** • **Zygomatic Process of the Temporal Bone**	The temporal bone contains the part of the face called the temple. This bone also contains the ear canal and the structures used for hearing. This bone also contains quite a few important anatomical structures that we learn.

Vomer



The vomer is a small bone right in the middle of the nasal cavity. If you look in the nasal cavity there will be a plate of bone right in the center. The top part of this plate is the perpendicular plate of the ethmoid bone. The bottom part of this plate is the vomer. If you look at the center plate of bone from the posterior nasal cavity, the entire plate is the vomer. A drawing of this relationship is placed here to help you.

Zygomatic Bone

- **Infraorbital Margin**
- **Temporal Process of the Zygomatic bone**
- **Zygomatic Arch**

The zygomatic bone is the "cheek" bone. It also helps make up part of the eye socket.

FYI: *(Just for fun…don't worry about for an exam)*

Based on various features of the skull, it is possible to determine the gender of the skull. In the table below is a list of features that differ between the sexes. Look at several skulls and see if you can determine their gender. For this exercise, it is better to use the real skulls rather than the models. Note that it is common for some of the features to appear more "male" and others "female"—if this happens, sex is determined by the greatest number of features. For example, if the skull demonstrates 4 male-like traits and 7 female-like traits, then you would classify the skull as female.

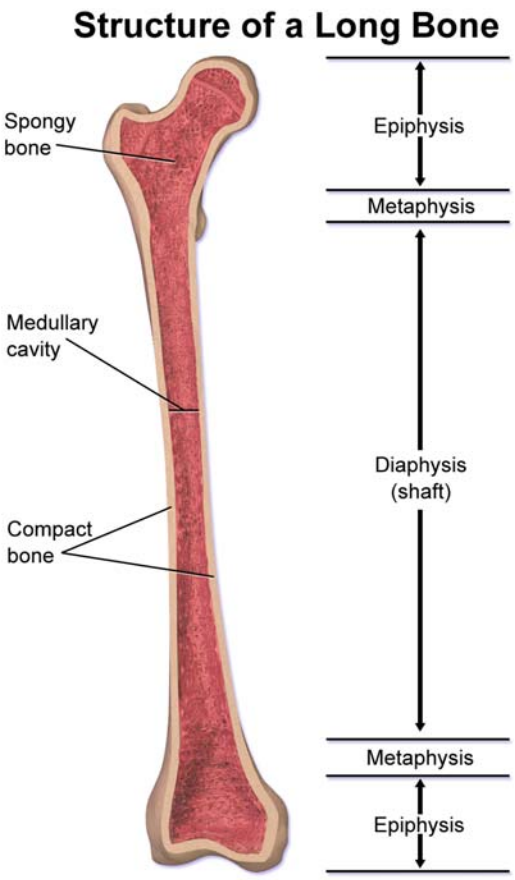
Gender Differences in the Skull

Skull Feature	Male Characteristic	Female Characteristic
general size	more robust	more gracile/delicate
external occipital protuberance and nuchal lines	well-demarcated nuchal lines and prominent bump or "hook"	external surface of occipital bone is smooth, with no bony projection
mastoid process	large, projects below the external auditory canal	Smaller
supraorbital margin (upper orbit rim)	thick, rounded, blunt border	thin, sharp border
supraorbital ridge ("brow ridges")	prominent	little or no prominence
mandible	squarish, greater forward projection	more pointed, little forward projection
angle of the mandible	125 degrees or less	125 degrees or more
ramus of the mandible	wide	Narrow
orbit	rectangular	Round
frontal bone	flattened and sharply angled	rounded both ways
hard palate	definite "U" shape	"V" shaped

Module 4 - The Skeletal System
Bones of the Arms and Trunk

In this module we will learn the bones, bone regions and bony structures for the trunk and arms. In the arms, we will see long bones. Long bones are bones that are longer than they are wide. Long bones also grow at growth plates which are found in the Metaphysis. Long bones also contain a medullary cavity which contains marrow. In children this marrow may be red marrow (marrow that makes red blood cells), but in adults the marrow of long bones is more likely to be yellow marrow (marrow containing mostly lipid and does not make red blood cells).

We will also ask you to be prepared to identify right and left for some of the bones. Any bone that has a description in the right column of the terms table is a required bone to tell right and left.



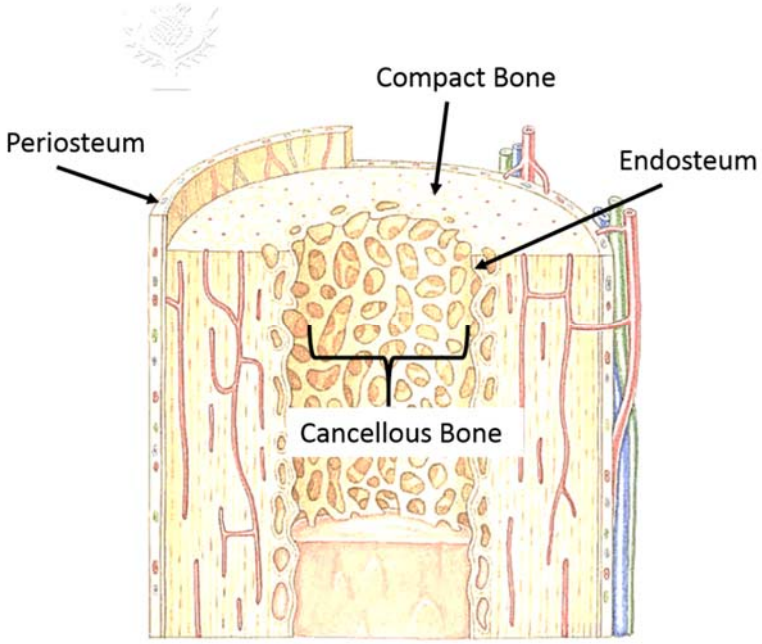


Figure 1: The picture on the right is a long bone (the femur) that has been cut in the frontal section. The picture on the right is a zoomed in look at the long bone. The picture on the right represents a section from the shaft or diaphysis.

LIST OF TERMS TO KNOW FOR THE STRUCTURE OF A LONG BONE	
Compact Bone	Also called Cortical Bone. This is one of two types of osseous tissue that form bones. This type of bone is much denser and is generally found at the outside edge of bone. Compact bone gives bone its strength and allows it to tolerate the force loads that go through it.
Diaphysis	The main midsection or shaft of a long bone. The edges are compact bone and the center generally contains yellow marrow.
Epiphysis	Found as the rounded ends of long bones. There is an epiphysis on the proximal and distal ends. Where bones form joints, the epiphysis is covered with hyaline cartilage. The epiphysis contains spongy or cancellous bone and it is quite common for the epiphysis to contain read marrow.
Medullary Cavity	The central cavity found in a bone shaft (or diaphysis). Generally contains yellow marrow although the marrow can be red marrow in children.
Metaphysis	Between the epiphysis and the diaphysis. In a growing bone, the growth plate (a ring of hyaline cartilage) is located here. After the growth plates fuse, the metaphysis contains a ring of ossified bone where the growth plate used to be.
Cancellous Bone	Also called Spongy bone or trabecular bone. This type of bone tissue is much less dense than compact bone. Cancellous bone is typically found at the end of long bones (in the epiphysis). Cancellous bone is highly vascular (contains a lot of blood).
Periosteum and Endosteum	Connective tissue coverings of bone. The periosteum is found on the outside surface of the bone and the endosteum is found lining the walls of the medullary cavity.

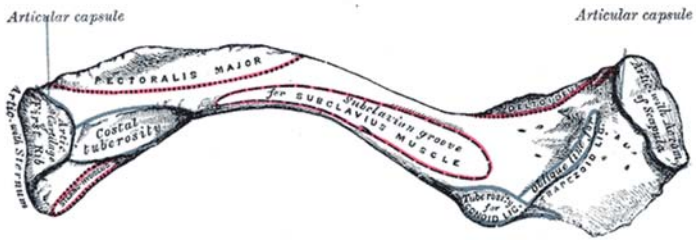
LIST OF TERMS FOR THE BONES AND BONY LANKMARKS OF THE ARMS AND TRUNK

Clavicle

- **Acromial (Lateral) End**
- **Conoid Process**
- **Sternal (Medial) End**

Sometimes this bone has been referred to as the "collar bone". But, don't use collar bone on the exam. This is the only long bone in the body that lies horizontally. This bone acts as a strut to connect the scapula to the sternum.

To identify right and left, turn the clavicle so the conoid process is both inferior and posterior. The acromial end always has to be lateral. In the picture below the conoid process is both inferior and posterior so the only way for the acromial end to be lateral is if this clavicle is on the left side of the body.

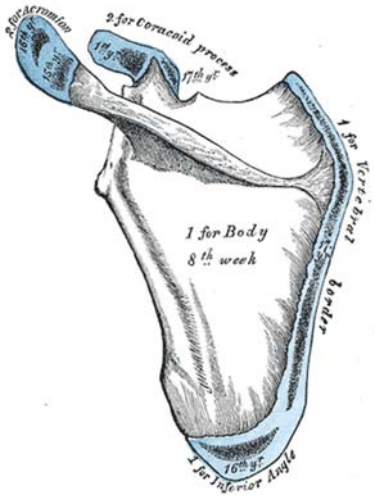


Scapula

- **Acromion Process**
- **Axillary (Lateral) Border**
- **Coracoid Process**
- **Glenoid Cavity**
- **Inferior Angle**
- **Infraspinous Fossa**
- **Scapular Notch**
- **Spine**
- **Subscapular Fossa**
- **Superior (Medial) Angle**
- **Superior Border**
- **Supraspinous Fossa**
- **Vertebral (Medial) Border**

It is thought that the word “scapula” comes from the Greek word *skaptein* which means to dig. In early times, anatomists thought the bone resembled a trowel or small shovel. This bone is a flat bone easily identified on the back of the upper trunk. This bone has several bony structures and landmarks to memorize.

To identify right and left, imagine that you are looking at this bone from behind a person and see the spine. Also, the glenoid cavity is lateral and ready to articulate with the humerus. Ask yourself which arm (right or left) would be articulating with this scapula and you know which scapula it is.



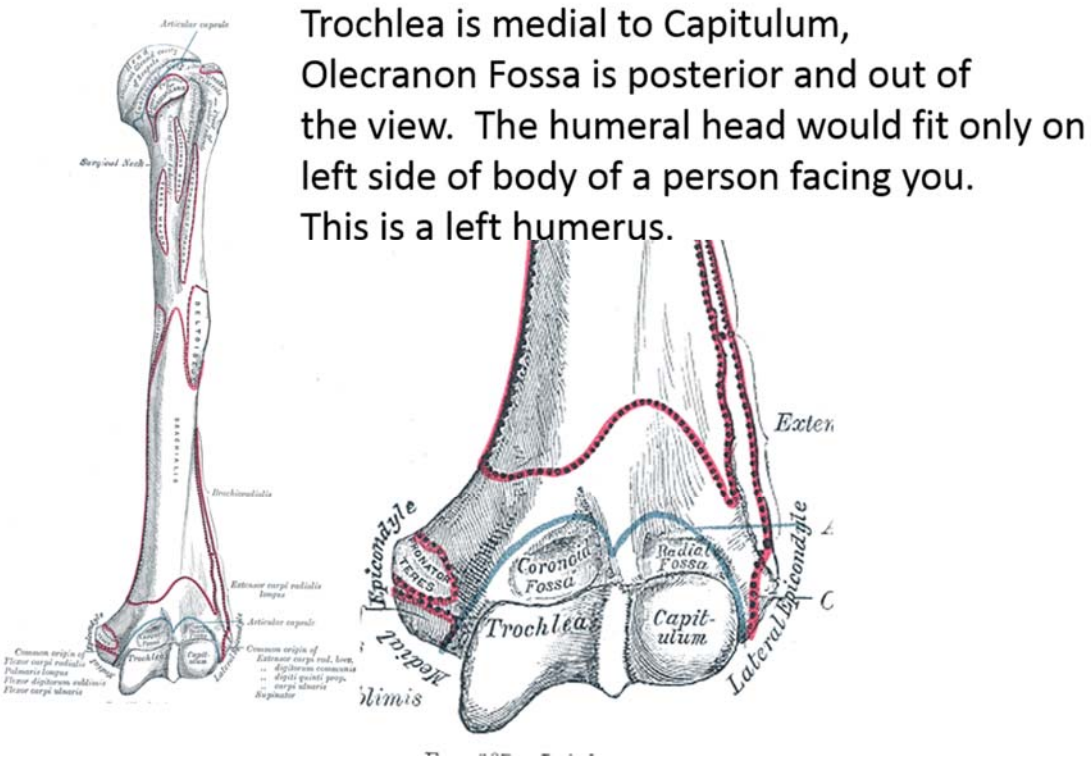
This Scapula is a left scapula

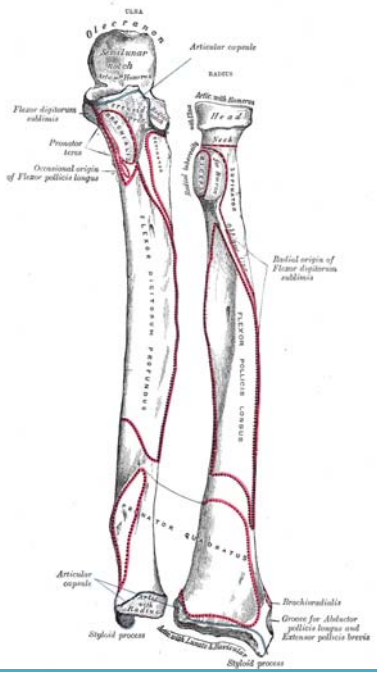
Humerus

- **Anatomical Neck**
- **Capitulum**
- **Coronoid Fossa**
- **Deltoid Tuberosity**
- **Greater Tubercle**
- **Head**
- **Intertubercular Groove**
- **Lateral Epicondyle**
- **Lesser Tubercle**
- **Medial Epicondyle**
- **Olecranon Fossa**
- **Radial Fossa**
- **Surgical Neck**
- **Trochlea**

The word humerus has nothing to do with laughter. The Latin term “umerus” means upper arm. This bone is the bone of the upper arm. It forms a joint with the scapula called a ball and pivot joint which gives this bone a lot of movement. It also has quite a few structures and landmarks to memorize.

To identify right and left, turn the humerus so that the trochlea is medial to the capitulum and the olecranon fossa is behind or posterior and out of your view. You are now looking at the anterior view of a humerus. Now, imagine in your mind what side of the body you would have to be on to connect the rounded head to a glenoid cavity.



Radius • **Head** • **Neck** • **Radial Tuberosity** • **Styloid Process** • **Ulnar Notch**	This is one of two large bones that make up the forearm. The other is the Ulna. The radius rotates around the ulna when you twist your forearm. This is how it got its name. **To identify right or left**, view the radius and ulna together. Test questions about identification of right and left of these two bones will include them together. Be sure trochlear notch is facing you. You are now looking at an anterior view. On the human body, the radius is always lateral and the ulna is always medial when a person is standing in anatomical position. With this knowledge, you should be able to examine the picture below and realize that this is an anterior view and because the radius is always lateral this would have to be a left forearm. 
Ulna • **Coronoid Process** • **Head** • **Olecranon Process** • **Radial Notch** • **Styloid Process** • **Trochlear (Semilunar) Notch** • **Ulnar Tuberosity**	Generally, this is the bone we refer to when we speak of our elbow bone. In fact, the olecranon process would be the point of the elbow. This is the other large long bone of the forearm. To identify right or left? We will always ask right and left questions of this bone when it is together with the radius. Use the same technique as the radius to tell right and left on this bone.
Carpals • **Scaphoid** • **Lunate** • **Triquetrum** • **Pisiform**	Carpal comes from the Latin root “carpus” which means wrist. The eight small carpal bones form two transverse rows. It is often easier to memorize the eight carpal bones by coming up with a Mnemonic Device (a sentence that helps us memorize a string

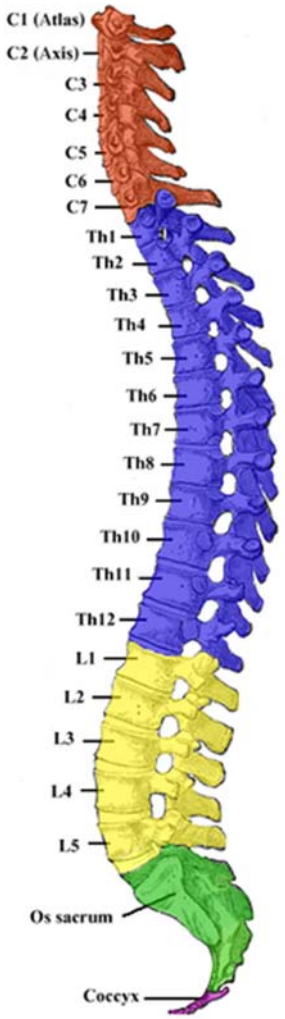
• **Trapezium** • **Trapezoid** • **Capitate** • **Hamate**	of words). For example, start with the proximal row of carpals on the thumb side. Take the first letter of each carpal bone from thumb side to pinky finger side and then start over on the distal row from thumb to pinky side. This gives you a string of letters S-L-T-P-T-T-C-H Then come up with a sentence like… "**S**ome **L**unatics **T**ry **P**ilates **T**hat **T**hey **C**an't **H**andle" This is the same order that the bones are listed in this list and the same order that the bones are shown in the online atlas. Mnemonic devices like this have helped students for many years as they try to keep track of the location of a string of anatomical structures. You might try coming up with others on your own when you think it might be helpful.
Metacarpals • **Metacarpal 1** • **Metacarpal 2** • **Metacarpal 3** • **Metacarpal 4** • **Metacarpal 5**	"Meta-" means "between" or in the middle. Metacarpals are bones found in the intermediate hand or between the carpal bones and the Digits. The area called your "palm" would be the anterior surface of the metacarpals. There are 5 metacarpals, one for each digit of the hand. The first metacarpal is the one that underlies the digit called the thumb and the 5th is proximal to the "pinky" finger.
Digits (Phalanges) • **Distal Phalanx** • **Middle Phalanx** • **Proximal Phalanx**	Also referred to as the fingers. Fingers are actually made up of three bones. Starting at the tips of the fingers, the bones that make up a finger include the distal, middle and proximal phalanx. Phalanx is the singular form for these bones. All together we call them phalanges. The thumb has only two phalanges, the proximal and distal phalanx. There is no middle phalanx in the thumb. There are 4 fingers and 1 thumb, but we say there are 5 digits. Digit one is the thumb and digit 5 is the pinky finger. Be sure to refer to the metacarpal and phalange bones by number. Resist the temptation to use names like thumb, index, middle, ring or pinky finger on the test.

Sternum • **Body** • **Calvicular Notch** • **Costal Notches** • **Jugular Notch** • **Manubrium** • **Sternal Angle** • **Xiphoid Process**	Sometimes called the breastbone. However, be sure to avoid using the term “breastbone” on the exam, We won’t give credit for common names when a more formal anatomical name is the term bolded to the left on these tables. The sternum is where most of the ribs attach on the anterior trunk. The sternum helps protect the heart and lungs. The sternum is made can be divided into 3 regions (the Manubrium, The Body and the Xyphoid).
Ribs • **Head** • **Tubercle** • **Neck** • **Angle** • **Body** • **Costal Groove** • **Costal Cartilage** • **False Ribs (5 pair)** • **Floating Ribs (2 pair)** • **True Ribs (7 pair)**	The ribs are long curve bones which form a cage on the human thorax. The ribs attach to the vertebrae through the head of the rib. On the anterior trunk, the ribs blend in with cartilage, called costal cartilage which attaches to the sternum. For the most part humans have 24 ribs (12 pairs). There can be a little variation as some people can be missing or have an extra pair of floating ribs. Males and females have the same number. When Adam donated a rib for Eve, his male children must have gotten it back☺.

Vertebrae

- **Vertebrae - General Features**
  - **Body**
  - **Inferior Articular Facet**
  - **Inferior Articular Process**
  - **Inferior Intervertebral Notch**
  - **Intervertebral Foramen**
  - **Lamina**
  - **Pedicle**
  - **Spinous Process**
  - **Superior Articular Facet**
  - **Superior Articular Process**
  - **Superior Intervertebral Notch**
  - **Transverse Process**
  - **Vertebral Arch**
  - **Vertebral Foramen**
- **Cervical Vertebrae (7)**
  - **Atlas (C1)**
  - **Axis (C2)**
  - **Bifid Spinous Process**
  - **Odontoid Process (Dens)**
  - **Transverse Foramen**
- **Thoracic Vertebrae (12)**
  - **Costal Facet**
- **Lumbar Vertebrae (5)**

The human spine generally contains 7 cervical vertebrae, 12 thoracic vertebrae, 5 lumbar vertebrae, 5 fused sacral vertebrae and 4 fused coccyx vertebrae. Rarely a person can have 1 or 2 less or 1 or 2 more. The most common area for an extra vertebrae is in the lumbar, sacral or coccyx region. Vertebrae have many structure names in common. Even though the structures can look quite different in different regions of the spine, we tend to use the same names. The online atlas will show an example of a cervical, thoracic and lumbar vertebrae for most of the common structures between them. The cervical vertebrae have a few special structures that are not found on any other vertebrae. The thoracic vertebrae has the costal facet where the ribs connect to the spine, and the other vertebrae do not have this structure.



Sacrum • **Anterior (Ventral) Sacral Foramen** • **Auricular Surface** • **Median Sacral Crest** • **Posterior (Dorsal) Sacral Foramen** • **Sacral Canal**	The sacrum is a large triangular shaped bone at the base of the spine. It is formed by the fusion of 5 vertebrae that are inferior to the lumbar spine. The sacrum connects to the spine and to the pelvis. This is why the sacrum is a kind of link that transfers forces from from the legs to the spine and from the spine to the legs. Its thick strong shape is well adapted for this job.
Coccyx	Commonly referred to as the "tail bone". Again, you would not want to use "tail bone" on the exam. The coccyx make up the final segment of the vertebral column. These bones sit just inferior to the sacrum. Some people say that the coccyx are not necessary and just make up a remnant of a tail. In reality the coccyx is a very important attachment point for several muscles.

Module 5 - The Skeletal System
Bones of the Pelvis and Legs / Joints and Movements

In this module we will learn the bones, bone regions and bony structures for the pelvis and legs. Similar to the arms, there a quite a few long bones in the legs. We will also learn the different types of joints in the body and the movements that occur at those joints. We have attempted to create an animation for each type of movement so that it will be clear what the movement is. These animations are found in the online atlas.

Similar the upper extremities, we will require you to be able to tell right and left bones for some of the bones. You may be required to tell right and left bones for any of the bones that have a description of how to tell right and left.

LIST OF TERMS FOR THE BONES AND BONY LANKMARKS OF THE PELVIS AND LEGS

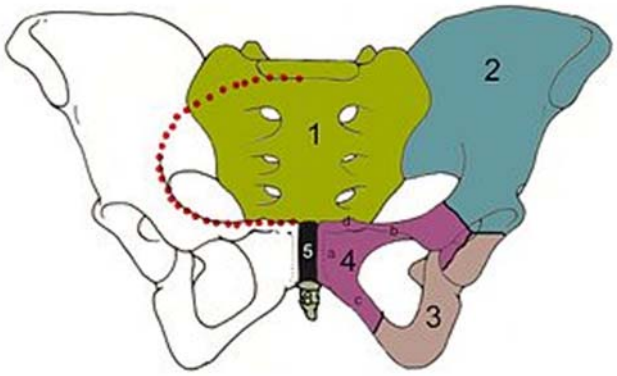
Os Coxae

- **Acetabulum**
- **Anterior Inferior Iliac Spine**
- **Anterior Superior Iliac Spine**
- **Auricular Surface**
- **Greater Sciatic Notch**
- **Iliac Crest**
- **Iliac Fossa**
- **Ilium**
- **Inferior Pubic Ramus**
- **Ischial Ramus**
- **Ischial Spine**
- **Ischial Tuberosity**
- **Ischium**
- **Lesser Sciatic Notch**
- **Obturator Foramen**
- **Posterior Inferior Iliac Spine**
- **Posterior Superior Iliac Spine**
- **Pubic Crest**
- **Pubis**
- **Superior Pubic Ramus**

A student holding a right os coxa bone like a phone. This is one of the favorite ways for students to tell which is right and which is left if they are given only one side to identify. It is probably fortuitous that the large hole in this bone is called the "obturator" foramen. I have heard more than one student hold this bone up and speak into it like a phone and say "hello is this the operator". It makes us laugh. But then, funny things are easier to remember.

This bone has had several names over the years. It has been called the hip bone, innominate bone, pelvic bone and coxal bone. This bone is actually made up of three smaller bones (the ilium, ischium and pubis). These three bones are fused to form the Ox Coxae. You can see these three bones in the picture below labeled 2,3 and 4. You can see the fusion of these three bones in the acetabulum. The acetabulum is the socket that the femur connects to at the hip joint. The pubic symphysis is where the two os coxa bones connect anteriorly. The auricular surface is where the os coxae bones connect to the sacrum. The greater sciatic notch is where the sciatic nerve leaves the pelvis and enters the posterior thigh. The other structures and bony landmarks on the list are regions or areas that muscles attach to.

To identify right or left, position the os coxa bone so that the pubic symphysis is anterior and the acetabulum is lateral. Then, imagine that you are connecting to the other pubic symphysis as you imagine which side of the body this would be on. Many of the students in class will hold the ox coxa like a phone. As long as the hand is in the greater sciatic notch in a way that the finger cross into the acetabulum, and the part that forms the pubic symphysis is where you would "speak into", then the hand that the bone is in is the side that the bone belongs on. The picture of the student holding the bone is showing a right os coxa.

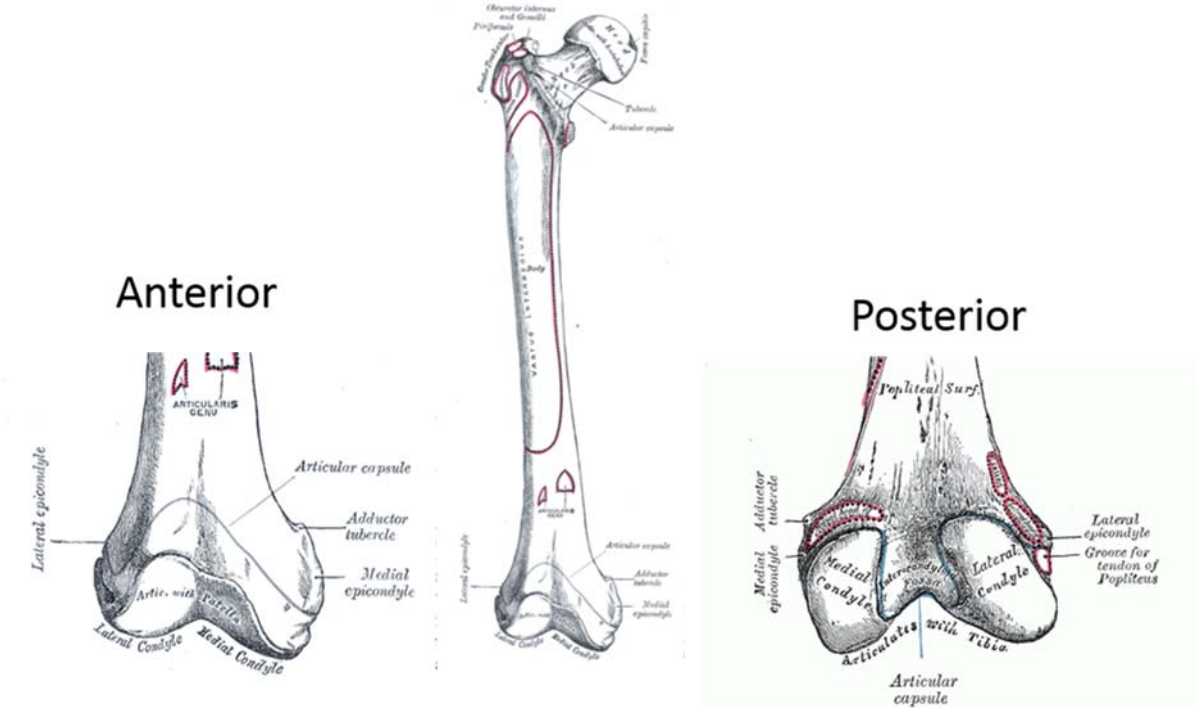


Femur

- **Body**
- **Fovea Capitis**
- **Gluteal Tuberosity**
- **Greater Trochanter**
- **Head**
- **Intercondylar Fossa**
- **Intertrochanteric Crest**
- **Lateral Condyle**
- **Lateral Epicondyle**
- **Lesser Trochanter**
- **Linea Aspera**
- **Medial Condyle**
- **Medial Epicondyle**
- **Neck**
- **Patellar Groove**

The femur is the largest, heaviest and strongest bone in the body. The height of the femur determines about a quarter of a person's height. Anthropologists who find partial remains of skeletons use this knowledge to estimate how tall a deceased person would have been.

To identify right or left. Notice that the condyles on the distal end of the femur have a between them. On the anterior side this groove is shallow because the patella glides there and makes contact with cartilage in this groove. On the posterior side the groove is quite deep. If you hold the femur so that the shallow groove is anterior then you can imagine which side of the pelvis the head of the femur would connect with. The picture below shows the grooves on the anterior and posterior sides and you should be able to imagine that the femur here is a right femur.



Patella

- **Anterior Surface**
- **Apex**
- **Base**
- **Lateral Articular Facet**
- **Medial Articular Facet**
- **Posterior Surface**

The patella is also known as the kneecap. This bone protects the hyaline cartilage of the knee joint. It also acts as a fulcrum for the tendons of the quadriceps muscle. This little bone greatly increases the force that can be applied to the lower leg.

To identify right or left, turn the patella around so that you can look at the posterior surface. The posterior surface has two facets. These facets contain cartilage in a living person and glide along the cartilage in the shallow anterior groove between the condyles of the femur. The facet that glides with the lateral condyle is always bigger. So, once you discover which facet is bigger, you have to imagine in your mind which leg the patella belongs to if the bigger facet is on the lateral side. The picture below shows a right patella. In class, I see students holding the patella down over their own knees to imagine which leg puts the larger facet on the lateral side. Those who study online sometimes tell us that they imagine putting their own knee right up to the screen on the picture of the posterior surface. This helps them keep track of which leg would put the larger facet on the lateral side.

Anterior

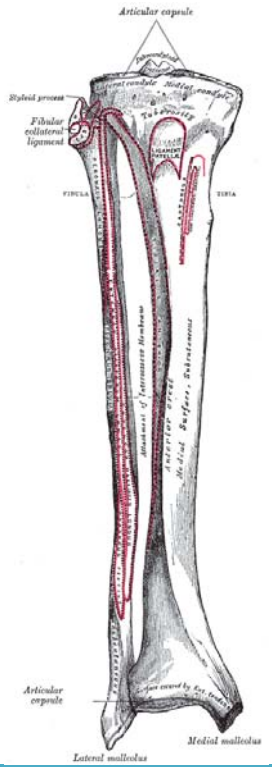
Posterior

Tibia

- **Anterior Crest**
- **Fibular Notch**
- **Intercondylar Eminence**
- **Lateral Condyle**
- **Medial Condyle**
- **Medial Malleolus**
- **Tibial Tuberosity**

Also known as the “shin bone”. This bone is one of two large long bones in the lower leg. The Fibula is the other bone. The Tibia is the larger of the two and is always on the medial side of the two bones in the lower leg. The tibia and fibula are connected to each other by a very strong fibrous membrane. This membrane has been removed in most skeletons and pictures used to teach anatomy, but it is there in a living person.

To identify right or left. Turn the tibia so that the tibial tuberosity is facing anterior and then realize that the medial malleolus is named “medial” because it is always on the medial side of the leg. Ask yourself which side of the body the bone would have to be on to make the anterior facing tibia have a malleolus on the medial side of the leg. The Tibia in this picture is a right tibia.



Fibula

- **Head**
- **Lateral Malleolus**

The fibula is always located on the lateral side of the tibia so it is always on the lateral side of the lower leg. It is much more slender than the tibia and does not carry nearly as much body weight. The lateral malleolus completes the bony containment of the ankle joint. The two malleoli (medial and lateral malleolus) are the rounded bumps on both sides of your ankle.

Tarsal Bones • **Talus** • **Calcaneus** • **Navicular** • **Medial Cuneiform** • **Intermediate Cuneiform** • **Lateral Cueniform** • **Cuboid**	Tarsal comes from the Greek root "Tarsus" which refers to the ankle. There are seven articulating tarsal bones. It is often easier to memorize the seven tarsal bones by coming up with a Mnemonic Device (a sentence that helps us memorize a string of words). For example, start with the Calcaneus and work your way distil to the Medial Cuneiform, then lateral the Cuboid. Take the first letter of each tarsal bone in this order and this gives you a string of letters T-C-N-M-I-L-C Then come up with a sentence like… "**T**hin **C**ountry **N**erds **M**eet **I**ncredible **L**ovely **C**uties" This is the same order that the bones are listed in this list and the same order that the bones are shown in the online atlas.
Metatarsal • **Metatarsal 1** • **Metatarsal 2** • **Metatarsal 3** • **Metatarsal 4** • **Metatarsal 5**	"Meta-" means "between" or in the middle. Metatarsals are bones found in the intermediate foot between the tarsal bones and the digits. There are 5 metatarsals, one for each digit of the foot. The first metatarsal is the one that underlies the digit called the "Big Toe" and the 5th is proximal to the "Little Toe".
Digits • **Distal Phalanx** • **Middle Phalanx** • **Proximal Phalanx**	Similar to the hand, the foot has digits. The digits in the foot are often referred to as toes. Like the fingers, toes are actually made up of three bones. Starting at the tips of the toes, the bones include the distal, middle and proximal phalanx. The big toe has only two phalanges, the proximal and distal phalanx. There is no middle phalanx in the big toe. Digit one is the big toe and digit 5 is the little toe.
Joints • **Cartilaginous Joints** • **Fibrous Joints** • **Synovial Joints**	A joint is where two bones join together. Some joints allow a lot of movement and other joints allow no movement. The online atlas has pictures of the different types of joints. You should be able to identify each of the examples shown in the online atlas. When you identify a joint be sure to name its category (Cartilaginous, Fibrous or Synovial) as well as its sub-type listed in the pull down menu for each category. For example if I was asked to name the type of joint that connected the two os coxae bones anteriorly, I would say a Cartilaginous Symphysis joint.

Movements

- **Abduction and Adduction**
- **Circumduction**
- **Dorsiflexion and Plantarflexion**
- **Elevation and Depression**
- **Fexion and Extension**
- **Inversion and Eversion**
- **Lateral and Medial Excursion**
- **Opposition and Reposition**
- **Protraction and Retraction**
- **Rotation**
- **Supination and Pronation**

Movement at a joint is described by the terms to the right. This is not every term used but this is a list of the most common ones.

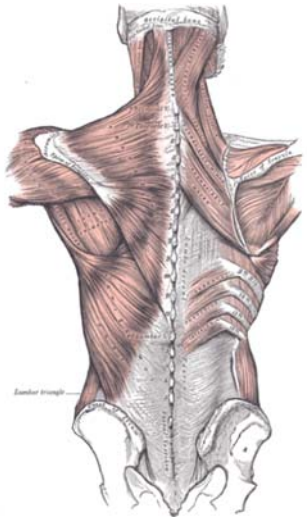
To help you visualize what happens with each of these motions, we have inserted animations in the online atlas. If you click through the animations and they won't play, clicking again as they sometimes play on the second click.

For the exam, you would want to be prepared to recognize the animation, or a picture with arrows or a verbal description of a joint movement.

BIO 264L Anatomy & Physiology

Module 6 - The Muscular System

Introduction to the Muscular System and Muscles of the Head, Neck and Shoulder



There will be three modules to cover the muscle anatomy of the body. The first module will cover the Head, Neck and Shoulder. The second module will cover the arms and trunk. The third module will cover the Hips and Legs.

Most skeletal muscles connect from one bone to another (although there are a couple of muscles in the face and neck area that don't attach to bones). So, muscles generally cross a joint. Synovial joints are the most common type of joint to be crossed so that when a muscle contracts or shortens, movement occurs at the joint. The muscle anatomy modules will require you to learn the name of the muscle, the origin and insertion and the major actions of most of the muscles listed.

If you are required to know the origin and insertion of a muscle then there will be a picture of the origin and insertion. All test questions on origin and insertion will be pictures, a short description of the action and multiple choice answers. This is the only content in Bio 264 that will be multiple choice on the exam. So, while you don't have to memorize detailed descriptions of origin, insertion and action, you do need to recognize this material enough to choose a correct answer out of a list of possible answers.

Here are a few remarks that we hope will help you in your learning of muscle anatomy.

1. Some muscles are named by their origin and insertion. If you can identify which muscles do this, you will realize that you are learning the muscle name, origin and insertion all at the same time. Watch for muscles that do this.
2. Learning muscle names can be easier if you realize that muscles are generally named because of one or more of the following descriptive concepts:
    a. *Location*: For example, pectoralis means chest, so a muscle with this name would probably be found in the chest
    b. *Size*: For example, maximus means large and brevis means short.
    c. *Shape*: The deltoid is triangular and the quadratus is square.
    d. *Orientation of the muscle fibers*: For example, the rectus is straight and the oblique is a muscle where fibers run at an oblique angle to the body.
    e. *Origin and insertion*: For example the sternocleidomastoid gives the name of the origin and then insertion in the name.
    f. *Number of heads*: bicepts means two heads, triceps means three heads, so what do you think quadriceps means?
    g. *Function*: An abductor abducts and an adductor adducts. A masseter helps us masticate or chew our food.

3. Origin is usually (but not always) the proximal attachment and Insertion is usually (but not always) the distil attachment.

A REMINDER…PLEASE NOTE: It will help you a lot if you keep in mind that test questions about origin, insertion and action will be multiple choice questions. So, it will be more critical that you learn to recognize pictures and descriptions of these things than it will be to reproduce all the details from memory. Only muscles with an associated picture require you to know origin, insertion and action.

LIST OF TERMS TO KNOW FOR THE MUSCLES OF THE HEAD, NECK AND SHOULDER

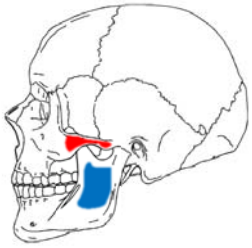
Muscles of the Face

It is important that students can recognize images or models of the muscles in this list, but students are **NOT** required to learn Origin, Insertion or Action for muscles of the face.

- **Buccinator**
- **Corrugator Supercilli**
- **Depressor Anguli Oris**
- **Depressor Labii Inferioris**
- **Levator Labbi Superioris**
- **Mentalis**
- **Nasalis**
- **Occipitofrontalis**
  - **Frontalis**
  - **Occipitalis**
  - **Epicranial (Galea) Aponeurosis** (Epicranial Aponeurosis can also be called the "Galea" which is another acceptable term)
- **Orbicularis Oculi**
- **Orbicularis Oris**
- **Platysma**
- **Risorius**
- **Zygomaticus Major**
- **Zygomaticus Minor**

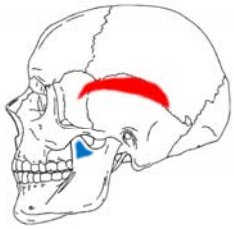
Muscles of Mastication

- **Lateral Pterygoid**
- **Masseter**



Action: Elevates and Retracts Mandible

- **Medial Pterygoid**
- **Temporalis**

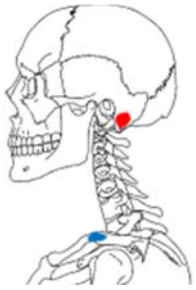


Action: Elevates and Retracts Mandible

Muscles of the Neck

- **Digastric**
- **Mylohyoid**

- **Sternocleidomastoid**

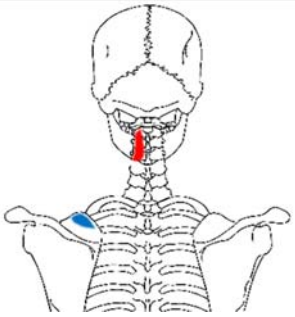


Action: Turns Head side to side and flexes the neck

- **Stylohyoid**

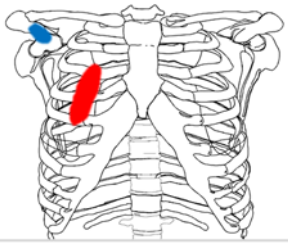
Muscles Acting on the Scapula

- **Levator Scapulae**



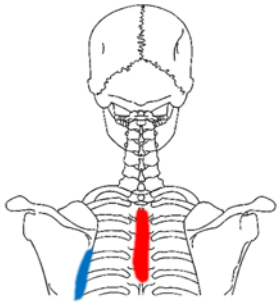
Action: Elevates the Scapula

- **Pectoralis Minor**



Action: Pulls Scapula forward and downward

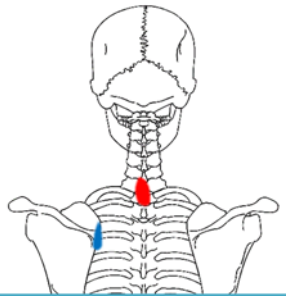
- **Rhomboideus Major**



Action: Scapular adduction and assists with scapular elevation and downward rotation.

- **Rhomboideus Minor**

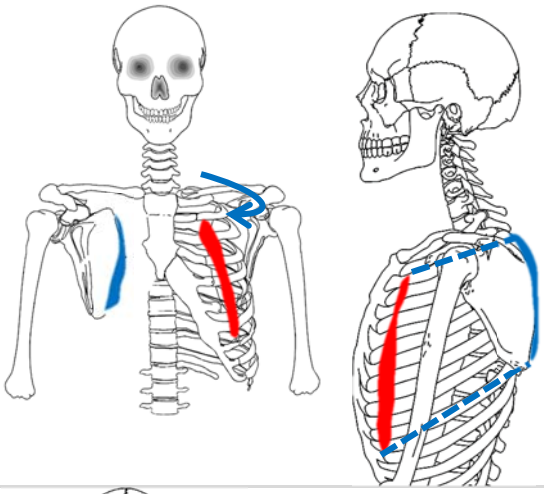
***Note:** The origin and insertion is similar for the levator scapulae, and the rhomboideus major and minor. Be sure to notice the small differences.



Action: Scapular adduction and assists with scapular elevation and downward rotation.

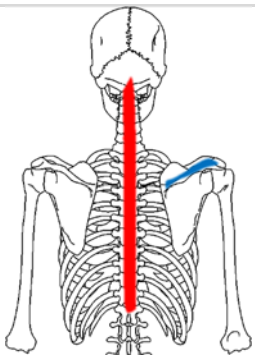
- **Serratus Anterior**

***Note:** The insertion for this muscle is a bit tricky. The picture on the left shows the ribs removed on the right side of the trunk to show where the muscle would insert for the right serratus. The left serratus would follow the ribs around and go "under" the scapular to insert on the vertebral border (see the arrow). The picture on the right side shows dashed lines to suggest that the muscle goes "under" the scapula to insert on the vertebral border.



Action: Scapular abduction (also can be called Scapular protraction).

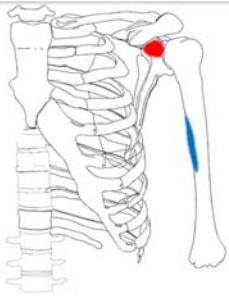
- **Trapezius**



Action: Scapular elevaton, adduction and helps with upward rotation.

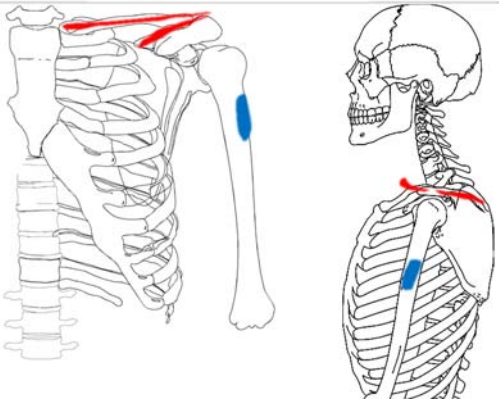
Muscles Which Move the Humerus

- **Coracobrachialis**



Action: Shoulder adduction and flexion

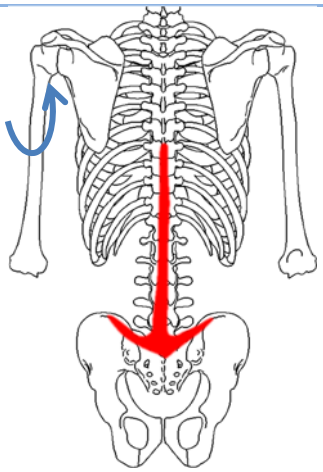
- **Deltoid**

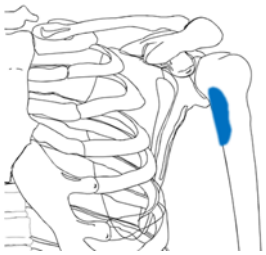


Action: Shoulder abduction is the main action. It helps with shoulder flexion and extension as well.

- **Latissimus Dorsi**

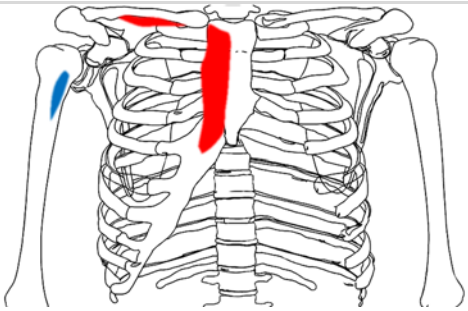
Note: Even though the origin of the latissimus is on the posterior trunk, the insertion is on the anterior humerus. The arrow suggests that the insertion cannot be seen because it is anterior and the picture to the right shows the anterior humerus.





Action: humerus extension, adduction and medial rotation.

- **Pectoralis Major**

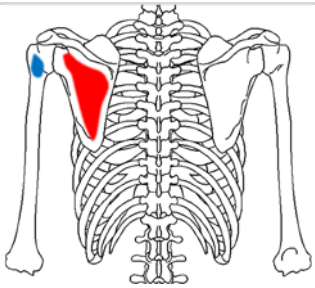


Action: humerus adduction, flexion and medial rotation.

- **Rotator Cuff**

Rotator cuff muscles are muscle that originate on the scapula and insert near the head of the humerus. The rotator cuff muscles are important for helping the humeral head glide appropriately in the glenoid cavity during large movements of the humerus. Throwing usually involves very aggressive and large movements of the humerus. One or more of the rotator cuff muscles frequently become injured in professional baseball pitchers.

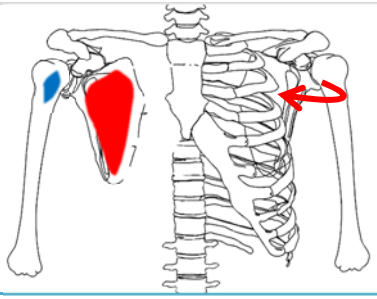
  - **Infraspinatus**



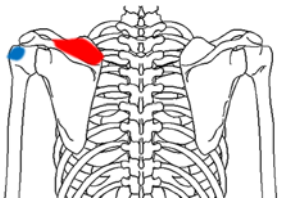
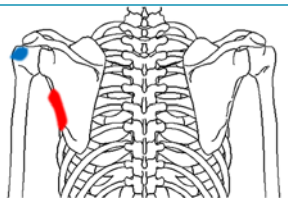
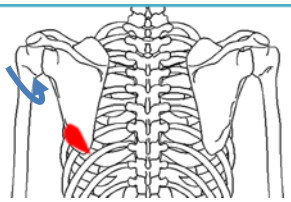
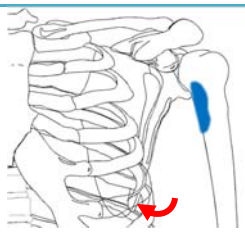
Action: humerus lateral rotation, extension and holds head of humeral head during abduction.

  - **Subscapularis**

***Note:** The origin of the subscapularis is on the anterior scapula which is against the ribs. Ribs are removed on the right side of this picture to show the origin.

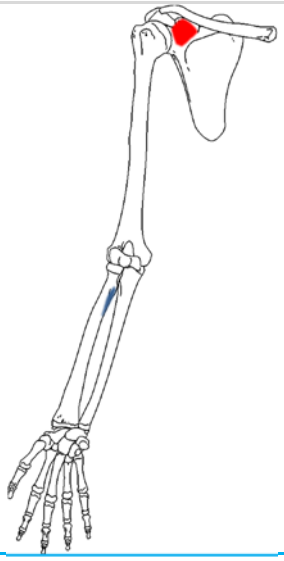


Action: humerus medial rotation and helps hold the humeral head during other shoulder movements.

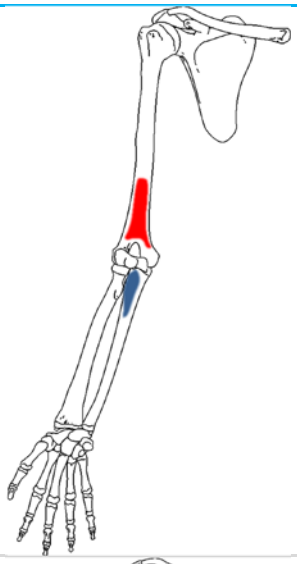
➢ **Supraspinatus**		**Action**: humerus abduction and helps hold humeral head during abduction.
➢ **Teres Minor**		**Action**: humerus lateral rotation and helps hold humeral head during other shoulder movements.
• **Teres Major** **Note:** Even though the origin of the teres major is on the posterior trunk, the insertion is on the <u>anterior</u> humerus. The arrow suggests that the insertion cannot be seen because it is anterior and the picture to the right shows the anterior humerus. This is very similar to the latissimus dorsi.	 	**Action**: humerus extension, adduction and medial rotation.

Module 7 - The Muscular System
Muscles of the Arm and Trunk

This Module will cover the muscle anatomy of the arms and trunk. We have already seen the muscles that move the humerus, so this module will start with the muscles that move the rest of the arm and then the trunk.

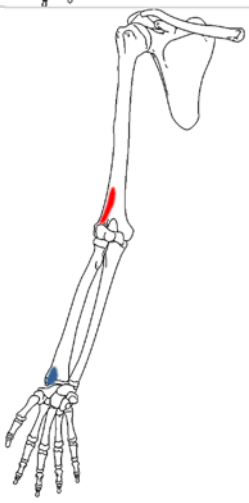
LIST OF TERMS TO KNOW FOR THE MUSCLES OF THE ARM AND TRUNK		
Muscles Acting on the Forearm		
• **Biceps Brachii**		**Action**: Flexes and helps supinate the forearm at the elbow

- **Brachialis**



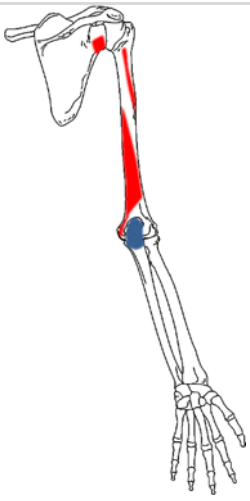
Action: Flexes the forearm at the elbow

- **Brachioradialis**



Action: Flexes and helps pronate the forearm at the elbow

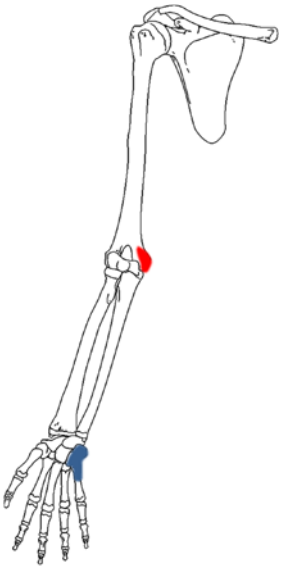
- **Triceps Brachii**



Action: Extends the forearm at the elbow

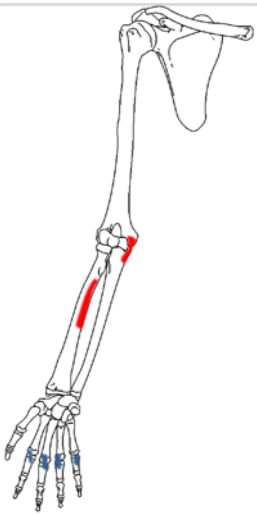
Muscles of that Move the Hand

- **Flexor Carpi Ulnaris**



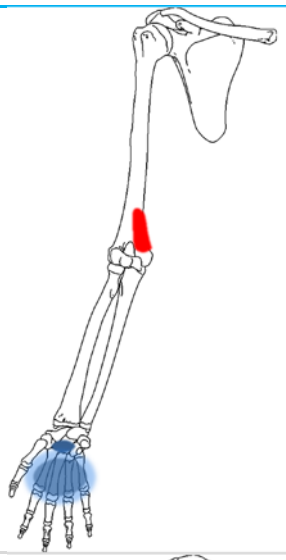
Action: Flexes hand at the wrist

- **Flexor Digitorum Superficialis**



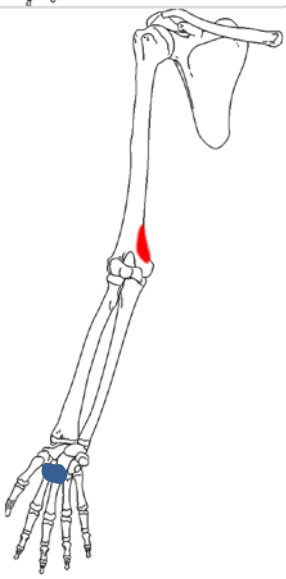
Action: Flexes fingers at the Middle Phalanges

- **Palmaris Longus**



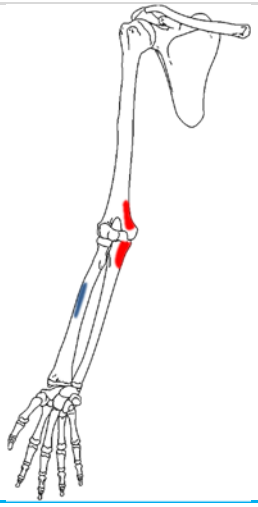
Action: Turns Head side to side and flexes the neck

- **Flexor Carpi Radialis**

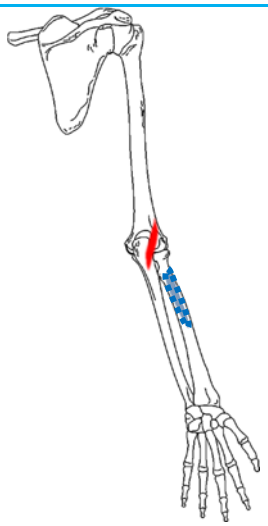


Action: Turns Head side to side and flexes the neck

- **Pronator Teres**



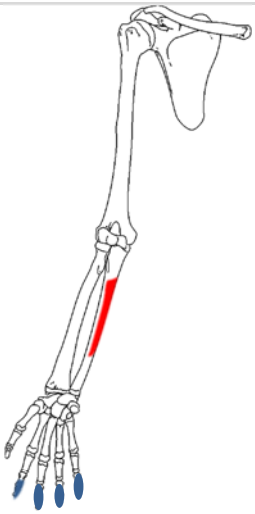
- **Supinator**



*Notice that the insertion on this posterior view of the arm is actually on the front of the radius.

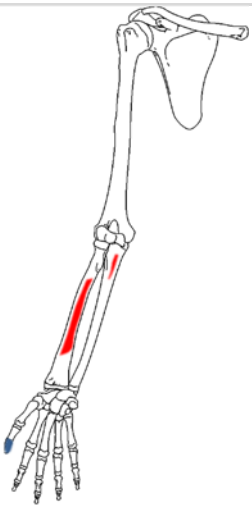
Action: Supinates the forearm and hand

- **Flexor Digitorum Profundus**



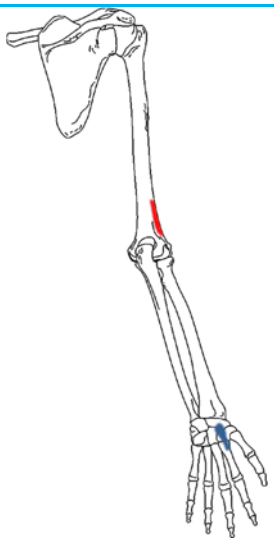
Action: Flexes the finger digits (or digits 2-5) at the distil phalanges and helps flex the wrist

- **Flexor Pollicis Longus**



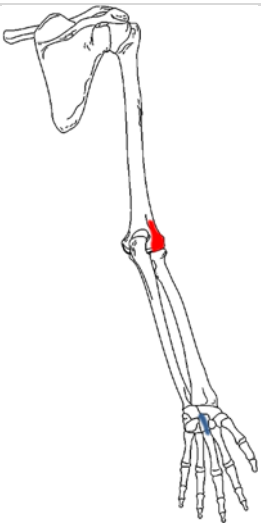
Action: Flexes the first digit or thumb at the distil phalanx

- **Extensor Carpi Radialis Longus**



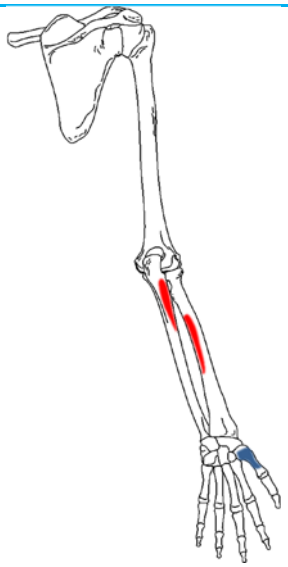
Action: Extends the wrist on the radial side

- **Extensor Carpi Radialis Brevis**



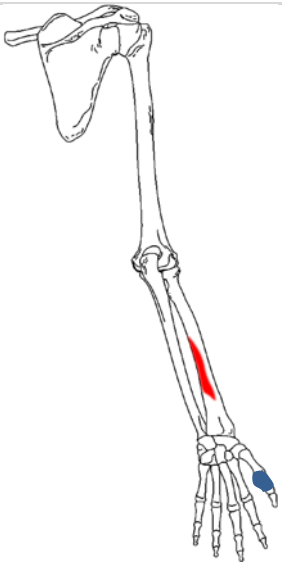
Action: Extends the wrist on the radial side

- **Abductor Pollicis Longus**



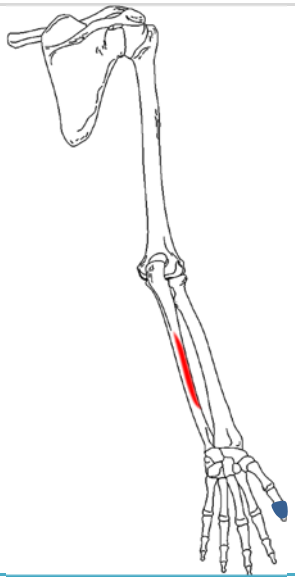
Action: Abducts the first digit or thumb and can help with thumb extension.

- **Extensor Pollicis Brevis**



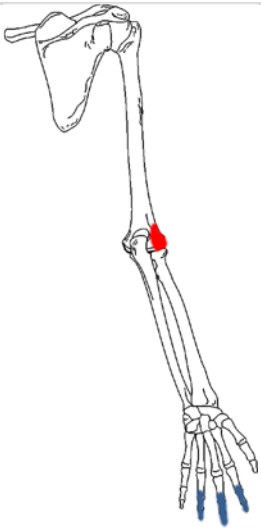
Action: Extends the thumb and helps with thumb abduction

- **Extensor Pollicis Longus**



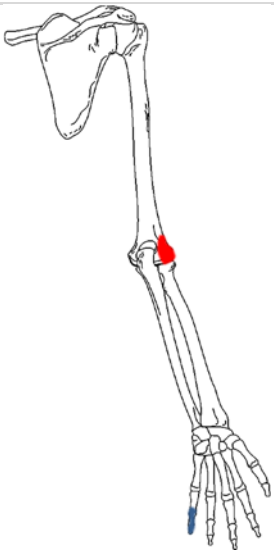
Action: Extends the thumb and helps with thumb abduction

- **Extensor Digitorum**



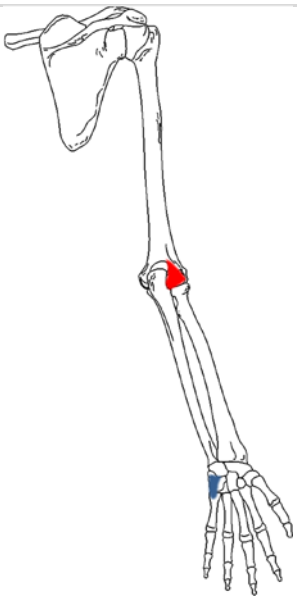
Action: Extends the digits 2-4 and can help with wrist extension

- **Extensor Digiti Minimi**



Action: Extends the digit 5 and can help with wrist extension

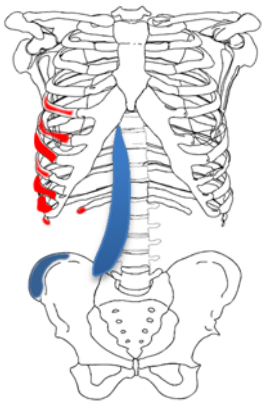
- **Extensor Carpi Ulnaris**



Action: Extends the wrist on the ulnar side

Muscles of the Abdominal Wall

- **External Abdominal Oblique**

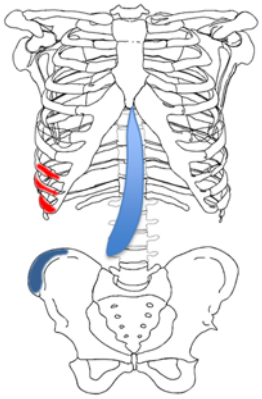


Action: Lumbar flexion and also laterally flexes the vertebral column

- **Inquinal Ligament**

This ligament is a band of dense connective tissue that runs over the top and contains the blood vessels, nerves and other soft tissues that run from inside the trunk to the lower extremity.

- **Internal Abdominal Oblique**

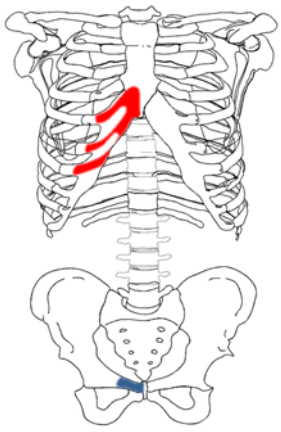


Action: Lumbar flexion and also laterally flexes the vertebral column

- **Linea Alba**

A dense connective tissue band that runs down the midline of the abdomen. It is formed by the fusion of the aponeuroses of the of the abdominal muscles. In humans it would be the vertical depression between the right and left halves of a “six pack”.

- **Rectus Abdominis**



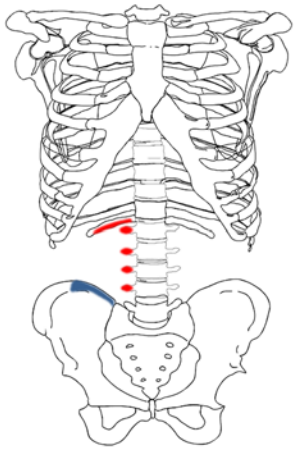
Action: Flexes the vertebral column, helps compress the contents of the abdomen and helps tilt the pelvis anteriorly

- **Transverse Abdominis**

This muscle is deep. It is deeper than the internal abdominal obliques. This muscle runs fairly parallel to the floor in a standing person. The Transverse Abdominal muscles are important for compressing the abdominal contents. You are not required to know origin and insertion for this muscle.

Muscles of the Vertebral Column

- **Quadratus Lumborum**



Action: Lumbar extension. Helps tilt the pelvis anteriorly and helps with lateral flexion of the vertebral column.

- **Sacrospinalis (Also called the Erector Spinae)**

You are not required to know origin, insertion and action for this muscle group, but you should be able to recognize it from almost any picture if you understand the descriptions to the right.

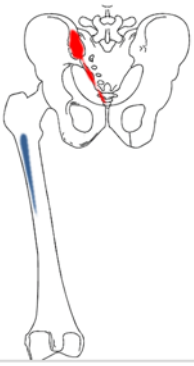
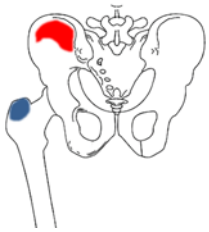
The sacrospinalis muscles or erector spinae are really a group of muscles that are found in three regions.

- The Iliocostalis group: These muscle arise from the common erector spinae origin that includes the sacrum, illium and low back. The fibers connect to various ribs along the posterior trunk.
- The Longissimus group: These fibers arise from the common erector spinae origin. Fibers also arise from various ribs and ultimately these fibers form bands of muscle that blend together to travel all the way to the posterior skull
- The Spinalis group: These fibers arise and insert on the spinous processes of the vertebrae. The bands of muscle formed can be a variety of lengths. Ultimately, however the muscle tissue appears to form a pattern of muscle that extends along the length of the vertebral spinous processes.

BIO 264L Anatomy & Physiology

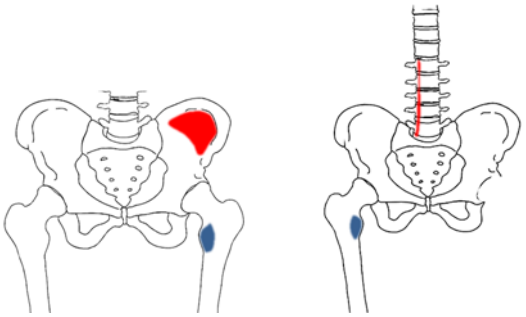
Module 8 - The Muscular System
Muscles of the Hips and Legs

This Module will cover the muscle anatomy of the hips and legs. First we will cover the muscles found around the hip region that move the femur. Next we will learn about the muscles found in the thigh region that move the foreleg. Finally, we will learn about muscles on the foreleg that for the most part will affect the foot, however there is one muscle that we have placed in the leg section that actually does not affect the foot. It is called the Popliteus. Look for it in your studies. It is a small muscle but has one important function which is to "unlock" the leg from a rigid standing position.

LIST OF TERMS TO KNOW FOR THE MUSCLES OF THE HIPS AND LEGS		
Muscles of the Hip		
• **Gluteus Maximus**		**Action**: Extends the femur at the hip joint. Also helps with lateral rotation, adduction or abduction depending on the starting point of the motion
• **Gluteus Medius**		**Action**: Hip Abduction. Can help with medial rotation and lateral rotation as well
• **Gluteus Minimus**	Helps the Gluteus Medius with all of its actions. This is a deep muscle and is not visible on the models in our lab. We generally have to describe where this muscle is or show pictures from other sources for testing purposes. We will not require you to know origin and insertion for this muscle.	

- **Iliopsoas**
  - **Iliacus**
  - **Psoas Major**

The Iliopsoas is actually made up of two muscles, the iliacus and the psoas major. These two muscle join together to form one muscle band at about the level of the inquinal ligament.



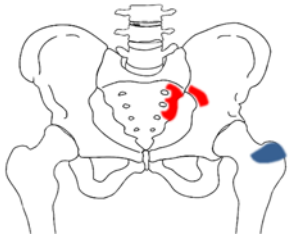
Illiacus Psoas Major

Action: Hip flexion. Also can help with lateral rotation and lumbar flexion. Helps tilt the pelvis anteriorly.

- **Iliotibial Band**

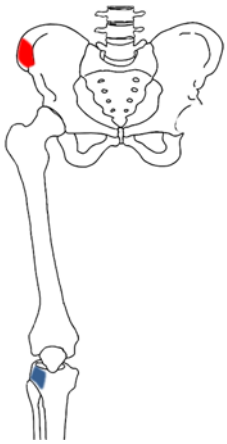
The Iliotibial band is a fibrous tissue that runs along the lateral leg and helps reinforce the thigh muscles. If you stand up and put your weight on a straight leg, you can feel the stiff Ilitibial band right along the lateral surface of your thigh. The ilitibial band is often called the "IT band".

- **Piriformis**



Action: Hip Lateral Rotation. Can also help with hip abduction and hip extension.

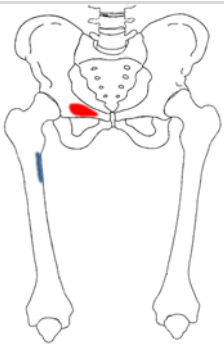
- **Tensor Fascia Latae**



Action: Hip Abduction. Can also help with hip flexion and hip medial rotation.

Muscles of the Thigh

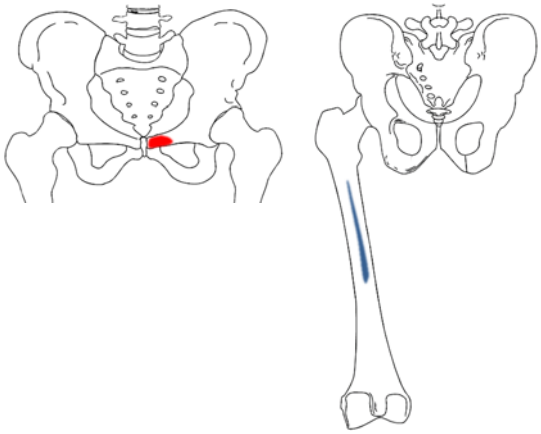
- **Pectineus**



Action: Hip adduction and flexion

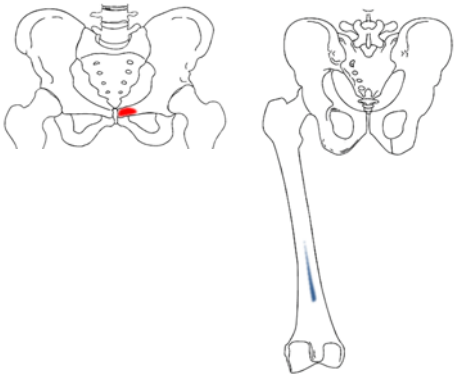
- **Adductor Brevis**

*Note that the insertion of this muscle and the next is on the posterior femur, thus an anterior origin view and a posterior insertion view



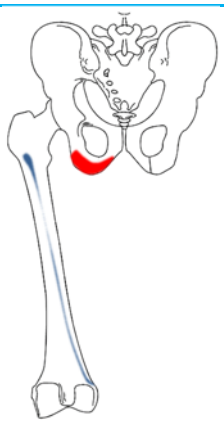
Action: Hip Adduction. Can also help with hip flexion and some lateral rotation.

- **Adductor Longus**



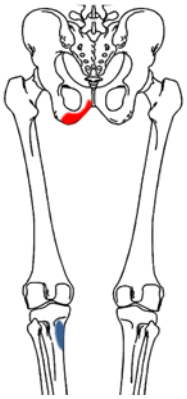
Action: Hip Adduction. Can also help with hip flexion and some lateral rotation.

- **Adductor Magnus**



Action: Hip adduction. Can also help with hip flexion and lateral rotation.

- **Gracilis**



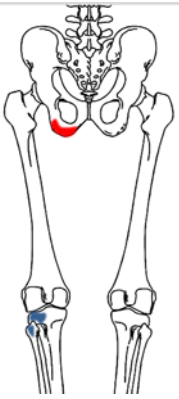
Action: Hip adduction. Can also help with hip flexion and medial rotation.

- **Hamstrings**

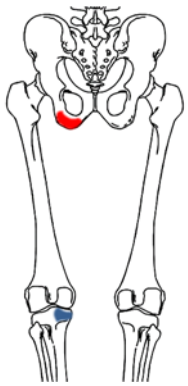
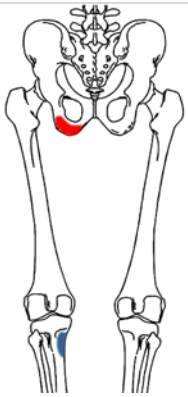
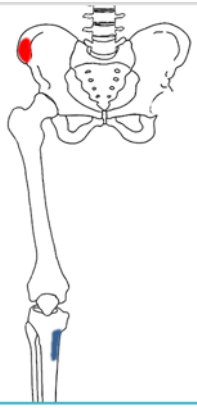
The Hamstrings are on the posterior thigh and are made up of three muscles. They all help with hip extension and knee flexion. They are important for sprinting and aggressive running can injure them.

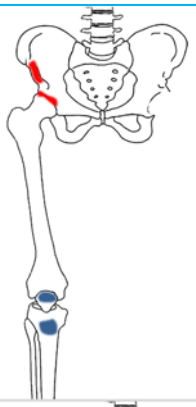
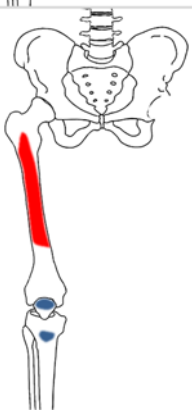
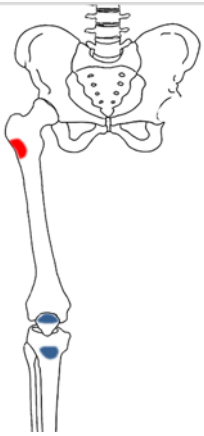
  - **Bicep Femoris**

*Note that the Bicep Femoris has two heads (thus the name “bicep”. However, we only learn one head here and that is the long head)



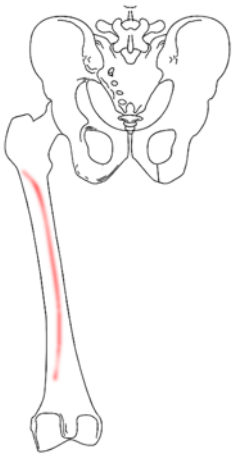
Action: Hip extension and knee flexion. Can also help with hip lateral rotation.

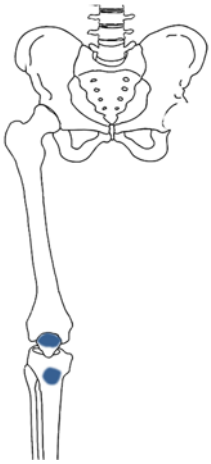
➢ **Semimembranosus**		**Action**: Hip extension and knee flexion. Can also help with hip medial rotation.
➢ **Semitendinosus**		**Action**: Hip extension and knee flexion. Can also help with hip medial rotation.
• **Sartorius**		**Action**: Hip flexion, abduction and lateral rotation. This muscle does the "figure four motion" – Or - the motion you do when you rest your foot on your knee.
• **Quadriceps Femoris**	The quadriceps femoris muscles are on the anterior thigh. They are often called the "Quads". The term Quad refers to the number 4 as there are 4 muscles that make up this group.	

➢ **Rectus Femoris**		**Action**: Knee extension and hip flexion (this is the only muscle of the "quads" that crosses the knee and can help with hip flexion
➢ **Vastus Intermedius** *This muscle is underneath or deep to the rectus and can be hard to see unless the rectus is removed.		**Action**: Knee extension
➢ **Vastus Lateralis**		**Action**: Knee extension

- **Vastus Medialis**

*This muscle attaches to the linea aspera and so the posterior view on the left shows this origin. The insertion however is on the anterior tibia (shown on the right).





Action: Knee extension

Muscles of the Leg

*Be aware that the images here and the model pictures in the online atlas may be different sides of the body.

- **Tibialis Anterior**

Action: Dorsiflexion of the ankle. Can also help with inversion of the foot.

- **Extensor Digitorum Longus**

Action: Extends digits 2-5 and can also help with dorsiflexion of the ankle

- **Extensor Hallucis Longus**

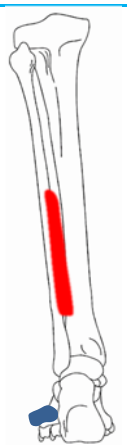
Action: Extends the 1st digit or "big toe". Also helps dorsiflex the ankle.

- **Fibularis Tertius**

*Note that there are three "fibularis" muscles. These muscles can also be called "peroneus" instead of fibularis. Older anatomy text books use the term peroneus and newer text books use the term fibularis.

This muscle is pretty small and can be hard to locate on our anatomy models. The tendon of this muscle is the easiest thing to locate on the models. We will not require you to know origin, insertion or action for this muscle.

- **Fibularis Brevis**



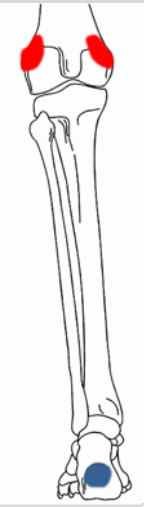
Action: Eversion of the foot. Can also help with some plantar flexion of the ankle.

- **Fibularis Longus**

*Note that the insertion of this muscle is on the opposite side of the foot from the origin. This happens because the tendon of this muscle crosses from lateral to medial by running along the arch of the plantar side of the foot. This muscle helps support the arch.

Action: Eversion of the foot. Can also help with some plantar flexion of the ankle.

- **Gastrocnemius**

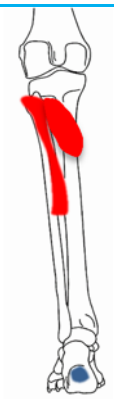


Action: A major action of this muscle is to plantar flex the ankle. This is the muscle that helps you stand on your tippy toes. This muscle can also help flex the knee.

- **Plantaris**

This muscle has a small muscle belly near the origin of the gastrocnemius muscle. It has a tendon that lies between the gastrocnemius and the soleus. It is not a strong muscle at all. It can help a little bit with plantar flexion but even if it was removed a person would not likely notice any strength loss. This muscle is a common one to be harvested for surgeries that involve a tendon graph somewhere else. You are not required to know origin, insertion and action for this muscle.

- **Soleus**

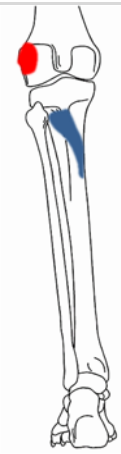


Action: Plantar flexion of the ankle

- **Tendo Calcaneous**

The tendo calcaneous is also commonly called the Achilles tendon. This tendon is very strong and serves as the common attachment point for the gastrocnemius, plantaris and soleus. After receiving all the muscle fibers from these three muscles, this tendon attaches to the posterior calcaneous where it pulls up and causes the front of the foot to drop (this motion is called plantar flexion).

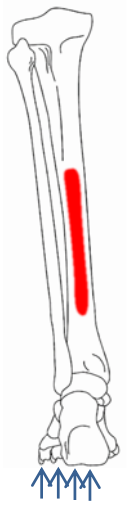
- **Popliteus**



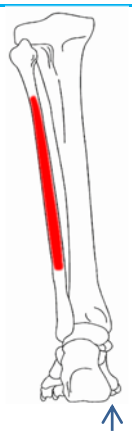
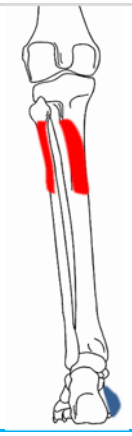
Action: Helps with knee flexion and medial rotation. This muscle is said to "unlock" the knee from a fully straight position to a slightly bent position.

- **Flexor Digitorum Longus**

*Note that the origin of this muscle is the plantar surface of the toes and so the arrows are alluding to this even though it cannot be clearly seen. This is the same for the next muscle as well.



Action: Flexes the digits 2-5. In other words, this muscle flexes the all of the toes accept the great toe or "big toe". This muscle can also help with plantar flexion of the ankle

• **Flexor Hallucis Longus**		**Action**: Flexes the first digit or great toe (“big toe”). This muscle can also help with plantar flexion of the ankle and some inversion of the foot.
• **Tibialis Posterior**		**Action**: Plantar flexion and inversion of the ankle and foot.

BIO 264L Anatomy & Physiology

MODULE 9: NERVOUS SYSTEM

An Introduction to the Anatomy of the Nervous System

The nervous system can be divided into two parts: 1) the central nervous system, which includes the brain and spinal cord, and 2) the peripheral nervous system, which is made up of nerves and ganglia. The nerves in the peripheral nervous system are classified according to their origin. Cranial nerves arise directly from the brain while spinal nerves arise from the spinal cord. In this lab you will learn to identify various components of the both the central and peripheral nervous system.

LIST OF TERMS FOR THE ANATOMY OF THE NERVOUS SYSTEM

Coverings of the Brain and Brain Blood Vessels

- **Meninges**
  - **Dura Mater**
  - **Arachnoid Mater**
  - **Pia Mater**
- **Falx Cerebri**
- **Falx Cerebelli**
- **Tentorium Cerebelli**
- **Dural Sinus**
- **Vertebral Arteries**
- **Basilar Artery**
- **Internal Carotid Arteries**
- **Arterial Circle (Circle of Willis)**

Meninges is a word that comes from ancient Greek and it means membranes. Dura means durable or "tough" and Mater means "mother". The **dura mater** is a meningeal layer around the brain that is made of dense connective tissue and helps contain and protect the soft tissues and fluids around the brain. Arachnoid means spider and refers to the "spider web" looking processes that extend from the **arachnoid mater** to the pia mater. Look for these in some of the pictures. Pia means "tender" and refers to the very delicate membrane that lies right against the brain surface called the **pia mater**.

Falx means "sickle" and refers to the shape of the dura mater as it divides the hemispheres of the cerebrum and the cerebellum. Note that the **falx cerebelli** is not nearly as large as the **falx cerebri**.

Tentorium refers to a "tent" like structure. The **tentorium cerebelli** is a tent like membrane the covers the superior surface of the cerebellum.

The **dural sinus** is an opening the superior portion of the dura mater. This opening collects the venus blood from the brain and drains it down the posterior skull until it enters the jugular veins that exit the skull.

The **vertebral arteries** travel through the transverse foramen of the cervical vertebrae and enter the skull through the foramen magnum where they join the **basilar artery**. The **Internal carotid arteries** come off the carotid arteries of the anterior neck and enter the skull through the carotid canals. The **arterial circle or circle of Willis** is a rare complete circle. Arteries branch off the

	circle and feed the brain. This circular structure allows for blood to get to both sides of the brain even if a vertebral or internal carotid artery blood supply is compromised on one side.
Ventricles of the Brain • **Lateral Ventricles** • **Third Ventricle** • **Fourth Ventricle** • **Cerebral Aqueduct** • **Choroid Plexus** • **Septum Pellucidum**	The **ventricles** of the brain are basically hollow aread deep in the brain tissue that contain cerebral spinal fluid, often called CSF. CSF I made by a tissue called the **choroid plexus** and the CSF helps "float" the brain. CSF is found in the ventricles and it also leaves the **fourth ventricle** to make its way around the brain between the pia and arachnoid membranes. The **third ventricle** is found in the diencephalon. The **septum pellucidum** is a membrane that separates the lateral ventricles. It is most easy to view in a medial view of the brain that has been separated in two parts via a sagittal section.
Structures of the Cerebrum and Cerebellum • **Cerebrum** ➢ **Cerebral Hemispheres** ➢ **Gyrus** ➢ **Sulcus** ➢ **Gray Matter** ➢ **White Matter** ➢ **Longitudinal Fissure** ➢ **Lateral Sulcus (or Fissure)** ➢ **Parietooccipital Sulcus** ➢ **Frontal Lobe** ➢ **Precentral Gyrus** ➢ **Central Sulcus** ➢ **Postcentral Gyrus** ➢ **Parietal Lobe** ➢ **Temporal Lobe** ➢ **Occipital Lobe** • **Cerebellum** ➢ **Vermis** ➢ **Cerebellar Hemiphere** ➢ **Arbor Vitae** • **Corpus Callosum** ➢ **Genu** ➢ **Splenium**	The **cerebrum** refers to the part of the brain that contains the cerebral cortex. The cerebral cortex is the outermost layer of brain neural tissue. The cerebral cortex is made up of gyri and sulci. A **sulcus** is a more shallow kind of "valley" in the cerebral cortex. A **gyrus** is the opposite of a "valley" and refers to a "ridge" on the cerebral cortex. A **fissure** is a deep division that separates different lobes or hemispheres. The cerebrum has two **hemispheres** that are connected at the **corpus callosum**. The **cerebellum** has two hemispheres that are joined together and not separated. The neural structure that is found at the point of union for the cerebellar hemispheres is called the **vermis**. The cerebrum has one **frontal lobe**, two **parietal lobes**, two **temporal lobes** and one **occipital lobe**. Again, gray matter is found in areas of cell bodies and white matter is where the axons of nerves travel. The **arbor vitae** it the white matter of the cerebellum.
Diencephalon • **Thalamus** ➢ **Intermediate Mass** • **Hypothalamus** ➢ **Mamillary Body** • **Fornix** • **Pineal Body** • **Pituitary Gland** ➢ **Infundibulum**	**Diencephalon** means "between brains". This region is an area that lies between the cerebrum and the brain stem. This area contain the **thalamus** which is an oval structure of gray matter on both sides and connected to each other by a small band of white matter called the **intermediate mass**. The **hypothalamus** is located below the thalamus and contains several regions of gray matter, one of which protrudes and is named the **mammillary body**. The **fornix** is a band of white matter that carries axons to the hypothalamus from other areas of the brain. The **pineal body** is a neural tissue that secretes the hormone

	melatonin. The **pituitary gland** "hangs" by and **infundibulum** below the hypothalamus and communicates with the hypothalamus. These communications are crucial for regulation of the production and release of several different hormones.
Brain Stem • **Medulla Oblongata** • **Pons** • **Midbrain** ➢ **Corpora Quadrigemina** ▪ **Superior Colliculi** ▪ **Inferior Colliculi**	The **brain stem** is below the diencephalon but is still found within the skull. Below the foramen magnum, we call the descending neural tissue "spinal cord". The brain stem looks much like a spinal cord at its most inferior end, but has some thickenings superiorly. The **medulla oblongata** is a thickening in the middle of the brain stem that contains nuclei "gray matter" important for control of vital body functions. The **pons** is another thickening on the brain stem that protrudes anteriorly. The pons contains nuclei important for motor control. The very superior end of the brain stem contains an area called the midbrain. The **midbrain** contains some nuclei called the corpora quadrigemina. The density of cell bodies in this area causes some protrusions that can be identified on the posterior mid brain. There are four protrusions called the inferior and superior colliculi, but all together we call these the corpora quadrigemina.
Cranial Nerves • **I. Olfactory Nerves** ➢ **Olfactory Bulb** ➢ **Olfactory Tract** • **II. Optic Nerve** ➢ **Optic Chiasma** ➢ **Optic Tract** • **III. Oculomotor Nerve** • **IV. Trochlear Nerve** • **V. Trigeminal Nerve** • **VI. Abducens Nerve** • **VII. Facial Nerve** • **VIII. Vestibulocochlear Nerve** • **IX. Glossopharyngeal Nerve** • **X. Vagus Nerve** • **XI. Accessory Nerve** • **XII. Hypoglossal Nerve**	Even though **cranial nerves** come off of the brain stem which is in the skull, they are actually peripheral nerves and part of the peripheral nervous system. Students should know the name and the roman numeral for each cranial nerve. The **olfactory nerve** has two parts, the **bulb** which is the very end and is more swollen than the **tract** which is a band of axons that connect the bulb to the brain. The **optic nerve** is the band of axons that connect the chiasma to the eyes. If the eyes have been removed from the specimen or model, the optic nerve will often show up as only small residual nerves coming off of the chiasma. The **chiasma** is where the optic nerves join and allow some axons to cross to the other side of the brain. The **optic tract** is the band of axons that carry axons into the brain "after" the chiasma. Chiasma means to cross. The rest of the cranial nerves are seen arising from the brain stem along its entire length. Some students have used the Mnemonic device below to memorize the cranial nerves. Helpful mnemonic for remembering the order or the cranial nerves: **O**n **O**n **O**n **T**hey **T**raveled **A**nd **F**ound **V**oldemort Guarding **V**ery **A**ncient **H**orcruxes Or for those who like animals: **O**h, **O**h, **O**h, **T**o **T**ouch **A**nd **F**eel **V**ery **G**rateful **V**ery **A**ppreciative **H**orses

Review of the Spinal Cord
• **Gray Matter**
• **White Matter**
• **Gray Commissure**
• **Horns**
  ➢ **Ventral Horn**
  ➢ **Lateral Horn**
  ➢ **Dorsal Horn**
• **Columns**
  ➢ **Ventral Column**
  ➢ **Lateral Column**
  ➢ **Dorsal Column**
• **Central Canal**
• **Anterior Median Fissure**
• **Posterior Median Sulcus**
• **Dorsal Root Ganglion**
	The spinal cord is still part of the central nervous system along with all the structures discussed so far in the brain. However, there is one structure in this list that is actually near the spinal cord but is not part of the spinal cord. The dorsal root ganglion is a collection of cell bodies that is part of the peripheral nervous system. Generally, gray matter is an area of cell bodies in the central nervous system and a ganglion is an area of cell bodies in the peripheral nervous system. The columns in the spinal cord are areas of nerve cell axons and can also be referred to collectively as white matter. The central canal is continuous with the fourth ventricle in the brain and it contains CSF. The fissure is an actual division of the spinal cord while the sulcus does not actually divide the spinal cord in half.

Anatomy of a Neuron • **Soma** • **Axon** • **Axon Hillock** • **Dendrites** • **Nucleus** • **Myelin Sheath and Schwann Cell** • **Node of Ranvier** • **Endoneurium**	**Soma** means “body” and refers to the part of a neuron that contains the nucleus of the cell. The **axon** protrudes from the soma and can travel for considerable distance before synapsing with another neuron. The **axon hillock** is the area of narrowing as the soma gives rise to an axon. Axons may be covered with a **myelin** sheath which is the cylindrical wrapping of a cell membrane belonging to yet another cell. In the peripheral nervous system myelin originates from a cell called a schwann cell *(in the centeral nervous system the cell that makes myelin is called an oligodendrocyte)*. A **node of ranvier** is the bare axon region that exists between schwann cells. Peripheral neurons are surrounded by a connective tissue sheath called the **endoneurium**.

BIO 264L Anatomy & Physiology

MODULE 10: SPECIAL SENSES

An Introduction to the Anatomy of the Eye and the Ear

The special senses include vision, hearing, smell and taste. However, this lab will cover only the foundational anatomy of the eye and the ear.

LIST OF TERMS FOR THE ANATOMY OF THE EYE AND THE EAR	
EYE	
Accessory Structures • **Eyebrows** • **Palpebrae** • **Palpebral Fissure** • **Caruncle** • **Eyelashes** • **Conjunctiva**	**Palpebrae** comes from ancient Latin and refers to the eyelid and blinking or winking. The **caruncle** is a small red triangular portion of the inferior medial corner of the eye. This structure contains modified sebaceous and sweat glands that produce material that helps lubricate the eye. The **conjunctiva** is a thin moist membrane that lines the inside of the eyelids and also covers the sclera. The cells that make up the conjunctiva secrete an aqueous substance that contains mucus and water. The conjunctiva is also important for lubricating the eye. You may have heard the term "pink eye" before. Generally this is referring to inflammation of the conjunctiva often caused by an infection.
Lacrimal Structures • **Lacrimal Gland** • **Lacrimal Canaliculi** • **Lacrimal Sac** • **Nasolacrimal Duct**	The **lacrimal structures** of the eye are structures that participate in the production and drainage of tears. The lacrimal gland produces the tears. The Lacrimal canaliculi, lacrimal sac and Nasolacrimal duct convey the tears away into the cavity of the nose. Have you ever noticed that if you were crying and weeping very hard or long that you got a runny nose. You can blame the lacrimal structures for that.
Extrinsic Eye Muscles • **Superior Rectus** • **Inferior Rectus** • **Medial Rectus** • **Lateral Rectus** • **Superior Oblique** • **Inferior Oblique**	The skeletal muscles called extrinsic eye muscles are under reflexive and voluntary control. Together they rotate the eye in its socket up / down; side to side; and can even cause the eye to spin. One particularly interesting feature is the fact that the **superior oblique** sends a tendon through a kind of "pulley" attachment in the upper medial part of the eye socket. This turns the direction of pull for this muscle and helps it spin the eye in a way that it is possible to look down towards the mouth.

Eye Cavities • **Anterior Chamber** • **Posterior Chamber** • **Aqueous Humor** • **Vitreous Chamber** • **Vitreous Humor**	The eye has three spaces that we refer to as chambers. The **anterior chamber** is found between the iris and the cornea. The **posterior chamber** is the space anterior to the suspensor ligaments and lens but posterior or "behind" the iris. In reality the anterior and posterior chambers are connected and the fluid in these chambers is the same fluid. It is called the **aqueous humor**. Aqueous refers to the watery nature of the fluid. The fluid in the vitrious chamber is much more viscous. The **vitreous chamber** is a large cavity that makes up the majority of the "eye ball". The vitreous chamber exists behind the lens and anterior to the retina. The **vitreous humor** is the fluid in the vitreous chamber and is not watery but more gel like.
Fibrous Tunic • **Sclera** • **Cornea**	Tunic refers to garment or layer. The eye has three main layers. The **fibrous tunic** is the outermost layer and contains the sclera and cornea both made of fibrous connective tissue. The vascular tunic is deep to the fibrous tunic and the Nervous tunic is the deepest layer and is in contact with the fluids inside the eye. The **sclera** is a fibrous connective tissue layer that is found on the external eyeball. When you hear the phrase "don't shoot until you see the whites of their eyes", the whites of their eyes is referring to the sclera. The **cornea** is a thin transparent covering over the iris and pupil.
Vascular Tunic • **Choroid** • **Ciliary Body** ➢ **Ciliary Muscles** ➢ **Suspensory Ligaments** • • **Iris** • **Lens** • **Pupil**	The **vascular tunic** is the middle layer of the eye. It is generally accepted that there are three parts to the vascular tunic, the choroid, ciliary body and the choroid. The lens and pupil are not directly part of the vascular tunic but we will consider these structures as being associated with the vascular tunic. The **choroid** is a vascular layer of the eye, so we find blood vessels in the choroid. The choroid also contains pigment that makes this layer dark. The dark color of the choroid helps keep light from reflecting around the globe of the eye. This makes vision sharper. FYI: the posterior part of the choroid in many animals contains pigments that give the choroid an iridescent appearance. You may have noticed this if you shined your headlights onto a dog and noticed that the eyes seemed to "glow" The **iris** is a thin circular structure composed mostly of connective tissue and smooth muscle fibers. This structure controls the diameter of the pupil through relaxation and contraction of the muscle fibers. This structure is also highly pigmented which gives rise the many colors of human eyes. The **lens** is a connective tissue structure that is oval shaped (thicker in the center then the edges). The **ciliary body** which is comprised of **ciliary muscle** tissue and **suspensory ligaments** controls the shape of the lens. The regulation of the shape of the lens helps bend light in a way that we can focus on things we are looking at. The **pupil** is not really a structure it is a hole. The pupil is the opening on the anterior eye that allows light to hit the lens.

Nervous Tunic (Retina)

- **Ora Serrata**
- **Macula Lutea**
- **Central Fovea (fovea centralis)**
- **Optic Disk**
- **Optic Nerve**

We generally refer to the nervous tunic as the **retina**. The retina contains several specific regions.

The **ora serrata** is a “serrated” edge that marks the boundary between the retina and the ciliary body.

The **macula lutea** is an oval shaped kind of yellow pigmented spot near the center of the posterior retina. The macaula lutea has a particularly high density of photoreceptors and is an area that we should focus light if we want to see greater detail. Also, because the lutea is yellow, it absorbs a lot of blue and ultraviolet light. This helps us see more clearly in bright sunlight. Finally, near the center of the macula lutea is a small pit called the **fovea centralis or central fovea**. This area contains the largest concentration of photosreceptors and light focused here will provide us with the most detailed sight of the thing we are looking at. For example we would want to focus the light coming from anything we read on the fovea to have the sharpes focus of the letters.

The **optic disk** is a yellow circular area on the posterior retina. This disk represents the convergence of neurons leaving the retina and entering the optic nerve. This particular location on the retina does not have photoreceptors and so light focused here will not be seen. This is called the “blind spot”.

The **optic nerve** is the structure that contains the neurons leaving the retina and coursing towards the brain. The optic nerve courses from the back or posterior of the eye to the optic chiasma.

EAR

External (Outer) Ear

- **Pinna (Auricle)**
- **Lobule**
- **Tragus**
- **External Auditory (Acoustic) Meatus**
- **Tympanic Membrane (Eardrum)**

The **external ear** refers to all the ear structures that can be seen on the lateral head as well as the ear canal and ear drum which can't be seen but are located inside the skull. The **pinna or auricle** is what we would traditionally call an "ear". It is the cartilage and skin that forms the structure of the external ear. The **lobule** is the ear lobe and the **tragus** is the cartilage projection just opposite and a bit superior from the ear lobe. The **external auditory meatus or acoustic meatus** (meatus is another word for canal) is the canal that one would put a Q-tip in to clean the ear *(not a good idea by the way and highly discouraged by those who treat the ear)*. The tympanic membrane or eardrum is a thin membrane at the end of the acoustic meatus and it vibrates when sound waves hit it.

Middle Ear (Tympanic Cavity)

- **Eustachian (Auditory) Tube**
- **Auditory Ossicles (Ear Bones)**
  - **Malleus**
  - **Incus**
  - **Stapes**
- **Tensor Tympani Muscle**
- **Stapedius Muscle**
- **Fenestra Vestibuli (Oval Window)**
- **Fenestra Cochlea (Round Window)**

The **middle ear** starts at the tympanic membrane and ends at the cochlea. The middle ear contains the **ossicles or ear bones**. The **stapes** of the middle ear connects to the **oval window** of the cochlea which is in the inner ear. The middle ear also contains a couple of muscles, the **tensor tympani muscle** and the **stapedius muscle** which can contract and reduce vibrations through the ossicles. This helps decrease the intensity of sound waves enterig the cochlea. The **round window** is covered with an elastic membrane that can absorb the sound waves after they have traveled through the cochlea.

Internal (Inner) Ear

- **Cochlea**
  - **Scala Vestibuli**
  - **Vestibular Membrane**
  - **Scala Tympani**
  - **Scala Media (Cochlear Duct)**
- **Organ of Corti (Spiral Organ)**
  - **Basilar Membrane**
  - **Tectorial Membrane**
  - **Hair Cells**
- **Vestibulocochlear (Auditory) Nerve**
- **Semicircular Canals**
  - **Lateral Semicircular Canal**
  - **Superior Semicircular Canal**
  - **Posterior Semicircular Canal**
  - **Ampullae**

The **inner ear** contains the cochlea, vestibulocochlear (auditory) nerve and the semicircular canals. The **cochlea** receives vibrations from the ossicles and transforms them into electrical signals. The sound waves travel in the **scala vestibule and scala tympani** and vibrate the **basilar membrane**. As the basilar membrane vibrates up and down, the **hair cells** are bent which depolarizes them and causes action potentials to occur in the **vestibulochochlear (auditory) nerve**. The **organ of corti or spiral organ** is really part of the cochlea but the online atlas does not have a third level of pull down menu so it is listed here as its own structure. The **semicircular canals** are positioned more or less in the three cardinal planes (frontal, sagittal and transverse). This how they can sense movement in in any direction. They are important for balance.