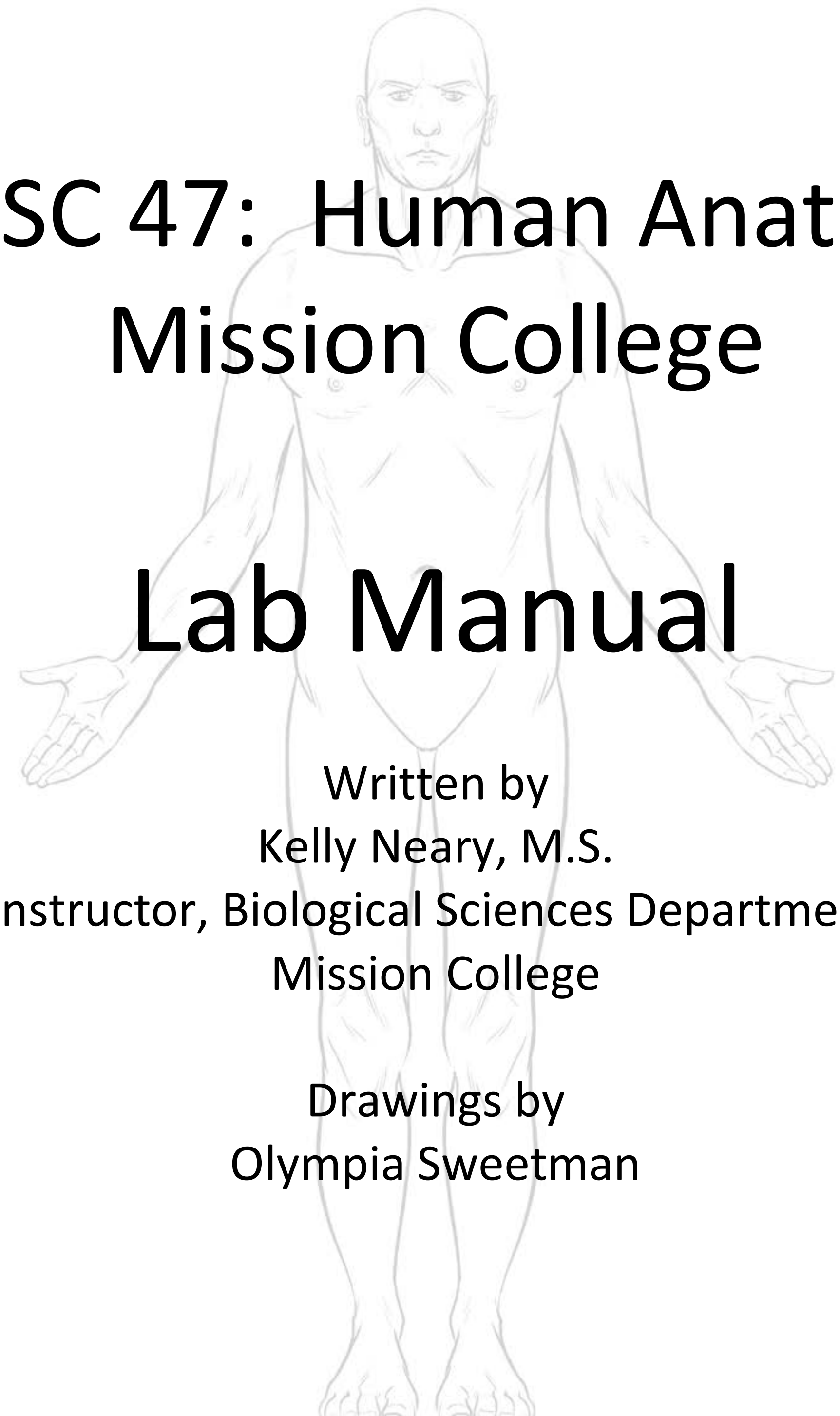

BIOSC 47: Human Anatomy
Mission College

Lab Manual

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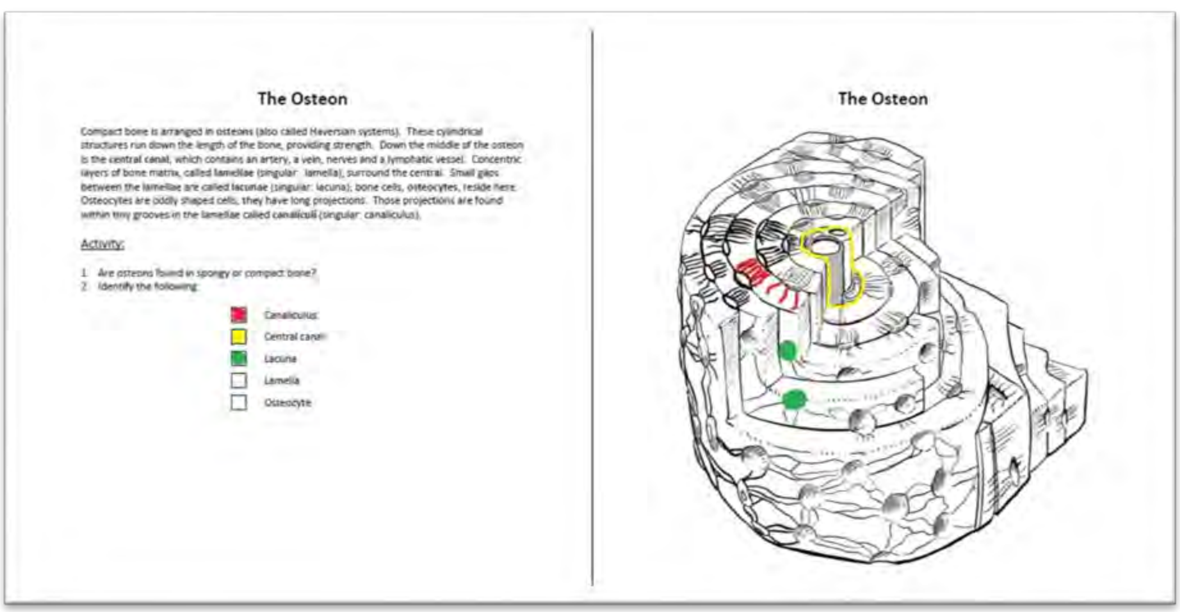
Instructions for how to use this manual

This manual was created to help you learn the required structures in lab. It includes drawings of the actual models that we use, as well as information on microscopy and histology. The manual is broken down into five units, one for each of the lab practical exams.

The anatomical drawings will be used as a coloring atlas. There is a page of text, describing the structures shown in a particular model and listing the required structures, followed by a page with the drawing. On the narrative page, next to the names of the structures are small boxes; color in these boxes with the same color you are using to color in the structures on the drawing (see example below).

For histology pages, there is a page of text describing the structures that can be seen on the slides, followed by a page on which you should draw and label what you see. The narrative explains which slide(s) should be used and with which objective lens it should be viewed.

This manual was designed with the intent that it would be printed on double sided paper and would be kept in a binder. When you open the binder to a particular page, the narrative will be on the left side and the image will be on the right side. It is your responsibility to print out the pages and bring them with you to lab. <u>To conserve paper</u>, you may want to consider printing only the microscopy activity and the coloring atlas and histology pages; then bring a laptop/tablet with you to lab to reference the table of contents and narrative.



Anatomical Position and Body Divisions

For consistency, all anatomists refer to the body regions using the anatomical position, a standardized view of the human body. In the anatomical position, the body is upright with the arms down by the side and the palms facing forward.

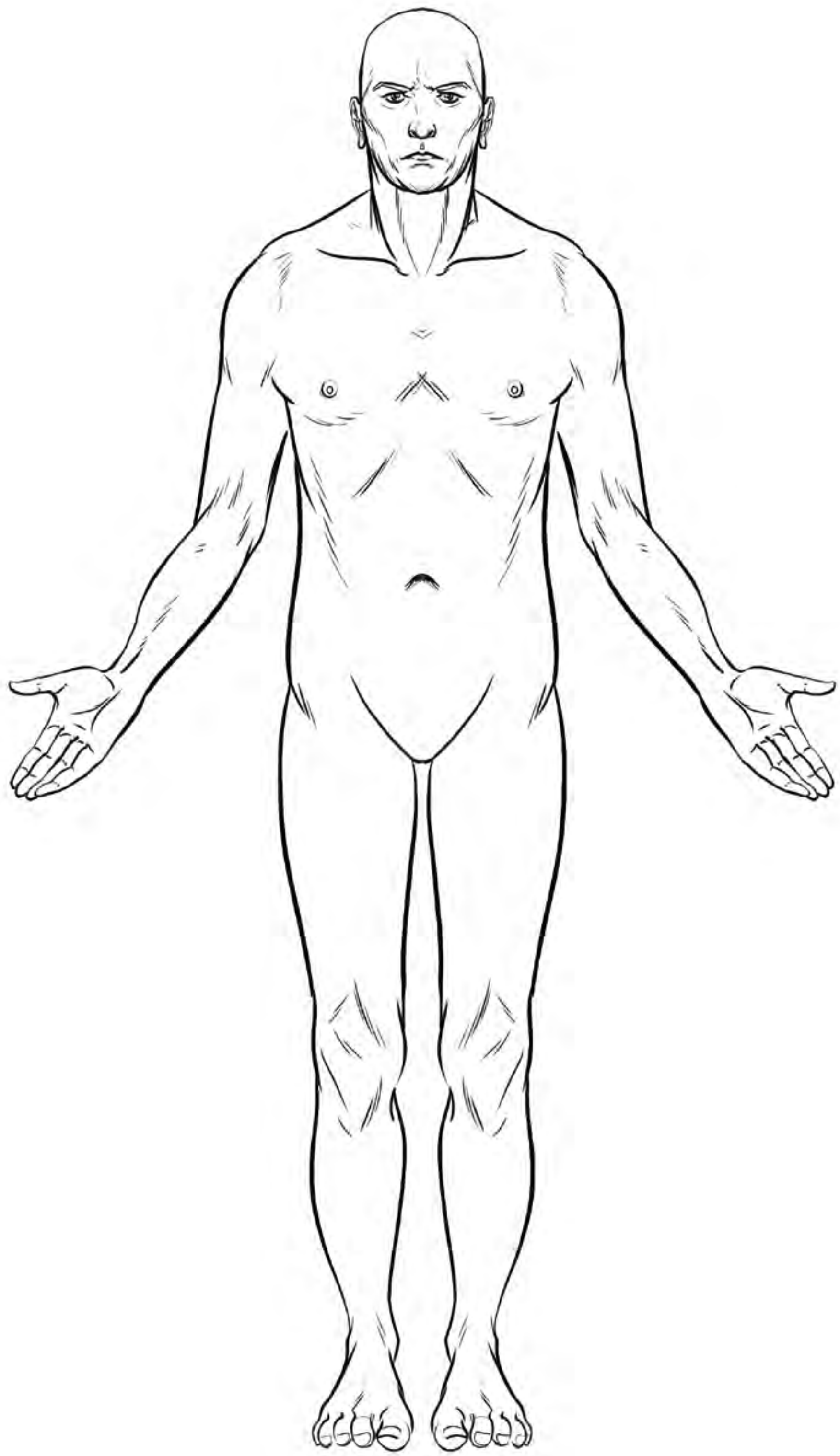
Using the anatomical position, we can identify different fundamental body divisions. The two basic divisions of the body are the axial region and the appendicular region. The **axial** region includes the **head**, **neck** and **trunk**. The trunk is then divided into the **thorax**, **abdomen, pelvis** and **perineum** (the area from the genitals to the anus). The **appendicular** region includes the **upper limbs** and **lower limbs** (i.e. appendages).

Activity:

1. Demonstrate anatomical position.
2. Identify and define these body divisions:

- ☐ Abdomen
- ☐ Appendicular region
- ☐ Axial region
- ☐ Head
- ☐ Lower limb
- ☐ Neck
- ☐ Pelvis
- ☐ Perineum
- ☐ Thorax
- ☐ Trunk
- ☐ Upper limb

Anatomical Position and Body Divisions



Anterior Regional Terms

Regional terms are used to describe more specific areas of the body. Whereas "common" terms are used for the body divisions, many of these regional terms will be new. These terms end in the suffixes *–al*, *-ar*, *-ary*, or *-ic*; all of these suffixes all mean "pertaining to". As you are reading through and defining the terms below, insert "pertaining to" before the body region. Below are terms pertaining to regions that can be seen from the anterior (front) of the body.

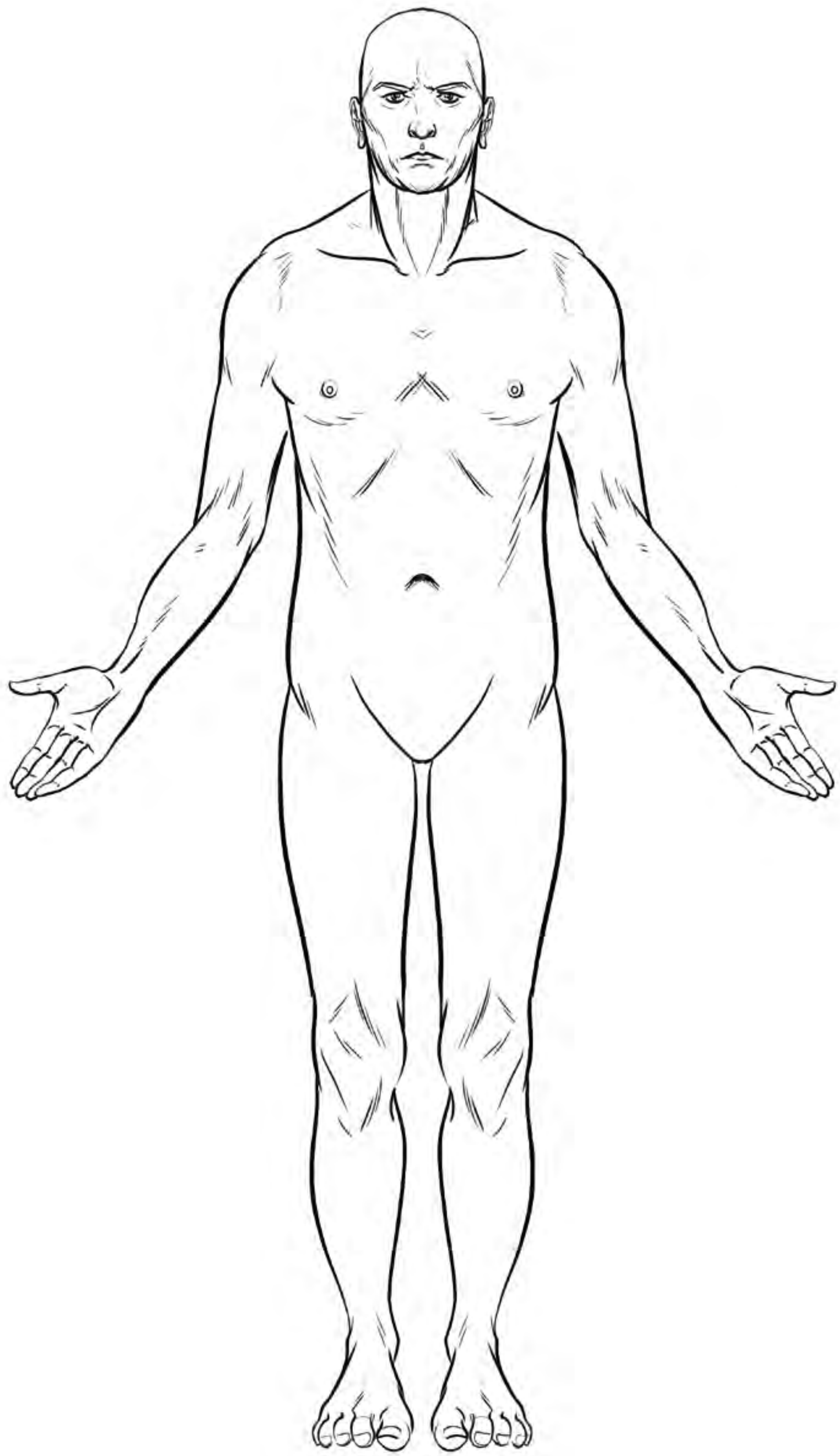
The **cephalic** (head) region includes: **frontal** (forehead), **orbital** (eye socket), **nasal** (nose), **oral** (mouth), and **mental** (chin). The **cervical** region is the neck. The **thoracic** (chest) region includes: **sternal** (breast plate), **axillary** (under arm) and **mammary** (breast). The **abdominal** region includes **umbilical** (belly button). The **pelvic** region includes **inguinal** (groin). The **pubic** region contains the genitals. The **upper limb** includes the **acromial** (shoulder), **brachial** (arm), **antecubital** (front of the elbow), **antebrachial** (forearm) and **carpal** (wrist). The **manus** (hand) includes **palmar** (palm), **digital** (fingers) and **pollex** (thumb). The **lower limb** includes **coxal** (hip), **femoral** (thigh), **patellar** (knee), **crural** (leg), and **fibular/peroneal** (lateral side of leg). Finally, the **pedal** (foot) region includes **tarsal** (ankle), **metatarsal** (part of the foot between ankle and toes), **digital** (toes) and **hallux** (big toe).

Activity:

1. Identify and define these regional terms:

☐ Abdominal	☐ Femoral	☐ Palmar
☐ Acromial	☐ Fibular/peroneal	☐ Patellar
☐ Antebrachial	☐ Hallux	☐ Pedal
☐ Antecubital	☐ Inguinal	☐ Pelvic
☐ Axillary	☐ Lower limb	☐ Pollex
☐ Brachial	☐ Mammary	☐ Pubic
☐ Carpal	☐ Manus	☐ Sternal
☐ Cephalic	☐ Mental	☐ Tarsal
☐ Cervical	☐ Metatarsal	☐ Thoracic
☐ Coxal	☐ Nasal	☐ Umbilical
☐ Crural	☐ Oral	☐ Upper limb
☐ Digital	☐ Orbital	

Anterior Regional Terms



Posterior Regional Terms

Below are terms pertaining to regions that can be seen from the posterior (back) side of the body.

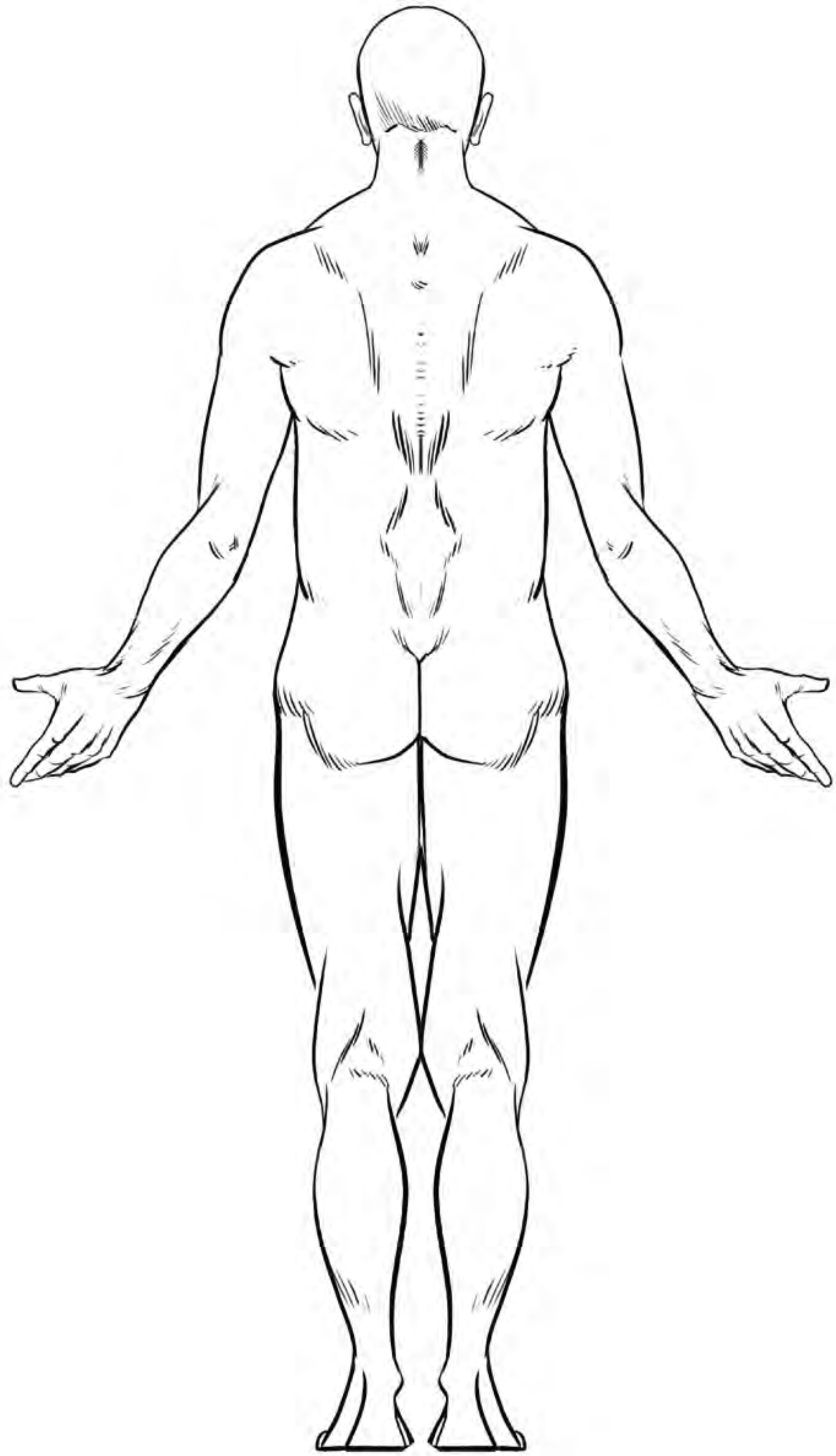
The **cephalic** region includes: **otic** (ear) and **occipital** (back of head). The **cervical** region is the neck. The **dorsal** (back) region includes: **scapular** (shoulder blade), **vertebral** (spine), **lumbar** (lower back), **sacral** (back of pelvis), **gluteal** (buttocks) and **perineal** (area between the genitals and anus). The **upper limb** includes: **acromial** (shoulder), **brachial** (arm), **olecranal** (elbow), and **antebrachial** (forearm). The **manus** includes: **metacarpal** (back side of hand) and **digital** (fingers). The **lower limb** includes: **femoral** (thigh), **popliteal** (back of knee), **sural** (calf), and **fibular/peroneal** (lateral side of leg). The **pedal** region includes: **calcaneal** (heel) and **plantar** (bottom of foot).

Activity:

1. Identify and define these regional terms:

☐ Acromial	☐ Fibular/peroneal	☐ Pedal
☐ Antebrachial	☐ Gluteal	☐ Perineal
☐ Brachial	☐ Lower limb	☐ Plantar
☐ Calcaneal	☐ Lumbar	☐ Popliteal
☐ Cephalic	☐ Manus	☐ Sacral
☐ Cervical	☐ Metacarpal	☐ Scapular
☐ Digital	☐ Occipital	☐ Sural
☐ Dorsal	☐ Olecranol	☐ Upper limb
☐ Femoral	☐ Otic	☐ Vertebral

Posterior Regional Terms



Directional Terms and Body Planes

We use directional terms to describe the location of parts of the body, and also to compare where one part of the body is located relative to another. **Superior** body regions are above **inferior** body regions. The terms **cranial** and **caudal** can be used in place of superior and inferior; however this is not commonly done in humans. **Anterior** body regions are on the front of the body; whereas **posterior** body regions are on the back. The terms **ventral** and **dorsal** can be used in place of anterior and posterior. **Medial** structures lie toward the midline of the body; whereas **lateral** structures are found away from the midline. The terms proximal and distal are most often (though not exclusively) used to compare structures in the limbs. **Proximal** refers to structures that are closer to the attachment site of the body part; **distal** refers to structures that are farther away from the attachment site of the body part. **Superficial** is used to describe areas that are at the surface of the body part; whereas **deep** is used to describe areas that are more internal. **Ipsilateral** is used to describe structures that are on the same side of the body; whereas **contralateral** is used to describe structures that are on different sides of the body.

Cadaver dissection involves cutting the body along different planes. Doing so then produces sections of the body that have the same name as the plane (e.g. cutting along the coronal plane of the head would produce a coronal section of the head). We don't do cadaver dissection in this course, but it is still important to understand the planes because many of the figures used in this manual and textbook are showing the body parts in sections. The **frontal/coronal plane** divides the body into anterior and posterior halves. The **sagittal plane** divides the body into right and left halves. Finally, the **transverse/horizontal plane** divides the body into superior and inferior halves.

Activity:

1. Define the following pairs of directional terms and be able to give examples of body comparisons using those terms:

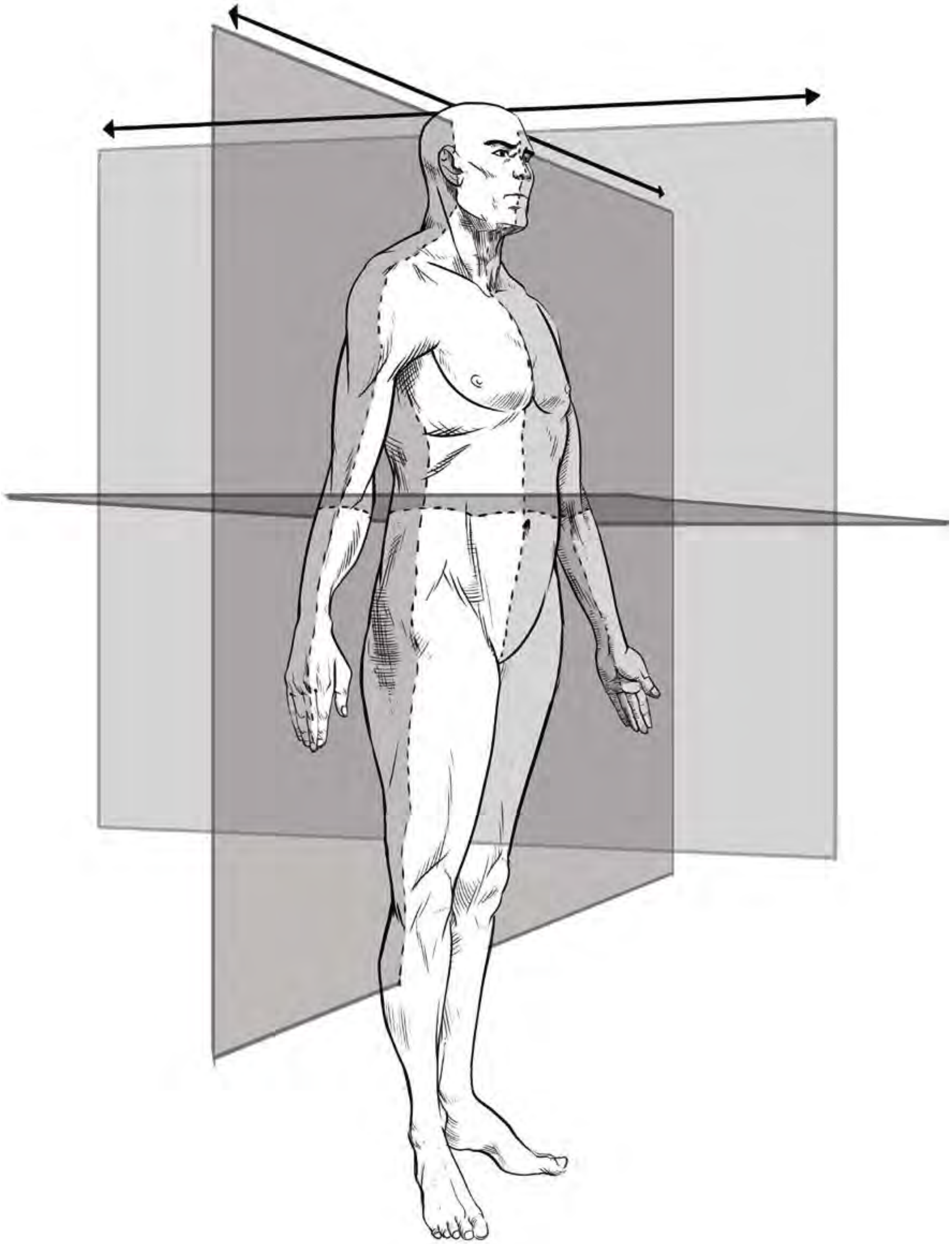
   Superior / Inferior
   Anterior / Posterior
   Medial / Lateral
   Proximal / Distal
   Superficial / Deep
   Ipsilateral / Contralateral

2. Identify the following body planes:

   ☐ Frontal/Coronal ☐ Sagittal ☐ Transverse

3. Into what two halves do the planes divide the body?

Directional Terms and Body Planes



Body Cavities

The human body has two cavities: **ventral** and **dorsal**. These both are further divided into smaller cavities. The dorsal cavity includes the **cranial** and **vertebral** cavities. The cranial cavity houses the brain and the vertebral cavity houses the spine. The ventral cavity includes the **thoracic** and **abdominopelvic** cavities. The thoracic cavity is subdivided into two **pleural** cavities, which contain the lungs, and the **mediastinum**. The mediastinum contains the esophagus, trachea and another cavity, the **pericardial** cavity, which houses the heart. The abdominopelvic cavity is subdivided into the **abdominal** and **pelvic** cavities. The abdominal cavity contains the liver, pancreas, stomach, spleen, kidneys and most of the small and large intestines. The pelvic cavity contains the remainder of the small and large intestines, the bladder and reproductive organs.

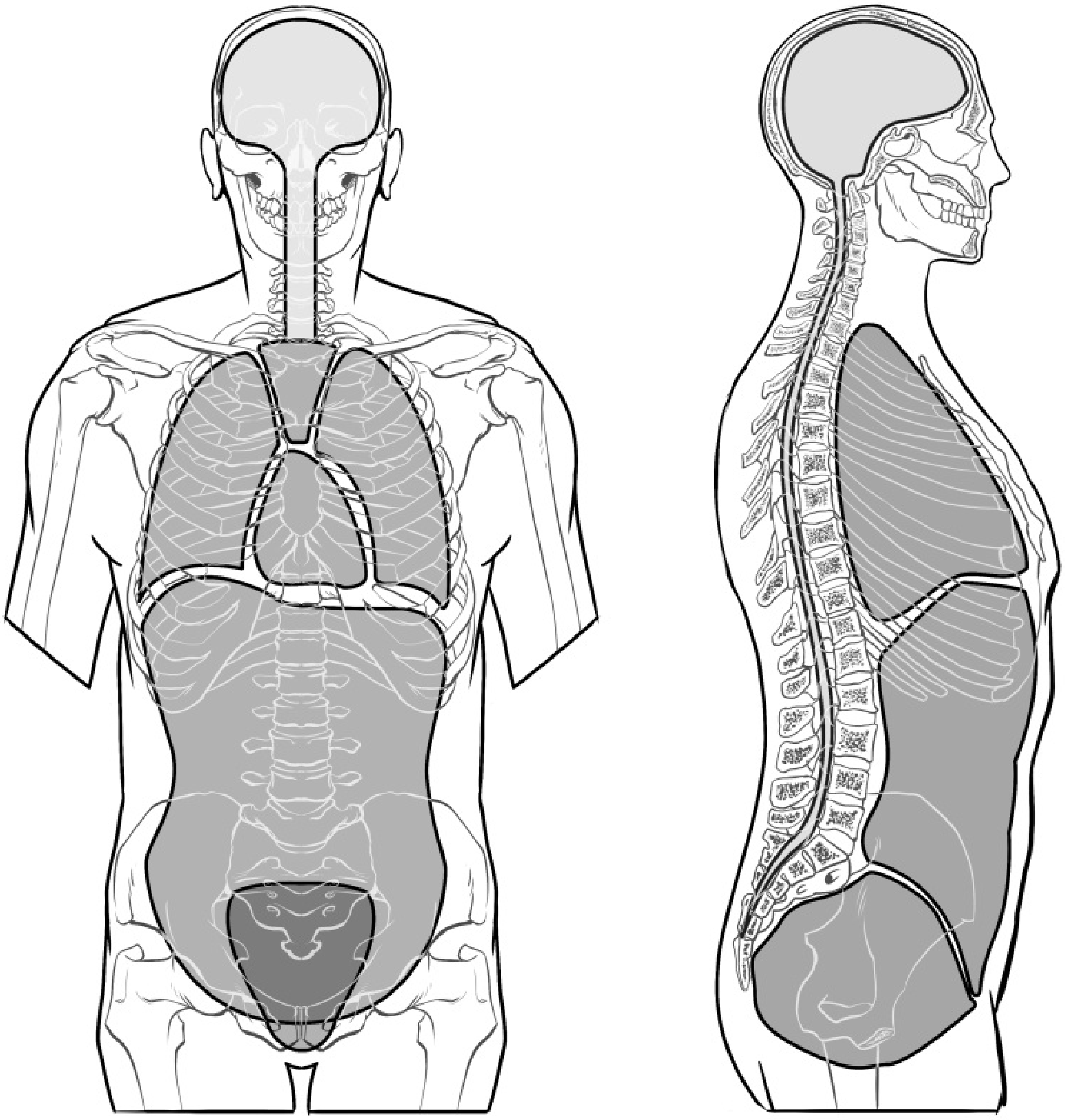
<u>Activity:</u>

1. Identify the following cavities:

☐	Abdominal	☐	Pericardial
☐	Cranial	☐	Pleural
☐	Dorsal	☐	Thoracic
☐	Mediastinum	☐	Ventral
☐	Pelvic	☐	Vertebral

2. What organ(s) are found in the cavities listed above?
3. What is the purpose of a serous membrane?
4. State the name of the three serous membranes in the body.
5. How many layers are there in a serous membrane? Name them.
6. What is the purpose of serous fluid?

Body Cavities



Abdominal Regions and Quadrants

Of all the body cavities, the abdominopelvic cavity is the most challenging for anatomists because it contains so many different organs. To make things easier, anatomists divide the abdominopelvic cavity into different areas. One way to do this is to create nine different regions. The middle region is the **umbilical region**, which contains some small intestine and some large intestine. Around the umbilical region are eight more regions. Working clockwise from the top left, the remaining eight regions are as follows, with the organs each contains in parentheses: the **right hypochondriac region** (liver, gall bladder, and kidney); the **epigastric region** (liver, stomach, large intestine); the **left hypochondriac region** (stomach, spleen and kidney); the **left lumbar region** (small and large intestine); the **left iliac region** (large intestine); the **hypogastric region** (small and large intestine, urinary bladder, reproductive organs); the **right iliac region** (large intestine and appendix); and the **right lumbar region** (large and small intestine).

Another way to compartmentalize the abdominopelvic cavity is to divide it into four quadrants with one vertical line and one horizontal line through the umbilicus. The **right upper quadrant** (RUQ) contains the liver, gall bladder, kidney, stomach, and small and large intestines. The **left upper quadrant** (LUQ) contains the stomach, liver, spleen, kidney and small and large intestines. The **left lower quadrant** (LLQ) contains the small and large intestines, urinary bladder, and reproductive organs. Finally, the **right lower quadrant** (RLQ) contains small and large intestines, appendix, urinary bladder and reproductive organs.

Activity:

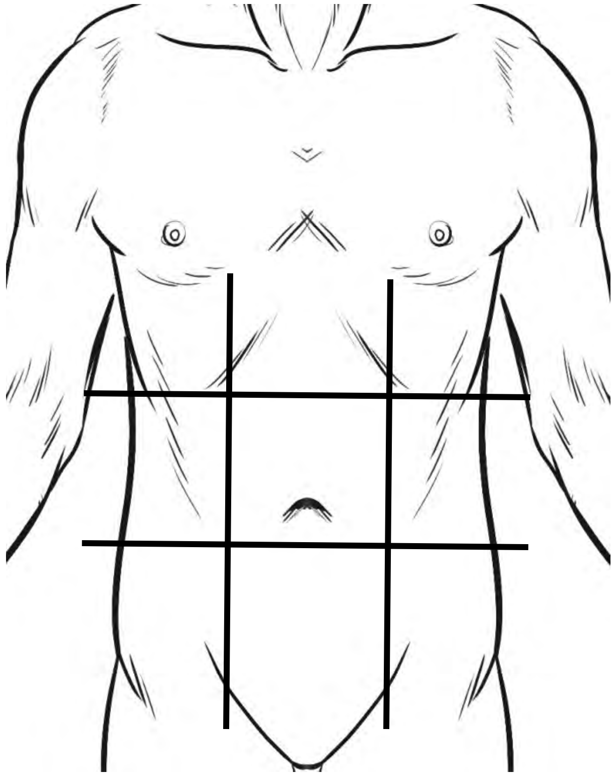
1. Identify the abdominal regions:

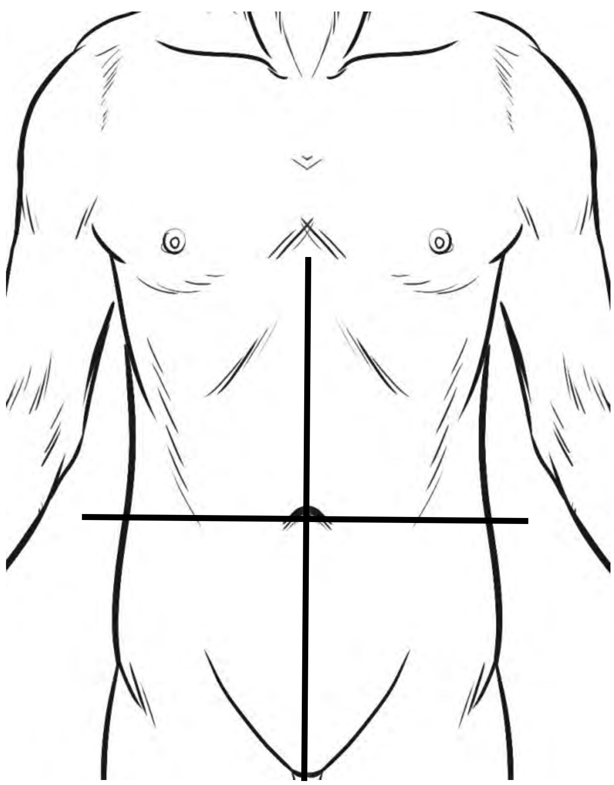
☐ Epigastric	☐ Left inguinal (iliac)	☐ Right inguinal (iliac)
☐ Hypogastric (pubic)	☐ Left lumbar	☐ Right lumbar
☐ Left hypochondriac	☐ Right hypochondriac	☐ Umbilical

2. Identify the abdominopelvic quadrants:

☐ Left lower	☐ Right lower
☐ Left upper	☐ Right upper

Abdominal Regions and Quadrants





Microscopy Lab

Light Microscopes

We will be using light microscopes throughout the semester to observe various tissue samples. It is important that you understand the basic parts of the microscope, as well as how to use the microscope, in order to effectively complete these future labs. Light microscopes are sufficient in both magnification and resolution for viewing the specimens that we are concerned with in this class; they can be used to observe specimens that are 0.25 µm or larger. A stronger microscope (e.g. an electron microscope) would be needed to view anything smaller than 0.25µm.

The two factors that influence microscopy are, (1) **magnification**, the amount that the microscope will enlarge the image beyond its actual size, and (2) **resolution**, how clearly the image can be seen. We can manipulate the light microscope's magnification, to a limit, with the different **objective lenses** (4X, 10X, 40X). Generally speaking, the higher the level of magnification, the lower the resolution of the image. Therefore, resolution tends to be the limiting factor in how well the microscope focuses on the image.

Parts of the microscope

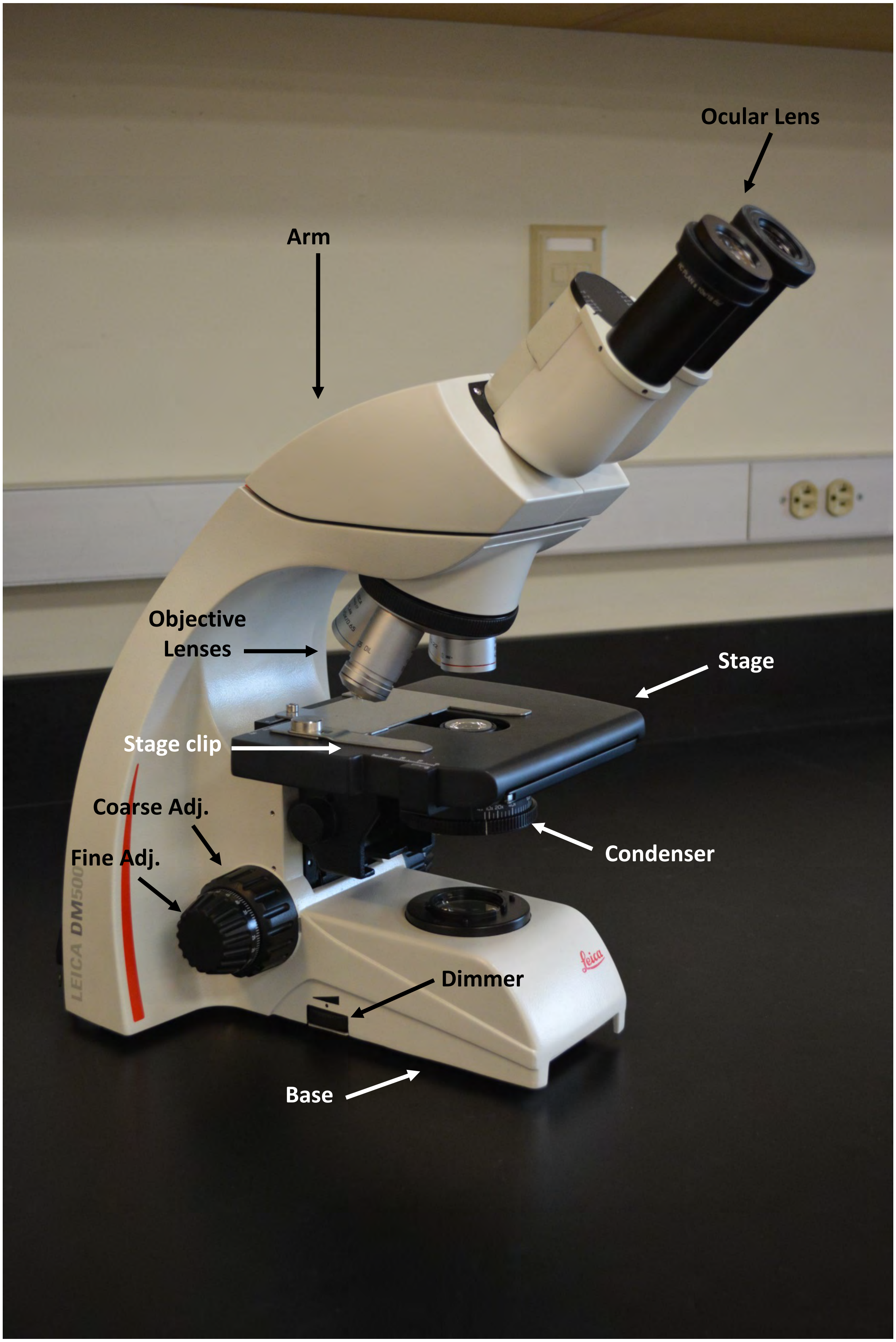
Eyepieces (ocular lens): our microscopes have two eyepieces. These are the last lenses that light passes through before entering the eye. Eyepieces magnify images 10X.
Arm: supports the eyepieces. Carry the microscope by placing one hand around the arm.
Base: stabilizes the microscope. Carry the microscope by placing one hand under the base.
Objective lenses: light passes through these lenses to magnify the image at different levels.
- **Scanning lens**: 4X; used to see the "big picture" during initial focusing
- **Low power lens**: 10X; usually sufficient for viewing most images
- **High power lens**: 40X; useful when greater detail is wanted

Stage: surface upon which slides are placed for viewing
- **Stage clip**: spring-loaded clamp to hold the slide in place
- **Adjustment knobs**: two knobs that control the movement of the stage, allowing different sections of the slide to be scanned. One knob moves the slide forward/backward; the other moves the slide right/left.

Focusing knobs: move the stage up and down in order to focus the image of the specimen.
- **Coarse adjustment**: the larger of the knobs; moves the stage in large increments; NEVER turn this knob when using the 10X or 40X objective lenses
- **Fine adjustment**: the smaller of the knobs; moves the stage in small increments

Condenser: lens under the stage which focuses light onto the specimen.
- **Condenser diaphragm**: opening which can be adjusted to control the amount of light hitting the specimen. This should be decreased when looking at specimens that don't have a lot of stain and have very little contrast

Dimmer: dial which allows the light intensity to be changed.


Ocular Lens
Arm
Objective
Lenses
Stage
Stage clip
Coarse Adj.
Fine Adj.
Condenser
Dimmer
Base
LEICA DM500
Leica

Terminology

Total magnification: the total amount that the specimen is enlarged; calculated by multiplying the ocular lens magnification (10X) by the power of the objective lens being used (4X, 10X or 40X). For example, the total magnification, when using the 4X objective lens, is 40X
Wet mount slide: a temporary slide preparation, in which the specimen is in liquid. Cover-slips are always used on these slides to prevent contact between the fluids and the microscope. The only wet-mount slides we will be using in this class are the cheek cell slides.
Prepared slide: a permanent slide preparation, in which the specimen is fixed under a cover slip. Most of the slides we use in this class fall under this category.

Image orientation

Because the light is passing through multiple lenses, it is refracted (bent). As a result, the image is in a different orientation than it appears on the slide. The image will be upside down and backwards, compared to the actual position of the specimen on the slide.

Use of the microscope:

1. Plug microscope into the nearest outlet (you would be surprised at how many people forget to do this!)
2. Turn on microscope
3. Make sure the scanning power objective (4X) is in the viewing position
4. Secure the slide onto the stage using the stage clamp
5. Center the specimen over the stage opening (i.e. the light source)
6. Look through the ocular lenses and, using the coarse adjustment knob, focus on the image. Note: NEVER use the coarse adjustment knob when using the 10X and 40X objective lenses.
7. Switch to the low power objective (10X) only AFTER you have focused with the scanning objective. Use the fine adjustment knob to focus the image.
8. Switch to the high power objective (40X) if necessary. Use fine adjustment knob to focus the image.

Activity 1: Components of the microscope

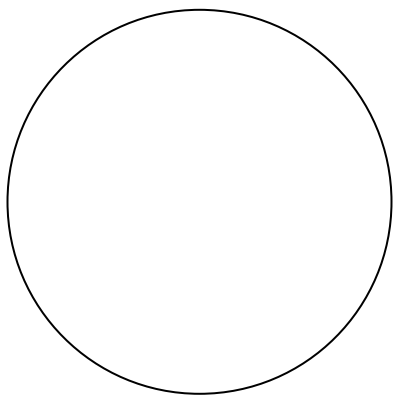
1. Obtain a microscope from the cabinet. Be sure to properly handle the microscope.
2. Locate all the microscope components identified in this handout.
3. Be able to state the function of all components.
   Question: What is the TOTAL magnification using the:
   4X objective? ____________
   10X objective?____________
   40X objective?____________

Question: Which focusing knob do you NEVER use under low or high power? Explain why.

Question: Under what conditions would you want to use the lowest overall power?

Activity 2: Correct use of the microscope

1. Obtain a prepared letter “e” slide from the side bench
2. Plug in your microscope and place the slide on the stage in the correct readable position, securing it with the clamps
3. Beginning with the scanning objective lens (4X) in viewing position, focus on the slide
4. Adjust the condenser diaphragm until you have the desired level of light intensity.
5. Observe the orientation of the “e” when viewed through the microscope. Sketch the appearance of the “e” below.



Question: How does the orientation of the “e” compare when you view the slide with the naked eye versus through the microscope?

6. Move the mechanical stage to the right, while observing the movement of the image.
7. Move the mechanical stage forward, while observing the movement of the image.
   Question: how does the movement of the image compare to the movement of the stage?

8. Change to the low power objective and re-focus, using the FINE adjustment knob. Adjust the light intensity to the desired level.
9. Change to the high power objective and re-focus, using the FINE adjustment knob. Adjust the light intensity to the desired level.

Question: Do you need more or less light when using the high power objective?

Activity 3: Estimating the diameter of the field of view

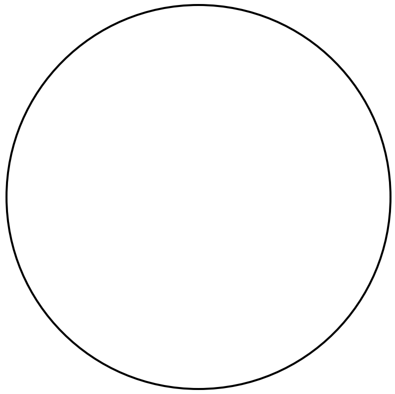
1. Obtain a plastic millimeter ruler
2. Place the ruler on the stage, with the millimeter marks across the center of the field of view.
3. Focus on the millimeter marks at the scanning power objective (4X).
4. Roughly estimate the diameter of the field of view, using the millimeter marks
5. Repeat with the other objective lenses

Field diameter at 4X: ____________
Field diameter at 10X: ____________
Field diameter at 40X: ____________

Question: What is the relationship between magnification and field of view?

Activity 4: Observation of a wet mount slide

1. Obtain a clean slide, cover-slip, toothpick, and a dropper vial with methylene blue stain.
2. Using the toothpick, scrape cells from the inside of your mouth, on your cheeks. You don't need to scrape very hard; these cells slough off very easily.
3. Smear the toothpick on the clean slide, in the center.
4. Put ONE drop of methylene blue over your sample.
5. Place a cover-slip over the fluid.
6. Dispose of your toothpick in the labeled container on the side bench.
7. Place your wet mount on the stage, secure and focus on the image (beginning at the scanning power and work your way up).
8. Cheek cells are flat cells (like pancakes) with a very prominent nucleus (darkly-stained center). Check with your instructor to make sure that you are looking at the correct thing.
9. Draw what you see in the space on the next page.
   Question: Given the information obtained in Activity 3, what is the estimated diameter of a typical cheek cell?



Total Magnification Level =

10. Once done with your slide, dispose of the coverslip in the biohazard container and place the slide in the bleach container on the side bench.

Activity 5: Storage of the Microscope

The microscopes are stored on shelves in the wall cabinets in the lab. Each shelf has numbered spaces, which correspond to the numbers on the microscopes. Please return the microscopes to the appropriate space at the end of each session. Before returning to the space, be sure to:

1. turn the microscope off
2. turn down the dimmer to level 1
3. clean the lenses with lens paper
4. remove all slides from the stage
5. move the scanning power objective into the viewing position
6. move the stage upward with the coarse adjustment knob
7. center the stage
8. coil the electric cord onto the microscope

Cell Structure

The structure of the cell is broken down into three parts: the plasma membrane, the nucleus, and the cytoplasm. The **plasma membrane** is composed of a bilayer of phospholipids with cholesterol, proteins and carbohydrates embedded amongst the phospholipids. It serves as a barrier between the extracellular environment and intracellular environment, and also controls transport into or out of the cell.

The **nucleus** is the control center, containing the genetic material of the cell. Along with **chromatin** (DNA and proteins), one or more **nucleoli** are also found within the nucleus. Ribosomes (another organelle to be discussed later) are manufactured in nucleoli.

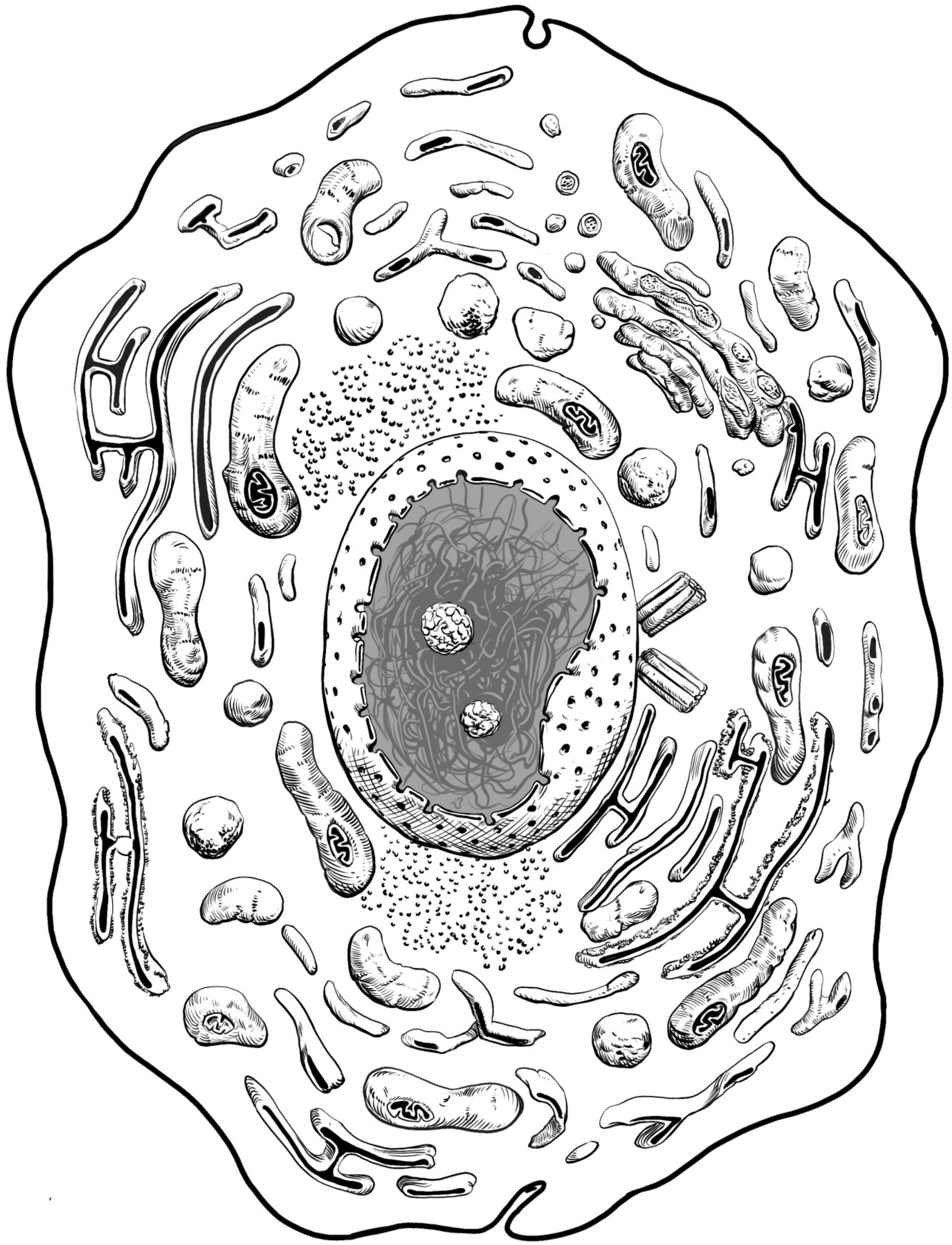
The **cytoplasm** has two components: **organelles** and **cytosol**. Cytosol is the watery fluid inside the cell, also called intracellular fluid (ICF). It is composed mostly of water, but also contains ions, nutrients, wastes and gases. Organelles are the "little organs" of the cell. There are membranous organelles, which are surrounded by a membrane similar to the plasma membrane. The endoplasmic reticulum is a network of membranes found around or near the nucleus. **Smooth endoplasmic reticulum** is responsible for synthesizing fat and storing calcium. **Rough endoplasmic reticulum** is responsible for modifying proteins. What makes it appear rough is that it has ribosomes on its surface. Near rough ER is the **Golgi apparatus**, another series of membrane sacs that are stacked on top of one another. Its purpose is to sort, modify and package proteins into vesicles to be sent to the membrane for exocytosis or to the cytoplasm for storage. One example of a storage vesicle is a **lysosome**, which breaks down cellular debris. Another storage vesicle is a **peroxisome**, which detoxifies the cell. The final example of a membranous organelle is the **mitochondrion**. It is actually a double membrane-bound organelle that is responsible for energy production. In addition to membranous organelles, the cytoplasm also has non-membranous organelles. **Ribosomes**, composed of protein and ribosomal RNA (rRNA), are either free (called **polyribosomes**) or bound to rough ER. They are responsible for protein synthesis. The final non-membranous organelle that can be identified is a **centriole**, which is a protein-based structure, responsible for cell motility (e.g. in flagellated cells) and for organizing chromosomes during cell division.

Activity:

1. Identify and state the function of the following:

☐	Chromatin	☐	Nucleus
☐	Centriole	☐	Peroxisome
☐	Golgi apparatus	☐	Plasma membrane
☐	Lysosome	☐	Ribosome
☐	Mitochondrion	☐	Rough endoplasmic reticulum
☐	Nucleolus	☐	Smooth endoplasmic reticulum

Cell Structure



Mitosis

Mitosis is the term given to the division of the cell. All cells in the body undergo mitosis at some point in their life. There are examples of cells (e.g. neurons) which stop undergoing mitosis once you are born. But most cells of the body do divide in order to allow for body growth and repair.

Once the cell is ready to divide, it enters into a phase of its life cycle called the **mitotic phase**, which has two phases within it: **mitosis** and **cytokinesis**. Mitosis is the division of the cell's nucleus (and hence genetic material); cytokinesis is the division of the plasma membrane and cytoplasm.

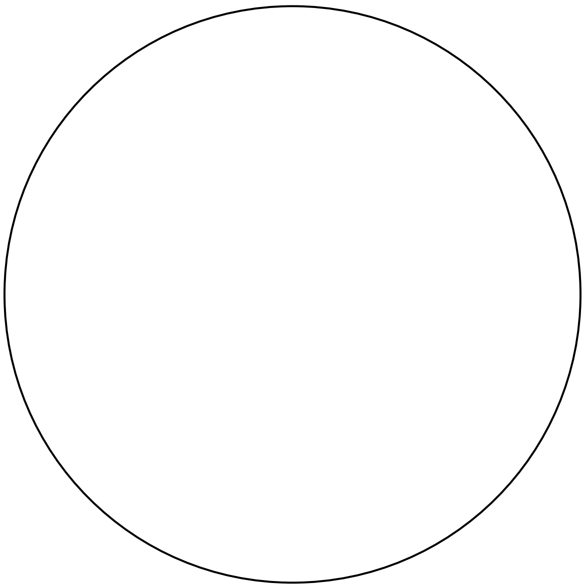
Mitosis is split into four phases: prophase, metaphase, anaphase, telophase (PMAT). During **prophase**, the chromosomes are first visible and the nuclear envelope is dissolved. The now visible chromosomes are composed of two identical arms, called sister chromatids, which are joined together by a protein-based centromere. The centriole of the cell is beginning to form a mitotic spindle, a protein-based structure that is necessary to organize and move the chromosomes during cell division. During **metaphase**, the fibers of the mitotic spindle have attached to the centromere of the chromosomes and have aligned them such that they are lined up single file down the center of the cell, in an area called the metaphase plate. During **anaphase**, the spindle fibers shorten, thereby pulling the sister chromatids apart at the centromere. Each chromatid migrates toward opposite poles of the cell. During **telophase**, the chromatids have completed migration toward opposite sides of the cell and a nuclear envelope is beginning to surround each of the two clusters of chromosomes. At the same time **cytokinesis** is occurring, whereby a cleavage furrow forms between the two nuclei and the cell divides its contents into two new daughter cells.

Activity:

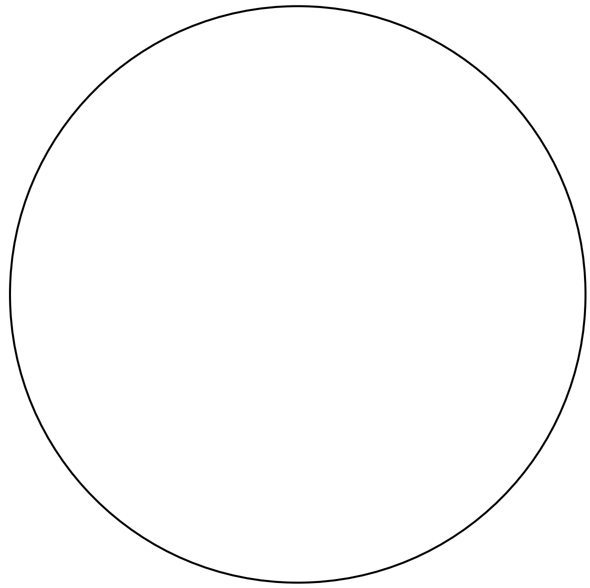
1. Obtain a prepared slide of whitefish blastula tissue, which contains cells in different phases of cell division.
2. Draw one example of each of the phases of mitosis in the spaces provided on the next page. Hint for distinguishing between the phases: look at the darkly-stained chromosomes and the shape of the plasma membrane.

Mitosis

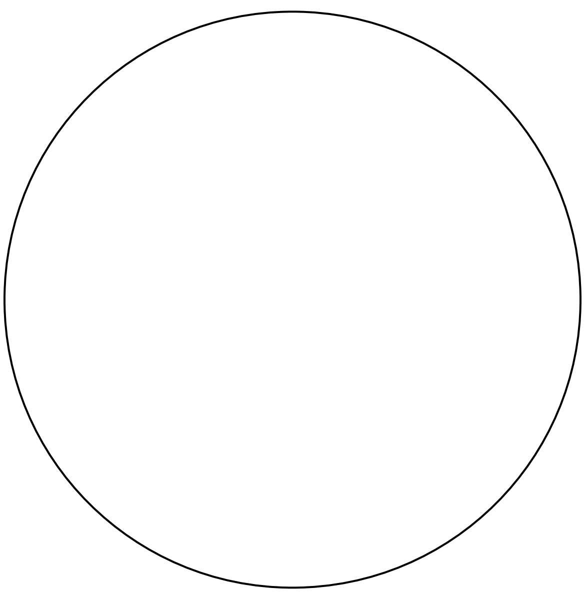
Prophase



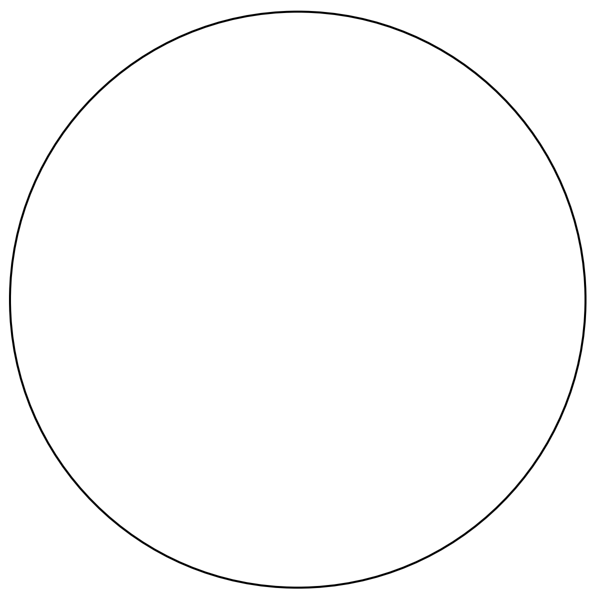
Metaphase



Anaphase



Telophase



Histology

A **tissue** is defined as a group of cells with similar functions. There are four primary types of tissues: epithelial, connective, muscle, and nervous. Each has its own properties and sub-types.

Epithelial tissue is our covering and lining tissue; it is found either covering structures (e.g. your skin) or lining body cavities (e.g. the inside of your mouth). There are three terms to describe the shape of epithelial tissue cells: squamous (flat), cuboid (square), and columnar (tall). There are two terms to describe the number of layers of cells: simple (one layer) and stratified (more than one layer). Combining these two categories of terms gives us the names of the different types of epithelial tissue. **Simple squamous** epithelium is composed of one layer of flat cells. Given that it is the thinnest type of tissue, it is found in areas of the body where fast transport is required (e.g. the lungs). **Simple cuboidal** epithelium is composed of a single layer of cube shaped cells. These tissues are good for secretion and absorption. An example of where this would be located is in the tubules of the kidneys. Finally, **simple columnar** epithelium is composed of a single layer of tall cells. This tissue is also good for secretion and absorption and can be found in areas such as the stomach. **Pseudostratified columnar** epithelium contains cells that have different heights. This gives the illusion of a stratified tissue, when in reality it is simple. Pseudostratified columnar can be ciliated, as is the case in the slide you will be looking at. This means that the apical surface has cilia to move objects (e.g. particles of dust) across the surface of the membrane. This type of epithelium is found in many areas of the respiratory system. **Stratified squamous** epithelium is composed of many layers of flat cells. All those layers provide protection; therefore this tissue is found in areas of the body that are subjected to a lot of friction (e.g. the skin). The cells of **transitional** epithelium change shape depending on the state of the organ. This tissue is found in the urinary system, e.g. in the urinary bladder which stretches as it fills. The cells of transitional epithelium change from stratified cuboidal cells when the organ is empty to stratified squamous cells when the organ is full.

Connective tissue is found throughout the body and acts to connect structures. All connective tissues are composed of cells and a matrix (an acellular substance that is made of protein fibers and ground substance). There are several subtypes of connective tissue: connective tissue proper, cartilage, bone and blood. Connective tissue proper can be further subdivided into loose and dense tissues. There are three types of loose connective tissue: areolar, adipose and reticular. The most abundant type of connective tissue is **areolar connective tissue**. This highly vascular tissue can be found under all epithelial tissues, allowing for nutrient and waste exchange. **Adipose tissue** is rich with adipocytes, which store fat for energy. This tissue acts as an excellent insulator under our skin (in our subcutaneous tissue) and as a shock absorber around some of our vital organs (e.g. our heart and kidneys). **Reticular tissue** derives its name from its abundant reticular fibers. This tissue forms the framework for some of our non-muscular organs, such as the spleen. There are three types of dense connective tissue: dense regular, dense irregular and elastic. **Dense regular** connective tissue is composed of parallel bundles of collagen which provide longitudinal strength in areas that require it (e.g. tendons). **Dense irregular** connective tissue is also composed of collagen, but the fibers are arranged in all different orientations so that the areas of the body plentiful in this tissue (e.g. the dermis of the skin) can be pulled in all different directions without tissue damage. **Elastic** connective tissue contains some collagen fibers, but is mostly composed of elastic fibers. This tissue provides strength and extensibility to organs that are subject to a lot of stretch, such as the elastic arteries. There are three types of cartilage: hyaline, fibrocartilage and elastic. The most common type of cartilage is **hyaline cartilage**. This tissue has a gelatinous matrix that gives it flexibility and strength. We find hyaline cartilage in areas of the body that require protection (e.g. the articulating surfaces of bones). **Fibrocartilage** is similar to hyaline cartilage, except that its collagen fibers are thicker and stronger. Fibrocartilage is a good shock absorber. For this reason, joints that undergo a lot of compression have fibrocartilaginous discs between the bones (e.g. the intervertebral discs and the menisci of the knees). **Elastic cartilage** is also similar to hyaline cartilage, except it contains elastic fibers in addition to collagen fibers. This tissue is also strong, but has the advantage of greater flexibility. This tissue is found, for example, in the pinna of the ear. **Bone** is the hardest of all the tissues in the body; its matrix is solid, with calcified salts. This tissue allows for mineral storage and protection of our vital organs. **Blood** is different from all the other connective tissues because its matrix (called plasma) is fluid. It is our body's primary transport medium.

Muscle tissue has two properties: excitability and contractility. Excitability is the tissue's ability to respond to stimuli by generating electrical impulses. Contractility is a physical property of cell whereby force is generated to move a load. There are three subtypes of muscle tissue: skeletal, smooth and cardiac. **Skeletal muscle** is found attached to bones. It is a voluntary, striated tissue that is composed of long, multinucleated cells called myofibers. **Smooth muscle** is found around hollow organs such as the stomach or blood vessels. It is an involuntary, non-striated tissue that is composed of short, spindle shaped cells. **Cardiac muscle** is found within the heart. This tissue has properties of both skeletal and smooth muscle: it is an involuntary, striated tissue that is composed of short, branched cells connected to each other by special cell junctions called **intercalated discs**.

Nervous tissue is another type of excitable tissue; however unlike muscle it cannot generate force. Nervous tissue is responsible for communication and decision making. Nervous tissue has two cells types: **neurons**, the functional cells of the tissue, and **neuroglia**, the supportive cells of the tissue.

Activity:

1. For each tissue, use the slide number written next to the tissue names on the following pages.
2. Locate the appropriate tissue on the slide. Some slides will have many different tissue types in the same sample. Verify with your instructor.
3. Draw what you see using the objective lens indicated in the parentheses.
4. You may take a picture of the image with a camera or phone, but you are still required to draw what you see as well.
5. What is the purpose of each tissue?
6. Give examples of where each is found.

Epithelial Tissues

Simple squamous (40X): #64

Simple cuboidal (40X): #4

Simple columnar (40X): #2

Pseudostratified columnar (40X): #8

Epithelial Tissues, cont.

Stratified squamous (40X): #6

Transitional (40X): #10

Connective Tissues

Areolar (40X): #12

Adipose (40X): #16

Connective Tissues, cont.

Reticular (40X): #16

Dense regular (40X): #18 (long.)

Dense irregular (40X): #28

Elastic (10X): #19

Connective Tissues, cont.

Hyaline cartilage (10X): #66

Fibrocartilage (10X): #24

Elastic cartilage (10X): #26

Bone (10X): #32

Connective Tissues, cont.

Blood (40X): #60

Muscle Tissues

Skeletal muscle (40X): #40

Smooth muscle (40X): #36

Muscle Tissues, cont.

Cardiac (40X): #37

Nervous Tissue

Neurons and Neuroglial cells (40X): #42

Skin

Skin is the largest organ in the body. It serves many functions, including sensation, protection and temperature regulation. Skin has two layers of tissue: the epidermis and the dermis.

The **epidermis**, the superficial layer, is composed of stratified squamous epithelium. In addition to epithelial cells, the epidermis also contains melanocytes, which create the skin pigment melanin, Merkel cells, which are sensory cells that respond to light touch, and dendritic cells, which are phagocytes to keep your epidermis healthy.

The **dermis** is connective tissue; the superficial, thin **papillary** layer is composed of areolar connective tissue while the deeper, thicker **reticular** layer is composed of dense irregular connective tissue. The papillary region contains **dermal papillae**, finger-like extensions of the dermis that project upward into the epidermis, which increase the surface area for nutrient and waste exchange. The majority of the skin's accessory structures are found in the reticular region. **Hair follicles** create new hairs. The **hair shaft** leaves the follicle and penetrates through a pore in the skin to the outer surface of the skin. Hair insulates the body and also enhances our sense of touch. Attached to the side of the hair follicle is the **arrector pili muscle**; this smooth muscle pulls the hair upward, creating a "goose bump" on the skin when we are cold or afraid. The dermis contains glands; **sudoriferous glands** produce sweat, while **sebaceous glands**, closely associated with hair follicles, produce sebum (oil). In addition to glands, there are many sensory neurons located in the dermis. **Free nerve endings** respond to temperature and pain. **Meissner's corpuscles**, located in the dermal papillae, respond to light touch and pressure. Deeper **Pacinian corpuscles** respond to deep pressure.

Though not technically part of skin, the **subcutaneous tissue** (hypodermis) can be seen on our models. This area is abundant in adipose tissue, which insulates our body and protects underlying tissue from trauma.

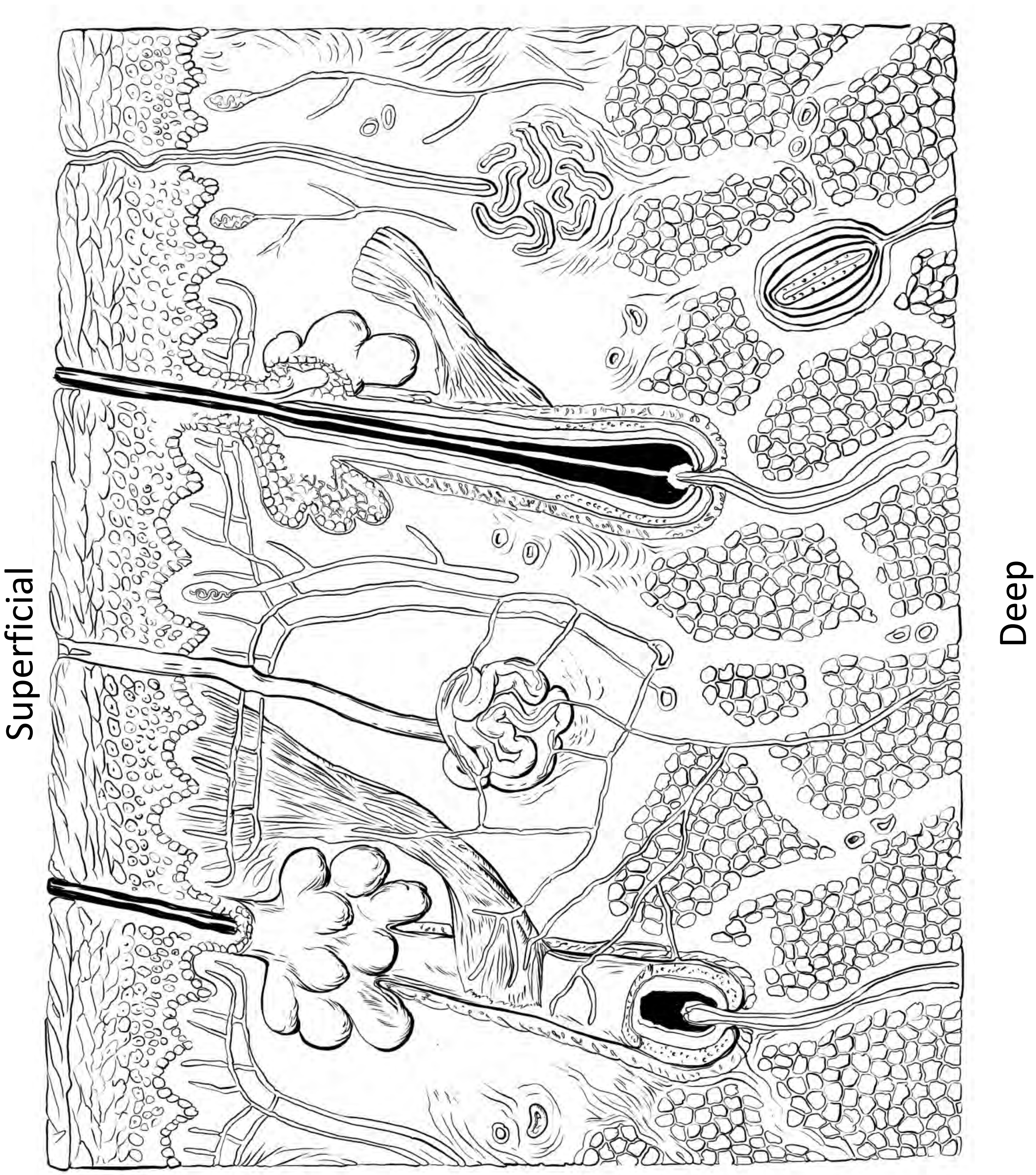
Activity:

1. Identify the following:

☐ Arrector pili*	☐ Free nerve endings*	☐ Pacinian corpuscle*
☐ Dermal papillae*	☐ Hair follicle	☐ Sebaceous gland*
☐ Dermis	☐ Hair shaft	☐ Subcutaneous tissue
☐ Epidermis	☐ Meissner's corpuscle*	☐ Sudoriferous gland*

2. What is the purpose of the structures above with the * next to them?
3. What type of connective tissue is found in the papillary and reticular regions of the dermis?

Skin



Skin Histology

Once you are familiar with the generalized structure of skin, you should be able to identify many of the features on prepared and stained sections of the skin.

The first slide is of human skin, in which the layers of skin (epidermis and dermis) can be seen, as well as sudoriferous glands.

The second slide of is hairy skin from a mammal. You can see the epidermis and dermis in this slide as well, in addition to the subcutaneous tissue. You will also see many hair follicles, some of which may still have strands of hair in them.

<u>Activity:</u>

1. Obtain slide number 28 from your slide box.
2. Using the 10X objective lens, locate the following:

   Epidermis
   Dermis
   Sudoriferous gland

3. Draw what you see on the following page, labelling the structures listed above.
4. Obtain slide number 30 from your slide box.
5. Using the 10X objective lens, locate the following:

   Epidermis
   Dermis
   Subcutaneous tissue
   Hair follicle

6. Draw what you see on the following page, labelling the structures listed above.

Skin Histology

Typical Long Bone

Bones are composed of two types of bone tissue: **compact** and **spongy**. Compact bone is densely packed with calcified salt and thus is very strong. It is also very heavy, and for this reason only the outer layer of bone has compact bone tissue. Spongy bone has many spaces within its matrix, which are filled with bone marrow. The holes make this tissue much weaker, but lighter. Spongy bone is found inside of our bones.

Bones can be classified based on their shape. There are **long bones**, **short bones**, **flat bones** and **irregular bones**. Here we are looking at the parts of a typical long bone.

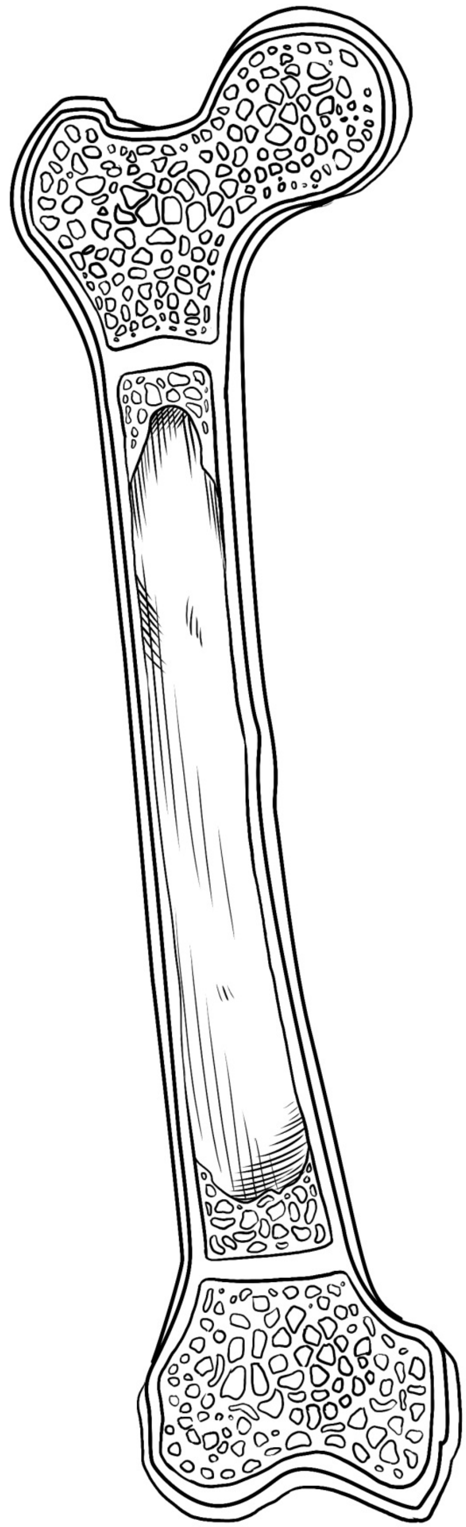
The **epiphyses** (singular: epiphysis) are the proximal and distal ends of the long bones. The shaft is called the **diaphysis**. Within the diaphysis is a cavity called the **medullary cavity**, which contains bone marrow. In most adult bones, the medullary cavity is predominately filled with **yellow bone marrow** (fat). There may still be some **red bone marrow**, which contains hematopoietic stem cells to produce new blood cells. When the bone is still growing in length, the junction between the epiphysis and diaphysis – called the **epiphyseal growth plate** – is composed of hyaline cartilage, which provides the framework for new bone growth. Once the skeleton is mature, that cartilage is replaced by compact bone to form the **epiphyseal line**.

Activity:

1. Describe the different bone types (e.g. long, short, etc.) and give examples of each.
2. What is found inside of the medullary cavity?
3. What are some differences between spongy and compact bone?
4. Identify the following:

- ☐ Compact bone
- ☐ Diaphysis
- ☐ Distal epiphysis
- ☐ Epiphyseal line
- ☐ Medullary cavity
- ☐ Proximal epiphysis
- ☐ Spongy bone

Typical Long Bone



The Osteon

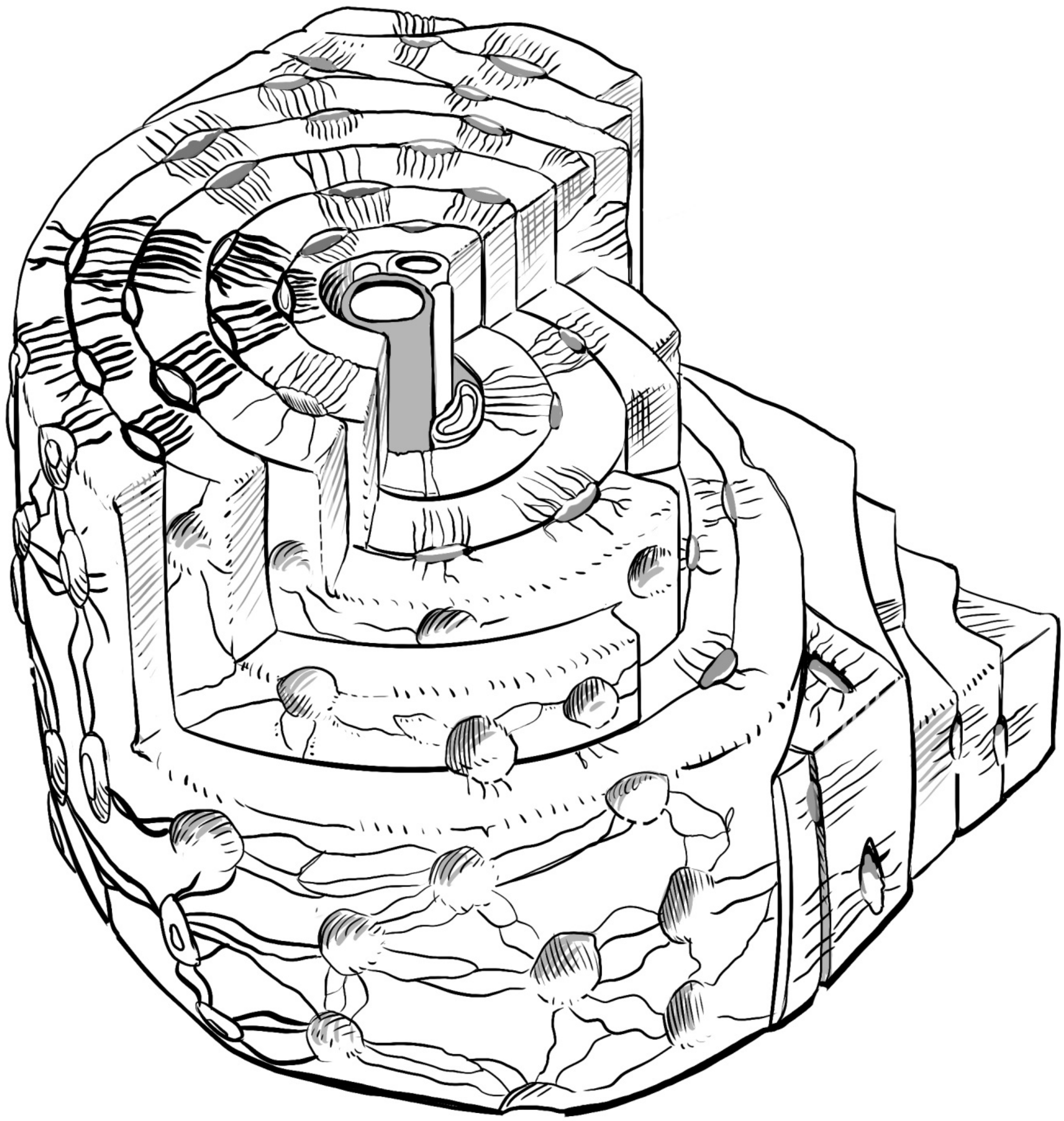
Compact bone is arranged in **osteons** (also called Haversian systems). These cylindrical structures run down the length of the bone, providing strength. Down the middle of the osteon is the **central canal**, which contains an artery, a vein, nerves and a lymphatic vessel. Concentric layers of bone matrix, called **lamellae** (singular: lamella), surround the central canal. Small gaps between the lamellae are called **lacunae** (singular: lacuna); bone cells, **osteocytes**, reside here. Osteocytes are oddly shaped cells; they have long projections. Those projections are found within tiny grooves in the lamellae called **canaliculi** (singular: canaliculus).

Activity:

1. Are osteons found in spongy or compact bone?
2. Identify the following:

- ☐ Canaliculus
- ☐ Central canal
- ☐ Lacuna
- ☐ Lamella
- ☐ Osteocyte

The Osteon



Bone Histology

Once you are familiar with the generalized structure of bone tissue, you should be able to identify many of the features on prepared and stained sections of compact bone.

This slide is a transverse section of compact bone tissue. Note that you can see several osteons. Filling in the spaces between osteons are interstitial lamellae, which are remnants of old osteons that underwent remodeling.

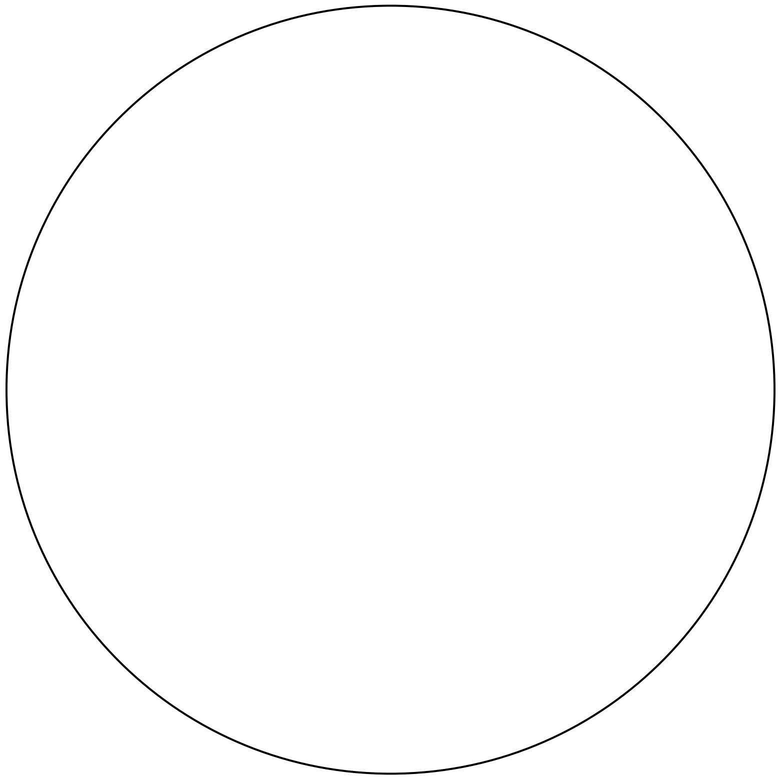
Activity:

1. Obtain slide number 32 from your slide box.
2. Using the 10X objective lens, locate the following:

    Central canal
    Concentric lamellae
    Lacunae

3. Draw what you see on the following page, labelling the structures listed above.

Bone Histology



The Skull
(Anterior View)

The skull is composed of 22 bones. The eight **cranial** bones encase the brain, whereas the 14 **facial** bones form the features of our face.

From this perspective, you can see several of the cranial bones. The **frontal** bone forms the forehead. In the majority of people, this is a single bone; a small proportion of the population has paired frontal bones fused along the mid-sagittal plane. The paired **temporal** bones form the temples. The paired **parietal** bones form the superior-most portion of the cranium. In the orbit where the eye is found, you can see two more cranial bones: the **ethmoid** bone in the medial wall of the orbit and the **sphenoid** bone in the posterior of the orbit.

Many of the facial bones can also be observed from the anterior perspective. The paired **zygomatic** bones form the cheekbones. The paired **nasal** bones form the bridge of the nose. The paired **maxillary** bones form the upper jaw, while the single **mandible** forms the lower jaw. The paired **lacrimal** bones can be found near the orbits, just posterior to the nasal bones and anterior to the ethmoid bone. Within the nasal cavity, the **vomer** can be seen, which forms the inferior portion of the nasal septum. Finally, the paired **inferior nasal conchae** can be found on the lateral wall within the nasal cavity. These bones form inferior ridges in the nasal cavity called turbinates, which warm the air we inhale; we will be looking at the nasal cavity more closely in a subsequent drawing.

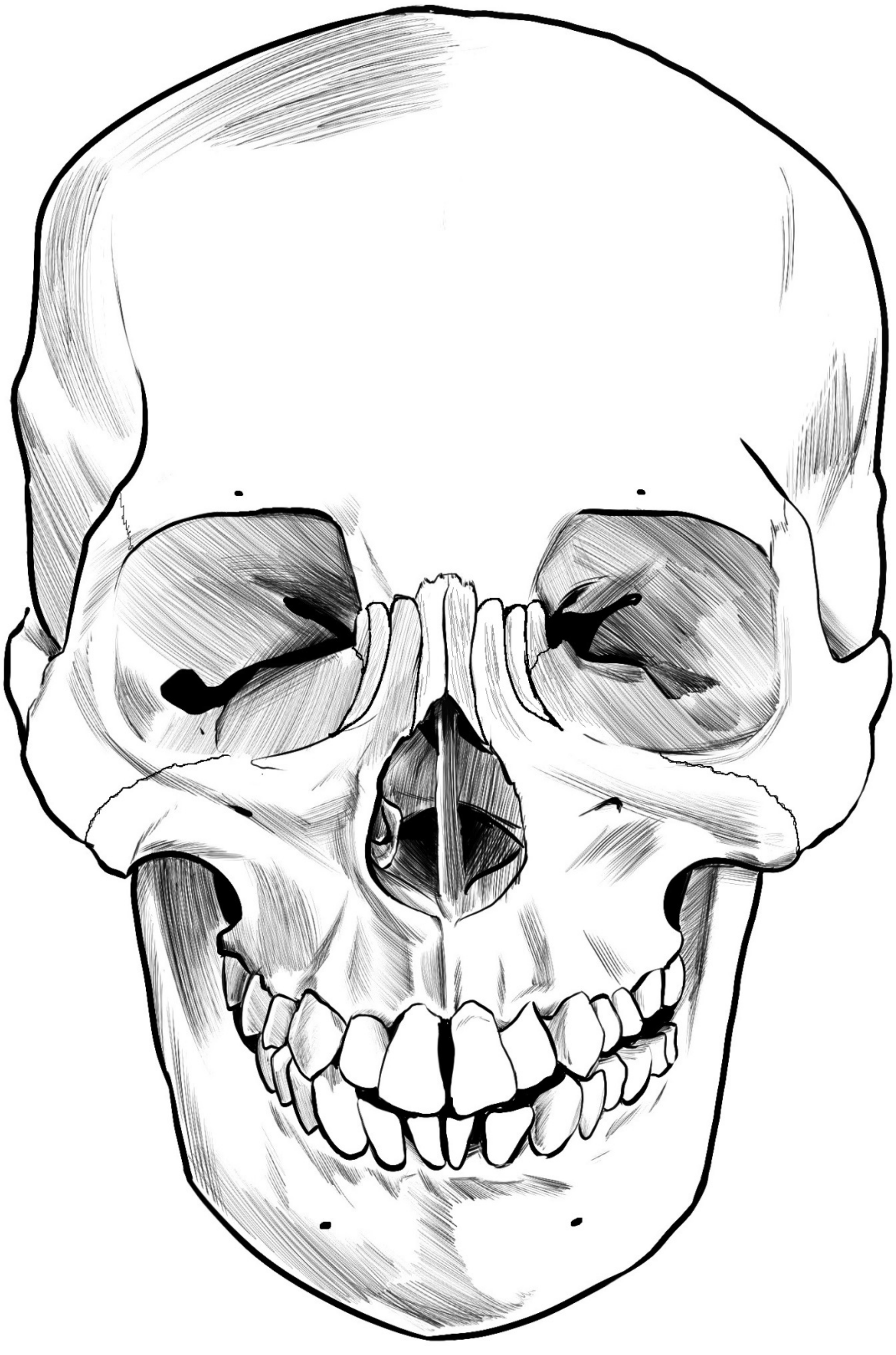
Activity:

1. Identify the bones:

☐	Ethmoid	☐	Mandible	☐	Sphenoid
☐	Frontal	☐	Maxilla	☐	Temporal
☐	Inferior nasal conchae	☐	Nasal	☐	Vomer
☐	Lacrimal	☐	Parietal	☐	Zygomatic

2. Which of the bones listed above are cranial bones? Which are facial bones?
3. Which of the bones are paired? Single?

The Skull
(Anterior View)



The Skull
(Lateral View)

The lateral view of the skull allows you to see the last of the cranial bones, the **occipital** bone which forms the posterior and inferior portions of the cranium. This perspective also allows you to see the entire shape of the **parietal** and **temporal** bones on the lateral sides of the cranium. You can also see where the **frontal** bone joins the parietal bone. Just anterior to the temporal bone and posterior to the zygomatic bone, you can see the lateral portion of the **sphenoid** bone. On the medial wall of the orbit, you can see a small sliver of the **ethmoid** bone.

Several of the facial bones can also be seen, including the **zygomatic**, **maxilla**, **mandible**, **nasal**, and **lacrimal** bones.

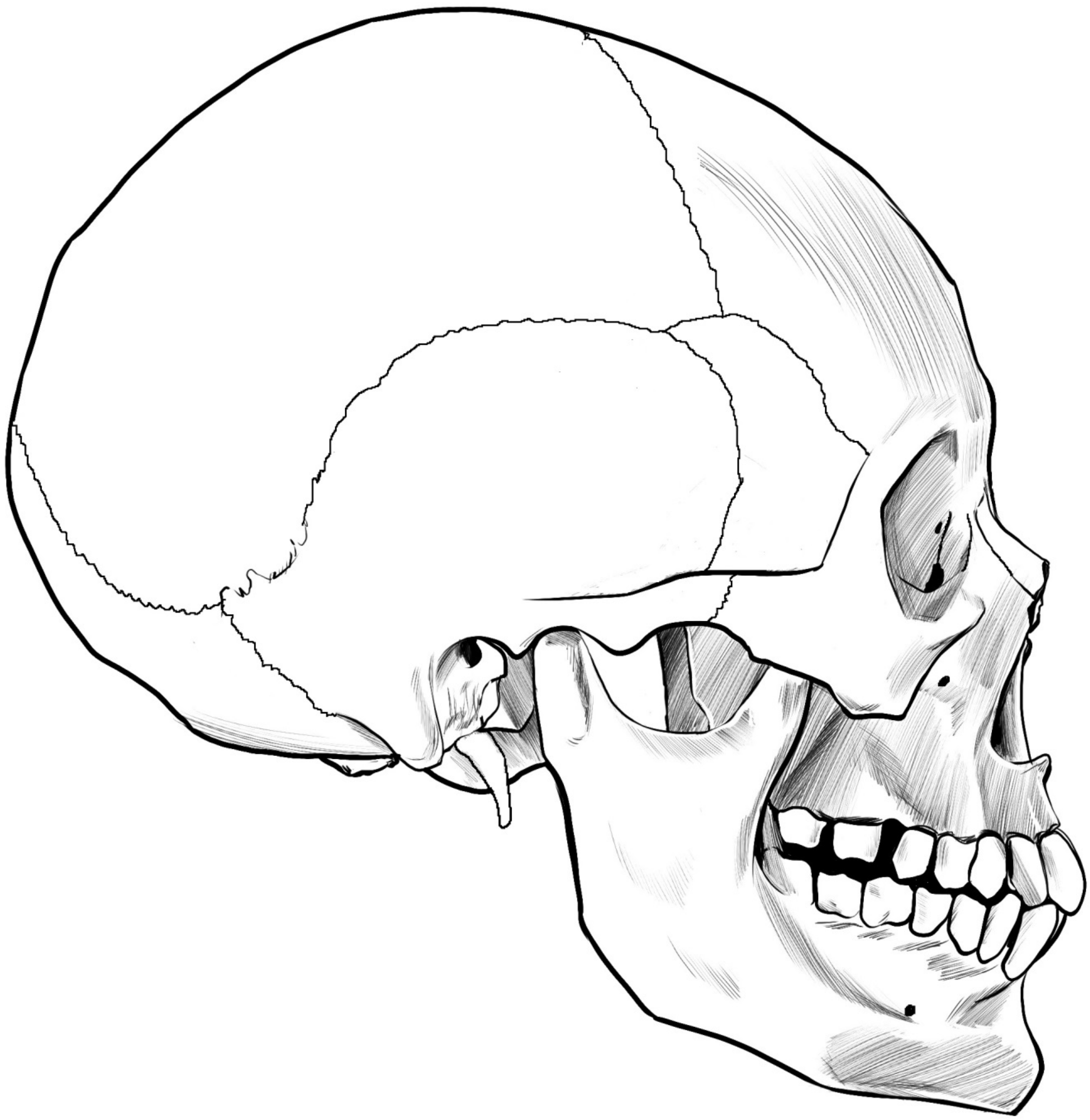
Activity:

1. Identify the bones:

☐ Ethmoid	☐ Maxilla	☐ Sphenoid
☐ Frontal	☐ Nasal	☐ Temporal
☐ Lacrimal	☐ Occipital	☐ Zygomatic
☐ Mandible	☐ Parietal	

2. Which of the bones listed above are cranial bones? Which are facial bones?
3. Which of the bones are paired? Single?

The Skull
(Lateral View)



The Skull
(Posterior View)

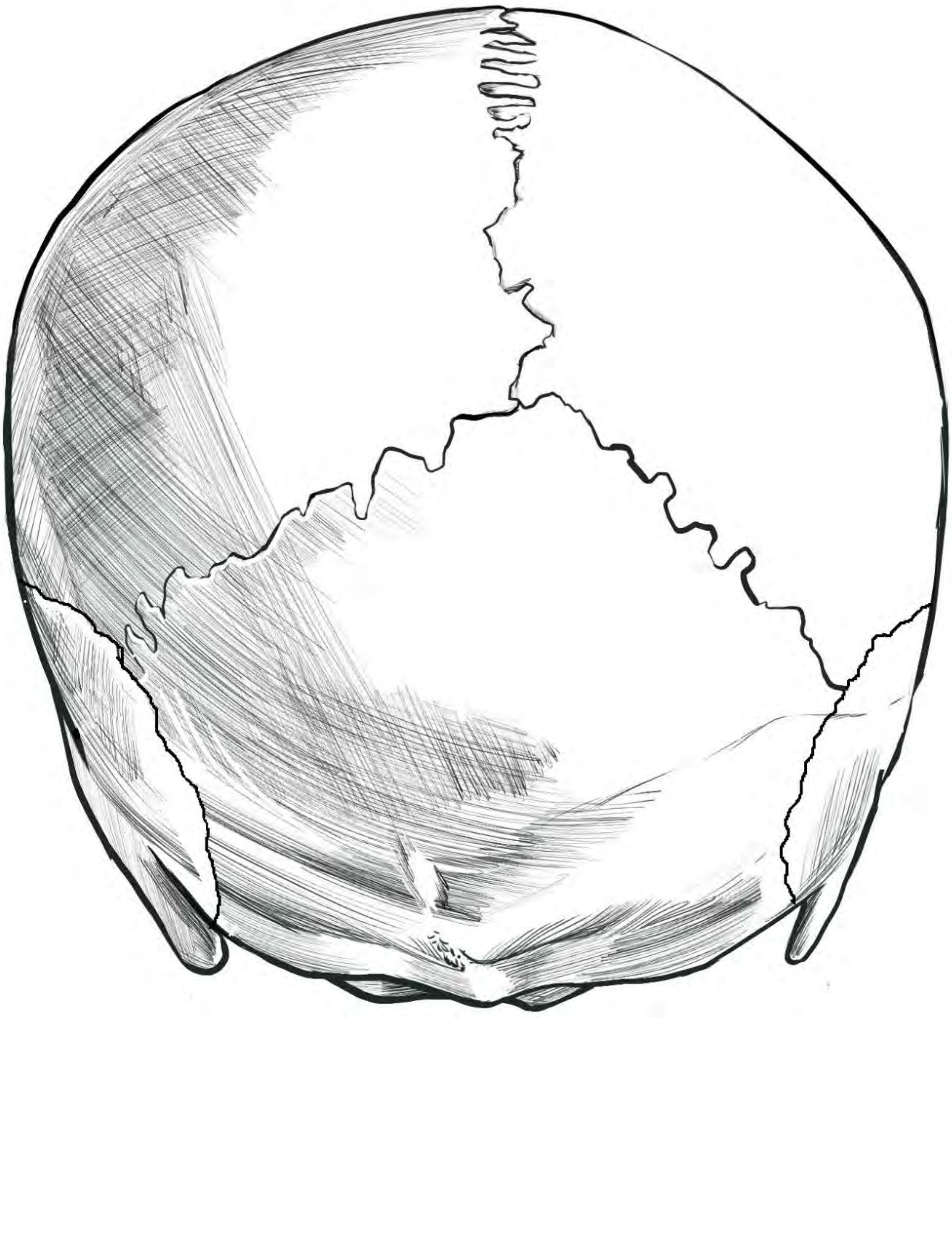
The posterior view of the skull allows you to see the posterior portion of the **parietal** and **occipital** bones. On the inferior, lateral portion of the posterior skull you can also see a small section of the **temporal** bone.

Activity:

1. Identify the bones:

☐ Occipital ☐ Parietal ☐ Temporal

The Skull
(Posterior View)



The Skull
(Inferior View)

Turning the skull upside down, you can see the remainder of the **occipital** bone, which forms the floor of the cranium. Just lateral to the occipital bone you can see the **temporal** bones and a small portion of the **parietal** bones.

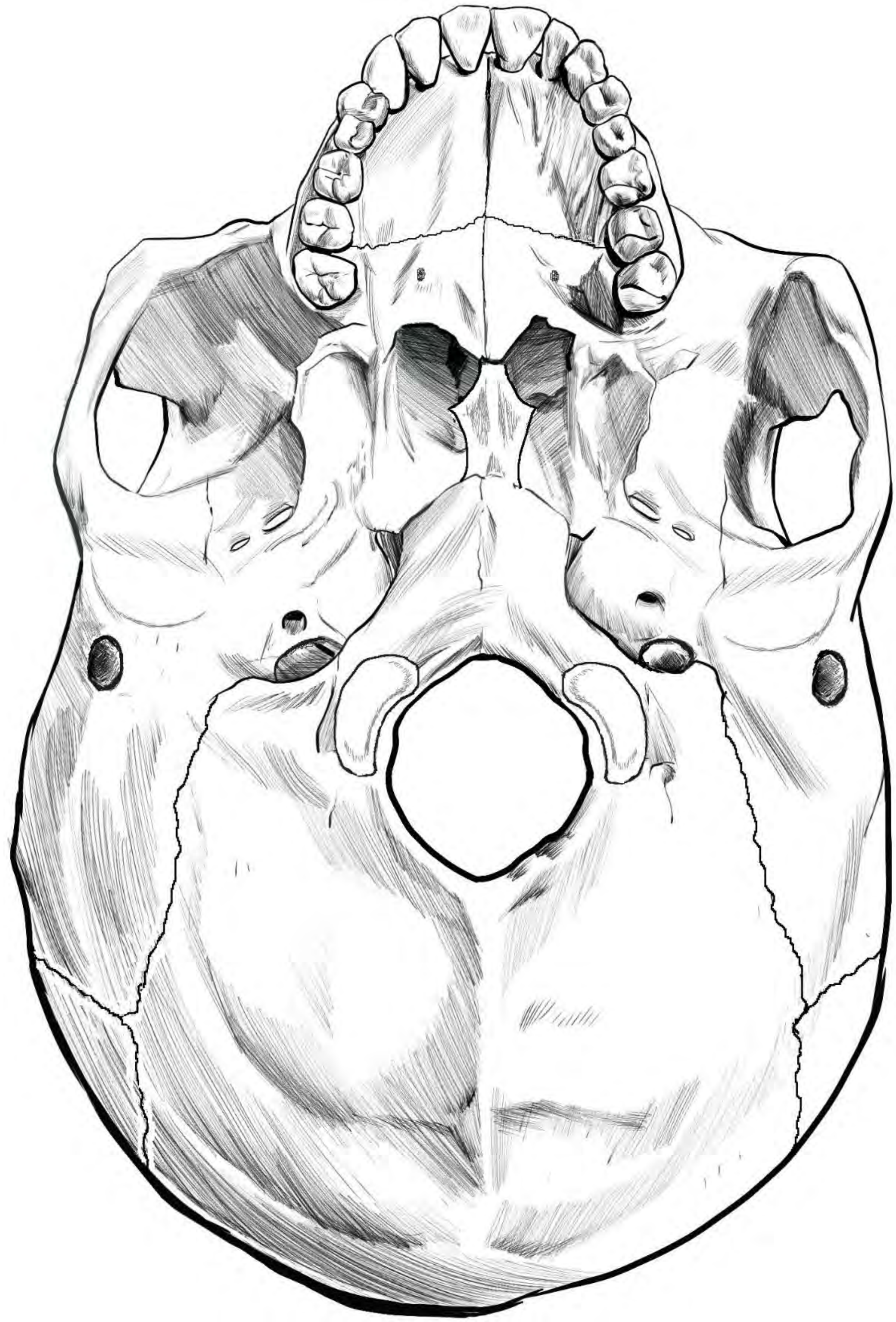
This perspective allows you to see the last of the facial bones – the **palatine** bones. These bones form the posterior part of the hard palate on the roof of the mouth. You can also see the underside of the **sphenoid** bone; this is the first perspective where the characteristic butterfly shape of this bone can be seen. In between the palatine bones and the sphenoid bone is the **vomer**. You can also see the underside of the **maxillary** bones and a small section of the **zygomatic** bones.

<u>Activity:</u>

1. Identify the bones:

☐ Maxilla	☐ Palatine	☐ Vomer
☐ Occipital	☐ Sphenoid	☐ Zygomatic
☐ Parietal	☐ Temporal	

The Skull
(Inferior View)



The Skull
(Internal View)

In this view, the top of the skull was removed so you can see into the internal chamber of the skull. This perspective provides the best view of the **ethmoid**, the small, irregularly shaped bone buried in the middle of the frontal bone. This view also shows the superior portion of the **sphenoid** bone, which, like the previous drawing, allows you to see the characteristic butterfly shape of the bone. You can also see portions of the **parietal**, **temporal** and **occipital** bones.

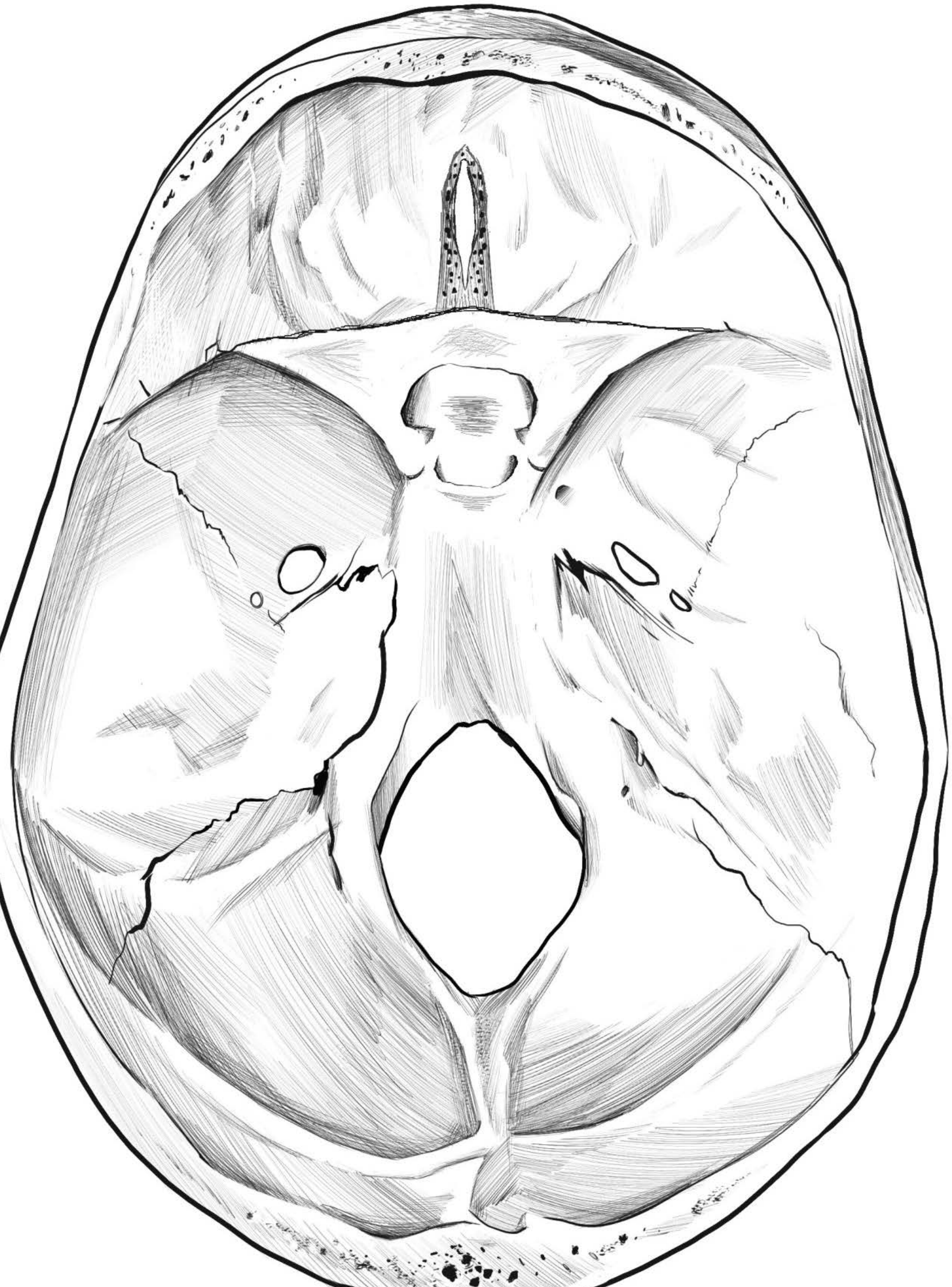
Activity:

1. Identify the bones:

☐ Ethmoid	☐ Occipital	☐ Sphenoid
☐ Frontal	☐ Parietal	☐ Temporal

The Skull

(Internal View)



The Skull
(Anterior View)

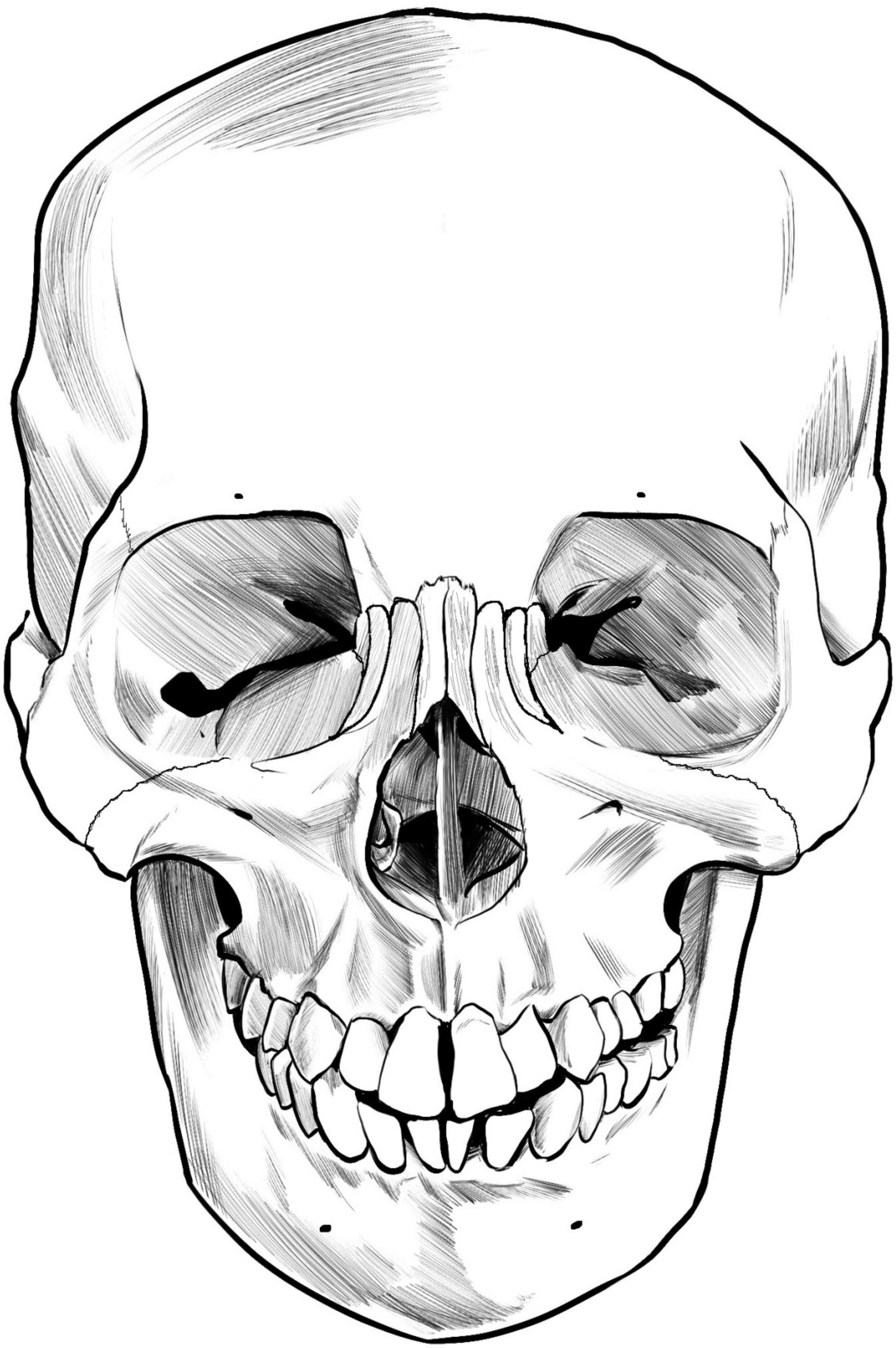
We are revisiting the anterior view of the skull to identify features of the different cranial and facial bones. The frontal bone includes a **supraorbital margin**, a ridge above the orbit that forms the eyebrow. These margins are sexually dimorphic; they are usually larger in men than in women. Features of the ethmoid bone can be seen within the nasal cavity. The **perpendicular plate** is a ridge of the bone that forms the superior portion of the nasal septum, separating the nasal cavity into its two halves. On both lateral sides of the perpendicular plate are the **middle nasal conchae**, masses that extend into the nasal cavity. The conchae are involved in warming and humidifying the air as it is breathed in; we will discuss this in further detail later. The mandible has holes called **mental foramina**, through which blood vessels and nerves pass. The teeth of both the upper and lower jaws rest in the **alveoli** of the maxilla and mandible.

Activity:

1. Identify the following bony features:

☐	Alveolar margin of mandible	☐	Middle nasal concha
☐	Alveolar margin of maxilla	☐	Perpendicular plate
☐	Mental foramen	☐	Supraorbital margin

The Skull
(Anterior View)



The Skull
(Lateral View)

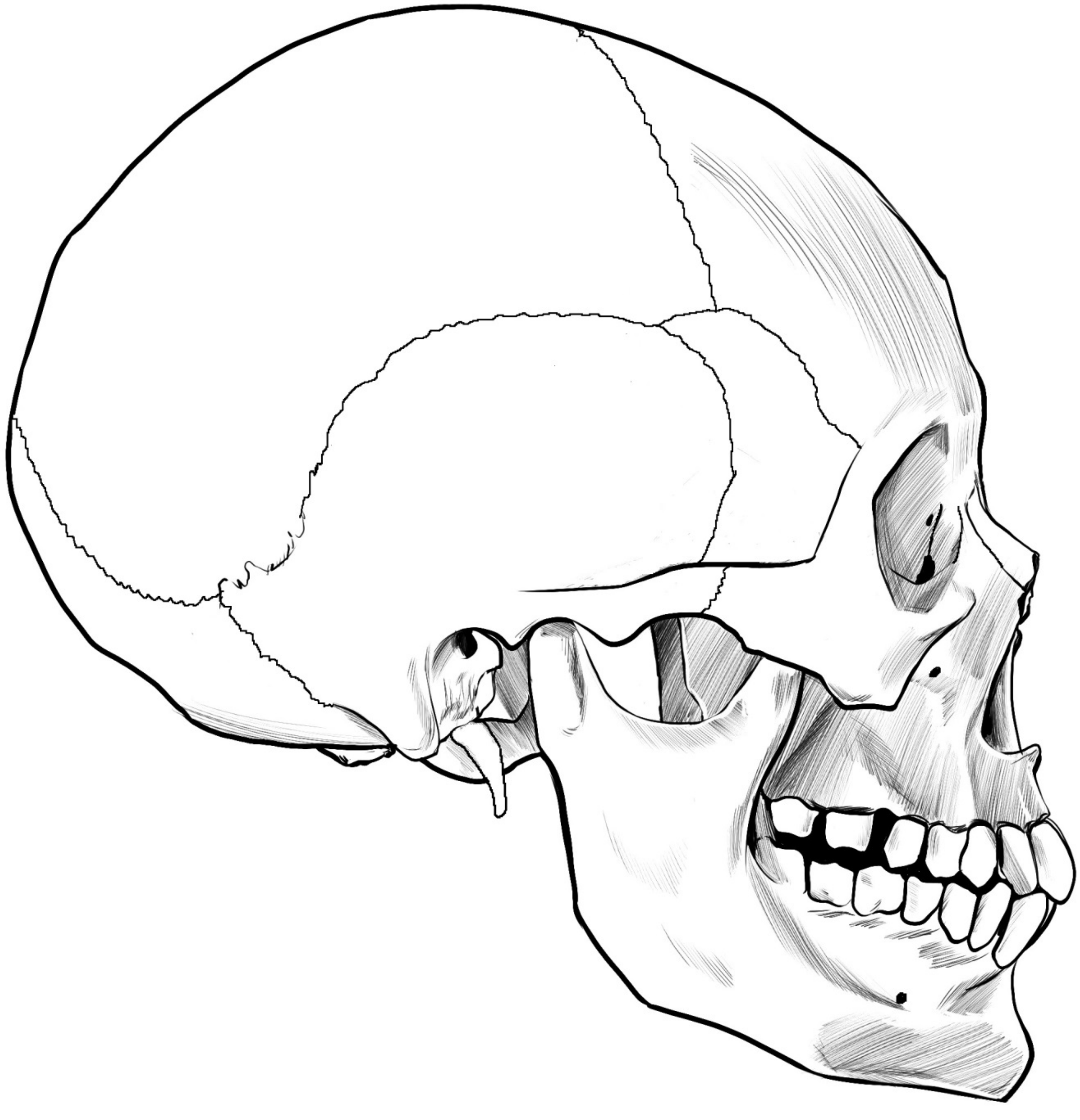
We are revisiting the lateral view of the skull to identify features of the different cranial and facial bones. Three of the skull's sutures can be seen from this perspective. The sutures are formed by articulations between the cranial bones. The **coronal suture**, which follows the coronal plane, connects the frontal bone to the parietal bones. The **squamous suture** connects the parietal and temporal bones. The **lambdoid suture** connects the parietal and occipital bones. The lacrimal bone has the **lacrimal fossa**, which is a groove that contains a lacrimal sac for draining tears into the nose. This is a landmark that can help you distinguish the lacrimal bones from the nasal and ethmoid bones. You can see the **alveolar margins** of the mandible and maxilla, where the teeth are found. Also on the mandible, the **mental foramen** can be seen, as well as the **mandibular condyle**, which articulates with the temporal bone at the jaw. This perspective allows you to see the **angle of the mandible**, another sexually dimorphic trait, which usually has a right angle in males and a more obtuse angle in females. Several features of the temporal bone can be seen from this view. The **zygomatic process** of the temporal bone articulates with the zygomatic bone, to form the **zygomatic arch**, or lateral ridge of the cheekbone. The **external acoustic meatus**, or ear canal, allows sounds waves to be transmitted toward the inner ear. The **mastoid process** is a large projection that points downward, and provides an attachment site for muscles. The **styloid process** sits anterior to the mastoid process, and is much thinner and more delicate; it also provides an attachment site for muscles.

Activity:

1. Identify the following bony features:

- ☐ Alveolar margin of mandible
- ☐ Alveolar margin of maxilla
- ☐ Coronal suture
- ☐ External acoustic meatus
- ☐ Lacrimal fossa
- ☐ Lambdoid suture
- ☐ Mandibular angle
- ☐ Mandibular condyle
- ☐ Mastoid process
- ☐ Mental foramen
- ☐ Squamous suture
- ☐ Styloid process
- ☐ Zygomatic process

The Skull
(Lateral View)



The Skull
(Posterior View)

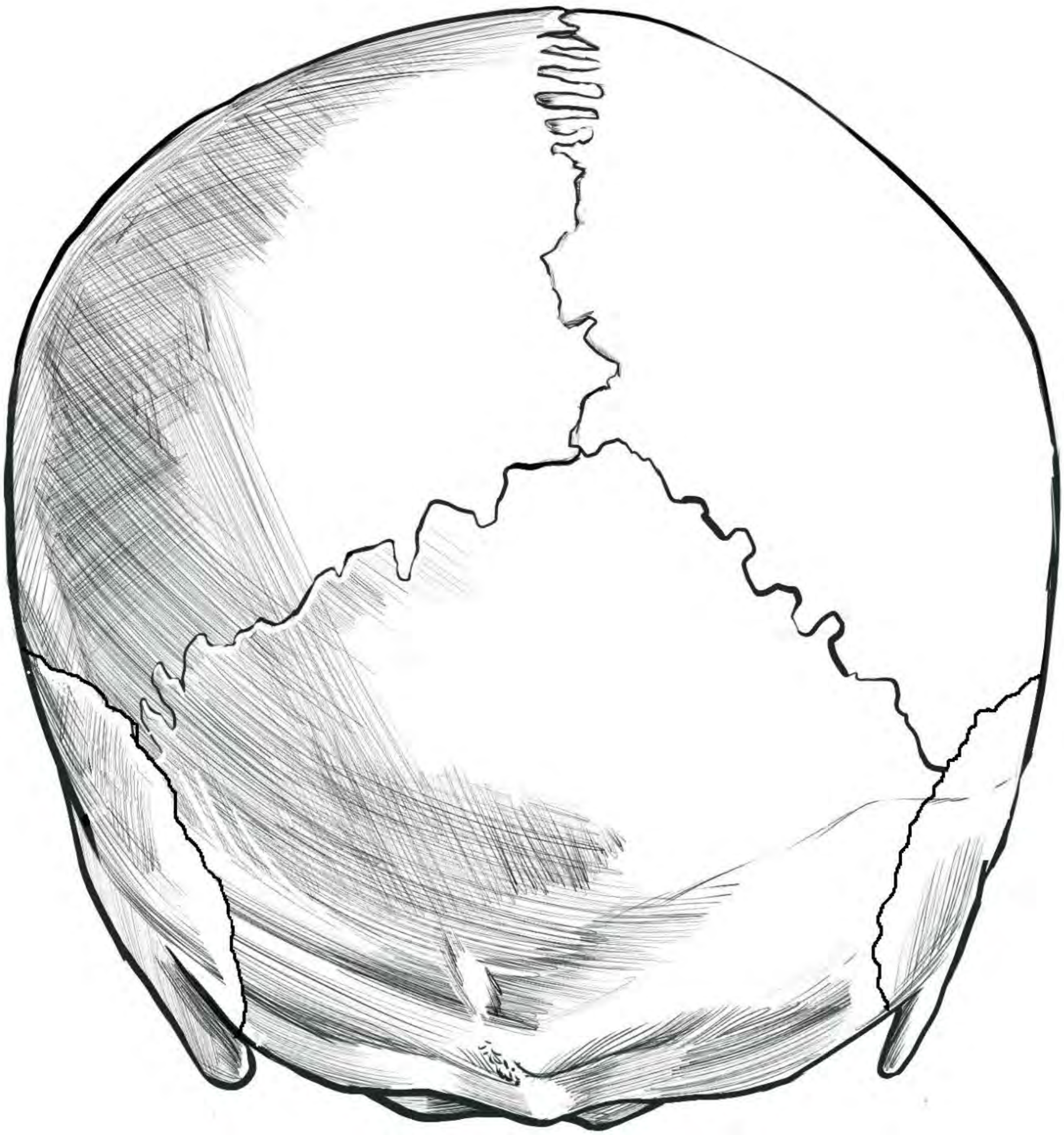
We are revisiting the posterior view of the skull to identify features of the different cranial and facial bones. Two of the sutures can be viewed from the posterior view. The **sagittal suture**, which follows the sagittal plane, connects the two parietal bones. The **lambdoid suture** connects the occipital bone to the two parietal bones; this suture is shaped like an upside down V, which is similar to the structure of the Greek letter, lamda (λ). A feature of the occipital bone can be seen from this perspective: the **external occipital protuberance**, often referred to as the inion. This bump on the back of the skull, which is an attachment site for muscles, varies in size between individuals.

<u>Activity:</u>

1. Identify the following bony features:

- ☐ External occipital protuberance
- ☐ Lambdoid suture
- ☐ Sagittal suture

The Skull
(Posterior View)



The Skull
(Inferior View)

We are revisiting the inferior view of the skull to identify features of the different cranial and facial bones. The hard palate, which separates the nasal from the oral cavity, can be viewed from the inferior perspective. Recall that the paired palatine bones form the posterior portion of the hard palate. The anterior portion is formed by the **palatine processes** of the maxillary bones. Connecting the right and left palatine processes and right and left palatine bones is the **median palatine suture**. The **zygomatic processes** and the **external acoustic meatus** of the temporal bone can be seen, as well as the **mandibular fossa**, the groove in the temporal bone that articulates with the mandibular condyle to form the temporomandibular joint (the jaw). Several features of the occipital bone can be seen, including the **external occipital protuberance**, which was previously discussed. The **foramen magnum** is a large hole that allows the spinal cord to connect to the brainstem. Just lateral to the foramen magnum are the right and left **occipital condyles**, which are convex, kidney-shaped surfaces that articulate with the first vertebra.

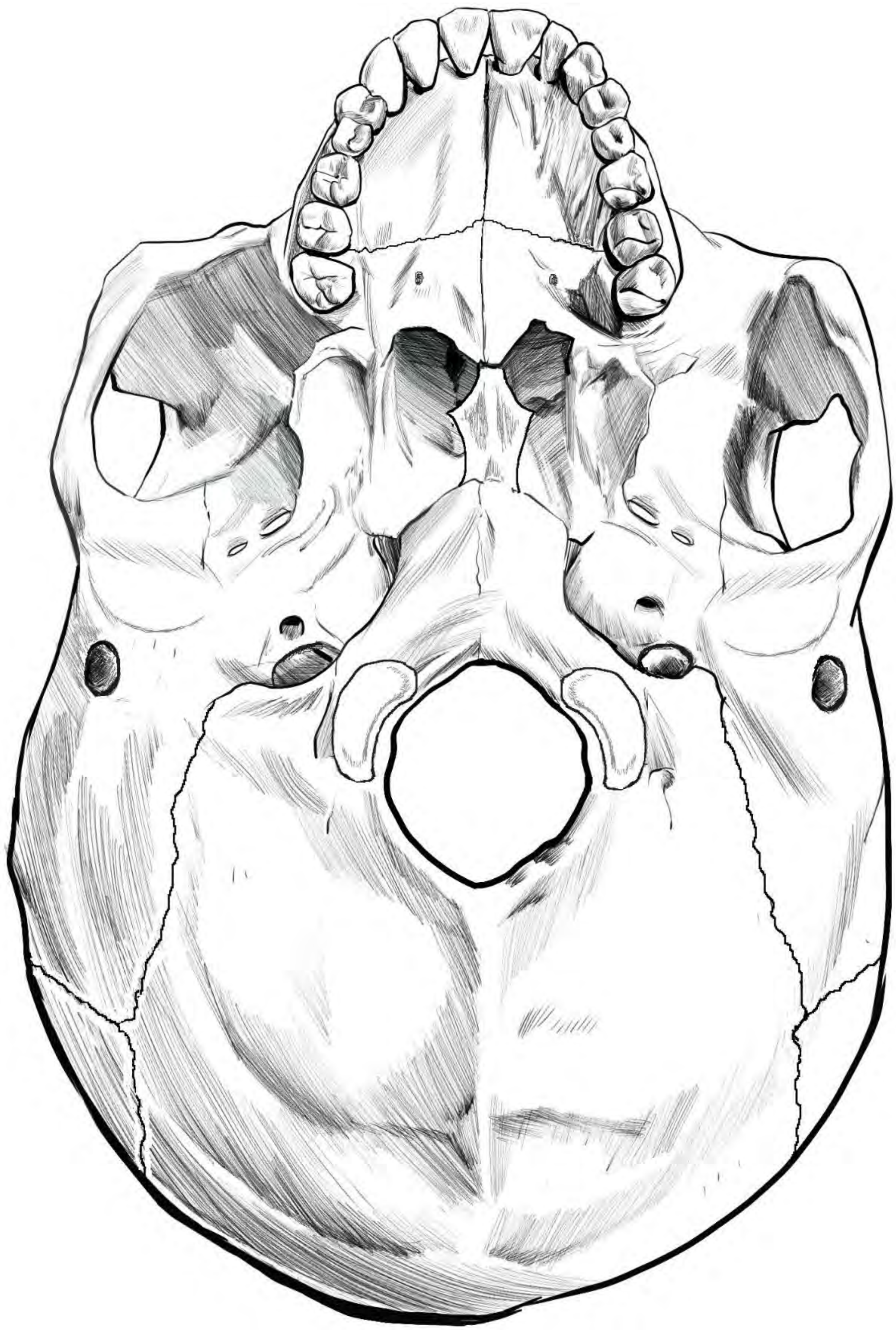
Activity:

1. Identify the following bony features:

- ☐ External acoustic meatus
- ☐ External occipital protuberance
- ☐ Foramen magnum
- ☐ Mandibular fossa
- ☐ Median palatine suture
- ☐ Occipital condyles
- ☐ Palatine process
- ☐ Zygomatic process

2. What structures form the hard palate?

The Skull
(Inferior View)



The Skull
(Internal View)

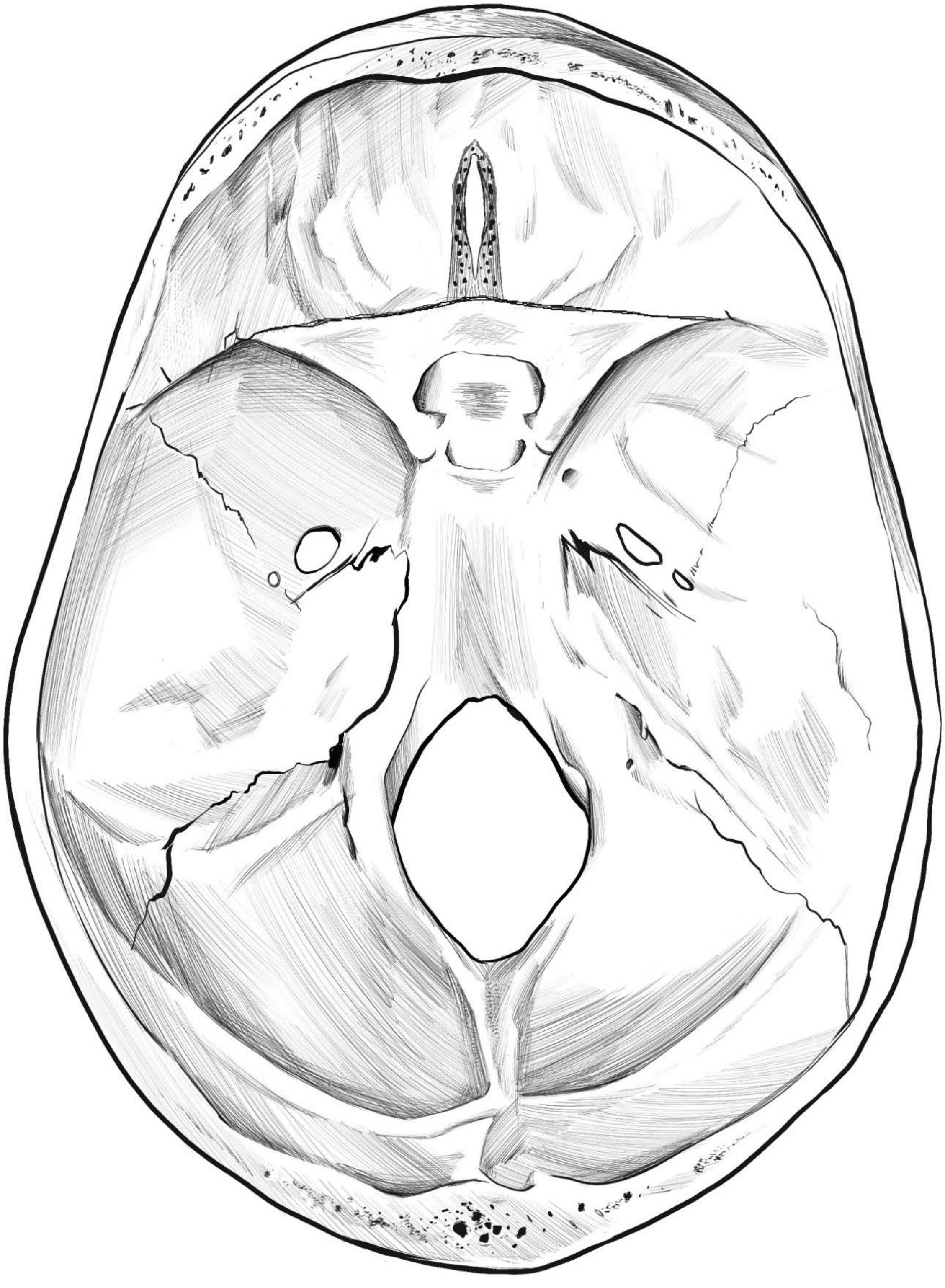
We are revisiting the internal view of the skull to identify features of the different cranial and facial bones. Features of the ethmoid bone include a central ridge, called the **crista galli**, which is an attachment site for a membrane that holds the brain in place, and a pair of plates on its lateral sides called the **cribiform plates**, which contain holes through which olfactory nerves run. The butterfly-shaped sphenoid bone has smaller, more anterior **lesser wings** and larger, most posterior **greater wings**. The body of the sphenoid bone includes the **sella turcica** ("Turkish saddle"), in which the pituitary gland rests. Two regions of the temporal bone can be identified. The **petrous portion** of the temporal bone is the hardest region of the skull and houses the tiny, delicate middle and inner ear structures that are vital for hearing and balance. Just as the temporal bone had an external acoustic meatus on its exterior surface, it has an **internal acoustic meatus** on its internal surface. Cranial nerves run though this meatus.

Activity:

1. Identify the following bony features:

- ☐ Cribiform plate
- ☐ Crista galli
- ☐ Greater wings
- ☐ Internal acoustic meatus
- ☐ Lesser wings
- ☐ Petrous portion
- ☐ Sella turcica

The Skull
(Internal View)



The Nasal Cavity

The **nasal cavity** consists of bone and cartilage lined by a mucous membrane that filters, warms and humidifies the air before it enters the lungs. Above the nasal cavity is the cribiform plate, which supports the olfactory nerves. Below is the hard palate, which separates the nasal from the oral cavity. Behind the nasal cavity is the sphenoid bone. Surrounding the cavity in adults are the paranasal sinuses, which are cavities within skull bones that are lined by the same mucous membrane. The sinuses are named: **frontal, sphenoid, maxillary and ethmoid sinuses.** The latter two cannot be seen on this image.

The first image, of the lateral walls of the nasal cavity, allows you to see the nasal conchae. The **superior and middle nasal conchae** are features of the ethmoid bone. The **inferior nasal concha** is a separate bone. Each concha has a corresponding groove underneath it: **superior, middle and inferior nasal meatus**. These structures act as turbinates, causing the air to swirl around as it is being humidified and warmed.

The second image is of the **nasal septum**, which separates the nasal cavity into right and left halves. It is mostly composed of bone, but has cartilage as well to give it some flexibility. The top portion of the septum is formed by the **perpendicular plate** of the ethmoid bone. The bottom portion is formed by the **vomer**. In between these two bones is the **septal cartilage**, composed of hyaline cartilage. Two of the paranasal sinuses can also be seen on this image. The **frontal sinus** is superior and anterior to the perpendicular plate; whereas the **sphenoid sinus** is posterior to the septum.

Activity:

1. Identify the parts of the nasal cavity:

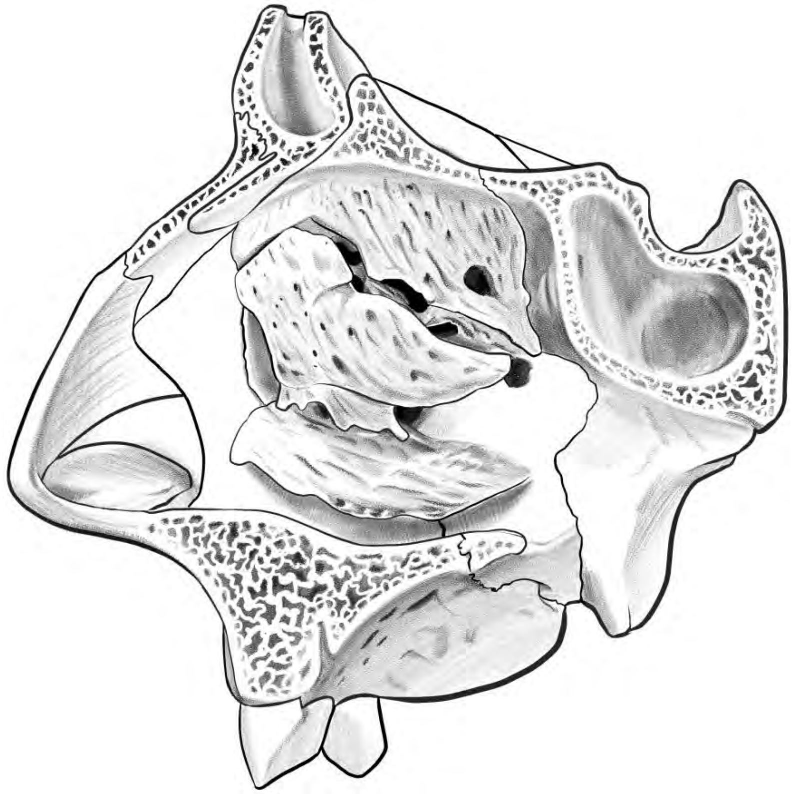
☐ Frontal sinus	☐ Middle nasal concha
☐ Inferior meatus	☐ Sphenoid sinus
☐ Inferior nasal concha	☐ Superior meatus
☐ Middle meatus	☐ Superior nasal concha

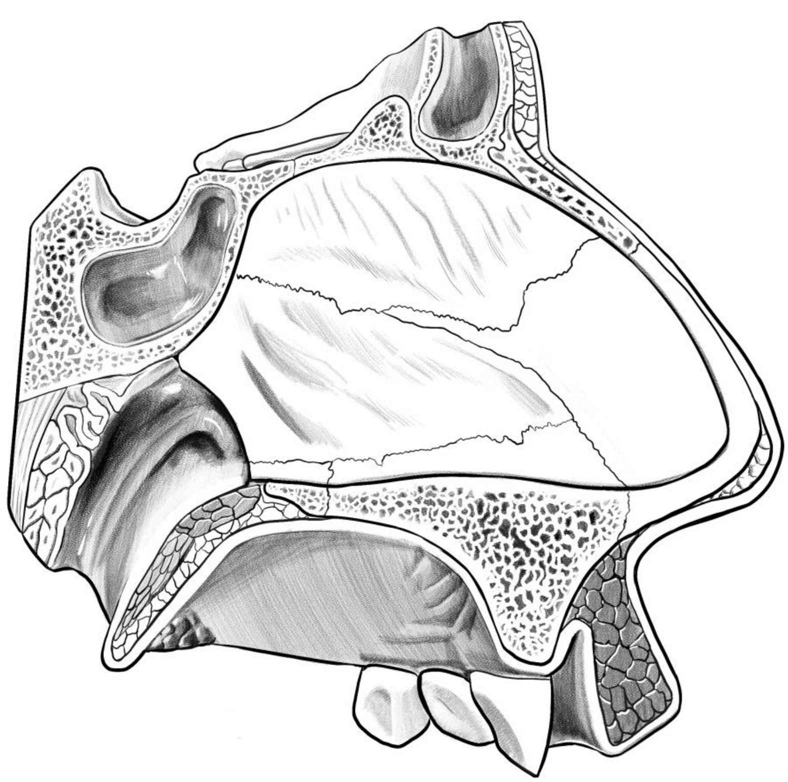
2. Identify the parts of the nasal septum:

☐ Frontal sinus	☐ Sphenoid sinus
☐ Perpendicular plate	☐ Vomer
☐ Septal cartilage	

3. Besides the two sinuses listed above, what are the other paranasal sinuses?

The Nasal Cavity





The Orbit

The **orbits** house the eyes. Seven different bones contribute to the orbit. The superior orbit is formed by the **frontal** bone. The lateral orbit is formed by the **zygomatic** bone. The base of the orbit is formed by the **maxillae** and **palatine** bones. The medial orbit is formed by the **lacrimal** and **ethmoid** bones. The posterior of the orbit is formed by the **sphenoid** bone.

Activity:

1. Identify the following bones of the orbit:

☐	Ethmoid	☐	Palatine
☐	Frontal	☐	Sphenoid
☐	Lacrimal	☐	Zygomatic
☐	Maxilla		

The Orbit

The Typical Vertebra
(Superior and Lateral Views)

This image will allow you to study the features of a typical vertebra. Once you have an understanding of general characteristics, you will learn about the unique characteristics associated with each type of vertebra.

Vertebrae have two basic parts which surround a hole in the center called the **vertebral foramen**; the spinal cord runs through this foramen. The anterior portion of the vertebra is the **body**, which bears the most weight, and is therefore the largest part. **Intervertebral discs**, with their tough outer **annulus fibrous** and gelatinous inner **nucleus pulposus**, rest between the bodies of the vertebrae, absorbing shock. The remainder of the vertebra is the **vertebral arch**, which includes several regions. The most lateral parts, extending to the right and left, are the **transverse processes**. The **pedicles** connect the transverse processes to the body. The most posterior region of the vertebra is the **spinous process**, which provides an attachment site for muscles and can be felt as you run your fingers down the spine. The **laminae** connect the spinous process to the transverse processes. **Superior articular processes and facets** are located on the top surface of the vertebra, at the points where the laminae and pedicles meet; there are also **inferior articular processes and facets** on the inferior surface. The superior facet articulates with the inferior facet of the vertebra just above it; the inferior facet articulates with the superior facet of the vertebra just below it.

When the vertebral column is viewed from the side, you can see **intervertebral foramina**, which form from notches on the superior and inferior surfaces of the pedicles. Spinal nerves run through these foramina.

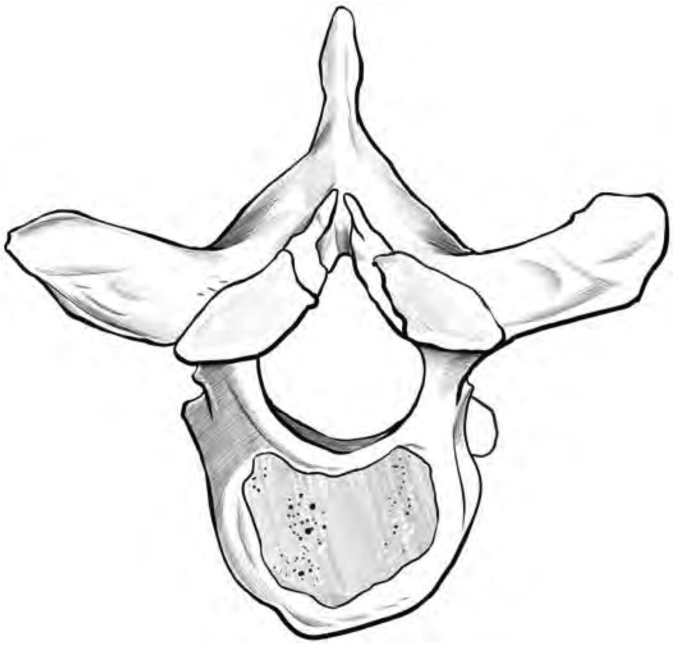
<u>Activity:</u>

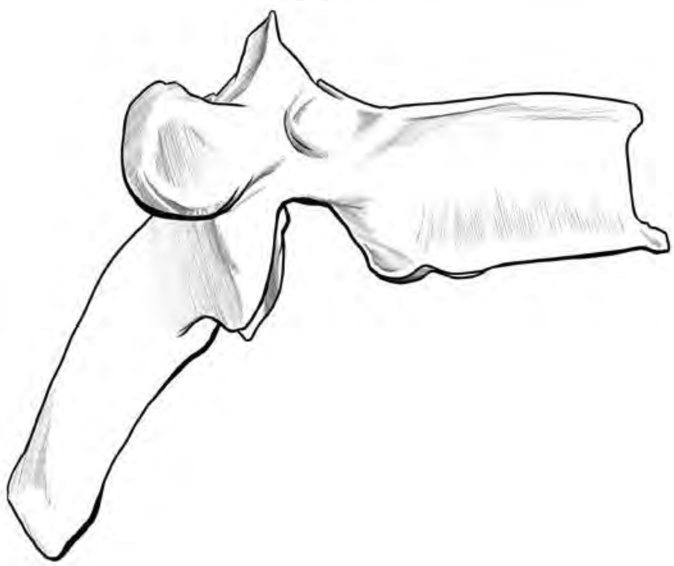
1. Identify the following bony features:

- ☐ Body
- ☐ Inferior articular process and facet
- ☐ Intervertebral foramen
- ☐ Lamina
- ☐ Pedicle
- ☐ Spinous process
- ☐ Superior articular process and facet
- ☐ Transverse process
- ☐ Vertebral arch
- ☐ Vertebral foramen

Mnemonic for regions:
Blood Pressure Tests (are) Life Saving

The Typical Vertebra
(Superior and Lateral Views)





The Vertebral Column
(Lateral View)

The **vertebral column** extends from the skull to the pelvis, and houses and protects the spinal cord. This image is showing the vertebral column from the lateral perspective; the anterior surface is on the left side of the image, and the posterior surface is on the right side of the image. It is composed of 26 bones that are separated by fibrocartilaginous discs called **intervertebral discs**, which act as shock absorbers.

There are five different regions of the vertebral column, each with vertebrae that have distinct morphological traits that will be discussed shortly. The column begins with seven **cervical** vertebrae in the neck region, then 12 **thoracic** vertebrae through the thorax, and then five **lumbar** vertebrae in the lower back. Below the lumbar vertebrae are five fused vertebrae, collectively referred to as the **sacrum**; the sacrum forms the posterior region of the pelvis. The inferior-most region of the vertebral column is the **coccyx**, which is composed of three to five fused vertebrae; this area is commonly referred to as the tail bone, and is a vestige from development.

The lateral perspective allows you to see the curvatures of the spine. The **cervical curvature** is concave; the **thoracic curvature** is convex; the **lumbar curvature** is concave; and the **sacral curvature** is convex. These curvatures give the spinal column a characteristic S shape, and provide flexibility during walking. Babies are born with thoracic and sacral curvatures; these curvatures are referred to as primary curvatures. The cervical curvature develops once we learn how to hold our head up. The lumbar curvature develops once we learn how to walk. The latter two curvatures are therefore referred to as secondary curvatures.

Activity:

1. Identify the following structures:

☐ Cervical curvature	☐ Lumbar curvature	☐ Sacrum
☐ Cervical vertebrae	☐ Lumbar vertebrae	☐ Thoracic curvature
☐ Coccyx	☐ Sacral curvature	☐ Thoracic vertebrae

2. How many vertebrae are there within each type listed above?
3. What is the purpose of the intervertebral discs?
4. What is the purpose of the spinal curvatures? Which are primary? Which are secondary and what makes them secondary?

The Vertebral Column
(Lateral View)

Atlas and Axis
(Superior View)

Recall that there are seven cervical vertebrae, numbered C1-C7, in the neck region of the vertebral column. These are the smallest of all the vertebrae because the bear the least amount of weight. The first two cervical vertebrae are worth special attention because they have unique features.

C1, also called **atlas**, articulates with the skull. It lacks the structures found in a typical vertebra, including a body and spinous process. Instead, there is an **anterior arch** and a **posterior arch** surrounding the **vertebral foramen**, which is very large to accommodate the spinal cord that is wide at this point. The **superior articular facets** articulate with the occipital condyles, allowing for flexion and extension of the head like nodding "yes". The **inferior articular facets** articulate with C2. There are short **transverse processes**, with small holes in them called **transverse foramina**, through which the vertebral arteries pass.

C2, also called **axis**, articulates with atlas. Unlike atlas, axis does include all the typical vertebral features. Its transverse processes also include transverse foramina (as do all cervical vertebrae). On the superior surface of the body is the **dens**, also called the odontoid process, which fits into the anterior arch of atlas and allows us to rotate our head from side to side as if nodding "no". Note that because atlas lacks a body, there is no intervertebral disc between atlas and axis.

<u>Activity:</u>

1. Be able to identify atlas and axis and distinguish them from other cervical vertebrae.
2. Identify the following bony features of atlas:

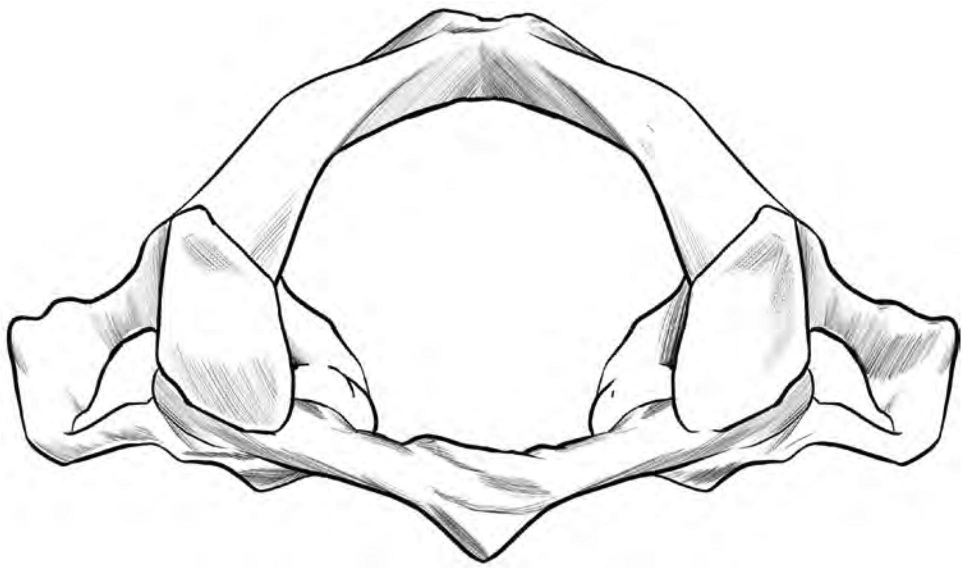
- ☐ Anterior arch
- ☐ Posterior arch
- ☐ Superior articular facet
- ☐ Transverse foramen
- ☐ Transverse process
- ☐ Vertebral foramen

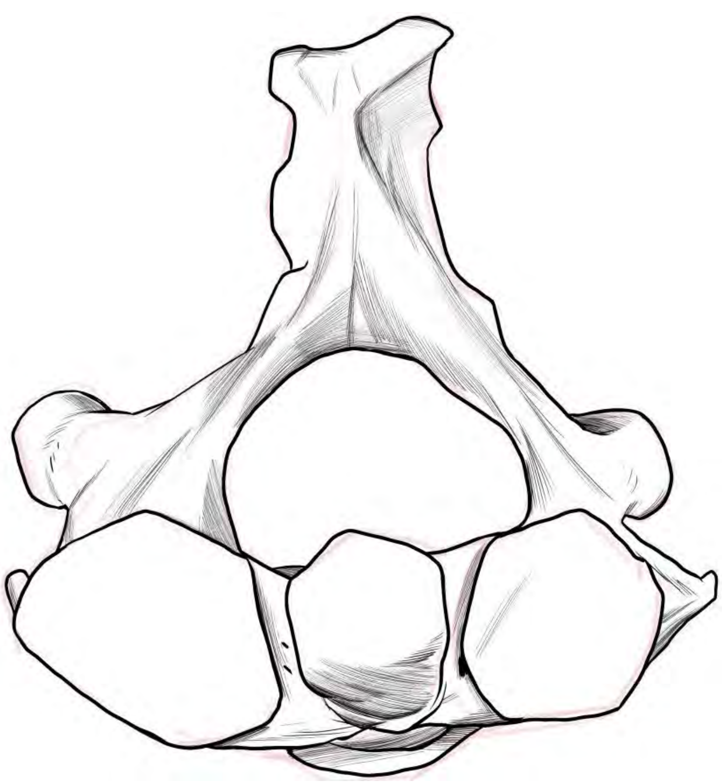
3. Identify the following bony features of axis:

- ☐ Body
- ☐ Dens
- ☐ Spinous process
- ☐ Superior articular facet
- ☐ Transverse process
- ☐ Vertebral foramen

Atlas and Axis

(Superior View)





Cervical Vertebra
(Superior View)

This image is showing the typical structure of the remaining **cervical vertebrae** (C3-C7). They have all the typical regions of the vertebra, including a body, and transverse and spinal processes.

Recall that the cervical vertebrae are the smallest of all the vertebrae because they bear the least weight. There are some other distinguishing features. The **spinous processes** of C3-C6, which are short, are **bifurcated** as a result of muscles of the neck pulling the bone into a V shape. The vertebral foramen is large to fit the spinal cord, which is still wide at this point. As we saw with atlas and axis, the **transverse processes** all contain **transverse foramina** to accommodate the vertebral arteries that supply the brain.

C7 has a particularly long, non-bifid, spinous process, which can be felt; it is referred to as the **vertebra prominens**.

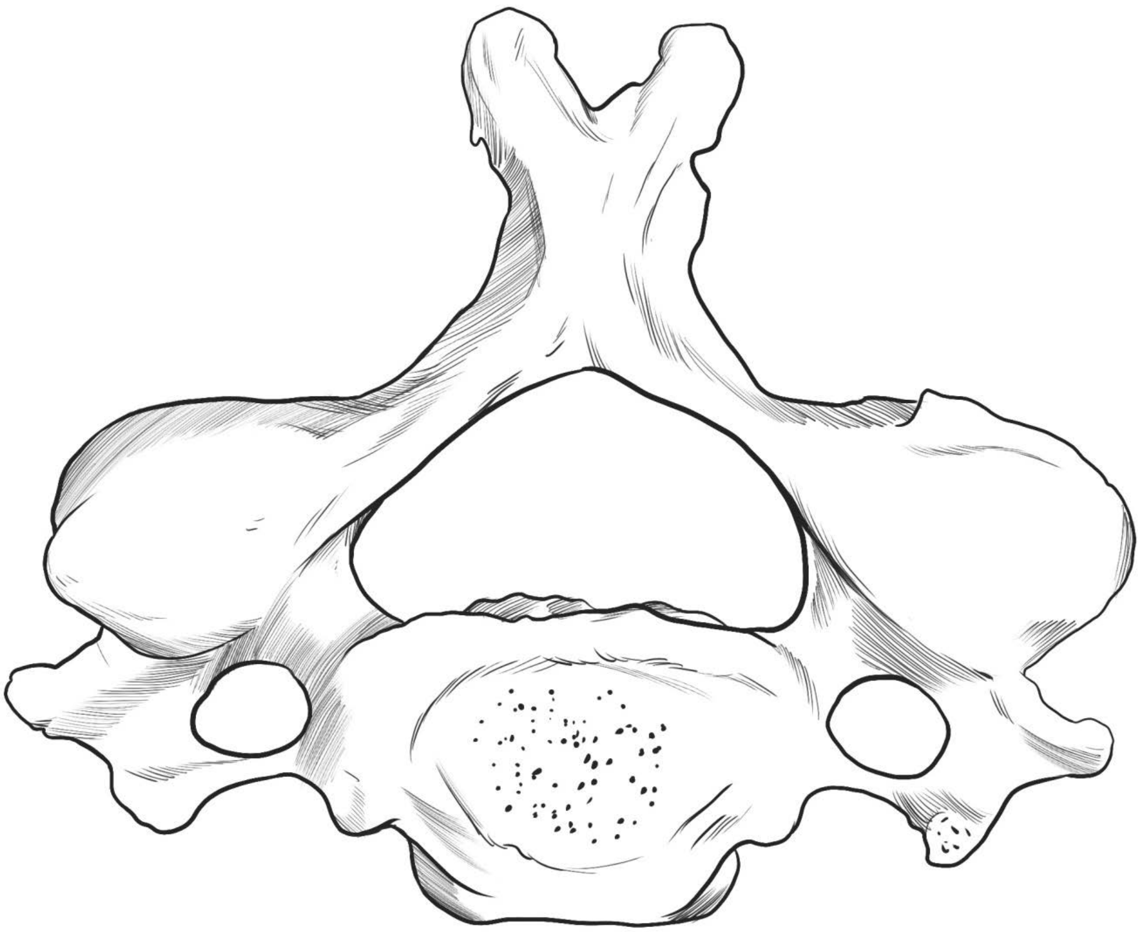
<u>Activity:</u>

1. Be able to distinguish cervical vertebrae from thoracic and lumbar.
2. Identify the following features:

☐	Bifid spinous process	☐	Transverse foramen
☐	Body	☐	Transverse process
☐	Superior articular facet	☐	Vertebral foramen

3. Which vertebra is considered vertebra prominens, and why?

Cervical Vertebra
(Superior View)



Thoracic Vertebra
(Superior and Lateral Views)

There are twelve **thoracic vertebrae**, numbered T1-T12. Thoracic vertebrae have all the features of a typical vertebra: **body**, **pedicles**, **transverse processes**, **laminae**, and a **spinous process** surrounding a **vertebral foramen**. The spinous process is long, and points downward. Note that the spinal cord is getting progressively smaller and the vertebral foramen is also getting progressively smaller. **Superior and inferior articular facets** allow the thoracic vertebrae to articulate with the vertebrae above and below them.

Thoracic vertebrae articulate with the ribs, and therefore have structural modifications to accommodate that purpose. On the lateral side of the body, you can see **superior and inferior costal facets.** These tiny facets allow the thoracic vertebrae to articulate with the head of the rib. The transverse processes of T1-T10 also have **transverse costal facets**, which articulate with the tubercle of the rib.

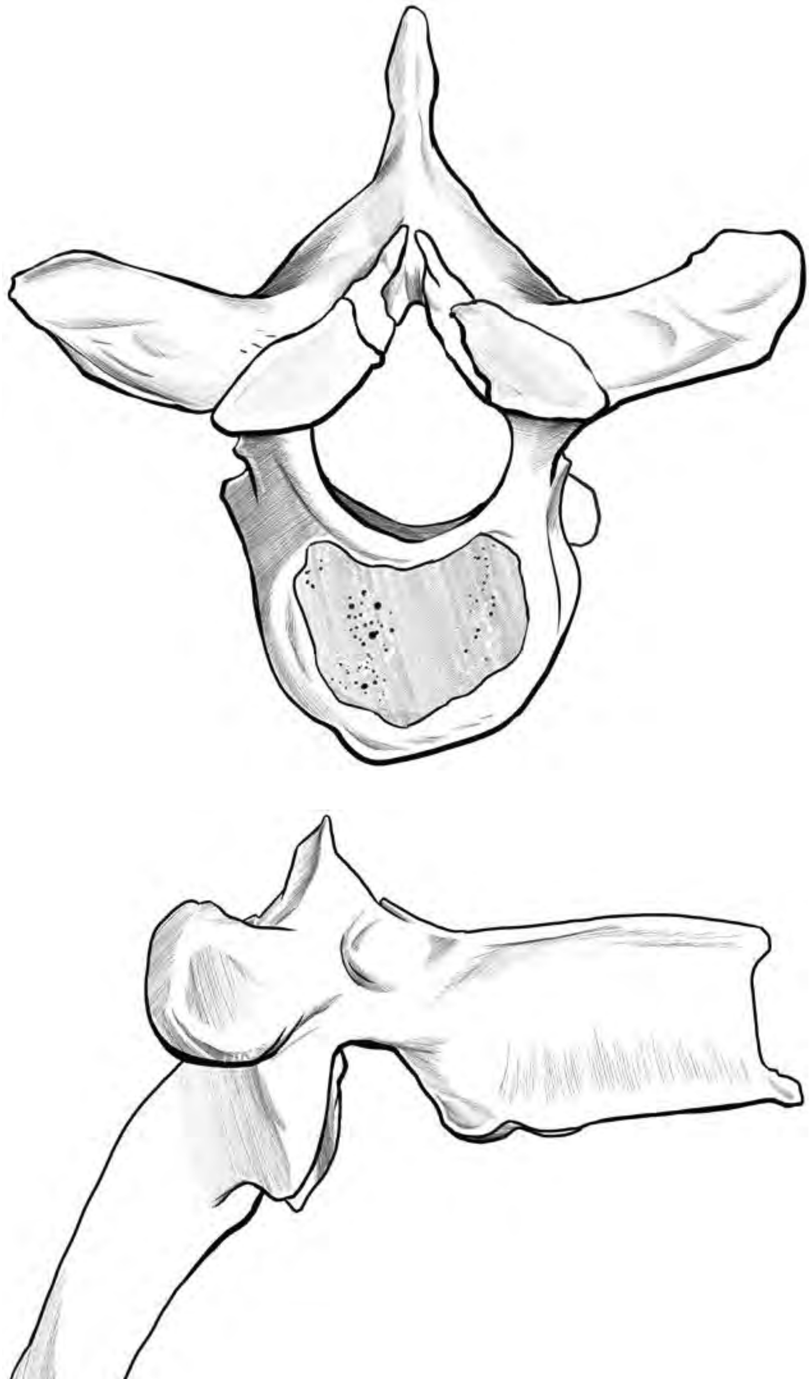
<u>Activity:</u>

1. Be able to distinguish thoracic vertebrae from cervical and lumbar.
2. Identify the following bony features:

☐	Body	☐	Superior costal facet
☐	Inferior costal facet	☐	Transverse costal facet
☐	Spinous process	☐	Transverse process
☐	Superior articular facet	☐	Vertebral foramen

3. What bones articulate with the costal facets?
4. What bones articulate with the articular facets?

Thoracic Vertebra
(Superior and Lateral Views)



Lumbar Vertebra

(Superior View)

There are five **lumbar vertebrae** in the lower back, numbered L1-L5. These are the largest of all the vertebrae because they bear the most weight. They include all the features of a typical vertebra. The **body** is large. The **transverse processes** are short and point straight to the side. The **spinous process** is short, thick, and straight. The **vertebral foramen** is small and triangle-shaped.

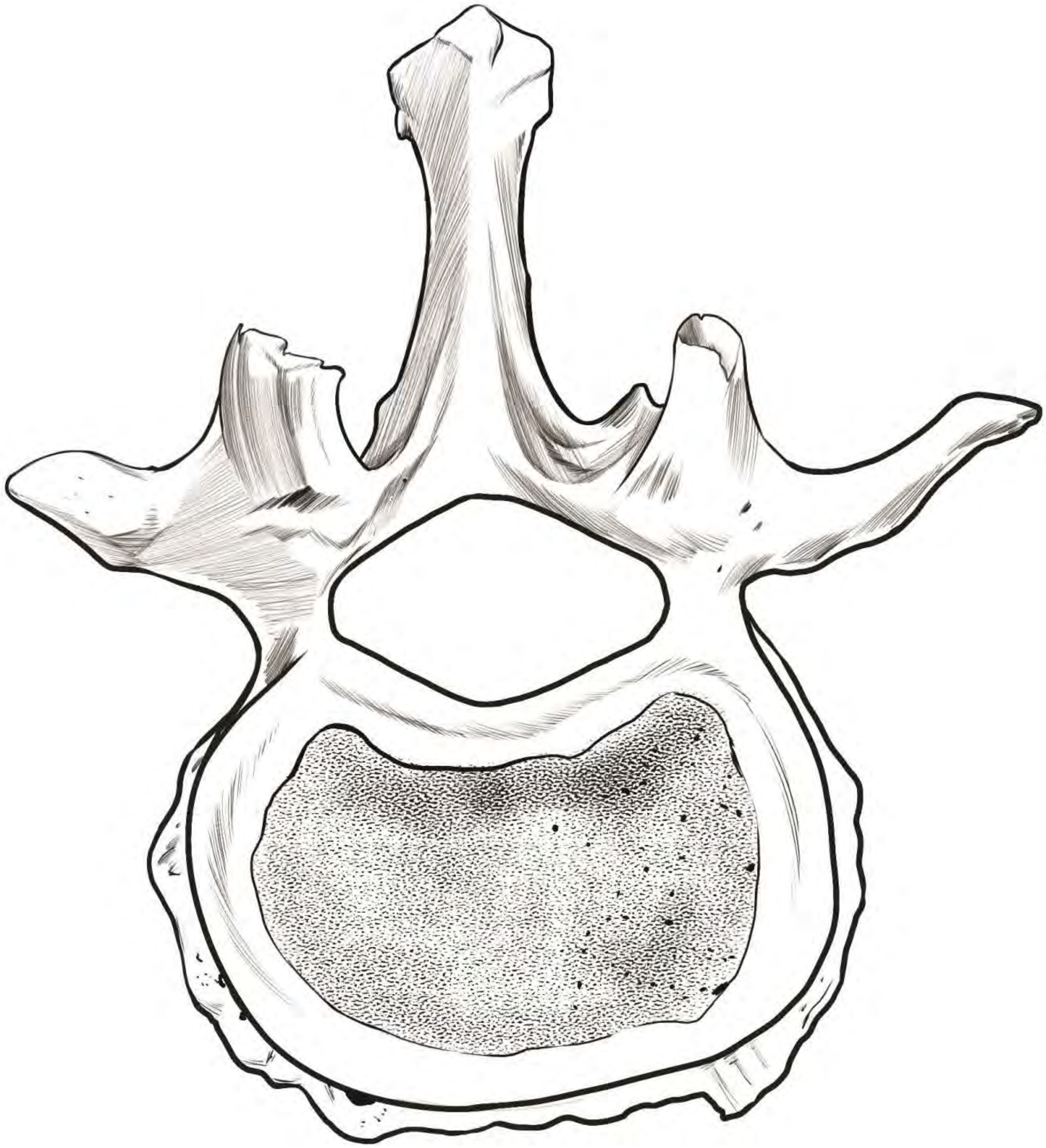
Activity:

1. Be able to distinguish lumbar vertebrae from cervical and thoracic.
2. Identify the following bony features:

☐	Body	☐	Transverse process
☐	Spinous process	☐	Vertebral foramen
☐	Superior articular facet		

Lumbar Vertebra

(Superior View)



Sacrum and Coccyx
(Anterior View)

The **sacrum** is created as a result of the fusion of five vertebrae; these vertebrae fuse by the time you are about 30 years old. The sacrum articulates with the fifth lumbar vertebra superiorly and the coccyx inferiorly. Laterally, the sacrum articulates with the two coxal bones (hip bones, to be discussed shortly). It forms the posterior wall of the pelvis. On the superior surface are **superior articular processes**, which articulate with the inferior articular processes of the fifth lumbar vertebra. There are four pairs of holes, called **sacral foramina**, through which nerves pass.

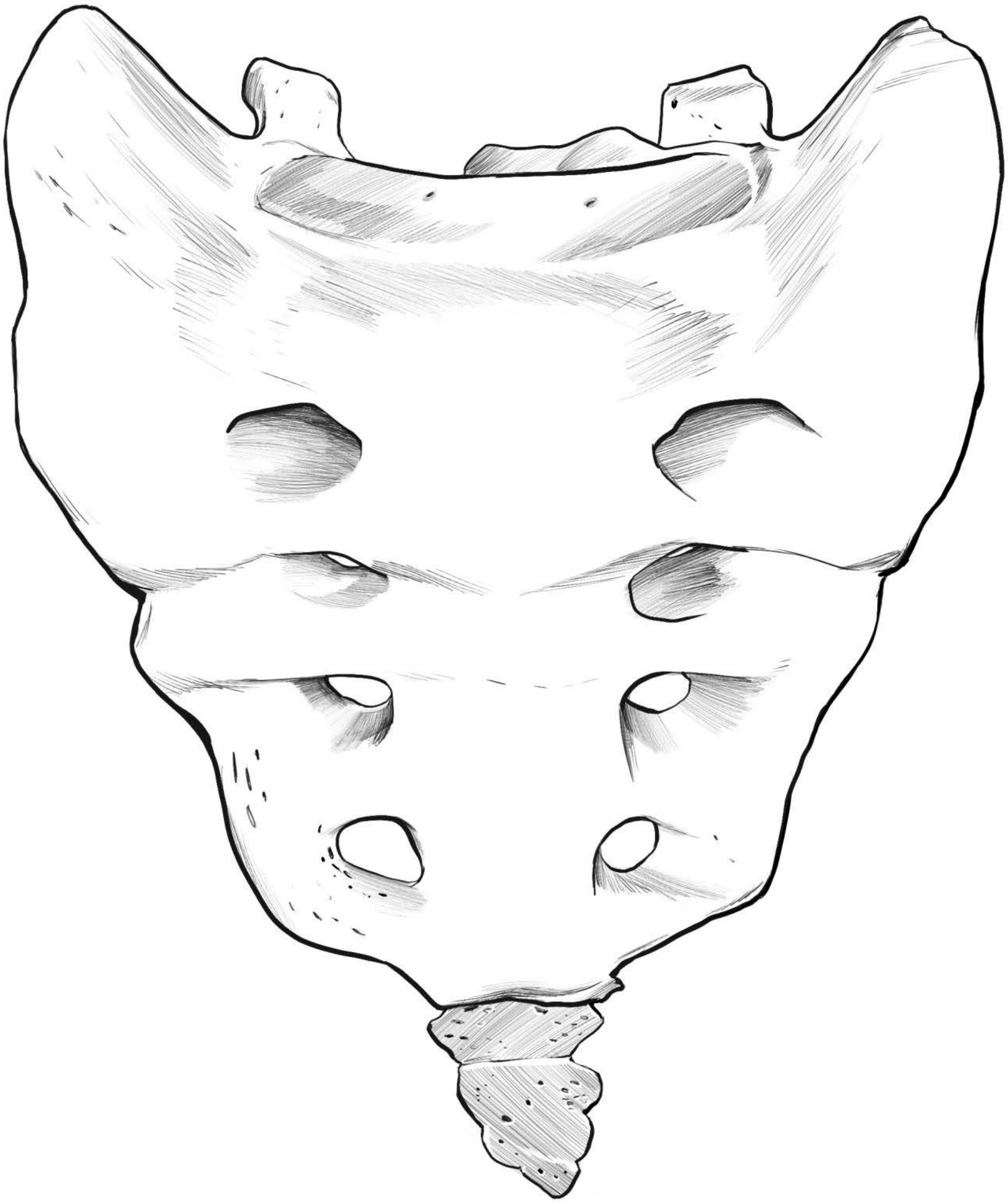
The **coccyx**, often referred to as the tail bone, is the most inferior region of the vertebral column. Three to five vertebrae, which may or may not fuse together, form the coccyx. All vertebrate embryos have a tail during the very early stages of development. As differentiation occurs, humans' tails degenerate and all that remains is the coccyx. It serves no practical purpose, other than to provide at attachment site for a ligament called the filum terminale which holds the spinal cord in place.

Activity:

1. Identify the following bony features:

☐ Coccyx	☐ Sacrum
☐ Sacral foramina	☐ Superior articular processes

Sacrum and Coccyx
(Anterior View)



The Thoracic Cage
(Anterior View)

The heart and lungs are protected within the **thoracic cage**, colloquially referred to as the rib cage. It is composed of bone and cartilage. Anteriorly, it is formed by the **sternum**. Posteriorly, it includes the twelve **thoracic vertebrae**. Between the vertebrae and the sternum are twelve pairs of **ribs** and **costal cartilage**. The costal cartilage, composed of hyaline cartilage, gives the thoracic cage flexibility to change volume during breathing. The ribs are numbered 1-12. The first 7 ribs are considered **true ribs**; the costal cartilage of these ribs attach directly to the sternum. Ribs 8-12 are considered **false ribs**; either their costal cartilage attaches to the sternum indirectly, or the ribs lack costal cartilage and an anterior attachment point altogether. Ribs 11 and 12 fall into that last category; therefore they are also referred to as **floating ribs**. The **costal margin**, the lower edge of the thoracic cage, is created by the costal cartilages of ribs 7-10. This margin can be felt.

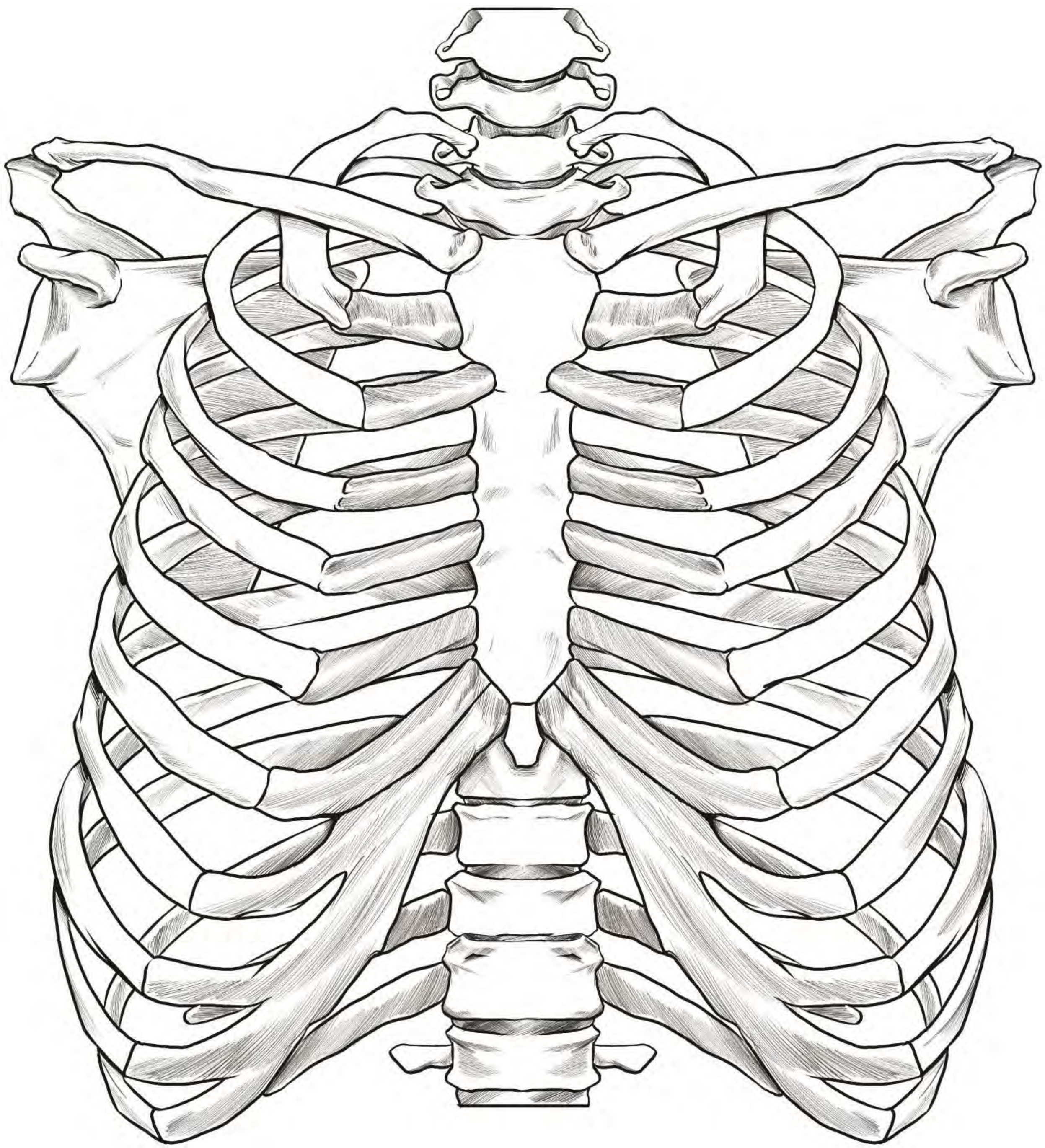
Activity:

1. Identify the following structures:

☐ Costal cartilage	☐ Sternum
☐ Costal margin	☐ Thoracic vertebrae
☐ False ribs	☐ True ribs
☐ Floating ribs	

2. Why doesn't the bone of the rib attach directly to the sternum?
3. How many true ribs are there?
4. How many false ribs are there?
5. What makes a rib "true" versus "false"?
6. How many floating ribs are there?
7. What makes a rib a "floating" rib?

The Thoracic Cage
(Anterior View)



The Rib
(Posterior View)

Recall that the **rib** articulates with the thoracic vertebrae posteriorly and the sternum via costal cartilage anteriorly (except for ribs 11 and 12, the floating ribs, which have no anterior attachment point). The **head** of the rib articulates with the superior and inferior costal facets of the body of the thoracic vertebrae, at the junction point where two vertebrae stack on top of one another. There are two small **articular facets**, one that articulates with the superior vertebra, and the other that articulates with the inferior vertebra. Just past the head is the **neck**. After the neck there is a small protuberance called the **tubercle**, which articulates with the transverse process of the vertebrae. The **shaft** of the rib forms a sharp angle as it curves around from the posterior of the thorax to the anterior. There is a groove on the inferior portion of the shaft, called the **costal groove**, through which nerves and vessels run. The sternal end of the rib is flat, and provides an attachment site for costal cartilage.

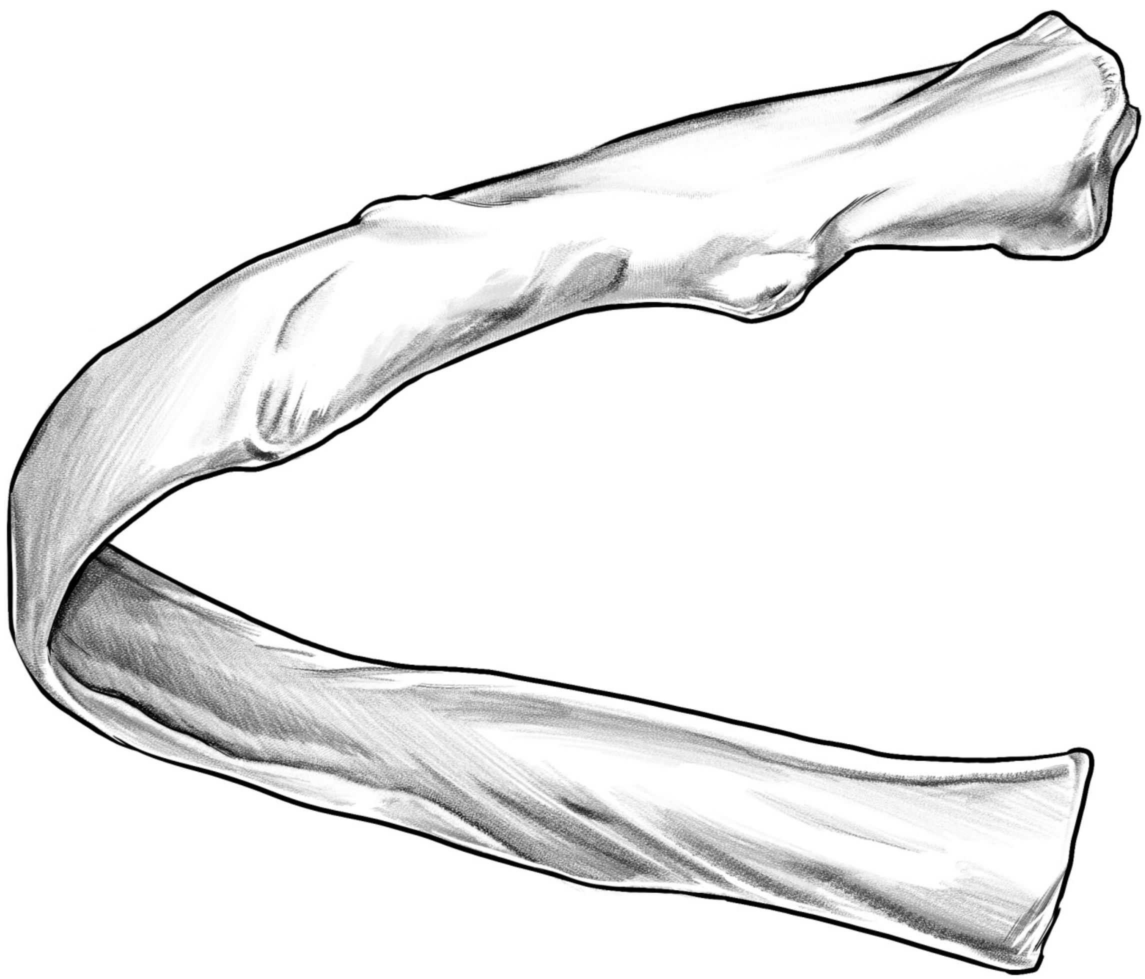
Activity:

1. Identify the following bony features:

☐ Articular facets	☐ Neck
☐ Costal groove	☐ Shaft
☐ Head	☐ Tubercle

2. Be able to distinguish right from left.

The Rib
(Posterior View)



The Sternum
(Anterior View)

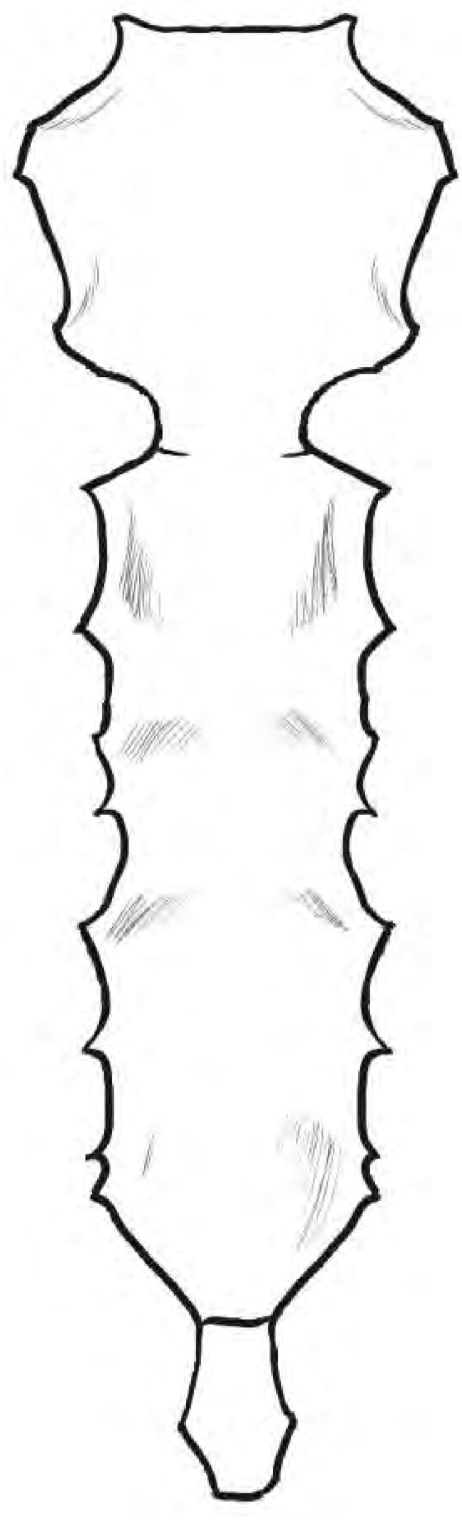
The **sternum** is commonly referred to as the breast bone. It is found in the center of the anterior side of the thoracic cage, and protects the heart. There are three sections to the sternum. The superior-most region is the **manubrium**, which is shaped like a quadrangle. It articulates with the clavicles at the right and left **clavicular notches**, which are located near the top of the manubrium. It also articulates with the first costal cartilage at its base. At the top of the manubrium is another notch, called the **jugular notch** (also called suprasternal notch). This landmark can easily be felt. At its base, the manubrium has a ridge called the **sternal angle**, which is created when the manubrium connects to the **body**. The costal cartilage of the second rib joins at the sternal angle as well. The body extends from the second rib to about the fifth rib. It articulates with the remaining costal cartilages. At its distal end, it forms the xiphisternal joint with the **xiphoid process**, the final region of the sternum. This part of the sternum is shaped like an arrow-head, and remains in its cartilage state until about 40 years of age.

<u>Activity:</u>

1. Identify the following features:

☐	Body	☐	Manubrium
☐	Clavicular notches	☐	Sternal angle
☐	Jugular notch	☐	Xiphoid process

The Sternum
(Anterior View)



The Clavicle
(Superior and Inferior Views)

The appendicular skeleton includes all of the bones that form the upper and lower appendages. The upper appendage begins at the pectoral girdle (the shoulder), which includes the clavicle and the scapula.

The **clavicle** is commonly referred to as the collarbone. It is an S-shaped bone that attaches the upper limb to the trunk. The **sternal end** attaches medially to the manubrium of the sternum. The **acromial end** attaches laterally to the acromion of the scapula. The superior surface of the clavicle is smooth, but the inferior surface has the **conoid tubercle**, a cone-shaped attachment site for the conoid ligament.

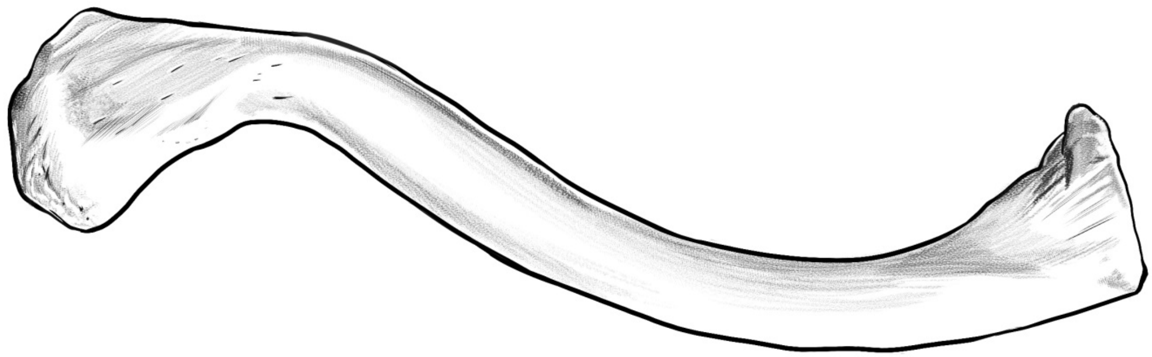
Activity:

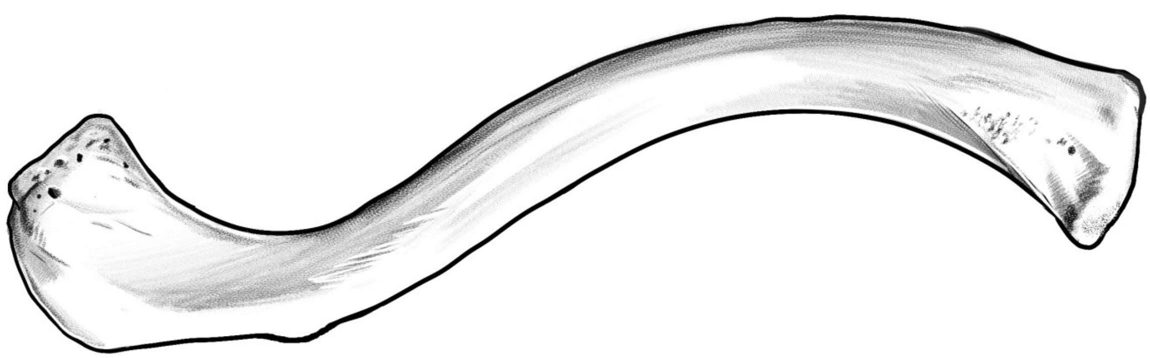
1. Identify the following bony features:

- [ ] Acromial end
- [ ] Conoid tubercle
- [ ] Sternal end

2. Be able to distinguish right from left.

The Clavicle
(Superior and Inferior Views)





The Scapula
(Anterior View)

The scapula is the second bone that is part of the pectoral girdle. This triangle-shaped bone is often referred to as the shoulder blade. The three borders of the scapula are the **superior border**, **lateral (axillary) border**, and **medial (vertebral) border**. The inferior most portion of the scapula comes to a point at the **inferior angle**. Several bony features of the scapula can also be seen. Near the lateral side of the superior border is the **coracoid process**, which is an attachment site for muscles. Behind the coracoid process is another prominence, called the **acromion**, which articulates with the clavicle. On the superior-most portion of the lateral border is the **glenoid cavity**, which articulates with the humerus. A large fossa is found on the anterior surface of the scapula, called the **subscapular fossa**; a muscle attaches here.

<u>Activity:</u>

1. Identify the following bony features:

☐ Acromion	☐ Lateral border
☐ Coracoid process	☐ Medial border
☐ Glenoid cavity	☐ Subscapular fossa
☐ Inferior angle	☐ Superior border

2. Be able to distinguish right from left.

The Scapula
(Anterior View)

The Scapula
(Posterior View)

From the posterior view, the **superior, lateral and medial borders** can be seen, as well as the **inferior angle**. A prominent **spine** is seen, which runs from the medial border, toward the lateral border and beyond the **glenoid cavity** to end at the lateral projection called the **acromion**; the acromion articulates with the clavicle. Above the spine is a small fossa called the **supraspinous fossa**, and below the spine is the larger **infraspinous fossa**; both fossae contain muscles.

Activity:

1. Identify the following bony features:

☐	Acromion	☐	Medial border
☐	Glenoid cavity	☐	Spine
☐	Inferior angle	☐	Supraspinous fossa
☐	Infraspinous fossa	☐	Superior border
☐	Lateral border		

The Scapula
(Posterior View)

The Humerus
(Anterior and Posterior Views)

The **humerus** is the arm bone. It articulates with the scapula at the pectoral girdle and the radius and ulna at the elbow.

At the proximal end of the humerus is the **head**, which articulates with the glenoid cavity of the scapula. Just distal to the head is the **anatomical neck**. Distal to that are the **greater and lesser tubercles**; the greater tubercle is larger than, and more superior to, the lesser tubercle. Both provide attachment sites for muscles. In between the tubercles is a groove called the **intertubercular sulcus**. The **surgical neck**, where the humerus is most often fractured, is distal to the tubercles.

The shaft of the humerus is fairly smooth, except mid-shaft on the lateral surface there is a **deltoid tuberosity**, named after the muscle that attaches to it.

At the proximal end of the humerus, the **trochlea**, on the medial side, articulates with the ulna. The **capitulum**, on the lateral side, articulates with the radius. Above these two condyles are two epicondyles: the **medial epicondyle** and the **lateral epicondyle**. These two features provide attachment sites for muscles. On the anterior surface there is a small **coronoid fossa**, in which a portion of the ulna fits. On the posterior surface is a much larger **olecranon fossa**, also in which a feature of the ulna fits.

Activity:

1. Identify the following bony features:

☐	Anatomical neck	☐	Head	☐	Medial epicondyle
☐	Capitulum	☐	Intertubercular sulcus	☐	Olecranon fossa
☐	Coronoid fossa	☐	Lateral epicondyle	☐	Surgical neck
☐	Deltoid tuberosity	☐	Lesser tubercle	☐	Trochlea
☐	Greater tubercle				

2. Be able to distinguish right from left.

The Humerus
(Anterior and Posterior Views)

The Ulna
(Anterior and Posterior Views)

The **ulna** is one of two bones that form the forearm. It is the longer of the two bones, and is located on the medial side of the forearm. The ulna articulates with the humerus at the elbow and the carpals at the wrist.

The ulna has a hook-like structure on its proximal end. The most superior region of the ulna is the **olecranon process**, which articulates with the olecranon fossa on the posterior surface of the humerus. Distal to that is the **trochlear notch**, in which the trochlea of the humerus sits. The notch ends in the **coronoid process**, which fits into the coronoid fossa on the anterior surface of the humerus. On the lateral side, near the coronoid process is the **radial notch**, which articulates with the radius at the proximal radioulnar joint.

The **head** of the ulna is located on the distal end of the ulna. The head articulates with the radius at the distal radioulnar joint. The distal end of the ulna comes to a point at the **styloid process**, which is an attachment site for a ligament. The ulna and carpals are not actually touching; they are separated by connective tissue. Therefore, the ulna is more important in the functioning of the elbow, rather than the wrist.

Activity:

1. Identify the following bony features:

☐	Coronoid process	☐	Radial notch
☐	Head	☐	Styloid process
☐	Olecranon process	☐	Trochlear notch

2. Be able to distinguish right from left.

The Ulna
(Anterior and Posterior Views)

The Radius
(Anterior and Posterior Views)

The **radius** is the second of the two bones of the forearm. It is shorter than the ulna and is located on the lateral portion of the forearm. Proximally it articulates with the humerus at the elbow and distally it articulates with the carpals at the wrist.

The **head** of the radius is located on the proximal end. It is shaped like a disc, with a concave portion on the top; the capitulum of the humerus sits in the head. The head also articulates with the ulna; the medial side of the head fits into the radial notch of the ulna. Distal to the head, is the **neck**. Distal to the neck, on the anterior surface, is the **radial tuberosity**; this is an attachment site for a muscle.

The distal end of the radius, which articulates with the head of the ulna at the distal radioulnar joint, comes to a point at the **styloid process**; this is an attachment site for a ligament. The radius articulates with the carpals at the distal end. Unlike the ulna, which was an important component of the elbow, the radius is more important in the functioning of the wrist.

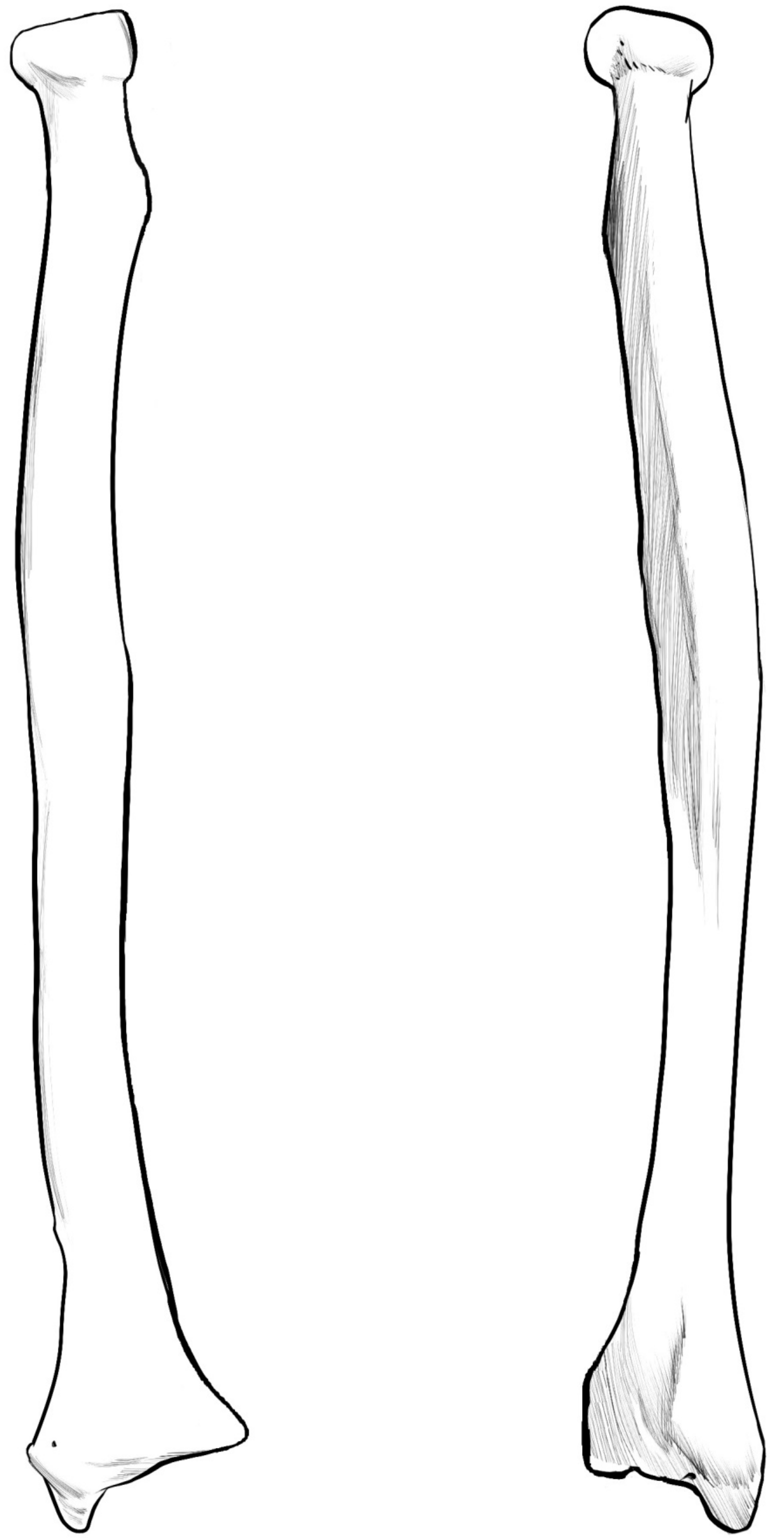
Activity:

1. Identify the following bony features:

☐	Head	☐	Radial tuberosity
☐	Neck	☐	Styloid process

2. Be able to distinguish right from left.

The Radius
(Anterior and Posterior Views)



The Hand
(Anterior View)

The hand is composed of carpal bones (forming the wrist), metacarpals (forming the palm) and phalanges (forming the digits). There are eight **carpal** bones; the anterior view is ideal for viewing all eight. There are two rows of four bones. Beginning with the proximal row, and naming from lateral to medial, there are the: **scaphoid**, **lunate**, **triquetrum** and **pisiform**. In the distal row, again naming from lateral to medial, there are: **trapezium**, **trapezoid**, **capitate** and **hamate**. The metacarpals are much easier to remember. There are five **metacarpals** – one for each digit – and they are numbered 1-5, from lateral (thumb side) to medial (pinky side). There are fourteen total phalanges, the bones that form the digits. Digits 2-5 have **proximal, middle and distal phalanges**; digit 1 (the thumb) only has proximal and distal phalanges.

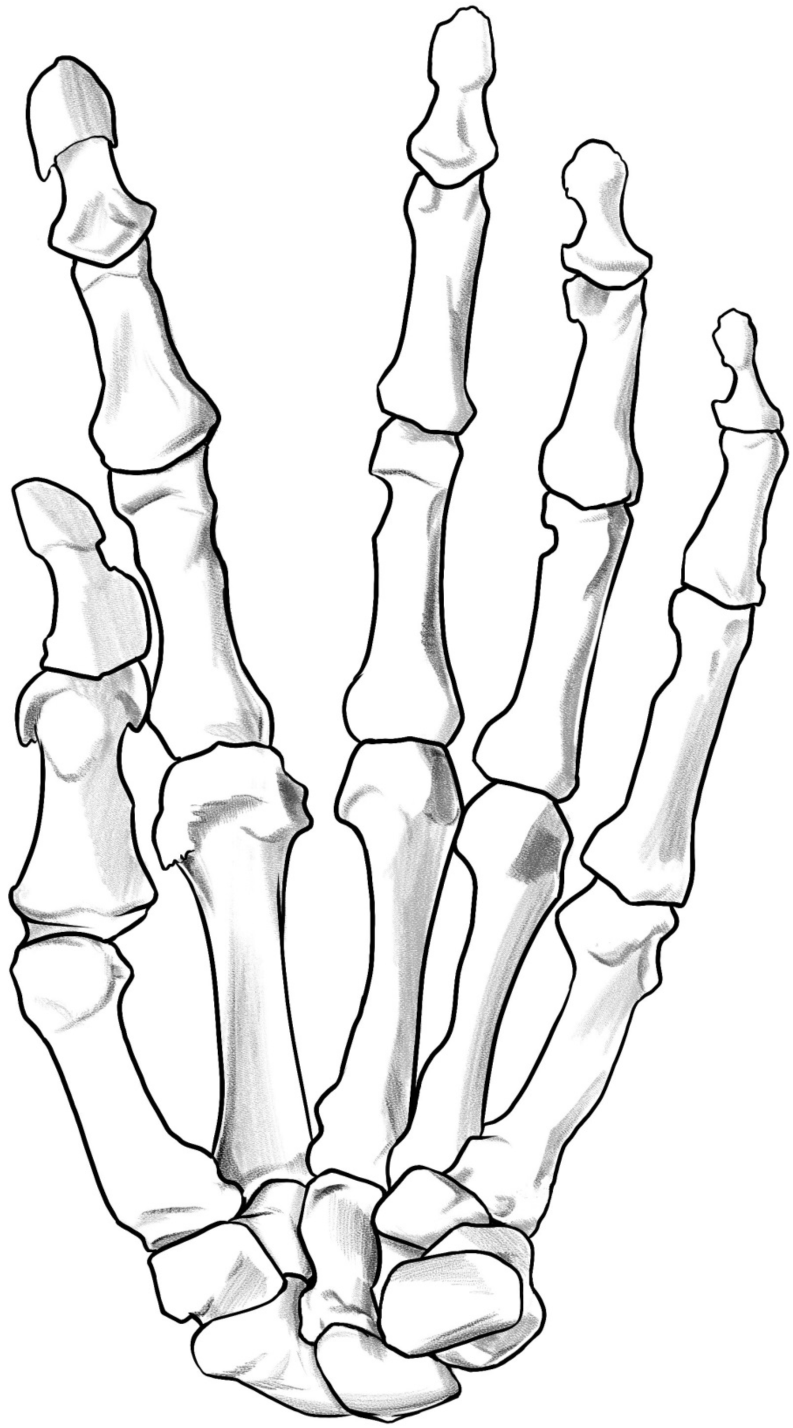
<u>Activity:</u>

1. Identify the following bones:

☐	Capitate	☐	Pisiform
☐	Distal phalanges	☐	Proximal phalanges
☐	Hamate	☐	Scaphoid
☐	Lunate	☐	Trapezium
☐	Metacarpals	☐	Trapezoid
☐	Middle phalanges	☐	Triquetrum

Mnemonic for the carpals:
Sally Left The Party To Take Cathy Home

The Hand
(Anterior View)



The Coxal Bone
(Lateral View)

The lower appendage begins at the pelvic girdle (the pelvis), which includes the **coxal bones** and the sacrum. The coxal bones, which are created by the fusion of three separate bones, attach the lower limb to the trunk. The three bones come together to form the **acetabulum**, a large cavity on the lateral side of the coxal bones, which forms the socket of the ball-and-socket joint of the hip.

The largest and most superior of the coxal bones is the **ilium**. The superior portion of the ilium forms the **iliac crest**, which is an attachment site for muscles. Anteriorly, the crest leads to two projections: the **anterior superior iliac spine** and the **anterior inferior iliac spine**. Posteriorly, the crest leads to two more projections: the **posterior superior iliac spine** and the **posterior inferior iliac spine**. These projections provide attachment sites for muscles and ligaments. Beneath the posterior inferior iliac spine is a groove, called the **greater sciatic notch**; muscles, nerves and blood vessels run through this notch. The ilium forms a little less than 40% of the acetabulum on its upper boundary.

The **ischial spine** of the ischium is found just underneath the greater sciatic notch. It is an attachment site for a ligament. Just beneath the spine is a small groove, called the **lesser sciatic notch**; nerves and blood vessels run through this notch. There is a prominent **ischial tuberosity** on the most inferior portion of the coxal bones. We sit on the ischial tuberosity, and a ligament also attaches here. The ischium forms a little more than 40% of the acetabulum on its inferior/posterior boundary.

The third bone is the **pubis**. Its features will be discussed shortly. The pubis forms less than 20% of the acetabulum on its inferior/anterior boundary.

Beneath the acetabulum is a large hole – the **obturator foramen** – through which nerves and blood vessels pass. It is formed by the ischium posteriorly and pubis anteriorly.

<u>Activity:</u>

1. Identify the following bony features:

- ☐ Acetabulum
- ☐ Anterior inferior iliac spine
- ☐ Anterior superior iliac spine
- ☐ Greater sciatic notch
- ☐ Iliac crest
- ☐ Ischial spine
- ☐ Ischial tuberosity
- ☐ Lesser sciatic notch
- ☐ Obturator foramen
- ☐ Posterior inferior iliac spine
- ☐ Posterior superior iliac spine

2. Label the borders of the ilium, ischium and pubis.

The Coxal Bone
(Lateral View)

The Coxal Bone
(Medial View)

Many of the same features of the ilium and ischium can be seen from the medial view, including the iliac crest, iliac spines, ischial spine and the two notches. You can also observe the obturator foramen. The **iliac fossa** of the ilium, in which there is a muscle, can be seen from this perspective.

The features of the pubis are better observed on the medial portion of the bone. The **articular surface** is a flattened region of the pubis where the contralateral pubis forms the pubic symphysis joint. Just above the articular surface is the **pubic tubercle**, which provides an attachment site for a ligament. Above the tubercle is the flat **superior ramus**, which fuses to the ilium, and below it is the **inferior ramus**, which fuses to the ischium.

<u>Activity:</u>

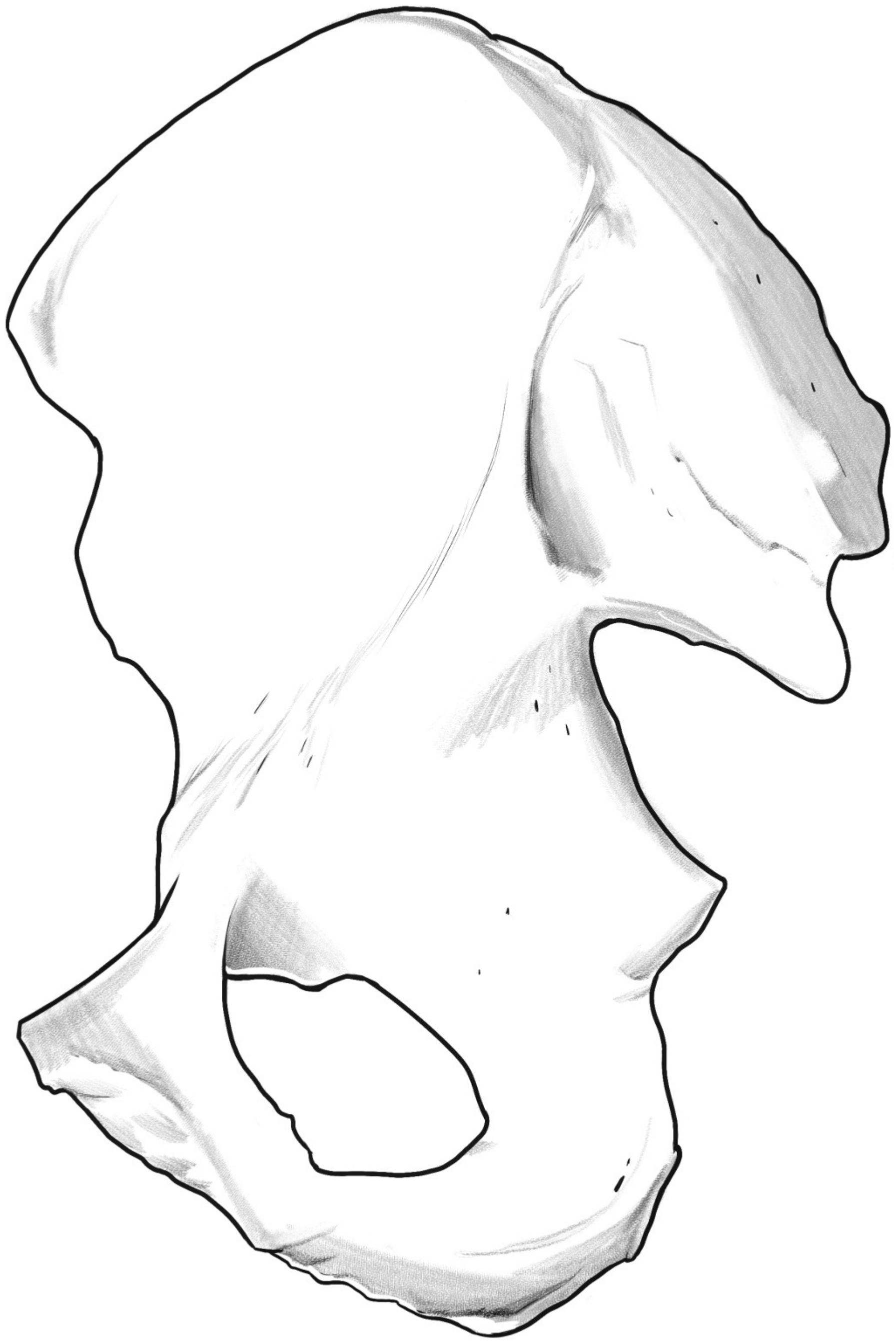
1. Identify the following bony features:

- ☐ Anterior inferior iliac spine
- ☐ Anterior superior iliac spine
- ☐ Articular surface of pubis
- ☐ Greater sciatic notch
- ☐ Iliac crest
- ☐ Iliac fossa
- ☐ Inferior ramus
- ☐ Obturator foramen
- ☐ Posterior inferior iliac spine
- ☐ Posterior superior iliac spine
- ☐ Pubic tubercle
- ☐ Superior ramus

2. Be able to distinguish right from left.

The Coxal Bone

(Medial View)



The Femur
(Anterior and Posterior Views)

The **femur** is the thigh bone. It articulates with the coxal bones at the pelvic girdle and the tibia at the knee.

On the proximal end of the bone is the **head**, which articulates with the acetabulum of the coxal bone. There is a pit in the center, called the **fovea capitis**, which is an attachment site for the ligament that holds the head in the acetabulum. Distal to the head, extending laterally, is the **neck**, which is much longer in the femur than in the humerus. Similar to the greater and lesser tubercles of the humerus, the femur has **greater and lesser trochanters**. The greater trochanter is larger than, and lateral to, the lesser trochanter. Both of these features are attachment sites for muscles. In between the trochanters is the **intertrochanteric crest**. Just distal to the trochanters, on the posterior surface, is the **gluteal tuberosity**, which continues down the shaft as a line called the **linea aspera**; these features are also attachment sites for muscles.

On the distal end there are **medial and lateral condyles**; these condyles articulate with the tibia, and are best seen from the posterior view. In between the condyles, on the posterior surface, is a deep indentation called the **intercondylar fossa**. On the anterior surface, between the condyles is the **patellar surface**, where the **patella** rests. Above the condyles are **medial and lateral epicondyles**; these features are attachments sites for muscles.

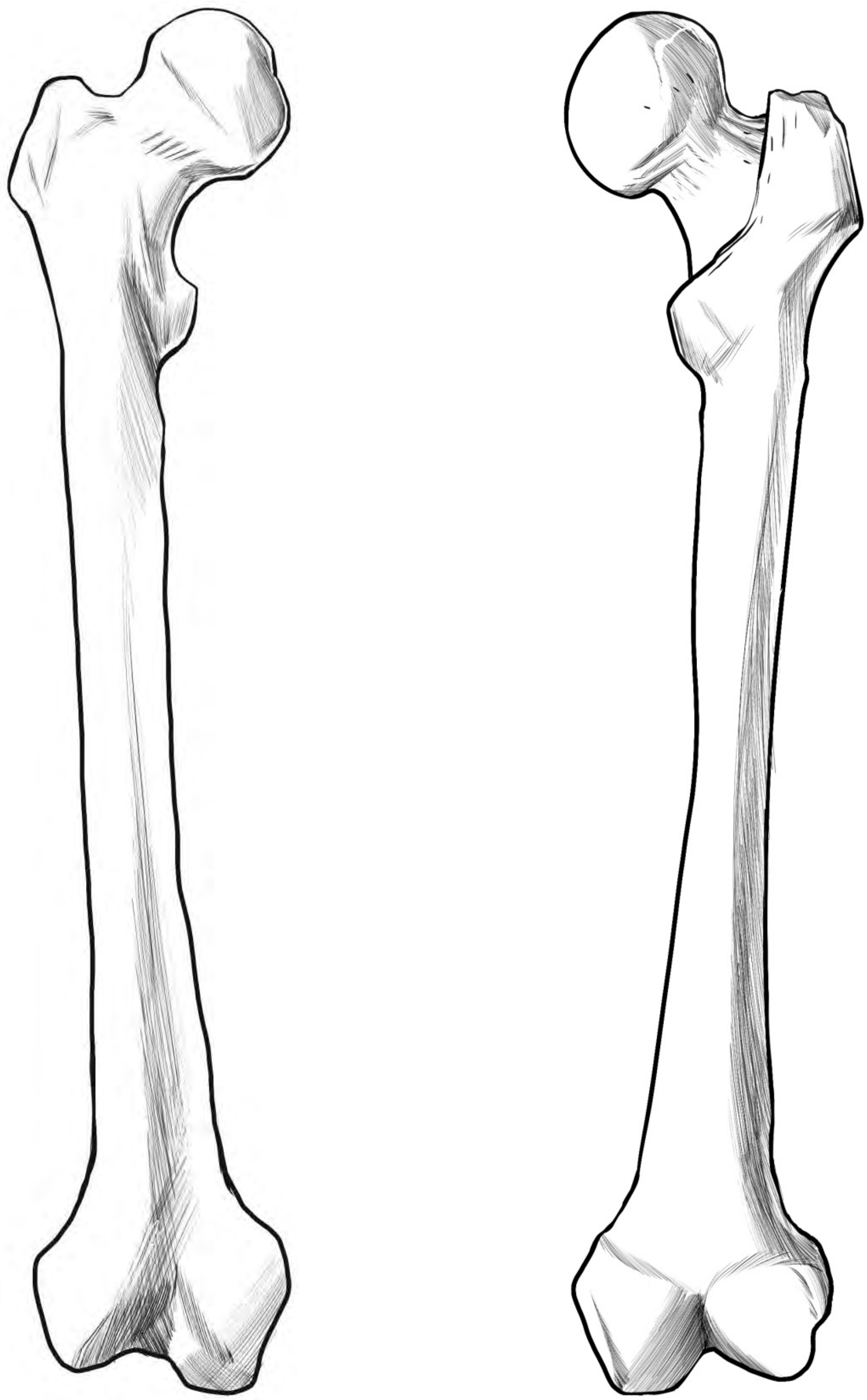
Activity:

1. Identify the following features:

☐ Fovea capitis	☐ Intertrochanteric crest	☐ Medial condyle
☐ Gluteal tuberosity	☐ Lateral condyle	☐ Medial epicondyle
☐ Greater trochanter	☐ Lateral epicondyle	☐ Neck
☐ Head	☐ Lesser trochanter	☐ Patellar surface
☐ Intercondylar fossa	☐ Linea aspera	

2. Be able to distinguish right from left.

The Femur
(Anterior and Posterior Views)



The Tibia
(Anterior and Posterior Views)

The **tibia** is one of two bones that form the leg. It is the larger of the two bones, and is located on the medial side of the leg. The tibia articulates with the femur at the knee joint and the tarsals at the ankle.

On the proximal end, there **are medial and lateral condyles**, which articulate with the medial and lateral condyles of the femur. The convex condyles of the femur fit into the concave condyles of the tibia to form the knee joint. On the anterior surface, just distal to the condyles, is the **tibial tuberosity**, which is an attachment site for muscles.

On the distal end there is the **medial malleolus**. This forms the bony projection on the medial side of your ankle, and can be felt. The medial malleolus articulates with talus, one of the tarsal bones of the ankle.

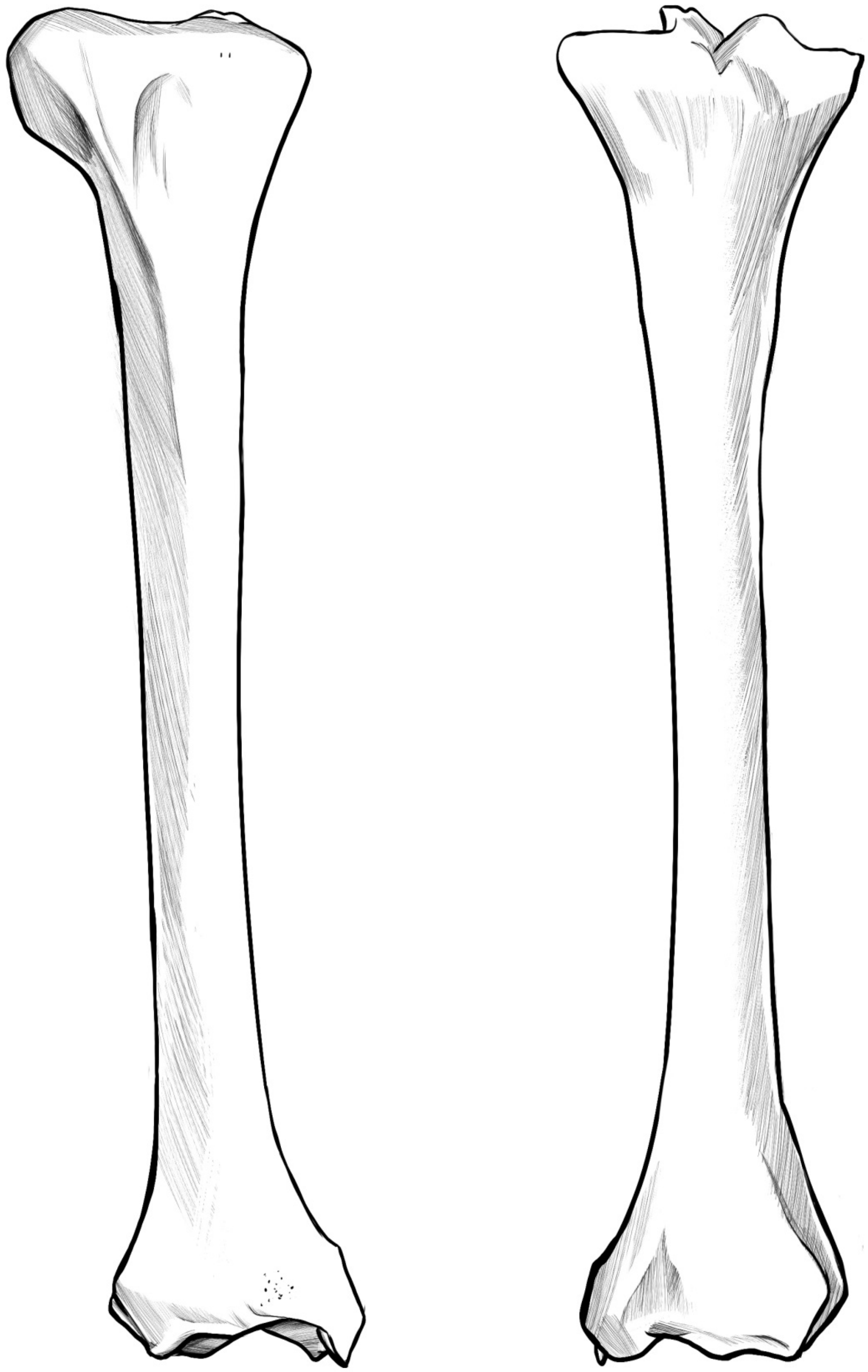
Activity:

1. Identify the following bony features:

☐	Lateral condyle	☐	Medial malleolus
☐	Medial condyle	☐	Tibial tuberosity

2. Be able to distinguish right from left.

The Tibia
(Anterior and Posterior Views)



The Fibula
(Anterior and Posterior Views)

The **fibula** is the second of the two bones of the leg. It is much thinner than the tibia and it located on the lateral portion of the leg. Proximally it articulates with the tibia and distally it articulates with the tarsals at the ankle. Note that the fibula is not part of the knee joint.

The **head** of the fibula is located on the proximal side of the bone. The head articulates with the lateral side of the tibia, just distal to the lateral condyle, to form the proximal tibiofibular joint.

The **lateral malleolus** forms the distal end of the fibula. It articulates with the lateral side of the distal tibia at the distal tibiofibular joint. It also articulates with the talus at the ankle joint.

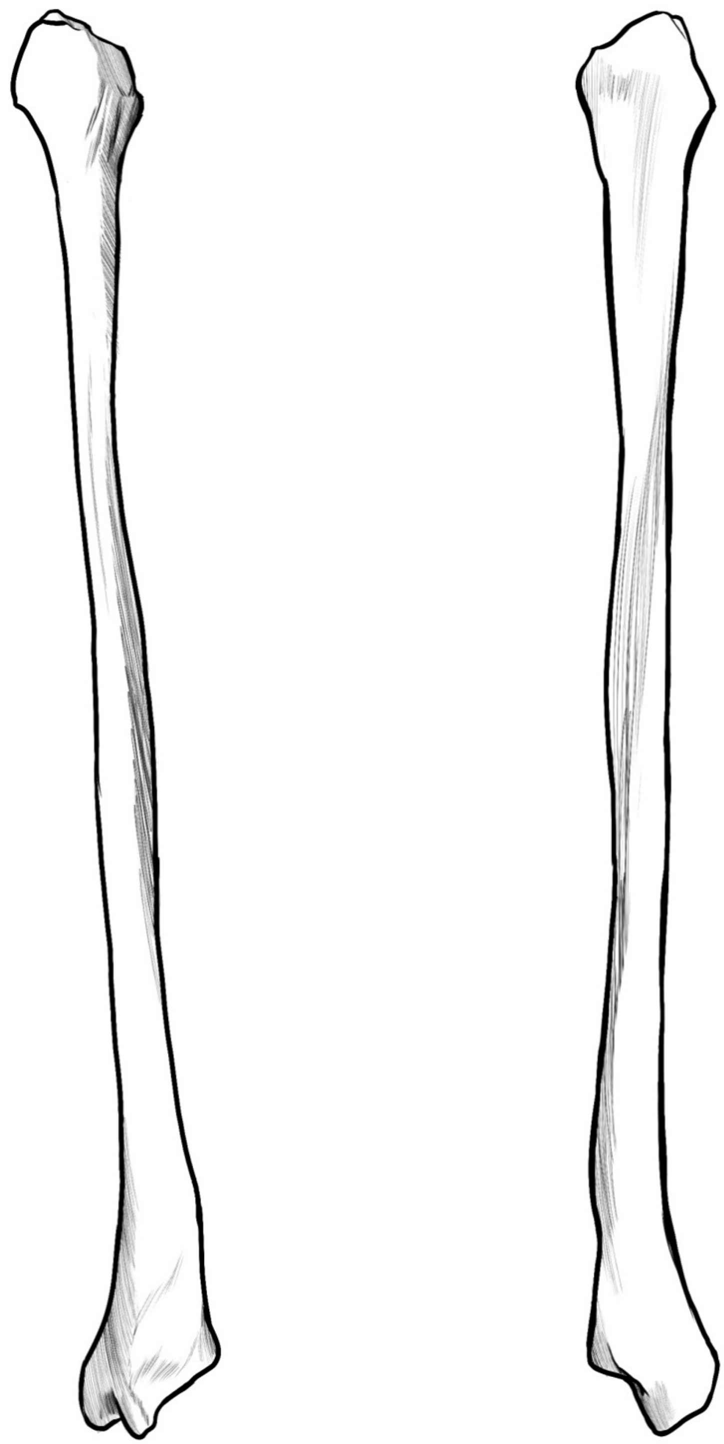
Activity:

1. Identify the following bony features:

   ☐ Head ☐ Lateral malleolus

2. Be able to distinguish right from left.

The Fibula
(Anterior and Posterior Views)



The Foot
(Superior View)

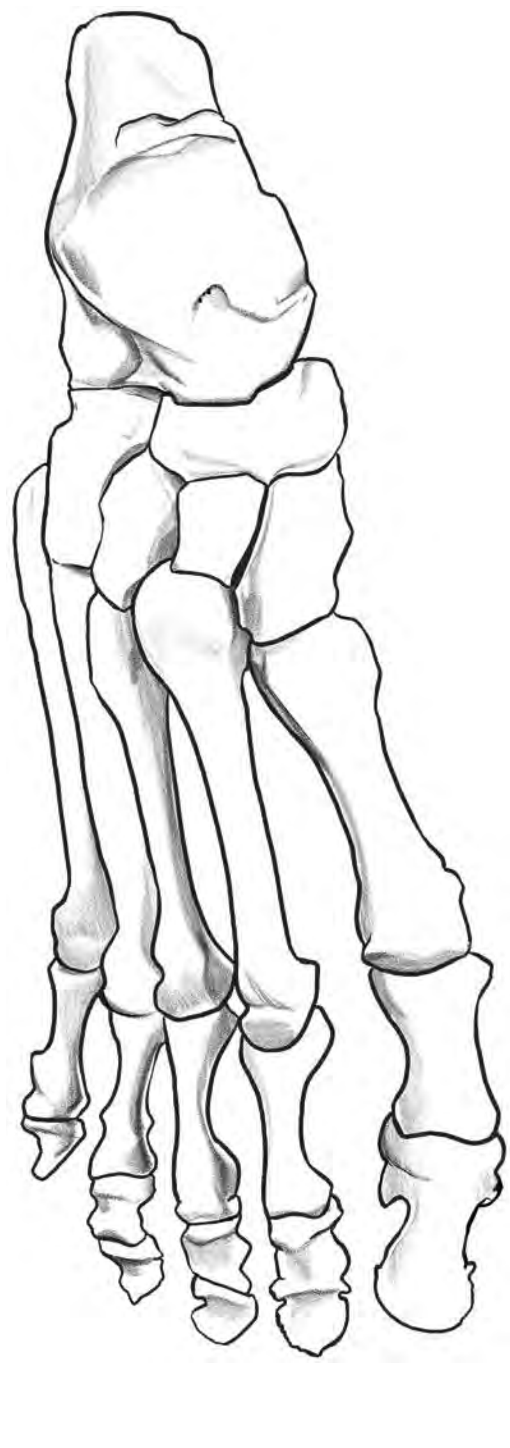
The foot has a similar anatomical plan to the hand: multiple, short tarsal bones in the ankle, metatarsal bones in the in-step (metatarsus), and phalanges in the digits. There are seven **tarsal** bones. The heel is formed by the **calcaneus**; because body weight is resting on this bone, it is very large compared to the other tarsals. Resting on top of the calcaneus is the **talus**, which articulates with the tibia and fibula. Anterior to the calcaneus and talus are the five remaining bones. Right in front of the talus is the **navicular**; the remaining four tarsals are in a row, named (from lateral to medial): **cuboid**, **lateral cuneiform**, **intermediate cuneiform** and **medial cuneiform**. There are five **metatarsal** bones, numbered 1-5 from the hallux (big toe) to digit #5. Similar to the hand, there are fourteen phalanges in the digits. Digits 2-5 have **proximal, middle and distal phalanges**, and the hallux has proximal and distal phalanges.

<u>Activity:</u>

1. Identify the following bones:

☐	Calcaneus	☐	Metatarsals
☐	Cuboid	☐	Middle phalanges
☐	Distal phalanges	☐	Navicular
☐	Intermediate cuneiform	☐	Proximal phalanges
☐	Lateral cuneiform	☐	Talus
☐	Medial cuneiform		

The Foot
(Superior View)



Skeletal Muscle Tissue

This figure shows a section of a **myofiber**, a skeletal muscle cell. Myofibers are long, cylindrical, striated cells with multiple nuclei. Surrounding the myofiber is the plasma membrane, called the **sarcolemma**. Packed within the **sarcoplasm** (cytoplasm) are bundles of **myofilament** proteins called **myofibrils**. These organelles, which are responsible for the mechanical action of contraction, take up the majority of the space in the sarcoplasm. Surrounding the myofibrils is a network of modified endoplasmic reticulum called **sarcoplasmic reticulum**, which stores the calcium necessary for muscle contraction. Along the length of the myofibrils, the sarcoplasmic reticulum enlarges in areas called **terminal cisterns**. These swellings, which contain a large amount of calcium, are in contact with invaginations of the sarcolemma called transverse tubules, or **T-tubules**. A **triad** is a single t-tubule flanked on both sides by two terminal cisterns; this structure ensures that the muscle action potential reaches the sarcoplasmic reticulum to cause adequate calcium release for muscle contraction. There are also plentiful **mitochondria** within the sarcoplasm, as is expected with a cell that requires a lot of energy to contract.

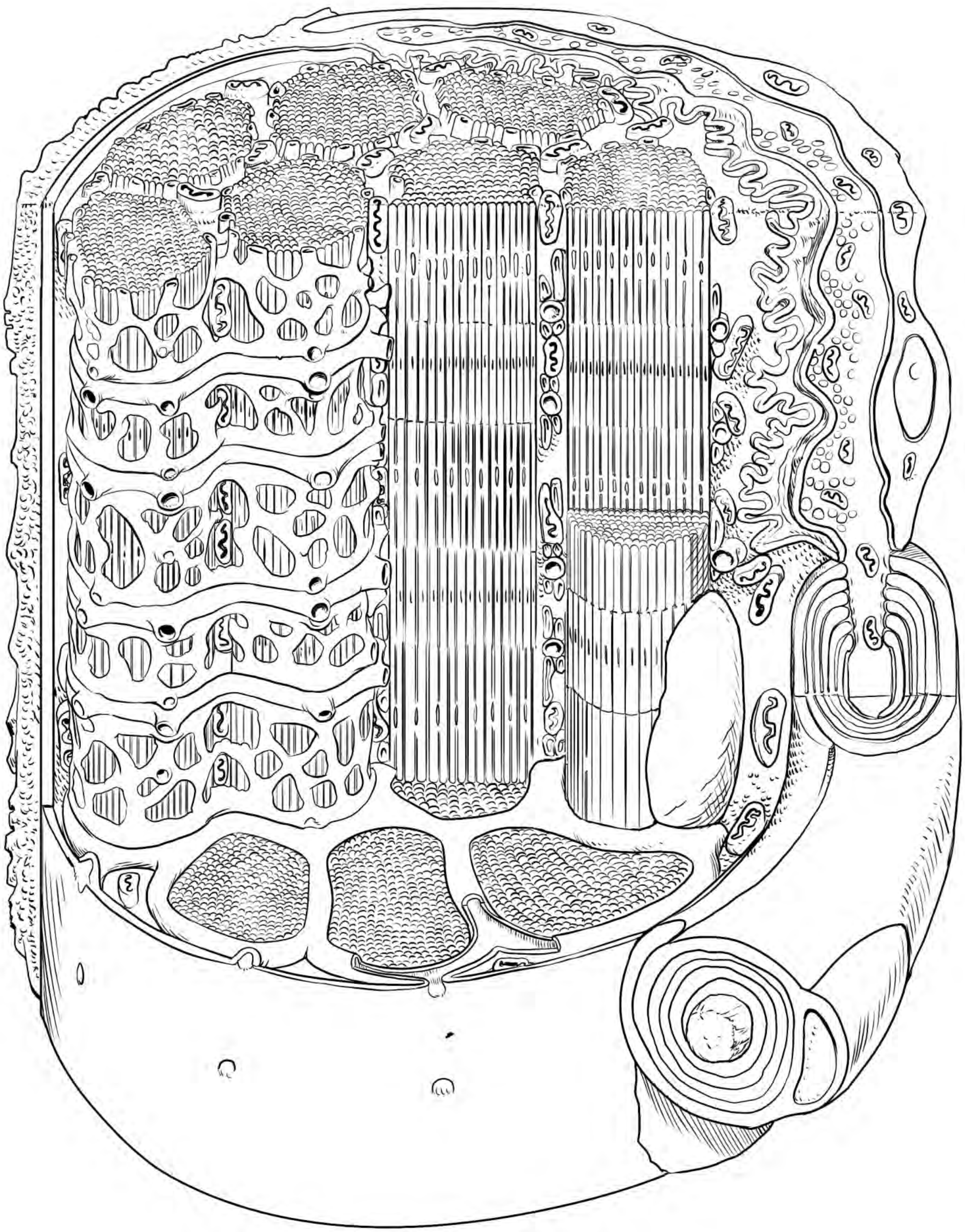
Also shown in this figure is the **neuromuscular junction**, or **motor end plate**. The **axon** of the somatic motor neuron, surrounded by a **Schwann cell**, delivers the action potential to the myofiber. The **axon terminal** of the neuron forms a synapse with the sarcolemma of the myofiber, with a thin space, called the **synaptic cleft**, separating the two cells. Within the axon terminal are many **synaptic vesicles**, which contain the neurotransmitter (acetylcholine) necessary for muscle action potential generation and contraction.

Activity:

1. Identify the following structures:

☐ Axon	☐ Sarcolemma	☐ Synaptic cleft
☐ Axon terminal	☐ Sarcoplasm	☐ Terminal cisterns
☐ Mitochondria	☐ Sarcoplasmic reticulum	☐ Triad
☐ Myofibrils	☐ Schwann cell	☐ T-tubule
☐ Nucleus of myofiber	☐ Synaptic vesicles	

Skeletal Muscle Tissue



Skeletal Muscle Histology

Once you are familiar with the generalized structure of the skeletal muscle tissue, you should be able to identify many of the features on prepared and stained sections of the skeletal muscle.

This slide is of myofibers and their motor neurons. Look closely to see the striations in the myofibers. You should also be able to see the motor end plates where the motor neurons innervate the myofibers.

Activity:

1. Obtain slide number 40 from your slide box.
2. Using the 40X objective lens, locate the following:

    Axon
    Motor end plate (neuromuscular junction)
    Myofiber

3. Draw what you see on the following page, labelling the structures listed above.

Skeletal Muscle Histology

Facial and Neck Muscles
(Lateral view)

Facial muscles fall into one of two categories. The first set are muscles that control facial expressions. The **frontalis** muscle is responsible for drawing the scalp forward, raising the eyebrows and wrinkling the forehead. The **occipitalis** muscle, which is connected to the frontalis muscle by a large tendon, causes the scalp to move back. Most anatomists consider them to be one muscle: the occipitofrontalis muscle. The **orbicularis oculus** muscle closes the eye. The **zygomaticus major** and **zygomaticus minor** muscles are responsible for smiling. The **risorius** draws the lips laterally. The **levator labii superioris** raises the upper lip. The **orbicularis oris** closes and protrudes the lips. The **depressor labii inferioris** muscle depresses the lower lip. The **depressor anguli oris** depresses the corners of the lips. Finally, the **buccinator** flattens the cheek. The second set of muscles are involved in mastication, or chewing. The **masseter**, which originates on the zygomatic arch and maxilla and inserts on the mandible closes and retracts the jaw. The **temporalis**, which originates on the temporal bone and inserts on the mandible also closes and retracts the jaw.

There are two neck muscles that we are going to focus on in this figure. Other muscles within this region will be discussed when we cover the muscles of the posterior trunk. The **sternocleidomastoid**, which originates on the manubrium of the sternum and the clavicle, and inserts on the mastoid process of the temporal bone, is responsible for obliquely rotating the head, flexing the neck and is an accessory muscle for inhalation. The **scalenes** are a series of three muscles, which originate on the transverse processes of C2-C7, insert on ribs 1-2, and flex the neck toward the side and are also accessory muscles for inhalation.

Activity:

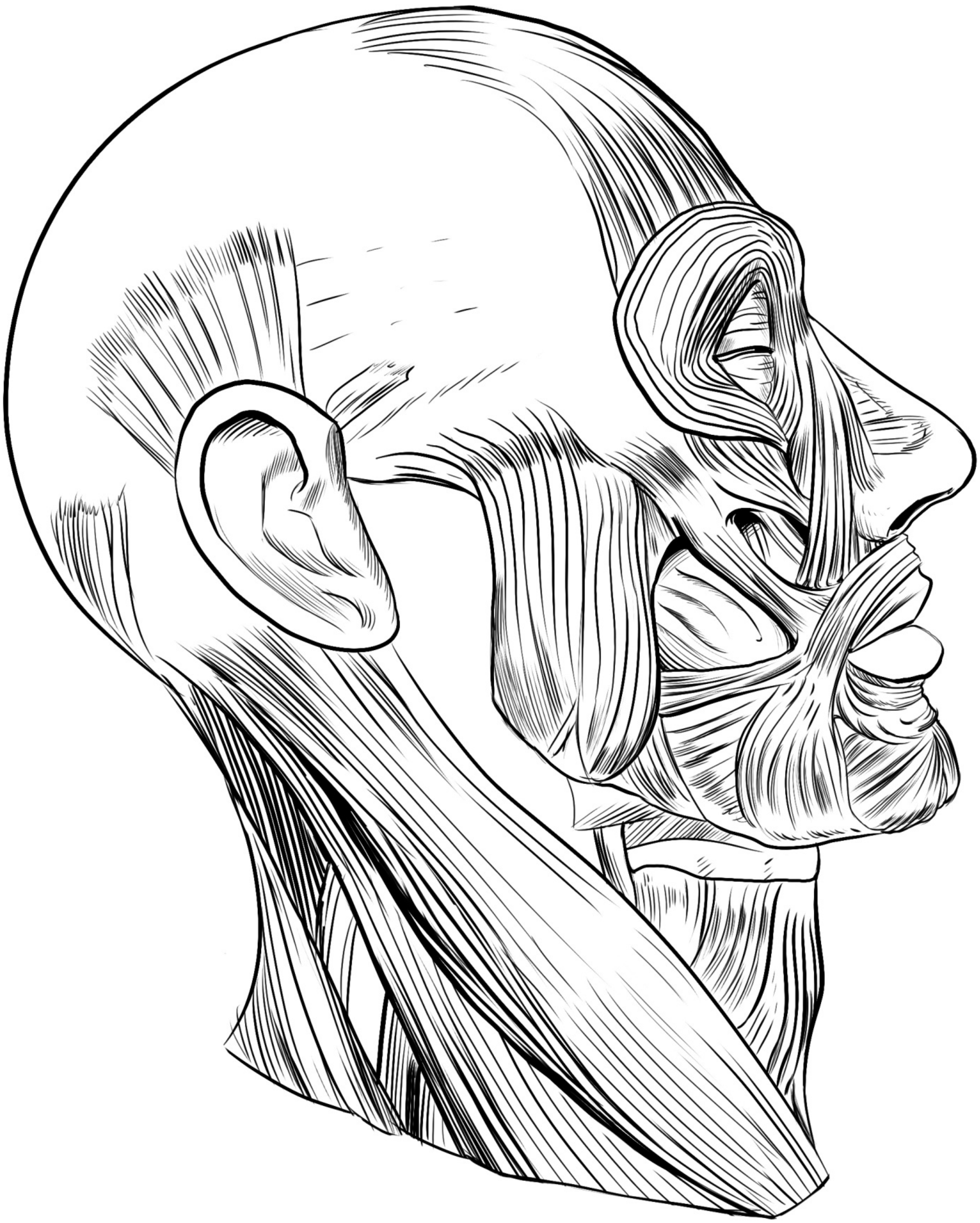
1. Identify and state the action of the following muscles:

☐ Buccinator	☐ Masseter*	☐ Scalenes*
☐ Depressor anguli oris	☐ Occipitalis	☐ Sternocleidomastoid*
☐ Depressor labii inferioris	☐ Orbicularis oculi	☐ Temporalis*
☐ Frontalis	☐ Orbicularis oris	☐ Zygomaticus major
☐ Levator labii superioris	☐ Risorius	☐ Zygomaticus minor

2. State the origin and insertion of the muscles indicated by a *.

Facial and Neck Muscles

(Lateral view)



Trunk Muscles

(Anterior view, superficial and intermediate layers)

There are four muscles in the abdomen involved in the movement of the trunk. Laterally, there are three layers of muscles. The superficial layer, the **external oblique**, has fibers that run obliquely, downward from the ribs toward the pubis. The middle layer, the **internal oblique**, has fibers that run obliquely, upward from the pelvis to the ribs. The fibers of internal oblique are perpendicular to those of the external oblique. The deepest layer, the **transversus abdominis** (which will be discussed shortly) has transversely oriented fibers. Fibers from all three muscles insert on a line down the center of the abdomen called the **linea alba**. Flanking either side of the linea alba is the **rectus abdominis**. This eight-bellied muscle extends from the pubic bone to the xiphoid process. All four muscles listed above compress the abdomen and all, except transversus abdominis, flex the vertebral column.

The thoracic muscles act on either the scapula or arm. The **pectoralis minor**, which originates on the ribs and inserts on the coracoid process, moves the scapula forward and downward. The **serratus anterior**, which originates on the ribs and inserts on the medial side of the anterior scapula, moves the scapula upward and laterally. The **pectoralis major**, which originates at the medial clavicle and sternum and inserts at the greater tubercle, flexes, adducts and medially rotates the arm.

<u>Activity:</u>

1. Identify and state the action of the following muscles of the superficial layer (left side):

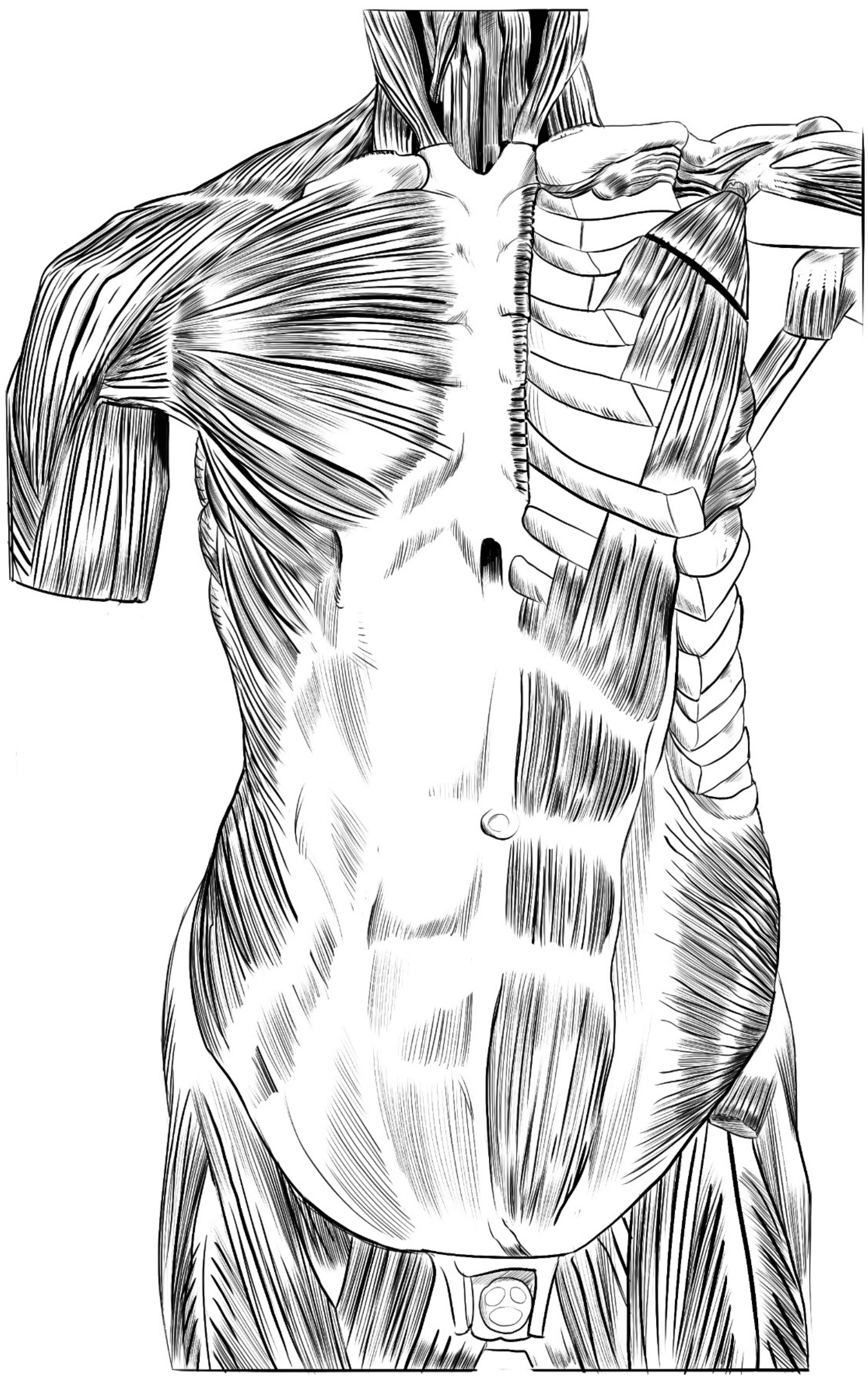
   ☐ External oblique ☐ Pectoralis major* ☐ Serratus anterior*

2. Identify and state the action of the following muscles of the intermediate layer (right side):

   ☐ Internal oblique ☐ Pectoralis minor* ☐ Rectus abdominis*

3. State the origin and insertion of the muscles with an * next to them.

Trunk Muscles
(Anterior view, superficial and intermediate layers)



Trunk Muscles
(Anterior view, deep layer)

Recall that there are three layers of muscles on the lateral sides of the abdomen. External and internal oblique form the superficial and middle layers, while **transversus abdominis** forms the deepest layer. Its transversely oriented fibers come from the lumbar region of the back, around to the midline of the abdomen to insert on the linea alba. The transversus abdominis is responsible for compression of the abdomen. But note that unlike the other abdominal muscles, it does not flex the vertebral column.

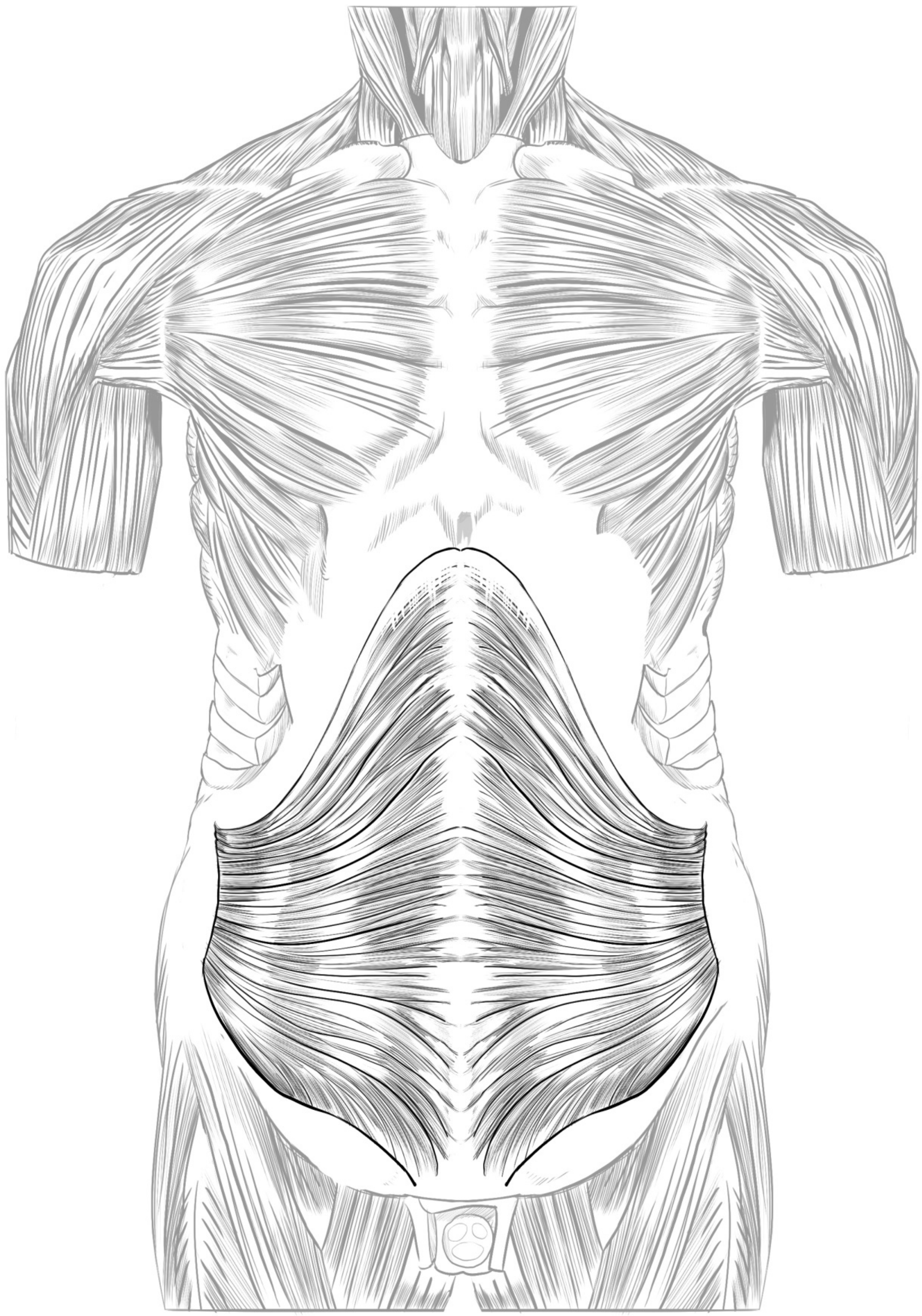
In order to view this muscle on our model, you will need view the back side of the abdominal wall.

<u>Activity:</u>

1. Identify and state the action of the following muscle:

☐ Transversus abdominis

Trunk Muscles
(Anterior view, deep layer)



Trunk Muscles
(Posterior View)

Trapezius is the most superficial muscle on the posterior trunk. This large, diamond-shaped muscle originates from the external occipital protuberance down to T12, and inserts on the lateral clavicle, and the acromion and spine of the scapula. It is responsible for adducting, elevating and depressing the scapula. Continuing from the insertion point of the trapezius is the **deltoid**, which forms the rounded portion of the shoulder and moves the arm. This muscle originates on the lateral clavicle and the acromion and spine of the scapula, and inserts on the deltoid tuberosity. The lateral fibers cause abduction, the anterior fibers cause flexion and medial rotation, and the posterior fibers cause extension and lateral rotation. Deep muscles are shown on the left side of the figure. Beginning in the neck, **splenius**, which has two groups (capitis and cervicis) extends the head. Lateral to splenius is **levator scapulae**. This muscle originates on the transverse processes of C1-C4, inserts on the upper, medial border of the scapula, and elevates and adducts the scapula. Inferior to levator scapulae is **rhomboid minor**, which originates on the spinous processes of C7-T1, inserts on the medial border of the scapula, and adducts the scapula. Inferior to rhomboid minor is **rhomboid major**, which originates on the spinous processes of T2-T5, inserts on the medial border of the scapula, and adducts the scapula.

Latissimus dorsi is a large, superficial muscle on the lumbar region of the back. It originates from T7 down to the iliac crest, inserts on the intertubercular sulcus of the humerus, and extends, adducts and medially rotates the arm. The deep muscles of the back include **erector spinae,** which has three groups of muscles. **Spinalis** is found closest to the spine, **longissimus** is lateral to spinalis, and **iliocostalis** is the most lateral group. All three groups extend the vertebral column. Longissimus and iliocostalis also laterally flex the vertebral column.

Activity:

1. Identify and state the action of the following muscles of the superficial layer (right side):

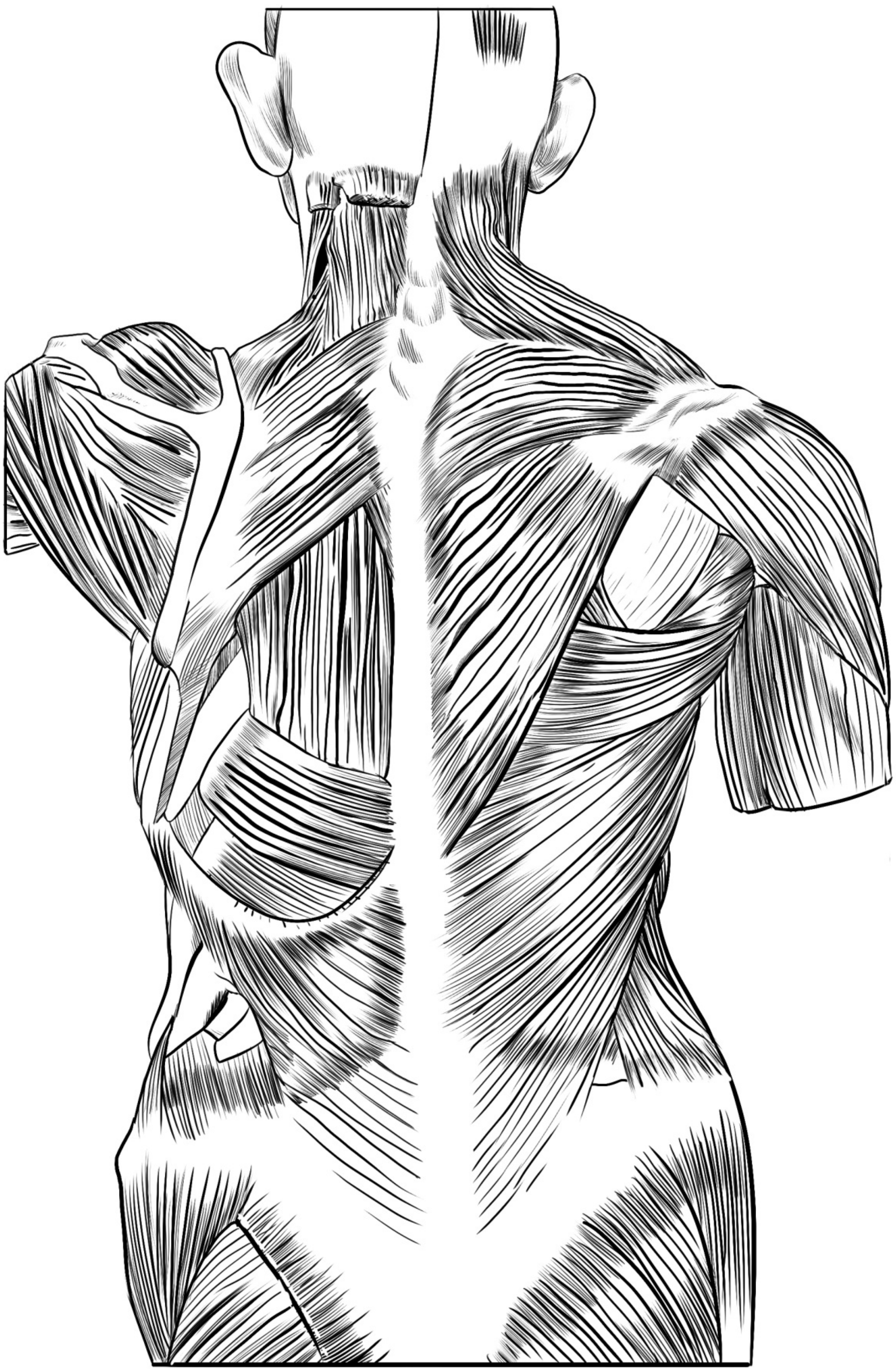
- ☐ Deltoid*
- ☐ Latissimus dorsi*
- ☐ Trapezius*

2. Identify and state the action of the following muscles of the deep layer (left side):

- ☐ Iliocostalis
- ☐ Rhomboid major*
- ☐ Splenius capitis
- ☐ Levator scapulae*
- ☐ Rhomboid minor*
- ☐ Spinalis
- ☐ Longissimus

3. State the origin and insertion of the muscles with an * next to them.

Trunk Muscles
(Posterior View)



Rotator Cuff
(Posterior view)

The tendons of four scapular muscles come together to form the rotator cuff, which reinforces the shoulder joint. The muscles are collectively referred to as the SITS muscles; the letters of the acronym correspond to the first letter of the names of the muscles. The first three muscles of the rotator cuff can be seen from the posterior view: the supraspinatus, infraspinatus and teres minor. We will cover the fourth muscle – the subscapularis – shortly.

The **supraspinatus** originates on the supraspinous fossa, inserts on the greater tubercle, and abducts the arm. The **infraspinatus** originates on the infraspinous fossa, inserts on the greater tubercle, and laterally rotates the arm. The **teres minor** originates on the lateral scapula, inserts on the greater tubercle, and laterally rotates the arm.

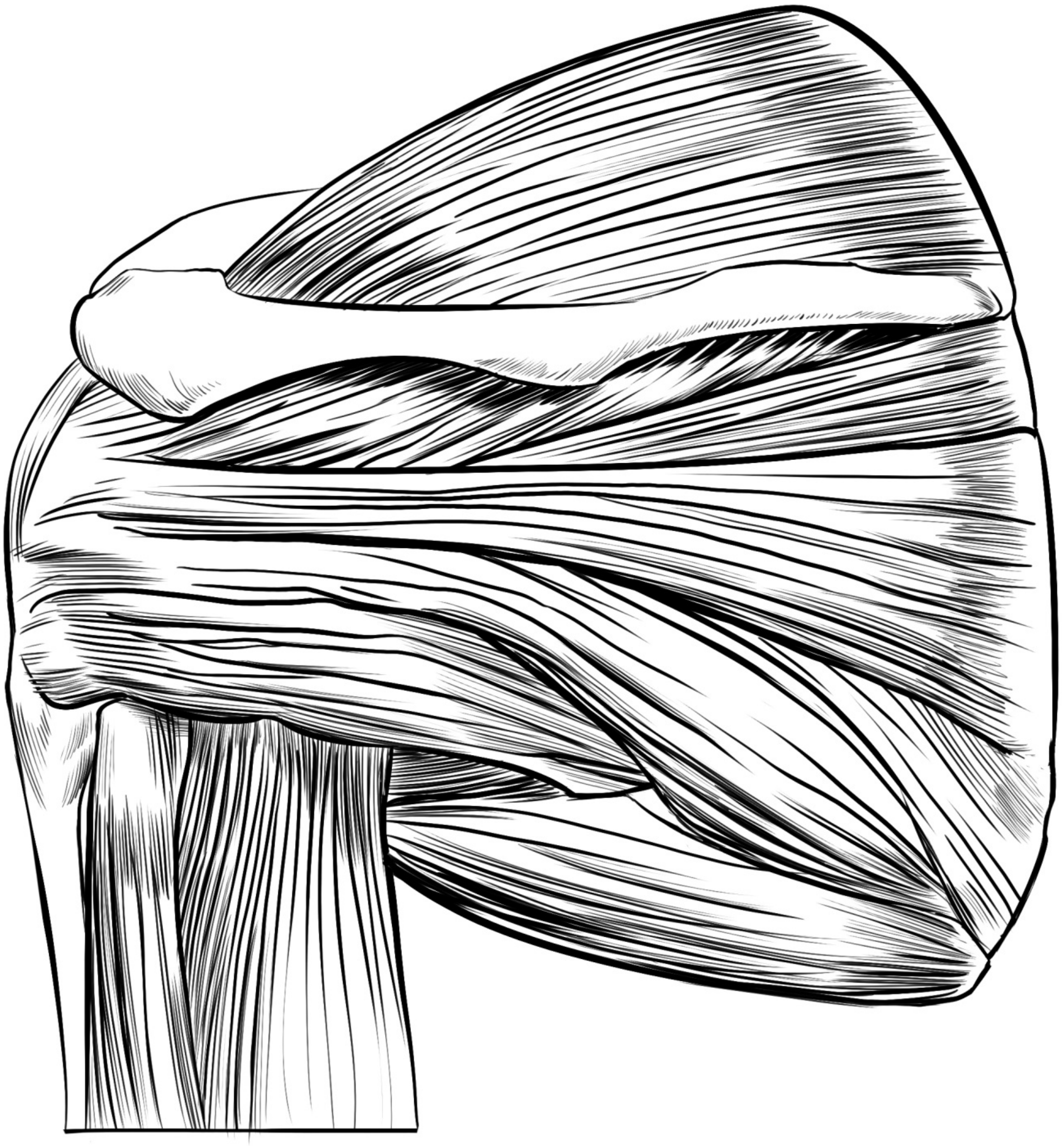
Though not technically part of the rotator cuff, the **teres major** can also be seen from this perspective. This muscle originates on the inferior angle of the scapula, inserts on the intertubercular sulcus, and medially rotates the arm.

Activity:

1. Identify, and state origin, insertion and action of the following muscles:

☐	Infraspinatus	☐	Teres major
☐	Supraspinatus	☐	Teres minor

Rotator Cuff
(Posterior view)



Rotator Cuff
(Anterior View)

The remaining rotator cuff muscle, the **subscapularis**, can be seen from the anterior view. This muscle originates in the subscapular fossa and inserts on the lesser tubercle of the humerus. It medially rotates the arm.

The **teres major** can also be seen from this perspective.

Activity:

1. Identify the following muscles:

☐ Subscapularis ☐ Teres major

2. State the origin, insertion and action of the subscapularis.

Rotator Cuff
(Anterior View)

Arm Muscles
(Anterior View, Superficial Layer)

Muscles on the anterior arm are responsible for moving the arm and forearm. The only muscle that can be viewed in its entirety, when looking at the superficial layer, is the biceps brachii. The **biceps brachii** is a two-headed muscle that inserts via a common tendon. The **long head** originates above the glenoid cavity and the **short head** originates on the coracoid process. Both bellies of this muscle insert on the radial tuberosity. The biceps is responsible for flexing the arm, and flexing and supinating the forearm. Sitting deep to the biceps brachii are the brachialis and coracobrachialis; these muscles will be discussed shortly.

<u>Activity:</u>

1. Identify and state the origin, insertion and action of the following muscles:

   ☐ Biceps brachii, long head ☐ Biceps brachii, short head

Arm Muscles
(Anterior View, Superficial Layer)

Arm Muscles
(Anterior View, Deep Layer)

Once the biceps brachii is removed, the **brachialis** can be seen. This muscle originates on the shaft of the humerus and inserts on the coronoid process. As a synergist to the biceps brachii, it also flexes the forearm. The **coracobrachialis** can also be seen once the biceps has been removed. This muscle originates on the coracoid process, inserts on the medial shaft of the humerus, and flexes and adducts the arm.

Activity:

1. Identify and state the origin, insertion and action of the following muscles:

☐ Brachialis ☐ Coracobrachialis

Arm Muscles

(Anterior View, Deep Layer)

Arm Muscles
(Posterior View)

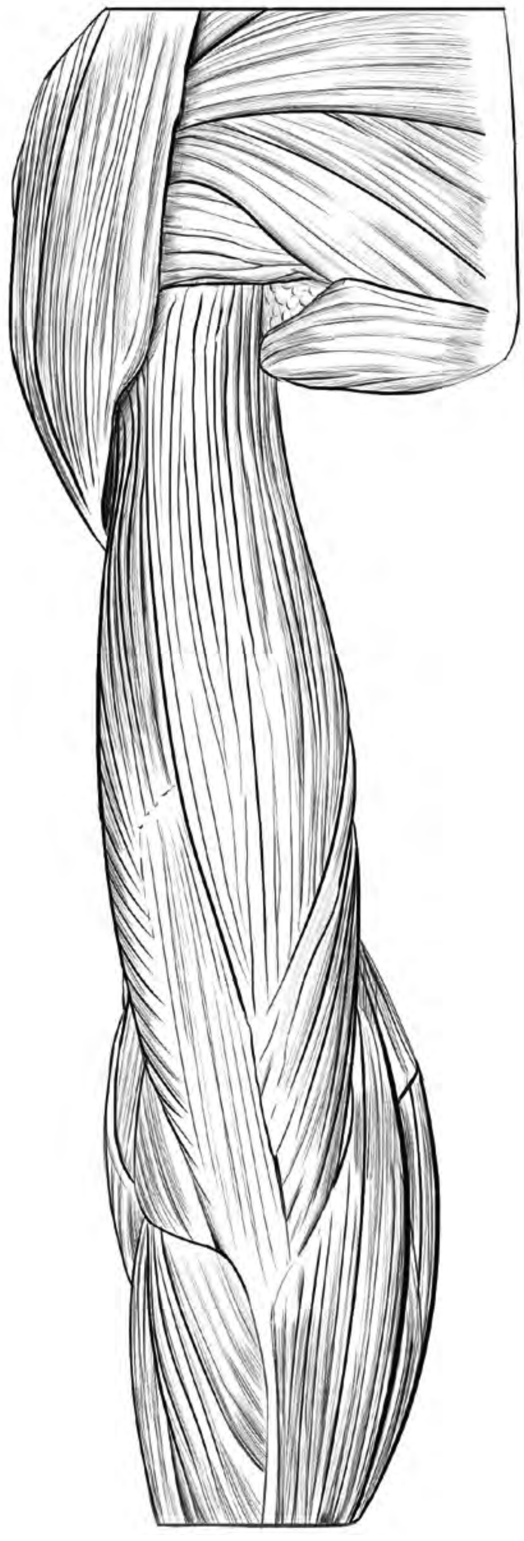
The only muscle on the posterior of the arm is the **triceps brachii**. This three-headed muscle, like the biceps, inserts via a common tendon. The **long head** originates below the glenoid fossa, the **lateral head** originates on the proximal shaft of the humerus, and the **medial head** originates on the distal shaft of the humerus. All three bellies insert on the olecranon process. The triceps is responsible for extension of the arm, and extension of the forearm.

<u>Activity:</u>

1. Identify and state the origin, insertion and action of the following muscles:

- ☐ Triceps brachii, lateral head
- ☐ Triceps brachii, long head
- ☐ Triceps brachii, medial head

Arm Muscles
(Posterior View)



Forearm Muscles
(Anterior View, Superficial Layer)

With one exception, most of the muscles seen on the forearm are responsible for moving the wrist, hand and fingers. That one exception is **brachioradialis**, which flexes the forearm. Brachioradialis originates above the lateral epicondyle and inserts on the styloid process of the radius.

The remaining muscles of the superficial layer of the anterior forearm all originate on the medial epicondyle, but have varying insertion points and actions. The lateral most muscle is the **pronator teres**; this short muscle inserts on the lateral radius and pronates the forearm. Medial to that is the **flexor carpi radialis**, which inserts on lateral metacarpals and flexes and abducts the wrist. Next is the **palmaris longus**; this muscle inserts on the palmer aponeurosis, a layer of fascia on the palm of the hand, and flexes the wrist. Interestingly palmaris longus is missing in about 15% of the population! The most medial muscle is the **flexor carpi ulnaris**, which inserts on the medial carpals and metacarpals and flexes and adducts the wrist. Sitting just under those four muscles, but still visible from this perspective is the **flexor digitorum superficialis**. This muscle inserts on the phalanges of digits 2-5 and flexes the wrist and digits 2-5.

Activity:

1. Identify and state the origin, insertion and action of the following muscles:

- ☐ Brachioradialis
- ☐ Flexor carpi radialis
- ☐ Flexor carpi ulnaris
- ☐ Flexor digitorum superficialis
- ☐ Palmaris longus
- ☐ Pronator teres

Forearm Muscles
(Anterior View, Superficial Layer)

Forearm Muscles
(Anterior View, Deep Layer)

In this figure, flexor digitorum superficialis, pronator teres and flexor carpi radialis have been removed so you can identify the deep muscles of the anterior forearm. From this perspective you can see two superficial muscles: **brachioradialis** and **flexor carpi ulnaris**.

Flexor digitorum profundus sits just deep to flexor digitorum superficialis. This muscle originates on the proximal ulna, inserts onto the distal phalanges of digits 2-5, and flexes the fingers. **Pronator quadratus** is the deepest of all the muscles on the anterior forearm, and sits just proximal to the wrist. It originates on the distal ulna, inserts on the distal radius, and as its name implies, it pronates the forearm.

Activity:

1. Identify and state the origin, insertion and action of the following muscles:

- [ ] Brachioradialis
- [ ] Flexor digitorum profundus
- [ ] Flexor carpi ulnaris
- [ ] Pronator quadratus

Forearm Muscles
(Anterior View, Deep Layer)

Forearm Muscles
(Posterior View, Superficial Layer, Left Arm)

Similar to the anterior forearm, the posterior forearm muscles have a common point of origin. In this case, the origin is the lateral epicondyle. There is one exception, which is **extensor carpi radialis longus**. This lateral muscle originates just above the lateral epicondyle, inserts on the lateral metacarpals, and extends and abducts the wrist. Next to that muscle is the **extensor carpi radialis brevis**, which inserts on the lateral metacarpals and extends and abducts the wrist. Next is the **extensor digitorum**, which inserts on the phalanges of digits 2-5 and extends the wrist and digits 2-5. Next is a small muscle called **extensor digiti minimi**, which inserts on the phalanges of digit #5 and extends digit #5. Finally, there is the **extensor carpi ulnaris**, which inserts on the medial metacarpals and flexes and adducts the wrist.

Activity:

1. Identify and state the origin, insertion and action of the following muscles:

- ☐ Extensor carpi radialis brevis
- ☐ Extensor digiti minimi
- ☐ Extensor carpi radialis longus
- ☐ Extensor digitorum
- ☐ Extensor carpi ulnaris

Forearm Muscles
(Posterior View, Superficial Layer, Left Arm)

Thigh Muscles
(Anterior View, Superficial Layer)

Muscles of the anterior thigh are all responsible for moving the thigh and leg. The most superficial muscle is **sartorius**, which originates at the anterior superior iliac spine, then runs obliquely across the thigh to insert on the medial side of the proximal tibia. This muscle is responsible for flexing, abducting and laterally rotating the thigh, and flexing the leg.

The majority of the anterior thigh is formed by the **quadriceps femoris** muscle, a four headed muscle with a common insertion point: the patella and tibial tuberosity. The quadriceps femoris is responsible for extending the leg. Three of the four heads can be seen on the superficial layer. The longest head is the **rectus femoris**, which originates on the anterior inferior iliac spine. In addition to extending the leg, this head also flexes the thigh. Lateral to rectus femoris is **vastus lateralis**, which originates on the greater trochanter and linea aspera. Medial to rectus femoris is **vastus medialis**, which originates on the linea aspera. The fourth head will be discussed shortly.

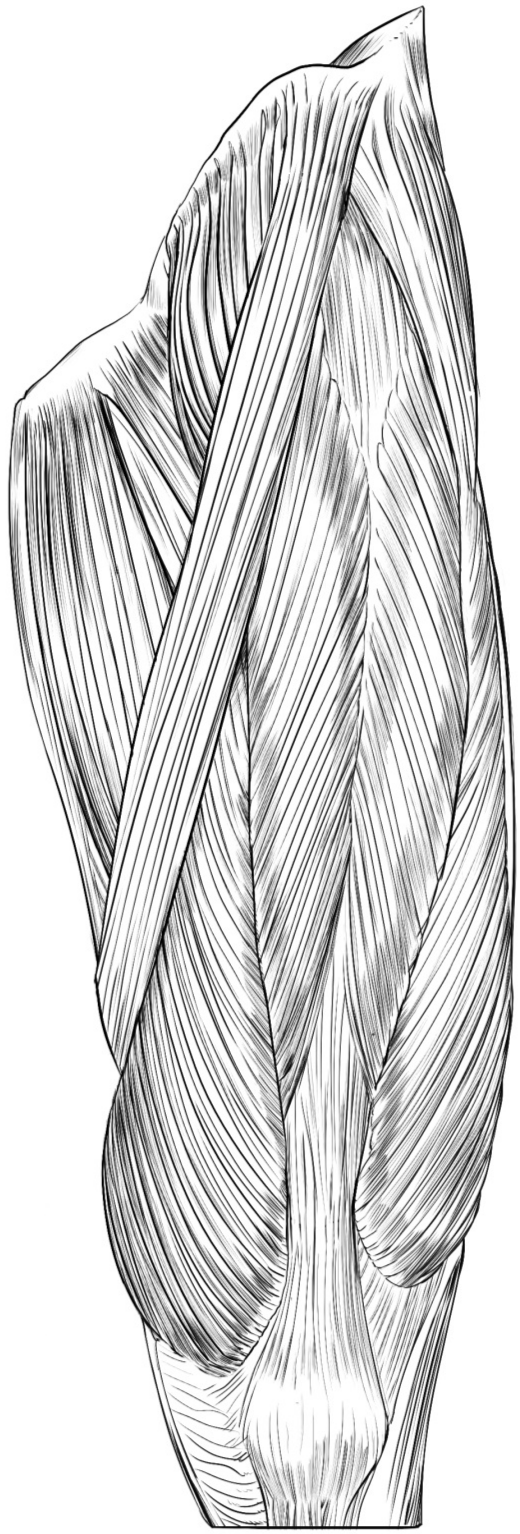
There are several adductor muscles of the thigh, one of which can be seen here. **Adductor longus** originates on the pubis, inserts on the linea aspera and is responsible for adducting, flexing and medially rotating the thigh.

<u>Activity:</u>

1. Identify and state the origin, insertion and action of the following muscles:

☐ Adductor longus	☐ Vastus lateralis
☐ Rectus femoris	☐ Vastus medialis
☐ Sartorius	

Thigh Muscles
(Anterior View, Superficial Layer)



Thigh Muscles
(Anterior View, Deep Layer)

In this figure, sartorius and rectus femoris have been removed so you can see the deep muscles of the anterior thigh. The fourth head of quadriceps can be seen. **Vastus intermedius** lies in between vastus lateralis and vastus medialis. It originates on the anterior and lateral surfaces of the proximal femur, inserts on the patella and tibial tuberosity, and extends the leg. Superior to vastus intermedius is **iliopsoas**. This muscle is actually composed of two muscles with a common insertion point. Iliacus originates on the ilium just under the iliac crest and psoas originates on the lumbar spine. Both insert on the lesser trochanter and flex the thigh.

<u>Activity:</u>

1. Identify and state the origin, insertion and action of the following muscles:

- ☐ Adductor longus
- ☐ Iliopsoas
- ☐ Vastus intermedius
- ☐ Vastus lateralis
- ☐ Vastus medialis

Thigh Muscles
(Anterior View, Deep Layer)

Thigh Muscles
(Posterior View, Superficial Layer)

Much like the anterior thigh, muscles of the posterior thigh are all responsible for moving the thigh and leg. There are three gluteus muscles, one of which can be seen from the superficial perspective. **Gluteus maximus**, the largest of the three, originates on the ilium, sacrum and coccyx, inserts on gluteal tuberosity, and is responsible for extending, abducting and laterally rotating the thigh.

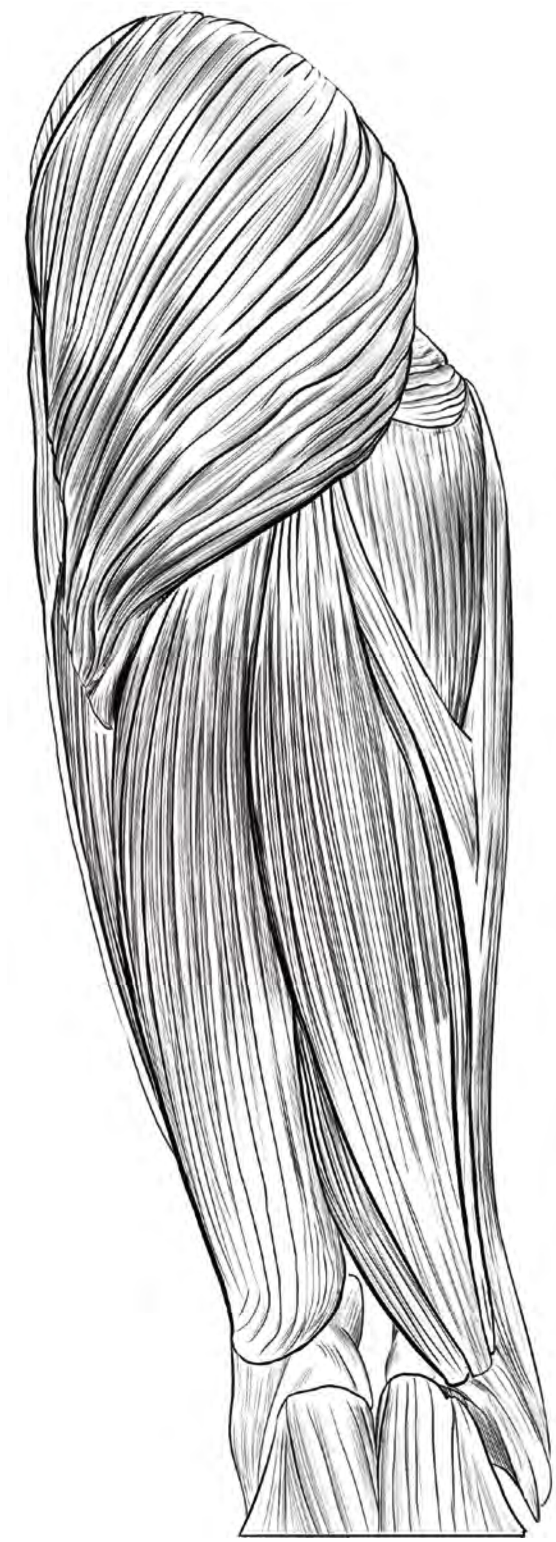
There are three muscles that run down the length of the posterior thigh, which are collectively referred to as the **hamstrings**. These muscles all extend the thigh and flex the knee. The **biceps femoris** forms that lateral portion of the hamstrings. This muscle has two heads (long and short) with a common insertion point on the lateral condyle of the tibia. The **long head** originates on the ischial tuberosity. The short head will be shown on the next page. The remaining two muscles form the medial portion of the hamstrings. **Semitendinosus** is the more superficial of the two; it originates on the ischial tuberosity and inserts on the medial shaft of the proximal tibia. The deeper muscle, **semimembranosus**, originates on the ischial tuberosity as well, but inserts on the medial condyle of the tibia.

Activity:

1. Identify and state the origin, insertion and action of the following muscles:

☐	Biceps femoris, long head	☐	Semimembranosus
☐	Gluteus maximus	☐	Semitendinosus

Thigh Muscles
(Posterior View, Superficial Layer)



Thigh Muscles
(Posterior View, Deep Layer)

In this view, gluteus maximum, biceps femoris long head, as well as semiteniosus and semimembranosus have been removed so you can identify the deep muscles of the posterior thigh. The **vastus lateralis** can be seen on this image.

This deeper view allows us to see the **biceps femoris, short head**. This muscle originates on the linea aspera, and, like the long head, inserts on the lateral condyle of the tibia. It helps to extend the thigh and flex the knee.

A second gluteus muscle, **gluteus medius**, can be seen. Gluteus medius is deeper and smaller than gluteus maximus. This muscle originates on the ilium, inserts on the greater trochanter, and abducts and medially rotates the thigh.

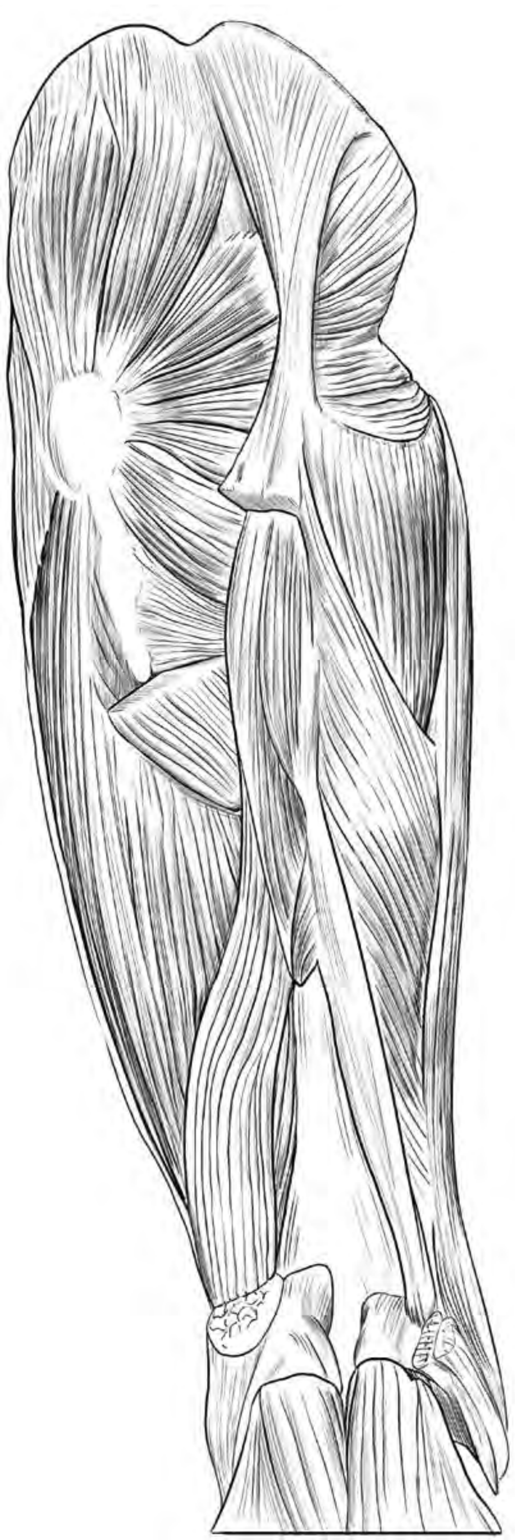
Two other pelvic muscles can be identified. **Piriformis** is found just distal to gluteus medius. This muscle originates on the sacrum, inserts on the greater trochanter, and laterally rotates the thigh. **Quadratus femoris** is distal to piriformis. It originates on the ischial tuberosity, inserts on the intertrochanteric crest and laterally rotates the thigh.

Activity:

1. Identify and state the origin, insertion and action of the following muscles:

- ☐ Biceps femoris, short head
- ☐ Quadratus femoris
- ☐ Gluteus medius
- ☐ Vastus lateralis
- ☐ Piriformis

Thigh Muscles
(Posterior View, Deep Layer)



Thigh Muscles
(Lateral View)

From the lateral perspective, you can see several of the muscles that we covered on the anterior view, including **rectus femoris** and **vastus lateralis**. Several posterior muscles can also be seen, including **gluteus maximus** and **biceps femoris**.

The most lateral muscle of the thigh is **tensor fasciae latae**. This muscle is unusual because it has a very small belly and a very long tendon, called the **iliotibial tract**. Tensor fasciae latae originates on iliac crest and anterior superior iliac spine and inserts on the lateral condyle of the tibia via the iliotibial tract. It is responsible for flexing, abducting, and medially rotating the thigh.

Activity:

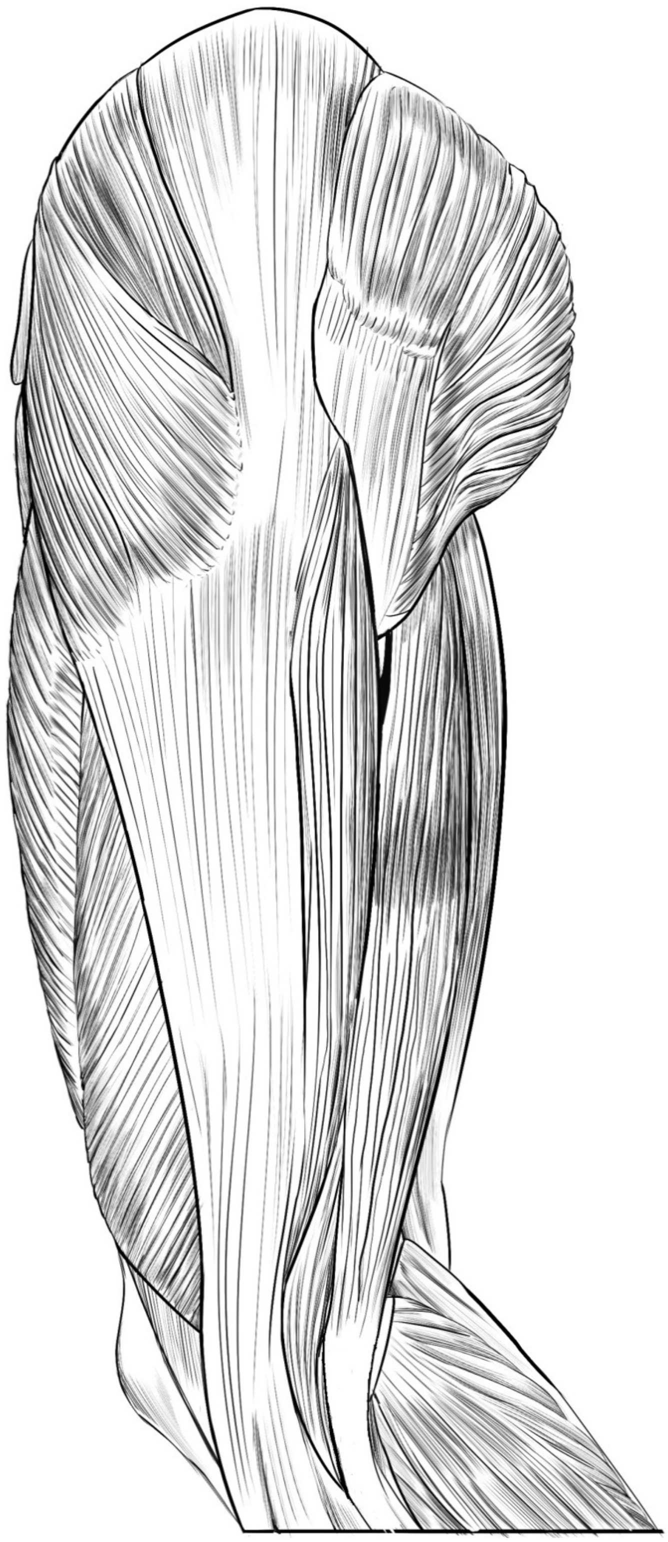
1. Identify and state the origin, insertion and action of the following muscles:

- ☐ Biceps femoris
- ☐ Gluteus maximus
- ☐ Rectus femoris
- ☐ Tensor fasciae latae
- ☐ Vastus lateralis

2. Identify the following structure:

- ☐ Iliotibial tract

Thigh Muscles
(Lateral View)



Thigh Muscles
(Medial View)

From the medial perspective, you can see several of the muscles that we covered on the anterior view, including **sartorius**, **vastus medialis** and **adductor longus**. Several posterior muscles, including **gluteus maximus**, **semitendinosus** and **semimembranosus**, can also be seen.

The most medial muscle of the thigh is **gracilis**. This relatively flat muscle originates on the pubis, inserts on the medial tibia, and adducts and medially rotates the thigh and flexes the leg.

A second adductor muscle can also be seen. The majority of **adductor magnus** is found posterior to gracilis, with a remaining small portion visible anterior to gracilis and distal to adductor longus. This muscle originates on the ischial tuberosity and the pubis and inserts on the linea aspera. The anterior portion of the muscle adducts, flexes and medially rotates the thigh, like the adductor longus. The posterior portion extends the thigh.

<u>Activity:</u>

1. Identify and state the origin, insertion and action of the following muscles:

☐	Adductor longus	☐	Sartorius
☐	Adductor magnus	☐	Semimembranosus
☐	Gluteus maximus	☐	Semitendinosus
☐	Gracilis	☐	Vastus medialis

Thigh Muscles
(Medial View)

Leg Muscles
(Anterior View)

The three muscles of the anterior compartment of the leg act on the ankle and toes. **Tibialis anterior** sits just lateral to the shaft of the tibia. It originates on the lateral condyle of the tibia, inserts on the medial cuneiform and first metatarsal, and dorsiflexes and inverts the foot. **Extensor digitorum longus** sits lateral to tibialis anterior. It originates on the lateral condyle of the tibia, inserts on the middle and distal phalanges of digits 2-5, and dorsiflexes the foot and extends digits 2-5. **Extensor hallucis longus** is deep to both extensor digitorum longus and tibialis anterior. It originates on the fibula, inserts on the distal phalanx of digit 1, and dorsiflexes the foot and extends digit 1 (the hallux).

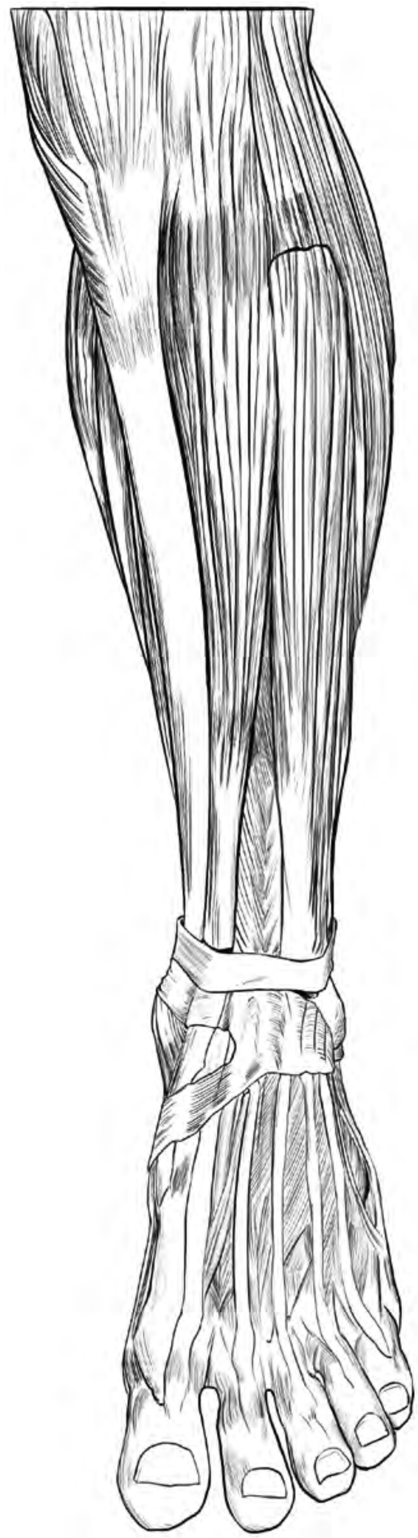
Activity:

1. Identify and state the origin, insertion and action of the following muscles:

☐ Extensor digitorum longus ☐ Tibialis anterior

☐ Extensor hallucis longus

Leg Muscles
(Anterior View)



Leg Muscles
(Posterior View, Superficial and Intermediate Layers)

The muscles of the posterior leg all work together to plantar flex the foot. A pair of muscles, collectively referred to as the **triceps surae**, with a common insertion point on the calcaneus, can be seen on the superficial and intermediate layers. **Gastrocnemius**, the more superficial of the two, originates on the lateral and medial condyles of the femur. **Soleus**, the deeper muscle, originates on the proximal tibia and fibula.

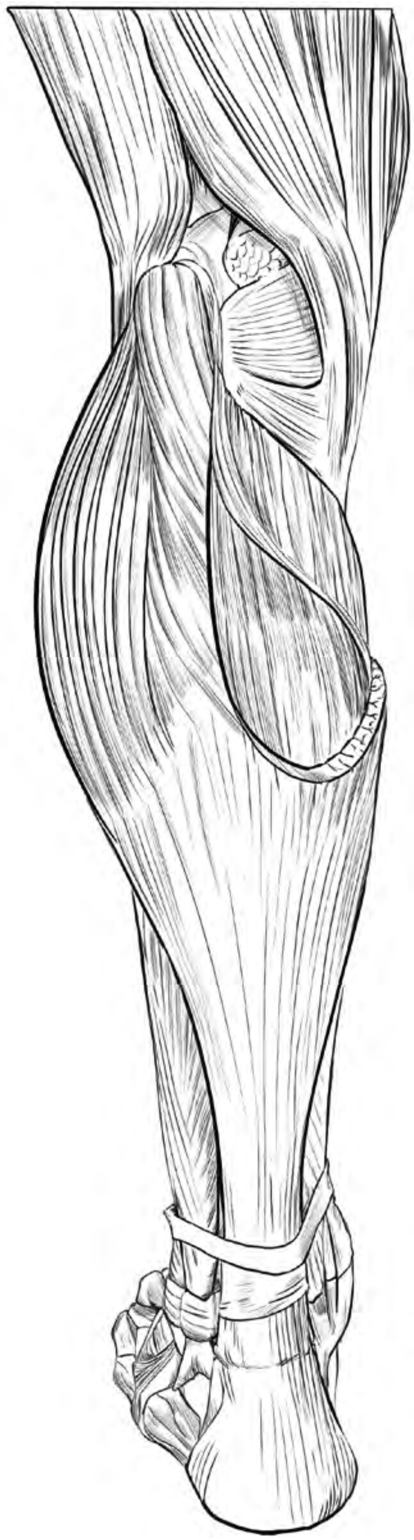
This image shows both the gastrocnemius and the soleus. The medial belly of the gastrocnemius has been removed so you can see the medial portion of the soleus underneath.

<u>Activity:</u>

1. Identify and state the origin, insertion and action of the following muscle:

☐ Gastrocnemius ☐ Soleus

Leg Muscles
(Posterior View, Superficial and Intermediate Layers)



Leg Muscles
(Posterior View, Deep Layer)

In this image, gastrocnemius and soleus have been removed so you can identify the deep muscles of the posterior leg. The most proximal of the four muscles in the deep layer is **popliteus**. This muscle originates on the lateral condyle of the femur, inserts on the proximal tibia and flexes and medially rotates the leg. Below popliteus are three muscles that act on the ankle joint to move the foot. **Flexor digitorum longus** originates on the posterior tibia, inserts on the distal phalanges of toes 2-5, and plantar flexes and inverts the foot, and flexes toes 2-5. **Flexor hallucis longus** originates on the shaft of the fibula, inserts on the distal phalanx of the great toe, and plantar flexes and inverts the foot, and flexes the great toe. **Tibialis posterior** originates on the proximal tibia and fibula, inserts on the navicular and medial cuneiform tarsals, and inverts and plantar flexes the foot.

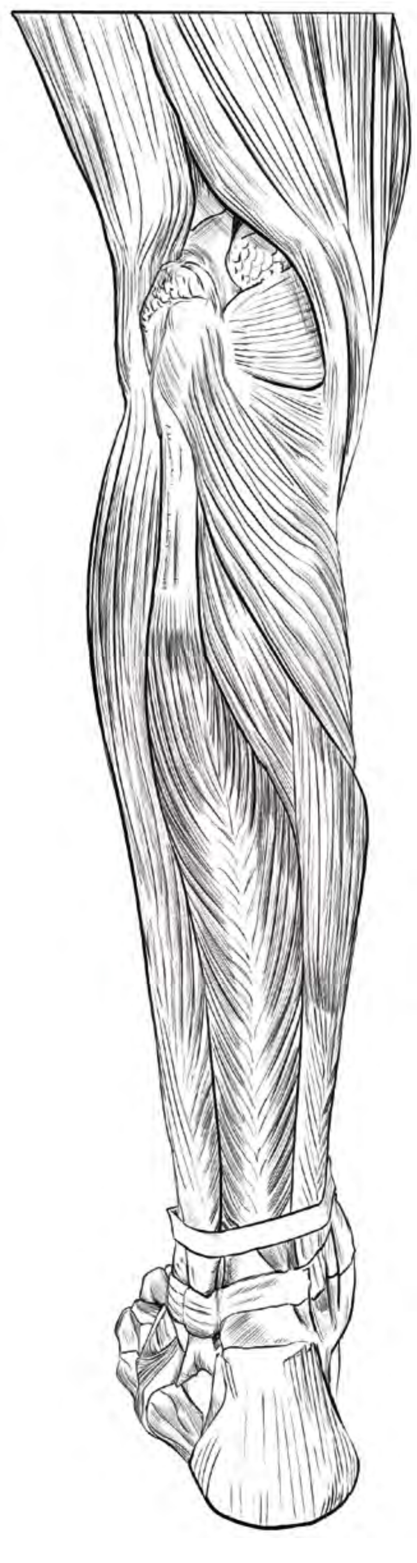
Note that **fibularis brevis and longus** can also be seen on this figure.

<u>Activity:</u>

1. Identify and state the origin, insertion and action of the following muscle:

☐	Fibularis brevis	☐	Flexor hallucis longus
☐	Fibularis longus	☐	Popliteus
☐	Flexor digitorum longus	☐	Tibialis posterior

Leg Muscles
(Posterior View, Deep Layer)



Leg Muscles
(Lateral View)

The lateral compartment of the leg includes two fibularis muscles, one long and one short, both of which are responsible for plantar flexion and eversion of the foot. **Fibularis longus** originates on the head of the fibula and inserts on the first metatarsal and medial cuneiform. **Fibularis brevis** originates on the distal fibula and inserts on the fifth metatarsal.

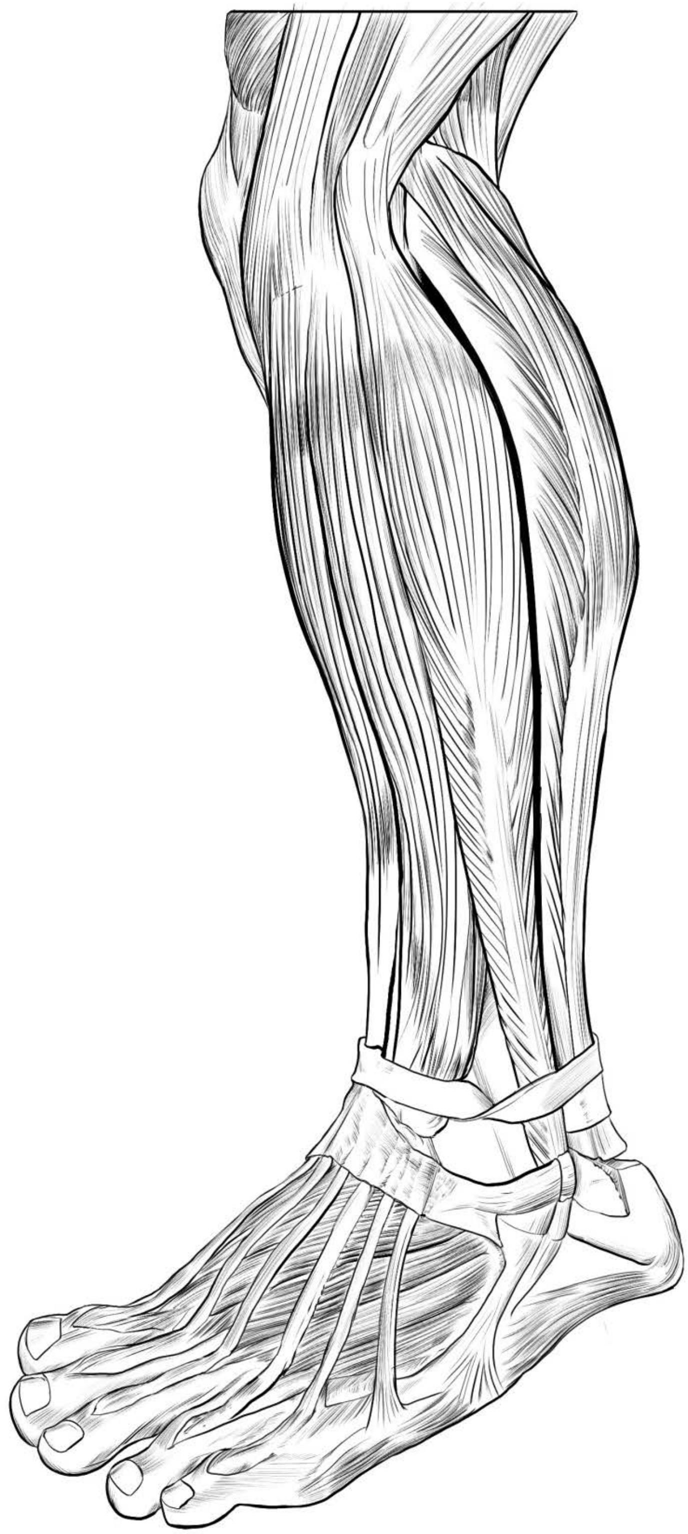
Note that from this perspective you can also see several muscles from the anterior compartment (**tibialis anterior**, **extensor digitorum longus** and **extensor hallucis longus**), and several from the posterior compartment (**gastrocnemius** and **soleus**).

<u>Activity:</u>

1. Identify and state the origin, insertion and action of the following muscles:

- ☐ Extensor digitorum longus
- ☐ Extensor hallucis longus
- ☐ Fibularis brevis
- ☐ Fibularis longus
- ☐ Gastrocnemius
- ☐ Soleus
- ☐ Tibialis anterior

Leg Muscles
(Lateral View)



The Neuron

Nervous tissue is composed of two cell types: neurons and neuroglial cells. Neurons are the functional cells of nervous tissue in that they are electrically excitable and are able to communicate with other cells. Neuroglial cells are the supportive cells of the nervous tissue, providing nourishment, insulation and protection.

Neurons contain four different regions: dendrites, a cell body, an axon and axon terminals. The input regions of the neuron are the **dendrites**, which are tree-like branches that extend from the neuron. Chemical signals come to the dendrites from other neurons. The dendrites are attached to the **cell body** (soma), which contains the nucleus of the neuron. Surrounding the nucleus are Nissl bodies – rough ER – which manufacture and package proteins, including neurotransmitters. The cell body narrows to form the **axon**, which allows for conduction of nerve impulses toward the output region of the neuron, the **axon terminals**. Inside the axon terminals are vesicles, which contain neurotransmitter. When a nerve impulse arrives at the axon terminal the neurotransmitter is released onto the post-synaptic neuron or effector, eliciting some change in that cell.

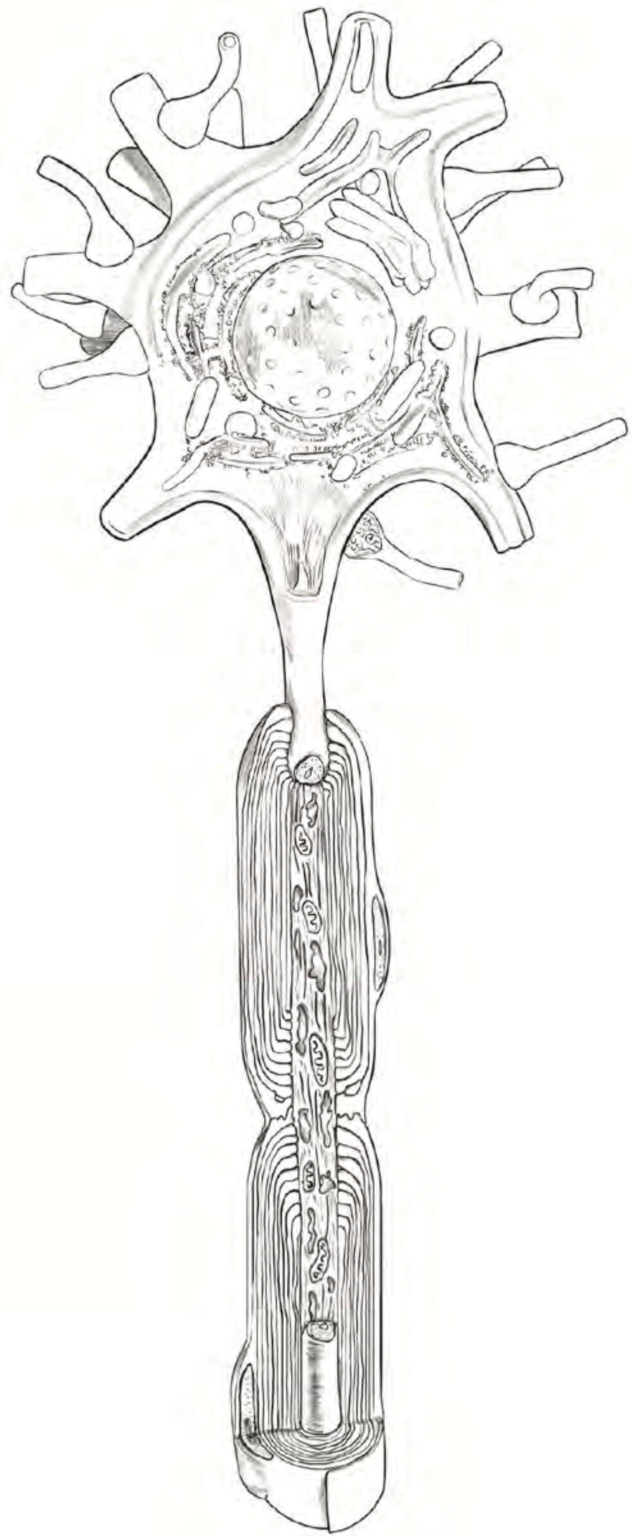
In most cases, nerve impulses must be conducted very rapidly down the length of the axon to the axon terminal. To allow for fast conduction these neurons have a **myelin sheath** surrounding them, insulating the axon. This myelin sheath is created by the wrapping of a **Schwann cell** around the axon.

Activity:

1. Identify and state the purpose of the following:

- ☐ Axon
- ☐ Axons terminals
- ☐ Cell body
- ☐ Dendrites
- ☐ Nissl bodies
- ☐ Node of Ranvier
- ☐ Nucleus of neuron
- ☐ Nucleus of Schwann cell
- ☐ Myelin sheath

The Neuron



Nervous Tissue Histology

Once you are familiar with the generalized structure of nervous tissue, you should be able to identify many of the features on prepared and stained sections of the nervous tissue.

The first slide is of giant multipolar neurons surrounded by neuroglial cells. You should be able to find the cell bodies of several neurons in this smear, as well as the various processes that branch off the cell body, and the numerous neuroglial cells that surround them.

The second slide is of a nerve, which is a bundle of myelinated axons held together by connective tissue called epineurium. You will be able to identify the axons and the myelin sheaths.

Activity:

1. Obtain slide number 42 from your slide box.
2. Using the 40X objective lens, locate the following:

    Neuroglial cells
    Neuron cell body
    Neuron processes

3. Draw what you see on the following page, labelling the structures above.
4. Obtain slide number 44 from your slide box.
5. Using the 40X objective lens, and focusing on the cross section of the nerve, locate the following structures:

    Axons
    Myelin sheath

6. Draw what you see on the following page, labelling the structures above.

Nervous Tissue Histology

The Meninges

The brain and spinal cord are surrounded by protective membranes, called the meninges. There are three layers of connective tissue that form the meninges. The outermost layer is called the **dura mater**, which is the toughest of the three layers. Deep to the dura mater, is a more delicate layer called the **arachnoid mater**. Its name is derived from the fact that this layer has a spider web-like appearance. The innermost layer of the meninges is the **pia mater**. This very thin, delicate layer is found touching the brain and spinal cord.

There are several spaces associated with the meninges. Outside of the dura mater is the **epidural space**, which contains fatty tissue in addition to lymphatic and blood vessels. In between the dura and arachnoid mater is the **subdural space**. This space is normally very thin and contains a trace amount of fluid. The space between the arachnoid and pia mater is called the **subarachnoid space**. This relatively large space is filled with nourishing and protective cerebrospinal fluid (CSF).

This model shows a transverse section of the spinal cord, in which you can see gray and white matter. **White matter** appears white because of the presence of myelin; therefore, this is where axons are found. **Gray matter** is composed of the regions of the neuron that lack myelin, the dendrites, cell bodies and axon terminals; synapses are formed in gray matter. In the spinal cord, the gray matter is deep, surrounding the central canal, while the white matter is superficial.

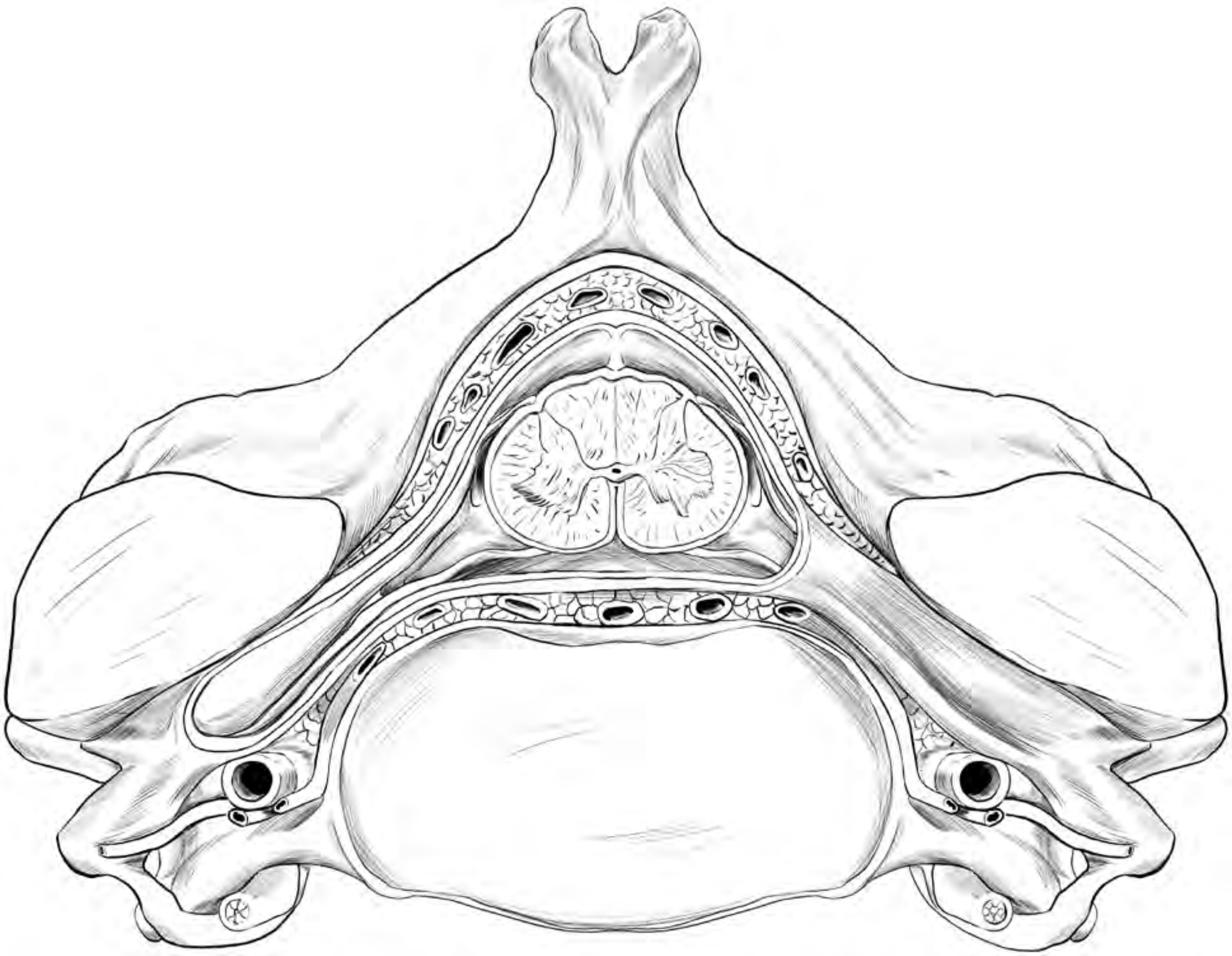
Activity:

1. Identify the following:

☐	Arachnoid mater	☐	Pia mater
☐	Dura mater	☐	Subdural space
☐	Epidural space	☐	Subarachnoid space
☐	Gray matter	☐	White matter

2. What is the difference between gray matter and white matter?

The Meninges



The Spinal Cord
(Posterior and Lateral Views)

The spinal cord is one of the two organs that are part of the central nervous system (CNS). It provides innervation to the organs from the neck down, allows for conduction of signals to and from the brain, and is also heavily involved in reflexes.

The spinal cord goes through the vertebral column, from the foramen magnum of the skull down to the first or second lumbar vertebra (L1/L2). The end of the cord forms a cone-shaped, pointed structure called the **conus medullaris**. Holding the end of the cord in place is a long piece of connective tissue called the **filum terminale**, which attaches the conus medullaris to the coccyx. The filum terminale is actually an extension of pia mater, the innermost layer of the meninges. Below the conus medullaris are lumbar and sacral nerve roots, collectively called the **cauda equina**, which means "horse's tail".

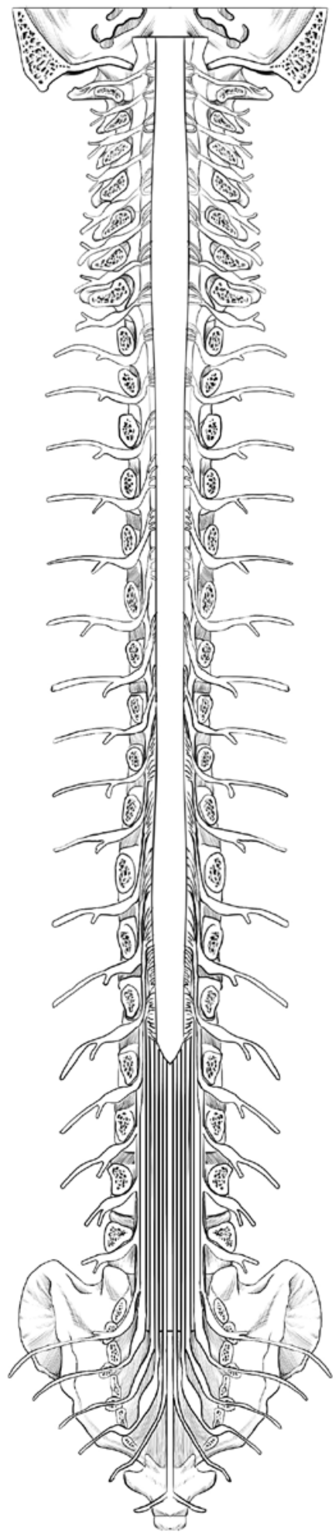
There are two regions of the spinal cord that are worth noting. First, is the **cervical enlargement**, which, as the name implies, is an enlargement in the width of the cervical region of the spinal cord. Nerves to the upper limb originate from this region of the spinal cord. The second is the **lumbar enlargement**, which is a widening of the lumbar region of the spinal cord. Similar to the cervical enlargement, the lower limb nerves originate from this region of the cord.

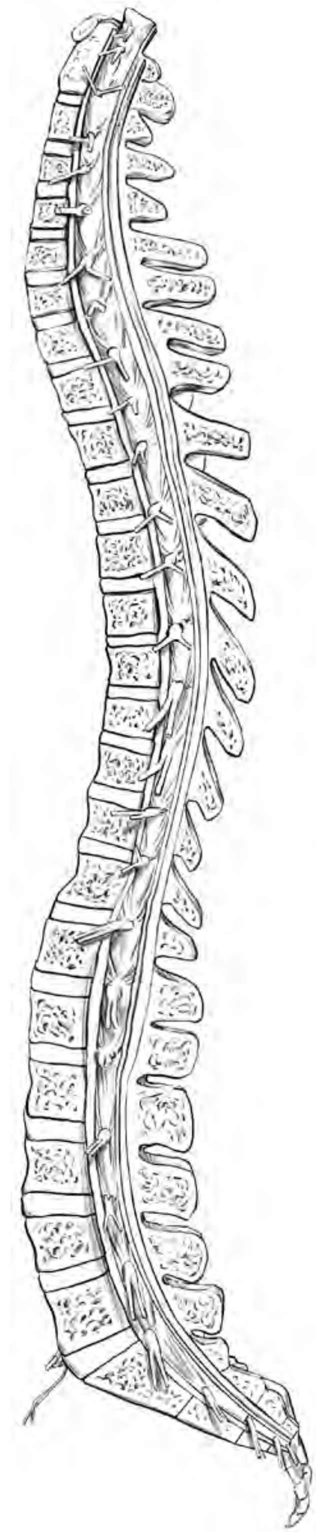
Activity:

1. Identify the following structures:

☐	Cauda equina	☐	Conus medullaris
☐	Cervical enlargement	☐	Lumbar enlargement

The Spinal Cord
(Posterior and Lateral Views)





The Spinal Cord
(Transverse Section)

This model is a transverse section of the spinal cord, which will allow you to see the internal structures of the cord. Down the center of the spinal cord is a hole, called the **central canal**, which contains cerebrospinal fluid (CSF). The cord is partially divided into right and left halves by two grooves that extend down the length of the cord: the **dorsal (posterior) median sulcus** and the **ventral (anterior) median groove**.

As previously discussed, the white matter of the cord is superficial, whereas the gray matter is deep. The white matter is arranged in three columns, called funiculi: the **ventral (anterior) funiculus, lateral funiculus** and **dorsal (posterior) funiculus**. All of the funiculi are part of the ascending and descending tracts of the spinal cord, sending sensory information up to, and motor information down from, the brain.

The gray matter is arranged in a butterfly-shaped structure. Within it, there are three columns of gray matter called horns. On the anterior side there are the **ventral horns**. Motor neuron cell bodies originate there; their axons leave the cord via the **ventral roots**, and become part of the **spinal nerve**. **Lateral horns** are found only in the T1-L2 region of the spinal cord; these columns are also involved in motor innervation. Whereas motor information is leaving the cord, sensory information is coming to it. Sensory neurons travel through the spinal nerve, into the **dorsal root ganglion**, which houses the cell bodies of the sensory neurons. Their axons then enter the cord via the **dorsal roots**, and then synapse with interneurons found in the **dorsal (posterior) horn**.

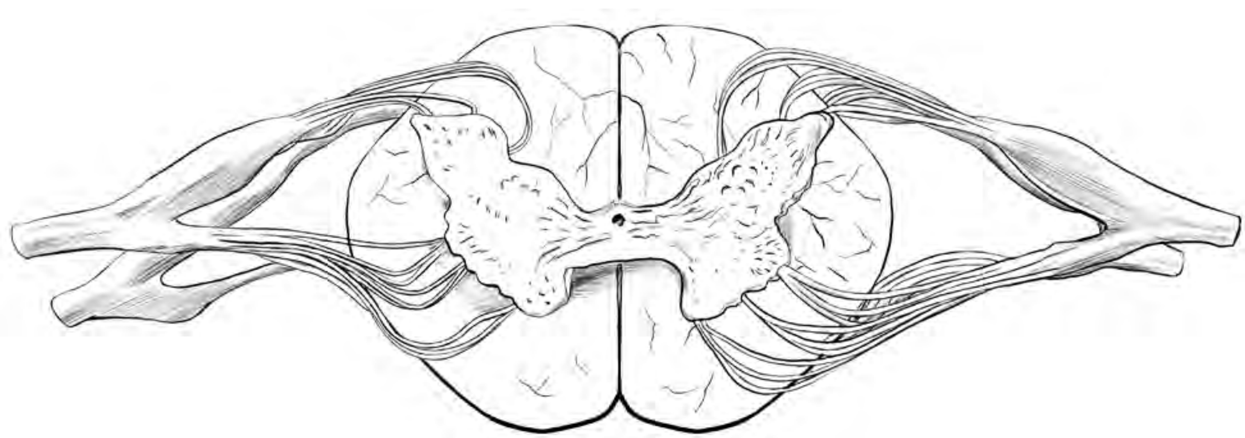
Activity:

1. Identify the following structures:

- ☐ Central canal
- ☐ Dorsal/posterior funiculus/column
- ☐ Dorsal/posterior horn*
- ☐ Dorsal/posterior median sulcus
- ☐ Dorsal root*
- ☐ Dorsal root ganglion*
- ☐ Lateral funiculus/column
- ☐ Spinal nerve
- ☐ Ventral/anterior funiculus/column
- ☐ Ventral/anterior horn*
- ☐ Ventral/anterior median fissure
- ☐ Ventral root*

2. Are the areas labeled with an asterisk (*) sensory or motor?

The Spinal Cord
(Transverse Section)



Spinal Cord Histology

Once you are familiar with the generalized structure of the spinal cord, you should be able to identify many of the features on prepared and stained sections of the spinal cord.

This slide is of a transverse section of the spinal cord, and includes the dorsal root ganglion.

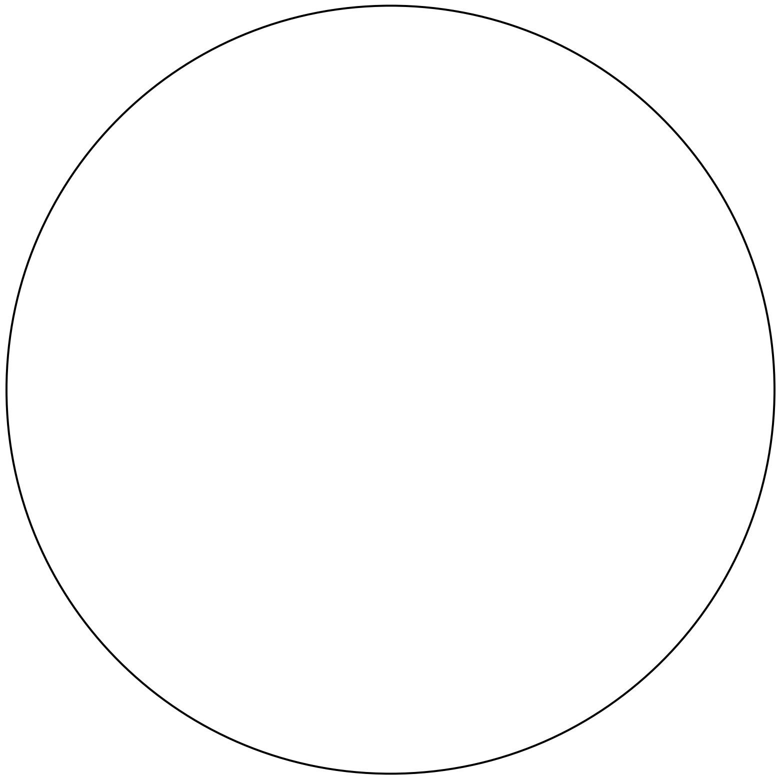
Activity:

1. Obtain slide number 46 from your slide box.
2. Using the 4X objective lens, locate the following:

   Central canal
   Dorsal horn
   Dorsal median sulcus
   Dorsal root ganglion
   Dorsal white funiculus
   Gray matter
   Ventral horn
   Ventral median fissure
   Ventral white funiculus
   White matter

3. Draw what you see on the following page, labelling the structures listed above.

Spinal Cord Histology



The Cerebrum
(Lateral View)

The brain is divided into four regions: the cerebrum, diencephalon, brain stem and cerebellum. In this figure, we will be focusing on the cerebrum. The **cerebrum** is the conscious part of our brain, allowing us to be aware of sensations coming to the brain as well as initiating voluntary body movements. Many aspects of our behavior are mediated here, as well as memory and emotions.

Note that the cerebrum is not flat. Rather it has grooves called **sulci** (singular, sulcus) in between raised ridges called **gyri** (singular, gyrus). Most gyri and sulci are uniform between individuals, and most of the gyri have been mapped so that we can understand which brain activities occur in those regions.

The cerebrum is divided into five lobes, four of which can be seen on this figure: the frontal, parietal, temporal and occipital lobes. The **frontal lobe** is separated from the parietal lobe by the **central sulcus**. The frontal lobe is responsible for initiating voluntary body movements, as well as certain aspects of our behavior and memory. Directly in front of the central sulcus, within the frontal lobe, is the **precentral gyrus**, where the primary motor area is found. The **parietal lobe** is a sensory lobe, involved in proprioception, somatosensation and vision. Directly behind the central sulcus, within the parietal lobe, is the **postcental gyrus**, where the primary somatosensory area is found. The **lateral sulcus** (fissure) separates the frontal and parietal lobes from the temporal lobe. The **temporal lobe** contains the primary auditory cortex, and is also involved in memory. The remaining lobe, the **occipital lobe**, contains the primary visual area.

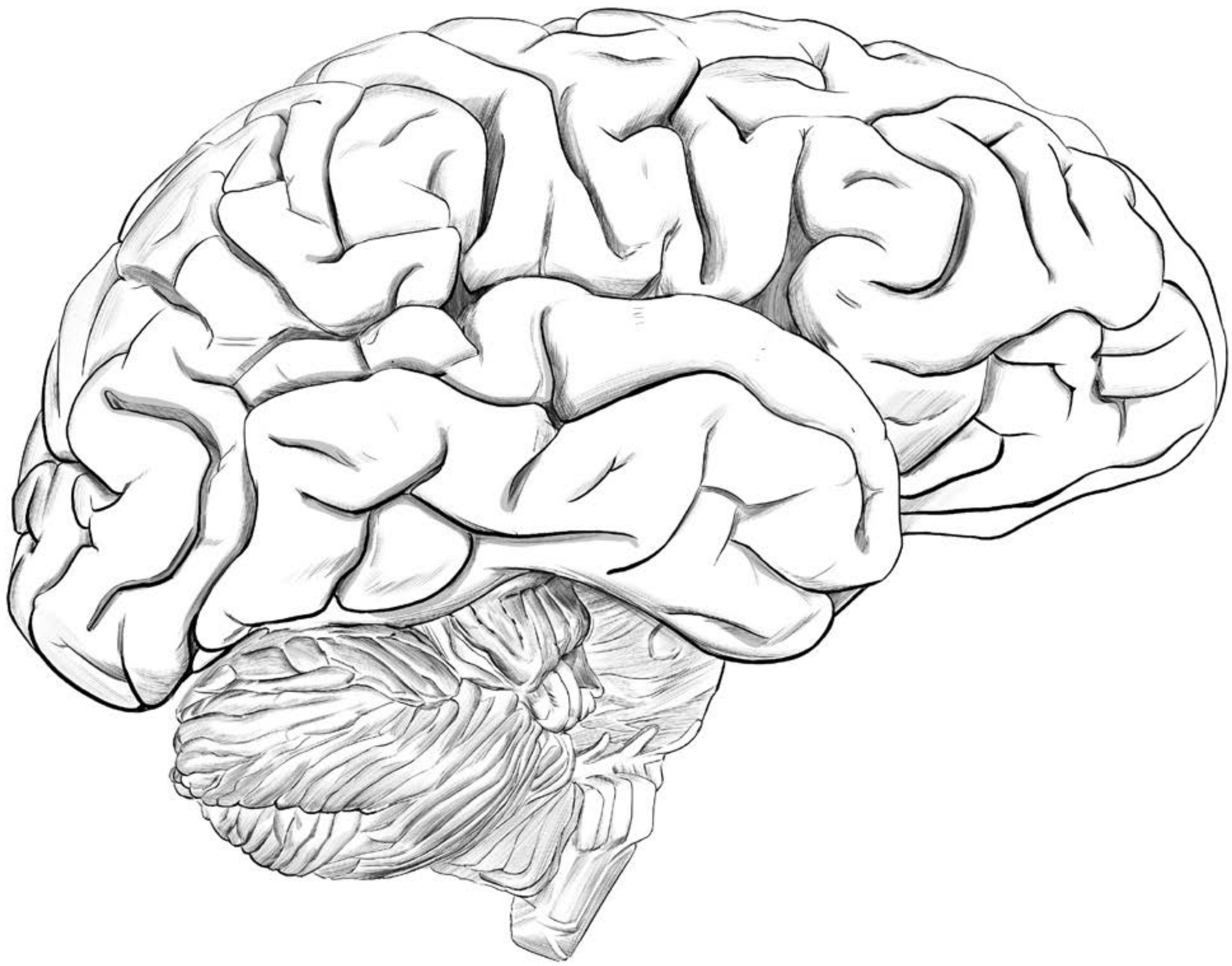
<u>Activity:</u>

1. Identify the following structures:

☐	Central sulcus	☐	Parietal lobe
☐	Frontal lobe	☐	Post-central gyrus
☐	Lateral sulcus	☐	Pre-central gyrus
☐	Occipital lobe	☐	Temporal lobe

2. What is the difference between a gyrus and a sulcus?
3. In what lobes are the following brain areas found? Motor, somatosensory, auditory, and visual

The Cerebrum
(Lateral View)



The Cerebrum
(Superior View)

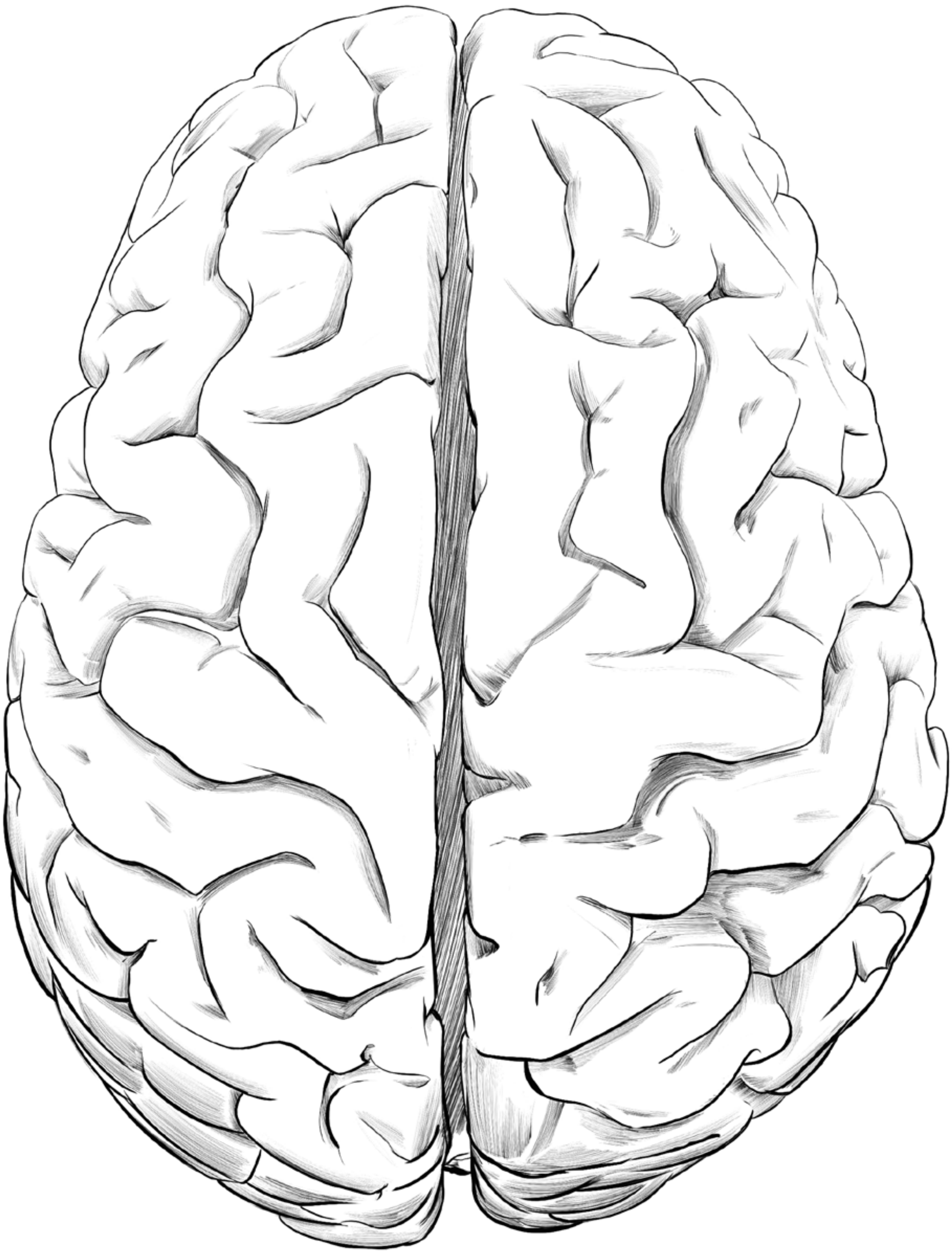
The cerebrum has two halves, called **hemispheres**, which are separated from one another by the **longitudinal fissure**. From the superior view, you can see three of the lobes (**frontal**, **parietal** and **occipital**) as well as the **central sulcus, precentral gyrus** and **postcentral gyrus**.

Activity:

1. Identify the following structures:

☐ Central sulcus	☐ Parietal lobe
☐ Frontal lobe	☐ Postcentral gyrus
☐ Left hemisphere	☐ Precentral gyrus
☐ Longitudinal fissure	☐ Right hemisphere
☐ Occipital lobe	

The Cerebrum
(Superior View)



The Brain
(Sagittal Section)

A sagittal section of the brain allows you to see the four different regions of the brain. Recall that the first region of the brain, the **cerebrum**, has two hemispheres; the hemispheres are held together by the **corpus callosum**. The second region of the brain, the **diencephalon**, has three parts: the thalamus, hypothalamus and epithalamus. The **thalamus**, which forms the majority of the diencephalon, surrounds the third ventricle. Its two halves are held together by the **intermediate mass**. The thalamus is a sensory relay area; all sensory information (except olfaction) goes through the thalamus, and can even be edited, before going to the sensory cortices. Just below the thalamus is the **hypothalamus**, which contains many different nuclei responsible for vital bodily functions, such as hunger, satiety, thirst, body temperature, and circadian rhythms. It also attaches to the endocrine pituitary gland below, controlling its actions. Just behind the thalamus is the **epithalamus**, part of which is the endocrine **pineal gland**; this gland secretes the hormone melatonin to cause feelings of tiredness.

The third region of the brain, the **brain stem**, has three parts: the midbrain, pons and medulla oblongata. The **midbrain** surrounds the cerebral aqueduct. On its dorsal side, there are two pairs of colliculi ("mounds"), collectively referred to as the **corpora quadrigemina**. The **superior colliculi** are involved in visual reflexes; the **inferior colliculi** are involved in auditory reflexes. The **pons** is a bulge of tissue that sits inferior to the midbrain and anterior to the fourth ventricle. It is a sensory and motor relay area, contains fibers that connect the cerebrum to the cerebellum, and also has centers involved in breathing. The **medulla oblongata**, which connects the brain to the spinal cord, has nuclei that control the heart, blood vessels and respiration, in addition to other miscellaneous functions such as hiccupping and vomiting.

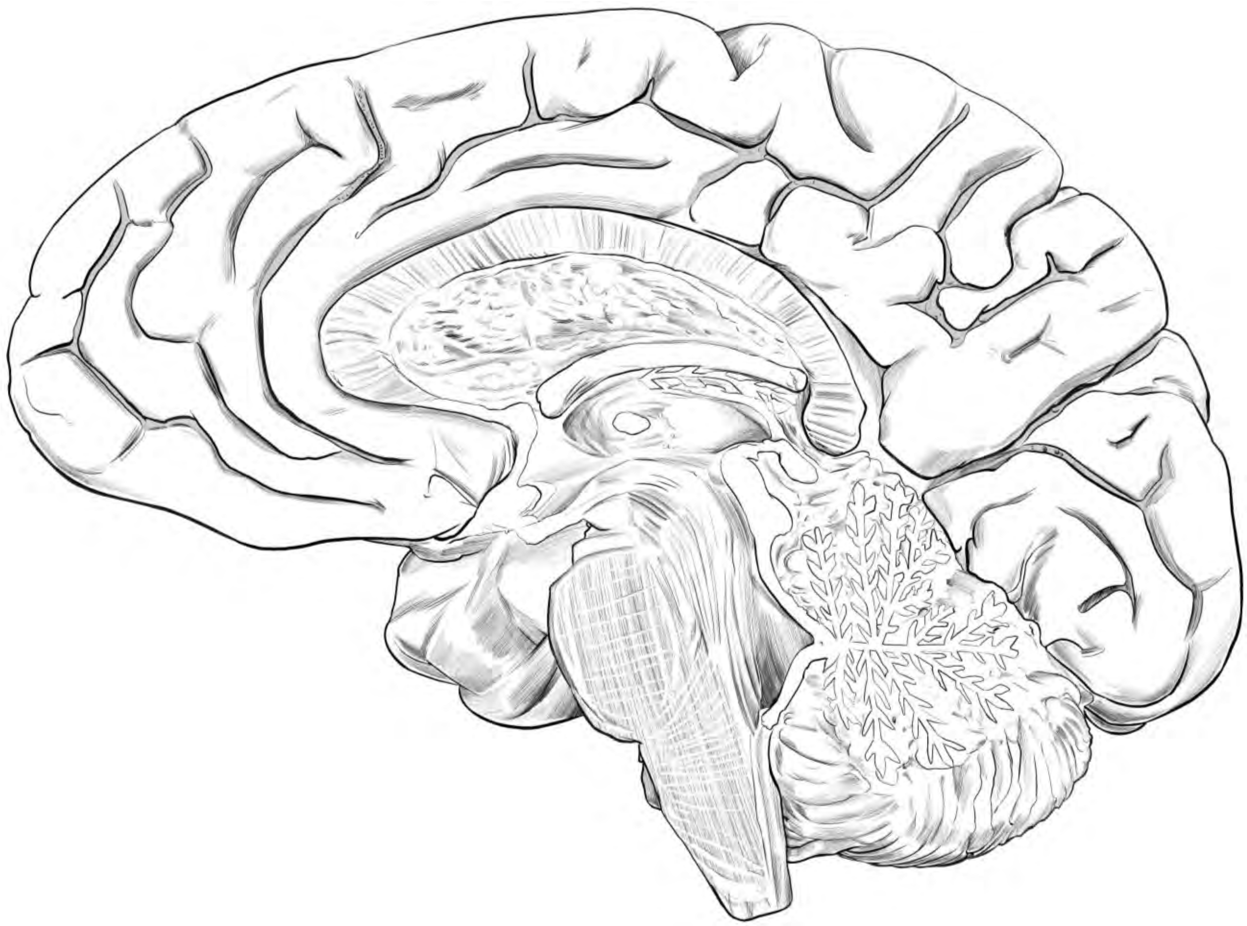
The **cerebellum**, which is the final region of the brain, is responsible for maintaining balance and equilibrium. Its anatomy will be discussed shortly.

Activity:

1. Identify and state the purpose of the following structures:

☐ Cerebrum	☐ Inferior colliculus	☐ Pineal gland
☐ Cerebellum	☐ Intermediate mass	☐ Pons
☐ Corpora quadrigemina	☐ Medulla oblongata	☐ Superior colliculus
☐ Corpus callosum	☐ Midbrain	☐ Thalamus
☐ Hypothalamus		

The Brain
(Sagittal Section)



The Cerebellum
(Posterior and Sagittal Views)

The **cerebellum** is the second largest region of the brain. It is located just posterior to the brainstem and fourth ventricle. Like the cerebrum, the cerebellum has two hemispheres; the cerebellar hemispheres are connected by the **vermis**. Also like the cerebrum, the surface of the cerebellum is not flat, but rather has folds. The ridges are called **folia**, which are separated by **fissures**. Recall that in the spinal cord there is a deep layer of gray matter surrounding the central canal, and a superficial layer of white matter. The brain structures have three areas: deep gray matter called nuclei, internal white matter, and a superficial layer of gray matter called the cortex. In the cerebellum, the white matter is called the **arbor vitae** ("the tree of life") because of its resemblance to tree branches.

Activity:

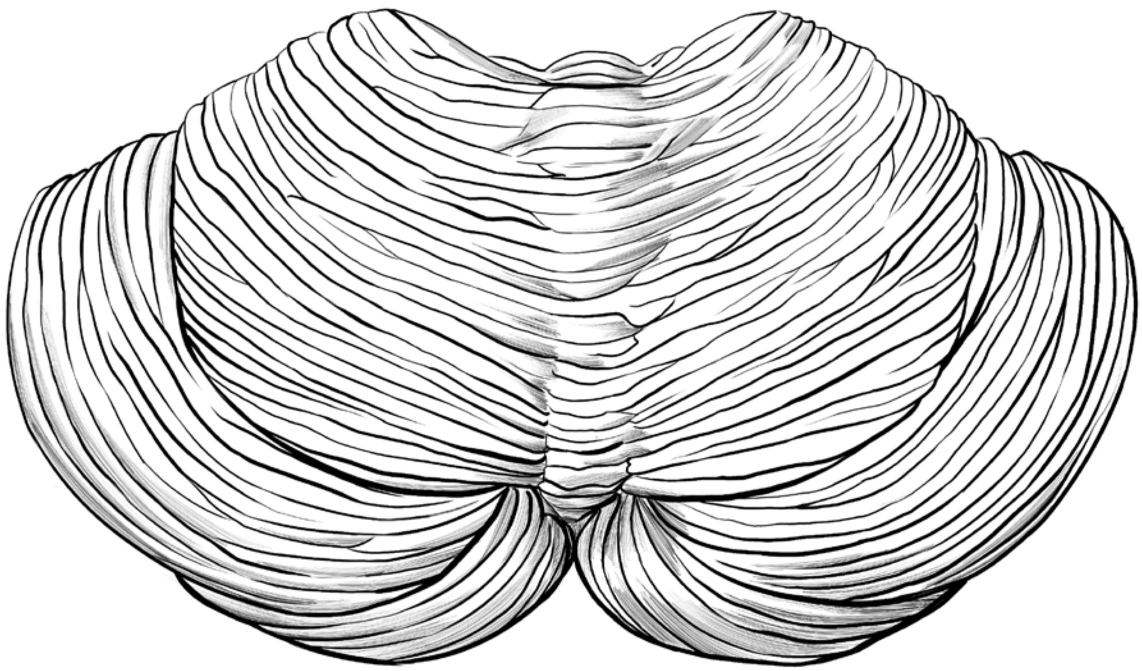
1. Identify the following structures on the posterior view of the cerebellum:

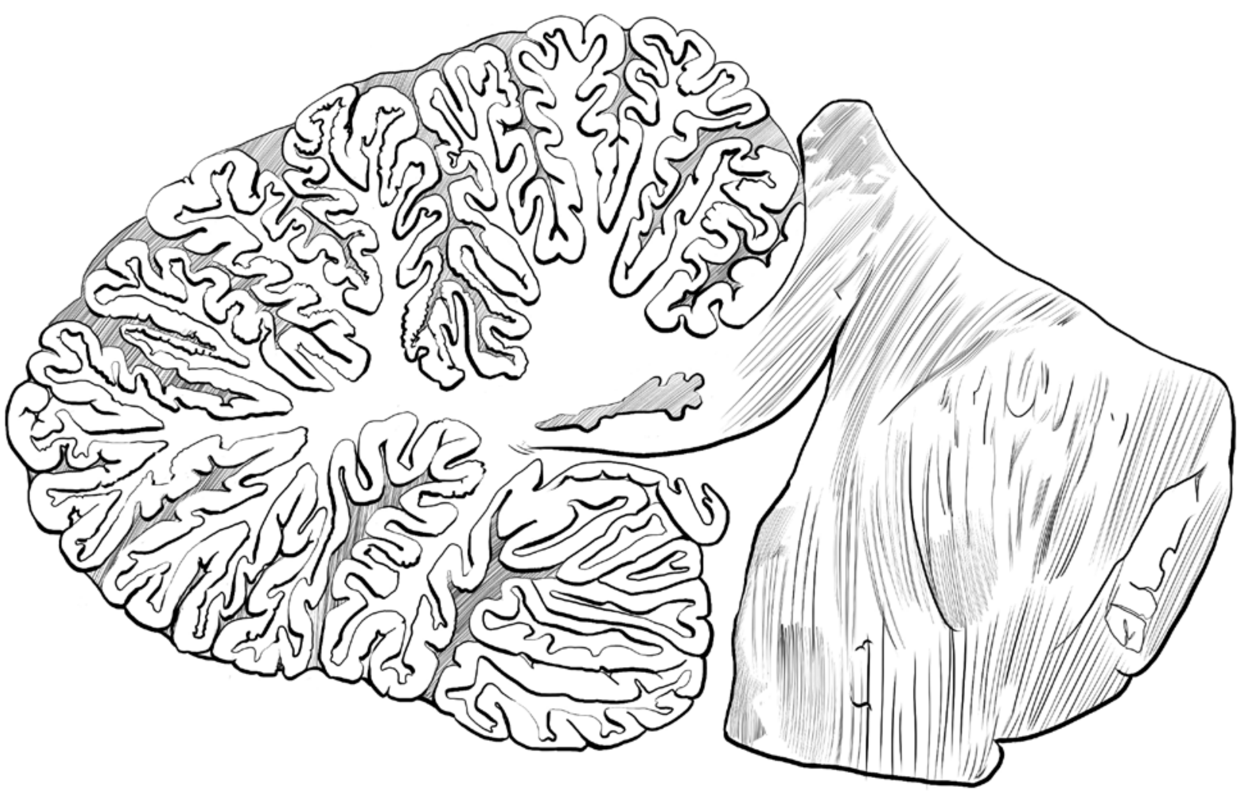
- ☐ Cerebellar hemispheres
- ☐ Fissures
- ☐ Folia
- ☐ Vermis

2. Identify the following structures on the sagittal view of the cerebellum:

- ☐ Arbor vitae
- ☐ Fissures
- ☐ Folia
- ☐ Gray matter

The Cerebellum
(Posterior and Sagittal Views)





The Ventricles
(Anterior and Lateral Views)

The **ventricles** are cavities within the brain that are filled with cerebrospinal fluid (CSF). They are lined by a type of glial cell, called an **ependymal cell**, which creates the CSF.

The two largest ventricles are the **lateral ventricles**; they are found within the cerebrum. Just inferior and medial to the lateral ventricles is the **third ventricle**; this ventricle is found within the diencephalon. Inferior to the third ventricle is the **fourth ventricle**; this ventricle is found within the brainstem.

All ventricles are connected to each other. The lateral ventricles are connected to the third ventricle by the two **interventricular foramina**. The third and fourth ventricles are connected by the **cerebral aqueduct**. The fourth ventricle is then connected to the **central canal** of the spinal cord.

The CSF enters the subarachnoid space by way of three openings from the fourth ventricle: two **lateral apertures** and a single **median aperture**.

Realize that the ventricles are cavities within a solid structure, the brain. So think of this model as a cast or mold of the inside of the cavities.

Activity:

1. Identify the following structures on both views of the ventricles:

☐	Central canal	☐	Lateral aperture
☐	Cerebral aqueduct	☐	Lateral ventricles
☐	Fourth ventricle	☐	Medial aperture
☐	Interventricular foramen	☐	Third ventricle

The Ventricles
(Anterior and Lateral Views)

Brain Histology

Once you are familiar with the generalized structure of the brain, you should be able to identify some of the features on prepared and stained sections of the brain.

The first slide is of the cerebrum; you can see sulci as well as the gray and white matter.

The second slide is of the cerebellum, in which you can see the folia as well as the gray and white matter.

Activity:

1. Obtain slide number 48 from your slide box.
2. Using the 10X objective lens, locate the following:

    Gray matter
    Sulcus
    White matter

3. Draw what you see on the following page, labelling the structures listed above.
4. Obtain slide number 50 from your slide box.
5. Using the 4X objective lens, locate the following:

    Folia
    Gray matter
    White matter

6. Draw what you see on the following page, labelling the structures listed above.

Brain Histology

Cutaneous Receptors

The peripheral nervous system (PNS) includes sensory receptors, motor nerve endings and the nerves that carry sensory information to, and motor information from, the CNS. We will begin by looking at the sensory receptors of the general senses first, followed by cranial and spinal nerves. Sensory receptors of the special senses will be discussed in the next unit of the lab, and motor nerve endings were previously discussed when we covered skeletal muscle tissue.

With this figure, we will be looking at the cutaneous receptors. There are two structural classifications of sensory receptors: free nerve endings and encapsulated nerve endings. **Free nerve endings** are naked dendrites, which respond to sensations such as temperature, light touch, and pain. **Merkel discs**, examples of free nerve endings, are found within the epidermis and the remaining free nerve endings are found in dermis of skin (and in most organs of the body). Encapsulated nerve endings are dendrites that are surrounded by a capsule composed of connective tissue. Most superficially, found in the dermal papillae, are the **Meissner's corpuscles** (also called tactile corpuscles), which respond to fine touch. Deeper in the dermis are the **Ruffini endings** (also called bulbous corpuscles), which respond to continuous pressure. Finally, deep in the dermis are the **Pacinian corpuscles** (also called lamellar corpuscles), which respond to pressure vibrations.

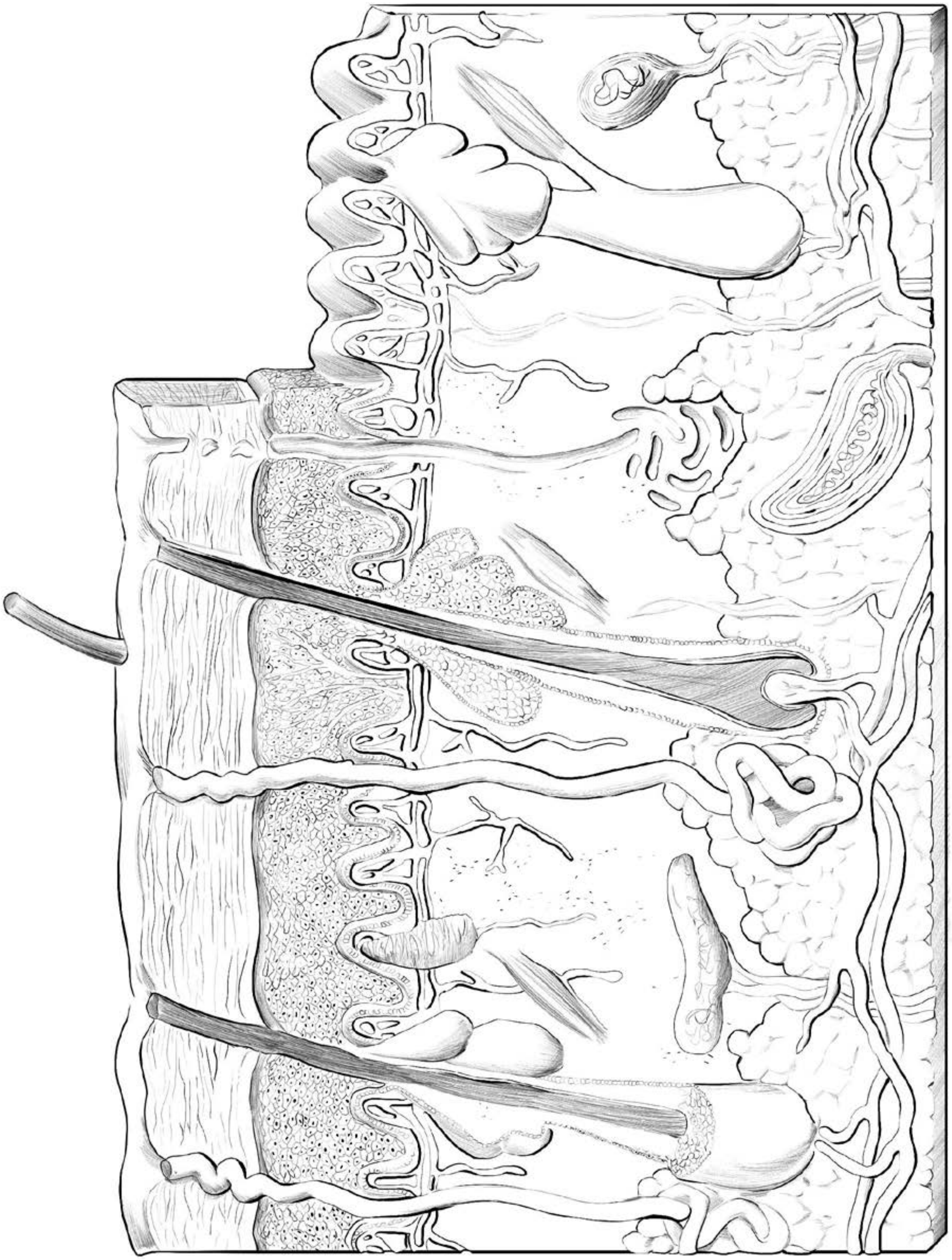
Activity:

1. Identify the following structures:

   ☐ Free nerve endings ☐ Pacinian corpuscles
   ☐ Meissner's corpuscles ☐ Ruffini endings
   ☐ Merkel discs

2. To what sensory modalities are the above sensory receptors sensitive?

Cutaneous Receptors



Cutaneous Receptor Histology

Now that you are familiar with the different types of cutaneous receptors, you will be able to identify these receptors on prepared and stained sections of the skin.

The first slide is of a Pacinian corpuscle, in which you can see both the capsule and the nerve ending.

The second slide is of human skin, in which you should be able to identify Meissner's corpuscles within the dermis.

Activity:

1. Obtain slide number 52 from your slide box.
2. Using the 10X objective lens, locate the following:

   Capsule
   Nerve ending

3. Draw what you see on the following page, labelling the structures listed above.
4. Obtain slide number 54 from your slide box.
5. Using the 10X objective lens, locate the following:

   Meissner's corpuscle

6. Draw what you see on the following page, labelling the structures listed above.

Cutaneous Receptor Histology

Cranial Nerves

There are 12 pairs of cranial nerves that originate from the brain and exit the skull through different foramina. The cranial nerves are numbered I-XII, from anterior to posterior. Nerves I and II originate from the cerebrum while nerves III-XII originate from the brainstem. All nerves, except CN X (the vagus nerve), innervate structures of the head and neck.

CN I is the **olfactory nerve**, a sensory nerve responsible for olfaction. CN II is the **optic nerve**, a sensory nerve responsible for vision. CN III is the **oculomotor nerve**, a motor nerve that innervates some extrinsic muscles of the eye. CN IV is the **trochlear nerve**, a motor nerve that innervates some extrinsic muscles of the eye. CN V is the **trigeminal nerve**, which is both sensory and motor. It carries general sensory information from the face, and innervates the muscles of mastication. CN VI is the **abducens nerve**, a motor nerve that innervates one of the extrinsic muscles of the eye. CN VII is the **facial nerve**, which is both sensory and motor. It carries taste information, and innervates muscles of facial expression. CN VIII is the **vestibulocochlear nerve**, a sensory nerve responsible for hearing. CN IX is the **glossopharyngeal nerve**, which is both sensory and motor. It carries taste and general sense information from the tongue and pharynx, and innervates muscles involved in swallowing. CN X is the **vagus nerve**, which is both sensory and motor. Sensory innervation includes general senses from thoracic and abdominal viscera, blood pressure, blood gas concentration and taste. It innervates muscles in the larynx and pharynx for swallowing and talking. It is also carries parasympathetic fibers to thoracic and abdominal viscera. CN XI is the **accessory nerve**, a motor nerve that innervates muscles that move the head and neck. CN XII is the **hypoglossal nerve**, a motor nerve that innervates the muscles of the tongue. For a complete list of the structures innervated by the cranial nerves, please refer to Table 14.2 in your textbook.

Activity:

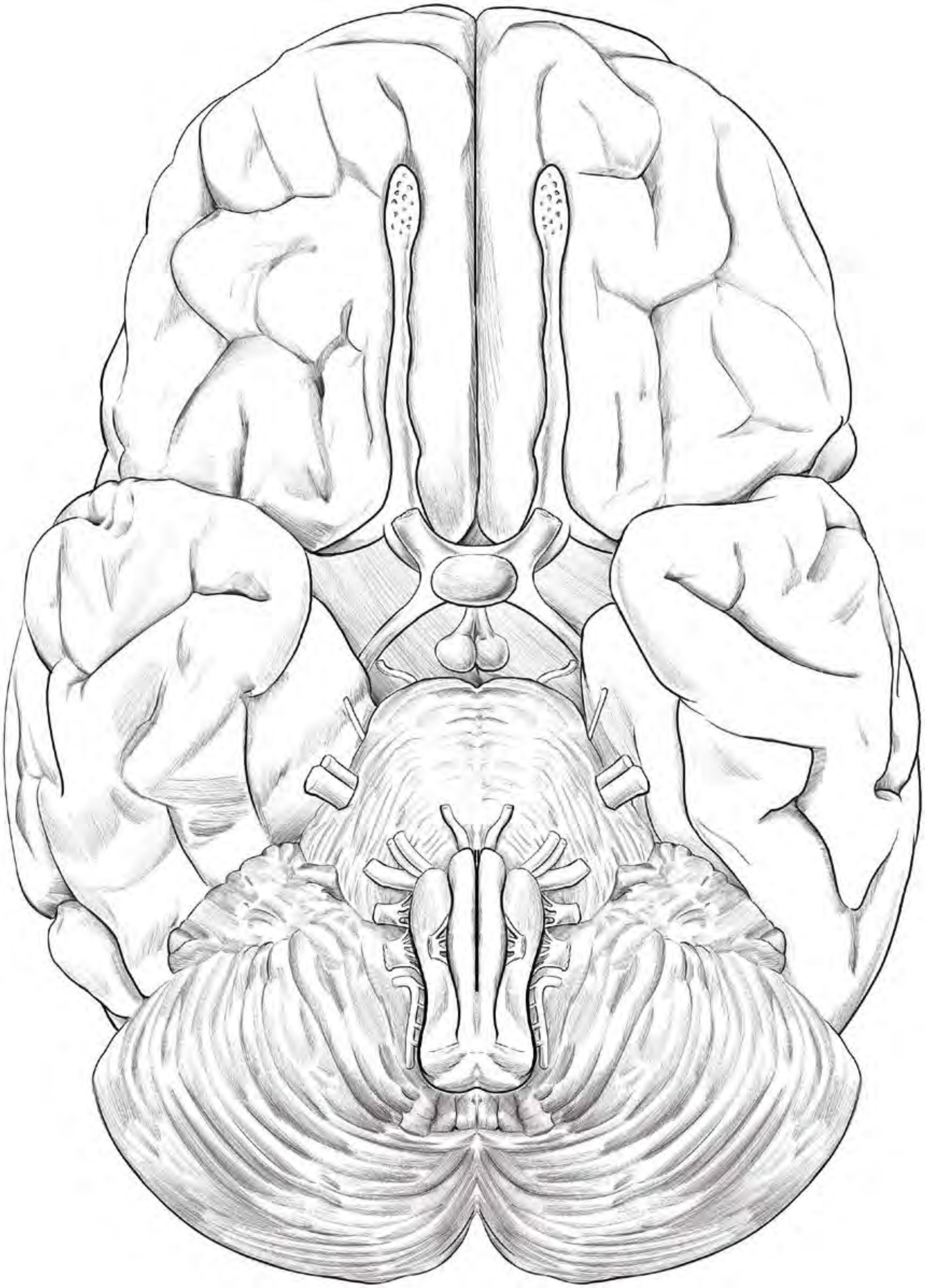
1. Identify the following cranial nerves:

☐ Abducens	☐ Hypoglossal	☐ Trigeminal
☐ Accessory	☐ Oculomotor	☐ Trochlear
☐ Facial	☐ Olfactory	☐ Vagus
☐ Glossopharyngeal	☐ Optic	☐ Vestibulocochlear

2. State the purpose of the cranial nerves listed above.
3. State whether the cranial nerves listed above are sensory, motor or both.

Mnemonics:
Name: On Old Olympus' Towering Top A Friendly Viking Grew Vines And Hops
Type: Some Say Marry Money But My Brother Says Big Brains Matter Most

Cranial Nerves



Spinal Nerves

There are 31 pairs of **spinal nerves**. The naming of these nerves is much easier than for cranial nerves; they are named according to the region of the spinal cord from which they originate.

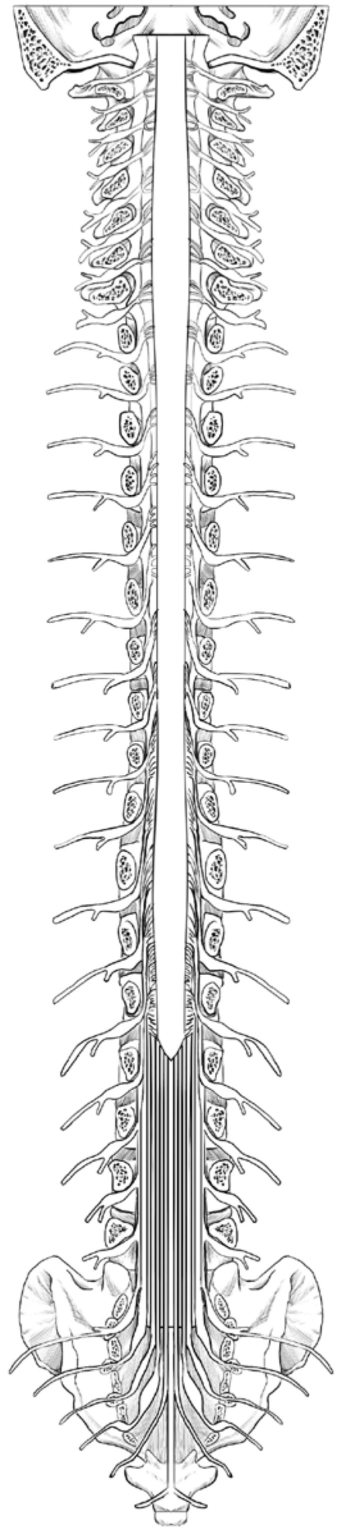
There are 8 cervical nerves, named **C1-C8**. Recall that there are only 7 cervical vertebrae. The discrepancy between the number of nerves and the number of vertebrae has to do with the fact that there is a nerve both above and below atlas (C1). There are 12 thoracic nerves, named **T1-T12**. There are 5 lumbar nerves, named **L1-L5**, and also 5 sacral nerves, named **S1-S5**. Finally, there is a single coccygeal nerve, named **Co1**.

Each spinal nerve begins where the ventral and dorsal roots converge on the lateral sides of the spinal cord. The spinal nerves are all mixed, carrying both sensory and motor information. The nerves themselves are only about an inch long before the split on their lateral side into **dorsal and ventral rami**. Unlike the dorsal and ventral roots, which are entirely sensory and motor, respectively, the dorsal and ventral rami are mixed. These rami then go on to form the various nerves and nerve plexuses that supply regions of the body from the neck down.

Activity:

1. Identify the 31 pairs of spinal nerves.
2. Are spinal nerves sensory, motor or both?
3. How many cervical nerves are there?
4. How many thoracic nerves are there?
5. How many lumbar nerves are there?
6. How many sacral nerves are there?
7. How many coccygeal nerves are there?

Spinal Nerves



The Eye
(Sagittal Section)

The eye has three layers, or tunics, of tissue. The outer **fibrous tunic** consists of the transparent **cornea** anteriorly, and the opaque **sclera** that wraps around the back of the eye. The sclera is composed of tough, dense irregular connective tissue, which protects the eye and contributes to its shape. The cornea is composed of dense regular connective tissue, with a layer of epithelial tissue on both the outer and inner surfaces. Deep to the fibrous tunic is the **vascular tunic**. The **choroid** sits just under the sclera and is rich with blood vessels and the pigment melanin, which absorbs light as it enters the back of the eye to prevent scattering. Anteriorly the choroid is connected to the **ciliary body**, which includes the **ciliary muscle** (smooth muscle) and finger-like folds called **ciliary processes**. The ciliary body controls the lens (discussed shortly). Anterior to the ciliary body is the **iris**, the colored portion of the eye, with a hole in its center called the **pupil**. The iris is composed of two layers of smooth muscle, which constrict and dilate the pupil. The deepest layer of the eye is the **inner tunic**, which contains the **retina**, where photoreceptors (cones and rods) are located, and the **optic nerve**. The inner tunic also has a pigmented layer to prevent light from scattering. The **fovea centralis**, composed entirely of cones, is the area of the retina with the highest visual acuity. Just medial to the fovea is the **optic disc**, where the optic nerve exits the eye. A blind spot is created on that region of the retina because there are no photoreceptors.

The internal eye contains the **lens**, a biconvex disc composed mostly of protein that changes shape to allow the eye to focus on objects from different distances. The lens is held in place by the **ciliary zonule**, a series of ligaments that connect the lens to the ciliary processes. In front of the lens is the **anterior segment**, which contains **aqueous** (water-like) **humor**. Behind the lens is the **posterior segment**, which contains **vitreous** (gel-like) **humor**.

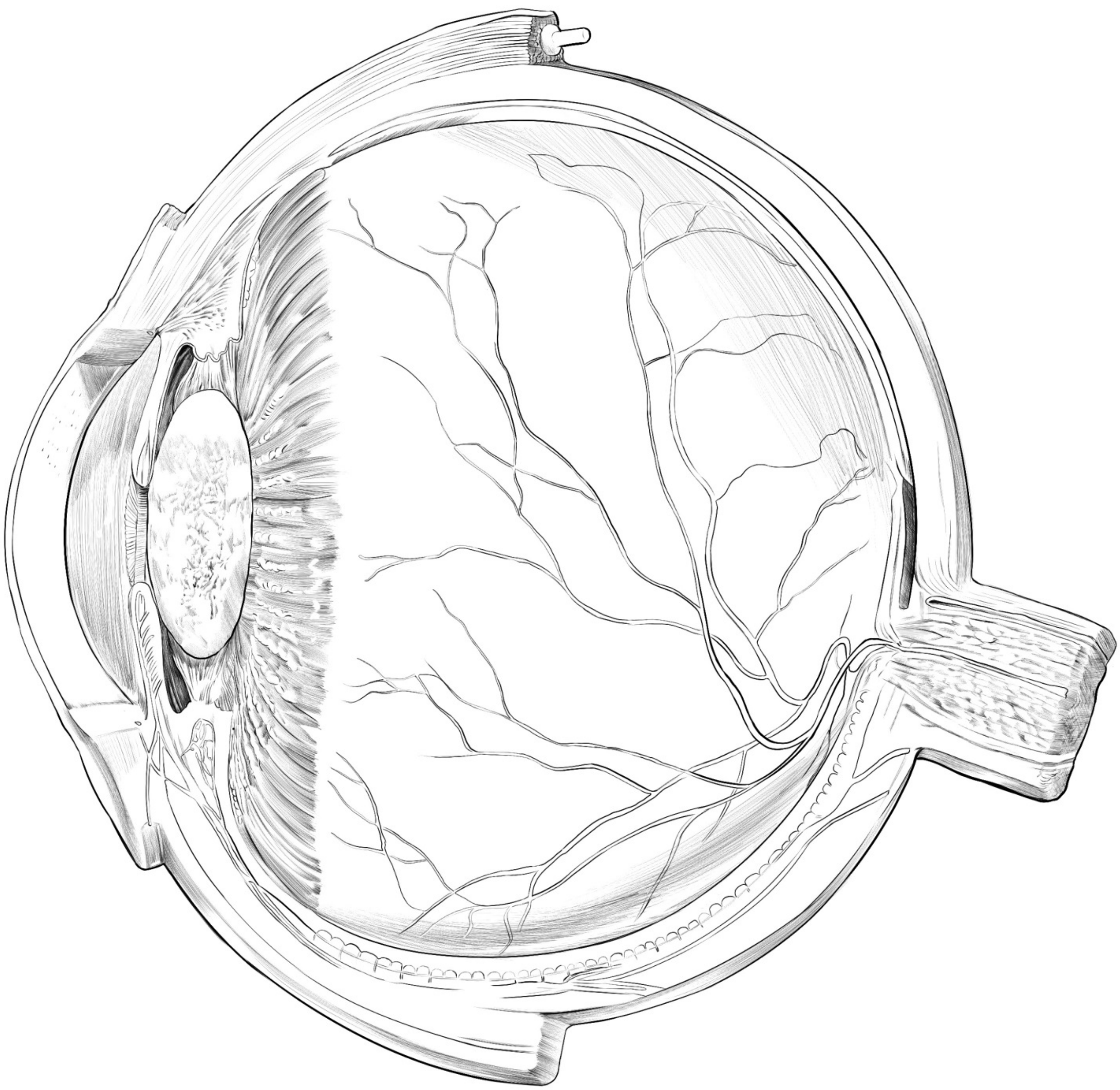
Activity:

1. Identify the following structures:

☐	Anterior segment	☐	Fovea centralis	☐	Posterior segment
☐	Choroid	☐	Iris	☐	Pupil
☐	Ciliary body	☐	Lens	☐	Retina
☐	Ciliary zonule	☐	Optic disc	☐	Sclera
☐	Cornea	☐	Optic nerve		

2. Where are aqueous humor and vitreous humor found?
3. What is unique about the fovea? What about the optic disc?
4. What structures are part of the fibrous tunic? Vascular tunic? Inner tunic?

The Eye
(Sagittal Section)



The Ciliary Body
(Sagittal Section)

This drawing provides a closer perspective of the **ciliary body** and its associated structures. The ciliary body consists of a **ciliary muscle**, which is smooth muscle, and **ciliary processes**, which are finger-like extensions of the ciliary muscle. Attached to the ciliary processes are tiny ligaments, called the **ciliary zonule**, which are attached to the sides of the **lens**. When focusing on distant objects, the ciliary muscle is relaxed, causing the ciliary zonule fibers to be tightly pulling on the sides of the lens, creating a thin, flat lens. When focusing on near objects, the ciliary muscle contract, loosening up the ciliary zonule, causing the lens to become thicker and rounder. This process is called accommodation.

The ciliary processes are responsible for creating **aqueous humor**. Aqueous humor is found in the **anterior segment** of the eye, which includes all the structures of the eye from the lens forward. The ciliary processes secrete aqueous humor into the **posterior chamber** of the anterior segment; it then circulates through the **pupil** of the **iris** into the **anterior chamber** of the anterior segment. Aqueous humor drains through the **scleral venous sinus** (also called canal of Schlemm) into venous blood. The circulation of aqueous humor is constant throughout life.

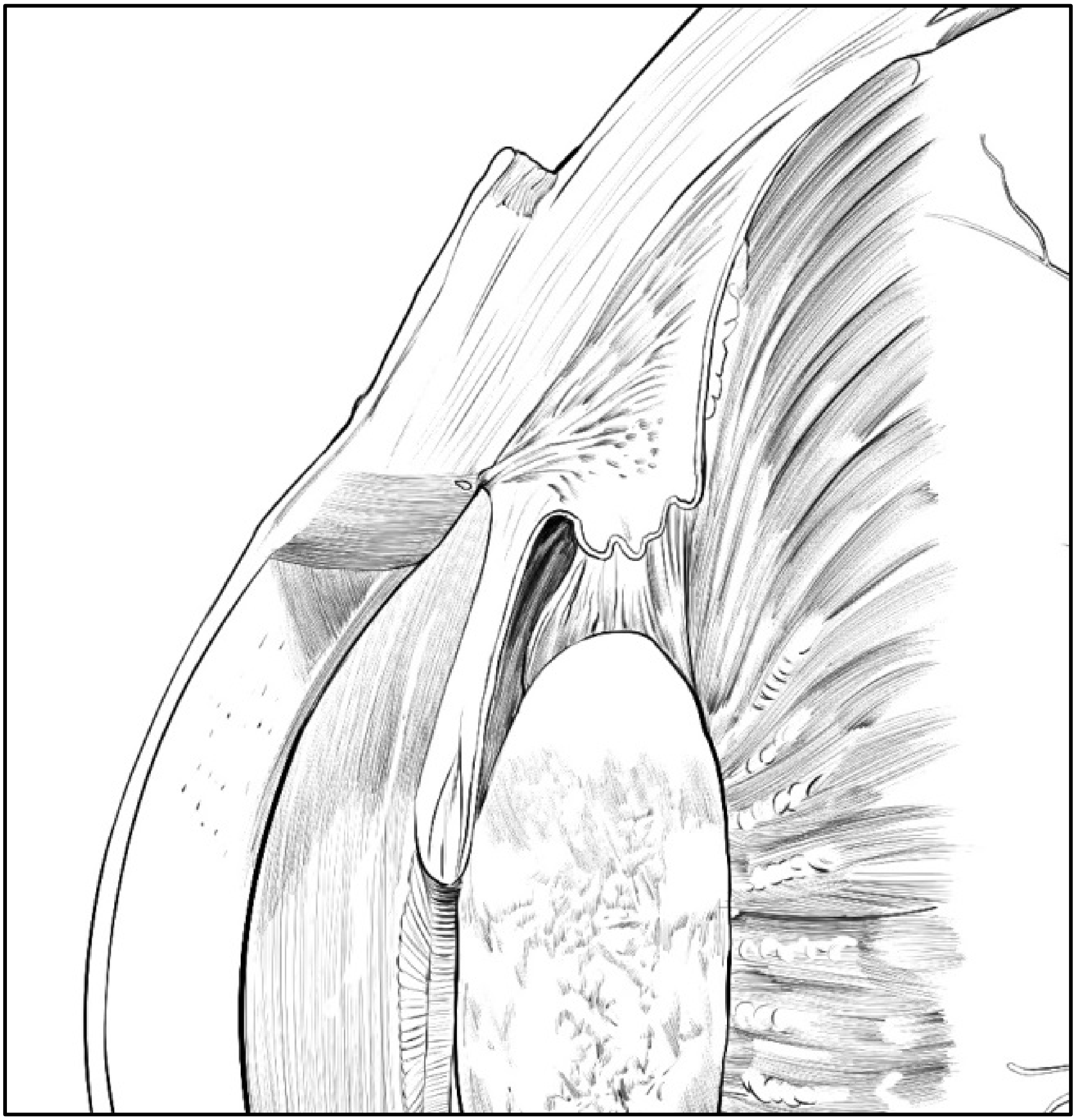
Behind the lens is the **posterior segment** of the eye, which contains **vitreous humor**. Unlike aqueous humor, which is constantly produced, vitreous humor is produced just once prior to birth.

<u>Activity:</u>

1. Identify the following structures:

☐	Anterior chamber	☐	Ciliary zonule	☐	Posterior chamber
☐	Anterior segment	☐	Cornea	☐	Posterior segment
☐	Ciliary muscle	☐	Iris	☐	Sclera
☐	Ciliary processes	☐	Lens	☐	Scleral venous sinus

The Ciliary Body
(Sagittal Section)



The Eye
(Anterior View)

The anterior view of the eye allows you to see some the parts of the eyeball, as well as the extrinsic muscles that move the eye.

Recall that the outer layer of the eye is called the fibrous tunic, which consists of the transparent **cornea** on the most anterior portion, and the opaque **sclera**, which wraps around the remainder of the eye. Through the cornea, you can also see the **iris** and **pupil**.

There are six extrinsic skeletal muscles that move the eye. Four of the muscles are “rectus” muscles, so named because their fibers are oriented straight from their origination on the back of the eye to their insertion points on the sclera. The **lateral rectus** muscle moves the eye laterally. The **medial rectus** muscle moves the eye medially. The **superior rectus** muscle moves the eye superiorly and medially. The **inferior rectus** muscle moves the eye inferiorly and medially. The remaining two muscles are “oblique” muscles, named from the fact that their fibers run obliquely (diagonally) from their origins to their insertions. The **inferior oblique** muscle originates in the medial orbit, loops under the eye, and inserts on the lateral sclera. It moves the eye superiorly and laterally. The **superior oblique** muscle originates on the back of the eye near the rectus muscles, runs medially toward orbit, loops through a ligament called the trochlea, and inserts on the superior sclera, behind the superior rectus. It moves the eye inferiorly and laterally.

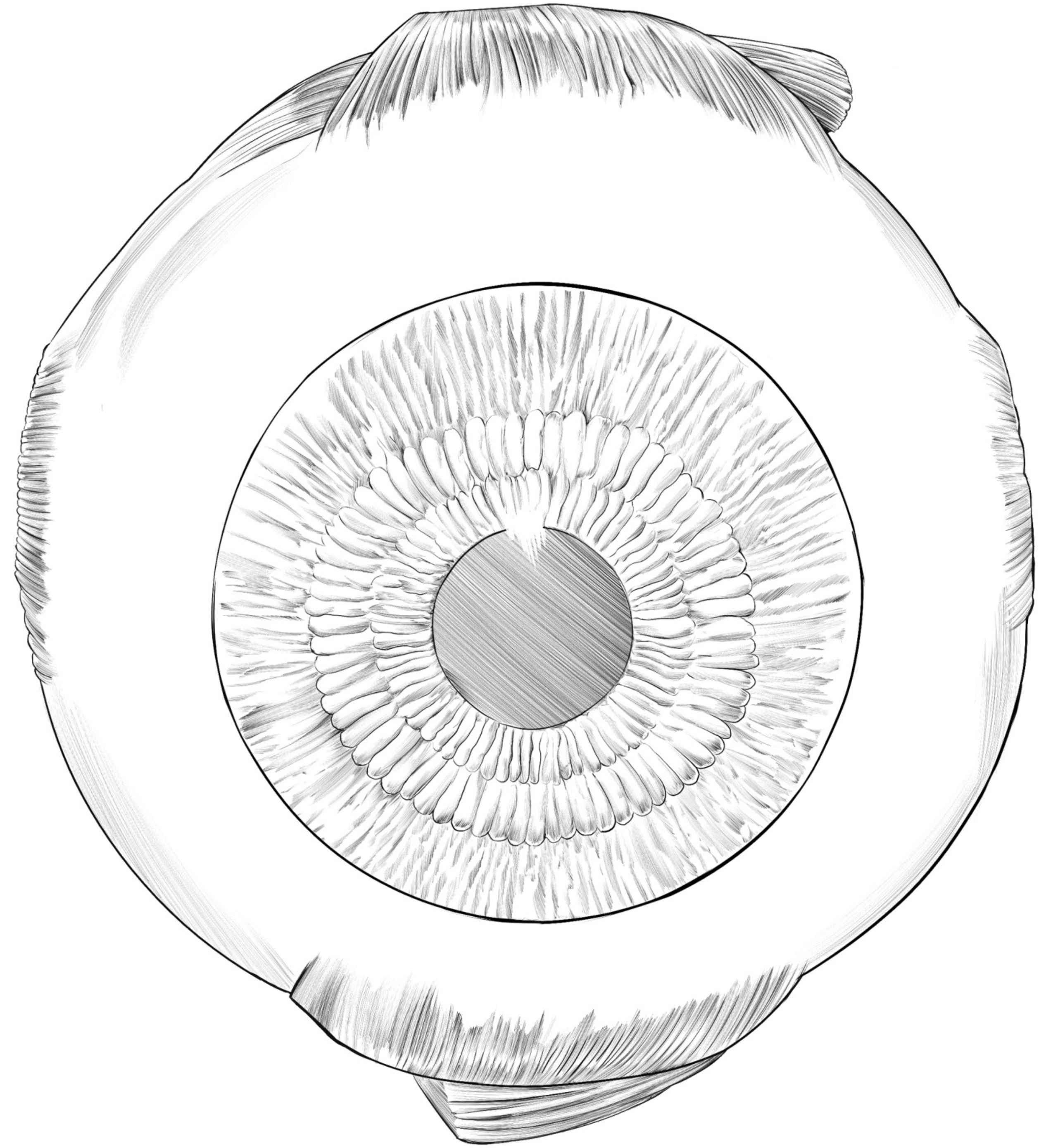
Activity:

1. Identify the following structures:

☐ Cornea	☐ Iris	☐ Sclera
☐ Inferior oblique	☐ Lateral rectus	☐ Superior oblique
☐ Inferior rectus	☐ Medial rectus	☐ Superior rectus

2. State the actions of the extrinsic muscles.

The Eye
(Anterior View)



Eye Histology

Once you are familiar with the generalized structure of the eye, you should be able to identify many of the features on prepared and stained sections of the eye.

This slide is a sagittal section of a monkey eye. To identify all the required structures, you will need to view the eye from two different positions: the anterior side of the eye and the posterior side of the eye.

Activity:

1. Obtain slide number 56 from your slide box.
2. Using the 4X objective lens, and focusing on the anterior side of the eye, locate the following:

    Anterior segment
    Ciliary body
    Cornea
    Iris
    Lens

3. Draw what you see on the following page, labelling the structures listed above.
4. Using the 4X objective lens, and focusing on the posterior side of the eye, locate the following:

    Choroid
    Posterior segment
    Retina
    Sclera

5. Draw what you see on the following page, labelling the structures listed above.

Eye Histology

The Ear

Anatomically, the ear is divided into three regions: external, middle and internal. The **external ear** captures the sound waves, the **middle ear** conducts the sounds waves to the deeper structures of the ear, and the **internal ear** detects the sound waves, and also has organs for equilibrium.

Sound waves are captured by the external (outer) ear. First, the **auricle** captures and conducts the sound waves toward the **external acoustic meatus**. The sound waves then vibrate against the **tympanic membrane**, which is colloquially referred to as the ear drum. The sound is next conducted to the middle ear, where three tiny bones, called **auditory ossicles**, are located. The middle ear is connected to the pharynx by way of the **pharyngotympanic tube**, which is commonly referred to as the Eustachian tube. This structure allows for pressure equalization between the middle ear and the pharynx. The ossicles conduct the sound waves to the organ of the internal ear that is responsible for hearing: the **cochlea**. The two other organs that are located in the inner ear – the **vestibule** and **semicircular canals** –are responsible for sensing balance and equilibrium.

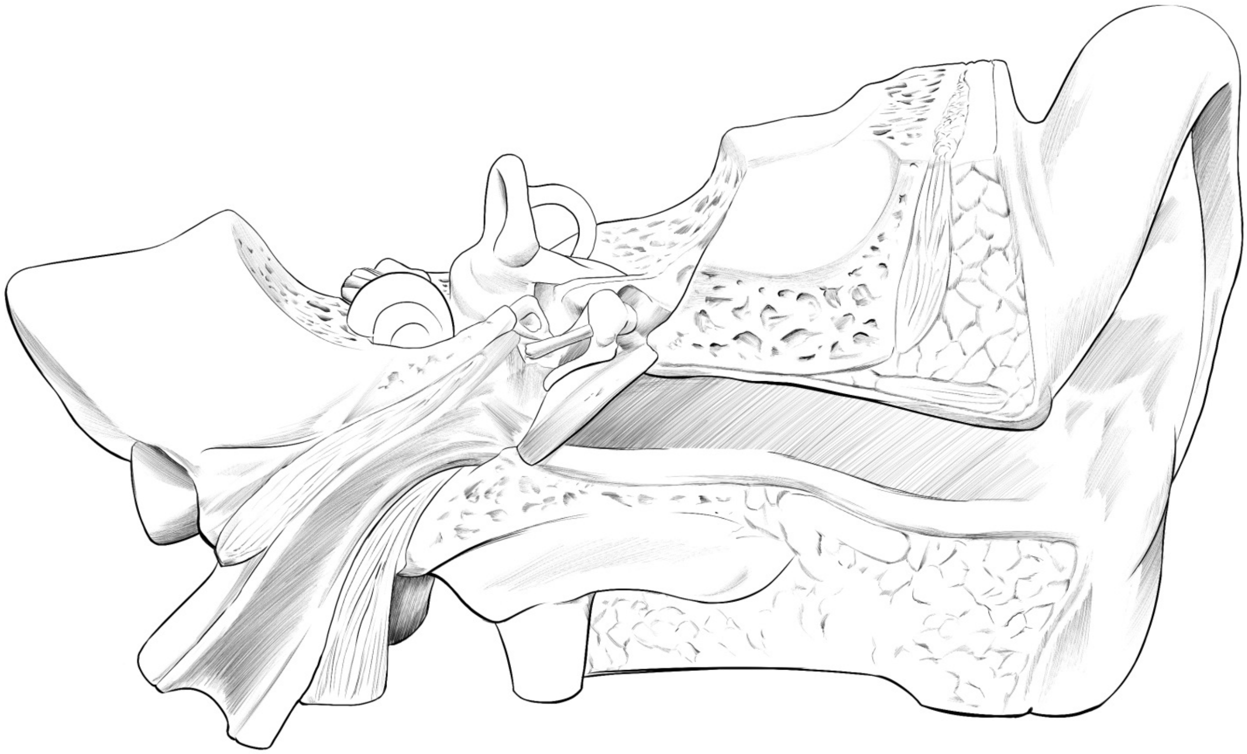
Activity:

1. Identify the following structures:

- ☐ Auricle*
- ☐ External (outer) ear
- ☐ External acoustic meatus*
- ☐ Internal (inner) ear
- ☐ Ossicles*
- ☐ Middle ear
- ☐ Pharyngotympanic tube*
- ☐ Tympanic membrane*

2. Which of the structures with * are found in the external ear? Middle ear? Internal ear?

The Ear



The Middle and Internal Ear

This drawing gives you a closer view of the structures of the middle and internal ear. The tympanic membrane of the external ear is included to give perspective.

The tympanic membrane is attached to the first of the three middle ear ossicles, called the **malleus**. When the tympanic membrane vibrates, the malleus begins to rock. This displaces the second ossicle, called the **incus**. Finally, the incus conducts the sound waves to the third ossicle, the **stapes**. The stapes then pushes the waves of sound up against a membrane called the **oval window**, which separates the middle ear from the vestibule of the internal ear. Through this process, sound waves are transferred from air (in the middle ear) to fluid (in the internal ear). The receptors for hearing, called **hair cells**, are located inside the cochlea, bathed in a special type of fluid called **endolymph**. When sound waves reach the cochlea, the fluid moves, thereby moving and ultimately exciting the hair cells. In this way, the cochlea is responsible for detecting sound.

The internal ear also includes two structures that are responsible for balance and equilibrium. These organs provide sensory information about body position and movement. The **vestibule**, located just posterior to the cochlea, contains to structures, the **utricle** and **saccule**, which sense linear movements (e.g. tilting the head forward). The three **semicircular canals**, which are just posterior to the vestibule, sense rotational movements (e.g. spinning around in a chair).

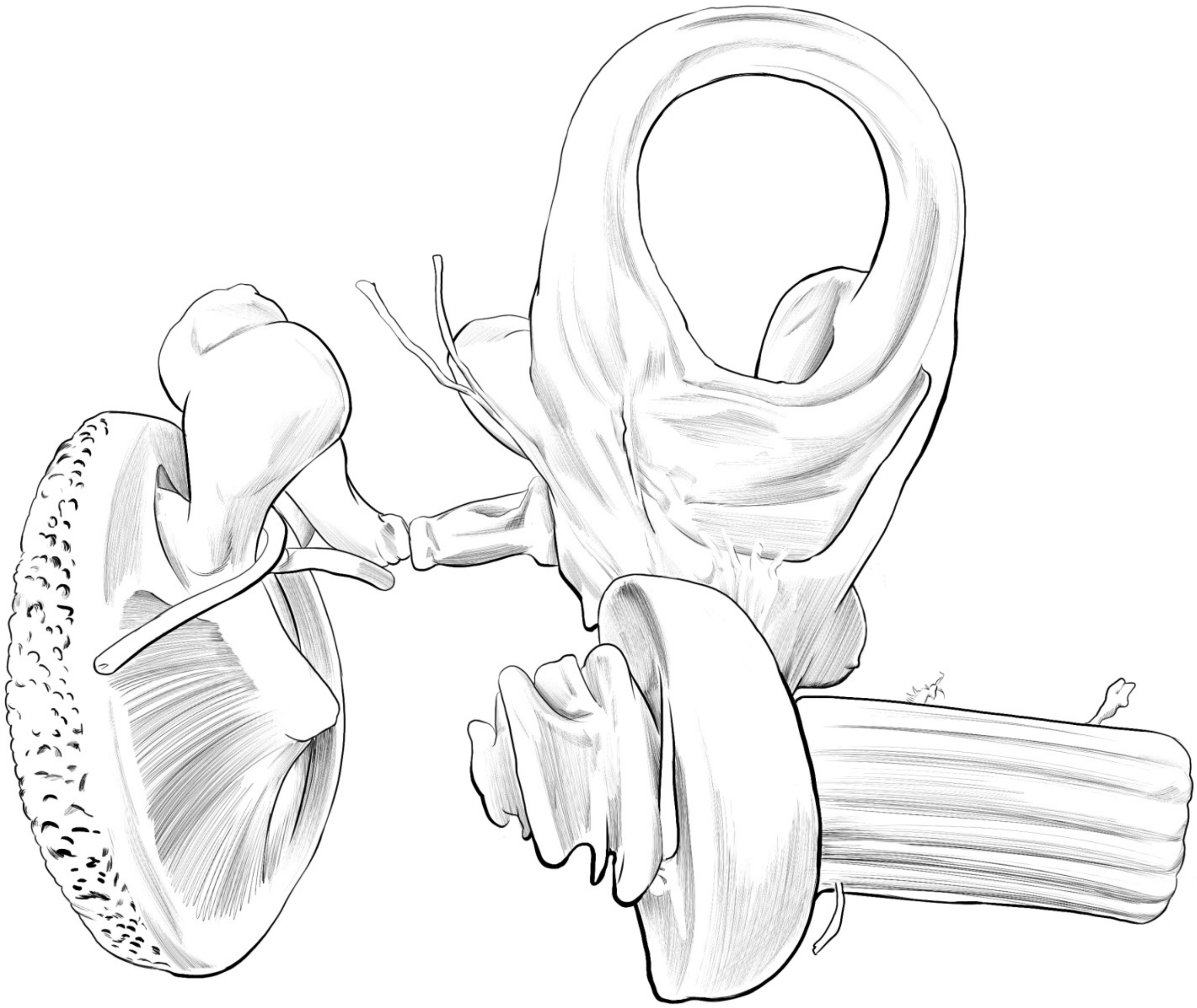
Activity:

1. Identify the following structures:

☐ Cochlea	☐ Semicircular canals
☐ Incus	☐ Stapes
☐ Malleus	☐ Tympanic membrane
☐ Oval window	☐ Vestibule

2. What is the purpose of the: cochlea, vestibule, semicircular canals?

The Middle and Internal Ear



The Cochlea
(Cross Section)

The **cochlea** is often described as the spiral organ, due to its characteristic snail shell shape. If you imagine uncoiling the cochlea, and taking a cross section of it, you will see that it is a three chambered structure. The top chamber is called the **scala vestibuli**, and the bottom chamber is called the **scala tympani**; both of these chambers are filled with a type of fluid called **perilymph**. Perilymph is very similar to cerebrospinal fluid. The chamber in the middle is the **cochlear duct** (also called **scala media**), which is where the receptors for hearing are located. The cochlear duct is separated from the scala vestibuli by the **vestibular membrane** and from the scala tympani by the acellular **basilar membrane**. The cochlear duct is filled with **endolymph**, a special type of fluid that is high in potassium ions (K^+).

The sensory epithelium for hearing is the **organ of Corti**, which is found within the cochlear duct. Resting on the basilar membrane are **hair cells**, the receptors of hearing. There are three rows of **outer hair cells** and a single row of **inner hair cells** amongst columnar supporting cells. These mechanoreceptors have finger-like projections on their apical surface called **stereocilia**. Stereocilia aren't true cilia because they are not motile, but they are also not considered microvilli because they are long. Resting on top of the stereocilia is the **tectorial membrane**, a gelatinous, acellular membrane.

When sound waves are transmitted to the fluid-filled chambers of the cochlea, the basilar membrane moves in a wave-like fashion. Because the hair cells are embedded in the basilar membrane, they move as well. The tectorial membrane, on the other hand, remains stationary. Therefore, the stereocilia bend against the tectorial membrane as the hair cells move. This bending excites the hair cells.

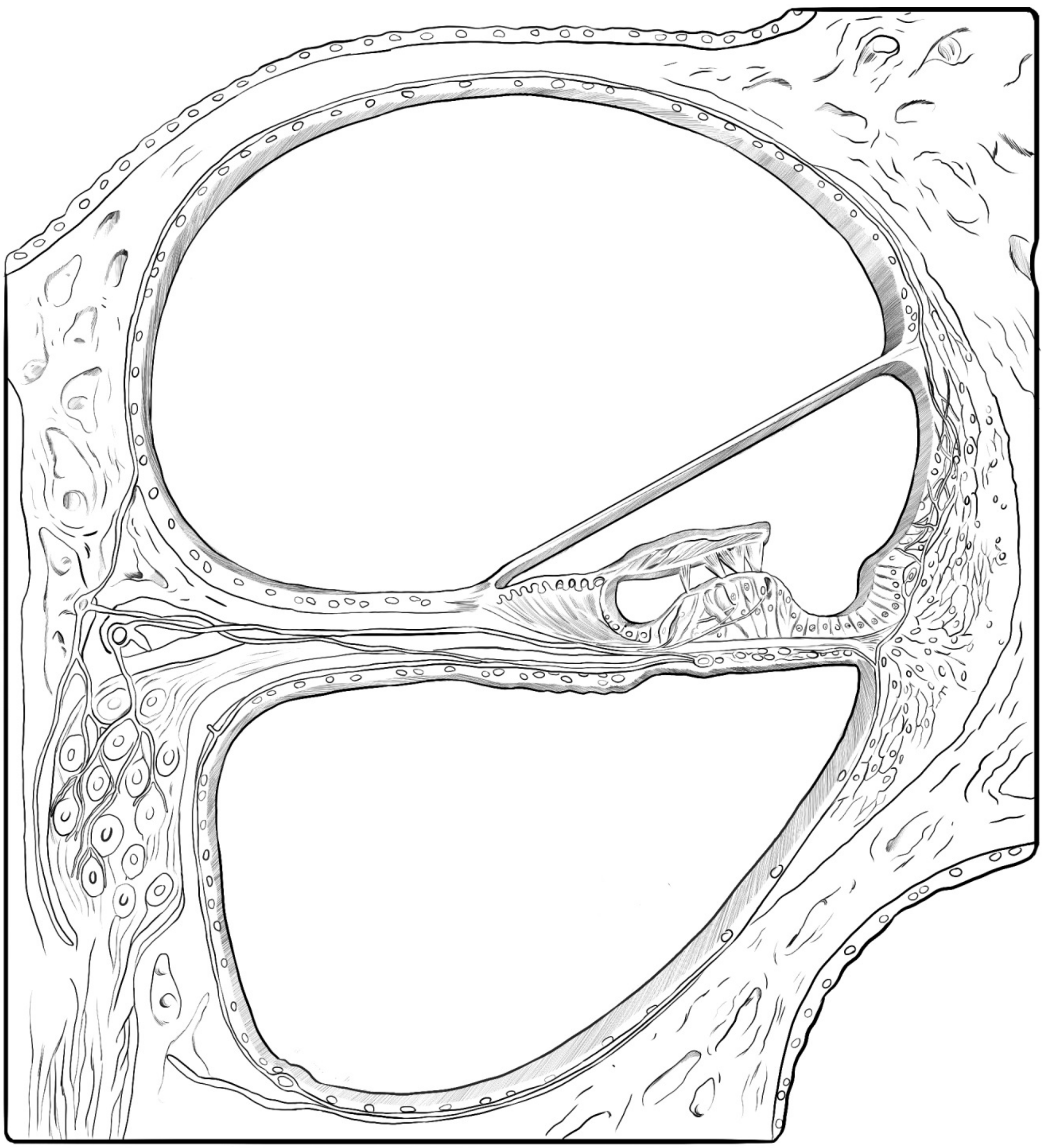
<u>Activity:</u>

1. Identify the following structures:

- [ ] Cochlear duct (scala media)
- [ ] Organ of Corti
- [ ] Basilar membrane
- [ ] Scala vestibuli
- [ ] Scala tympani
- [ ] Tectorial membrane
- [ ] Vestibular membrane
- [ ] Hair cells

2. Draw a box around the organ of Corti.
3. Which chambers contain perilymph? Which contain endolymph?

The Cochlea
(Cross Section)



The Organ of Corti
(Cross Section)

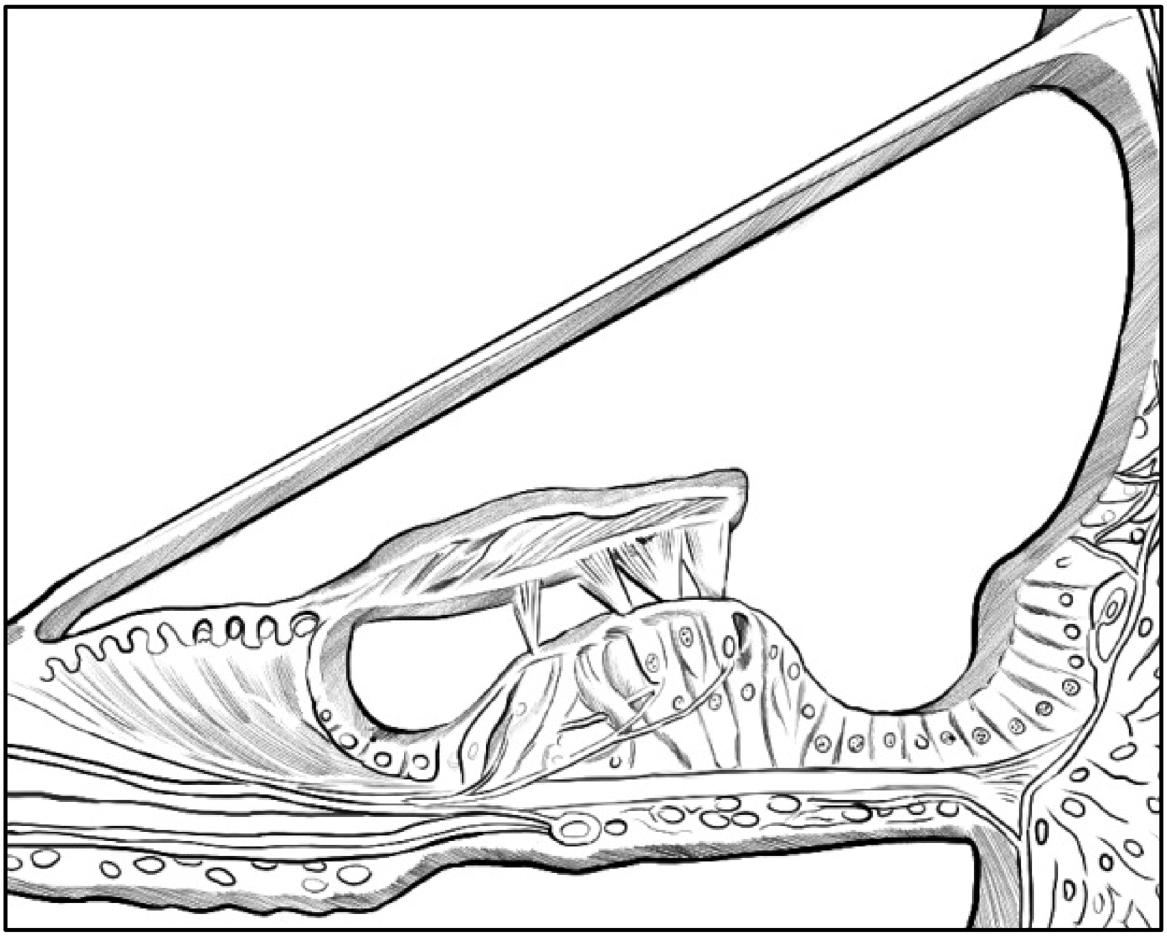
This drawing gives a closer perspective of the organ of Corti. You can see the **vestibular membrane**, separating the scala vestibuli from the cochlear duct, and the **basilar membrane**, supporting the structures of the organ of Corti. Resting on the basilar membrane are the **supporting cells** and hair cells of the organ of Corti. Note the three **outer hair cells** and single **inner hair cell**, with their axonal projections leaving the cochlea as the **cochlear nerve** (part of cranial nerve VIII). Finally, observe the **tectorial membrane** resting on the stereocilia of the hair cells.

<u>Activity:</u>

1. Identify the following structures:

- ☐ Basilar membrane
- ☐ Cochlear nerve
- ☐ Inner hair cell
- ☐ Outer hair cells
- ☐ Supporting cells
- ☐ Tectorial membrane
- ☐ Vestibular membrane

The Organ of Corti
(Cross Section)



Cochlea Histology

Once you are familiar with the generalized structure of the cochlea, you should be able to identify many of the features on prepared and stained sections of the cochlea.

This slide is a cross section of a cochlea from a guinea pig. You will see many turns of the cochlea. Focus on one turn of the cochlea to identify the required structures.

Activity:

1. Obtain slide number 58 from your slide box.
2. Using the 10X objective lens, locate the following:

    Basilar membrane
    Organ of Corti
    Scala media (cochlear duct)
    Scala tympani
    Scala vestibule
    Tectorial membrane
    Vestibular membrane

3. Draw what you see on the following page, labelling the structures listed above.

Cochlea Histology

Blood Histology

Blood is a type of connective tissue and like all connective tissues it is composed of a matrix, called **plasma**, and cells, called **formed elements**.

There are three types of formed elements: erythrocytes, leukocytes and thrombocytes. **Erythrocytes**, also called red blood cells, are responsible for oxygen transport. **Thrombocytes**, also called platelets, are involved in hemostasis, or blood clotting. **Leukocytes**, also called white blood cells, are responsible for fighting disease. Leukocytes are the most diverse of the formed elements, with many different types serving distinct roles in disease resistance.

Leukocytes are classified based on how they stain. When Wright's stain is applied to a blood smear, this purple stain adheres to certain parts of the WBCs, making them visible under the microscope. Some of the cells end up having a grainy looking cytoplasm because the stain adheres to their vesicles. These cells are collectively referred to as **granulocytes**. There are three types of granulocytes, which are named based on how they stain. The vesicles of **eosinophils** stain red; these cells are responsible for fighting parasitic infections and are pretty rare. The vesicles of **basophils** stain blue; these cells are responsible for the inflammatory response. The vesicles of **neutrophils** are a light purple color; these abundant cells are responsible for phagocytosis of foreign bodies. The two remaining WBCs are considered **agranulocytes** because their vesicles do not stain and therefore are not visible. **Lymphocytes** are probably the most important of all of the WBCs because these cells are responsible for immunity (fighting and remembering diseases). **Monocytes**, the largest of all of the WBCs, work alongside neutrophils as phagocytes.

Activity:

1. Obtain slide number 60 from your slide box.
2. Using the 40X objective lens, locate all of the formed elements.
3. Draw what you see on the following page.
4. What is the difference between a granulocyte and an agranulocyte? Which of the WBCs are granulocytes? Which are agranulocytes?
5. What is the most common WBC? Rarest?
6. What is the purpose of all the different formed elements?

Mnemonic:
Abundance of WBCs: Never Let Monkeys Eat Bananas

Blood Histology

RBCs & Platelets

Neutrophil

Lymphocyte

Monocyte

Eosinophil

Basophil

The Heart
(Anterior View)

The human heart has four chambers, the superior chambers, the **right atrium** and **left atrium**, and the inferior chambers, the **right ventricle** and **left ventricle**. The heart is leaning on its right side, with the **apex** of the heart (the lowest portion) pointing downward and leftward.

Many large blood vessels bring blood to, and carry blood away from, the heart. On the right side of the heart two large veins – the **superior vena cava** and **inferior vena cava** – bring deoxygenated blood to the right atrium. On the front of the heart, the large **pulmonary trunk** takes deoxygenated blood from the right ventricle to the lungs. Shortly after the pulmonary trunk rises above the heart, it branches into the right and left **pulmonary arteries**. Coming from the right and left lungs, and meeting together at the posterior surface of the heart, are the four **pulmonary veins**, which carry oxygenated blood to the left atrium. Finally, between the superior vena cava and the pulmonary trunk is the **ascending aorta**, the large artery that carries oxygenated blood from the left ventricle to all of the body's systems. The ascending aorta turns left and posterior to become the **aortic arch.**

Connecting the pulmonary trunk to the aorta is a ligament called the **ligamentum arteriosum**. Prior to birth, this structure is a vessel called the **ductus arteriosus**; it detours blood from the pulmonary trunk to the aorta, bypassing the lungs, since the fetus is not yet breathing.

The vessels of the coronary circuit will be discussed shortly.

Activity:

1. Identify the following structures:

☐ Aortic arch	☐ Left pulmonary artery	☐ Pulmonary trunk
☐ Apex	☐ Left pulmonary veins	☐ Right atrium
☐ Ascending aorta	☐ Left ventricle	☐ Right ventricle
☐ Inferior vena cava	☐ Ligamentum arteriosum	☐ Superior vena cava
☐ Left atrium		

2. Which of the vessels listed above carry deoxygenated blood? Which carry oxygenated blood?

The Heart
(Anterior View)

The Heart

(Posterior View)

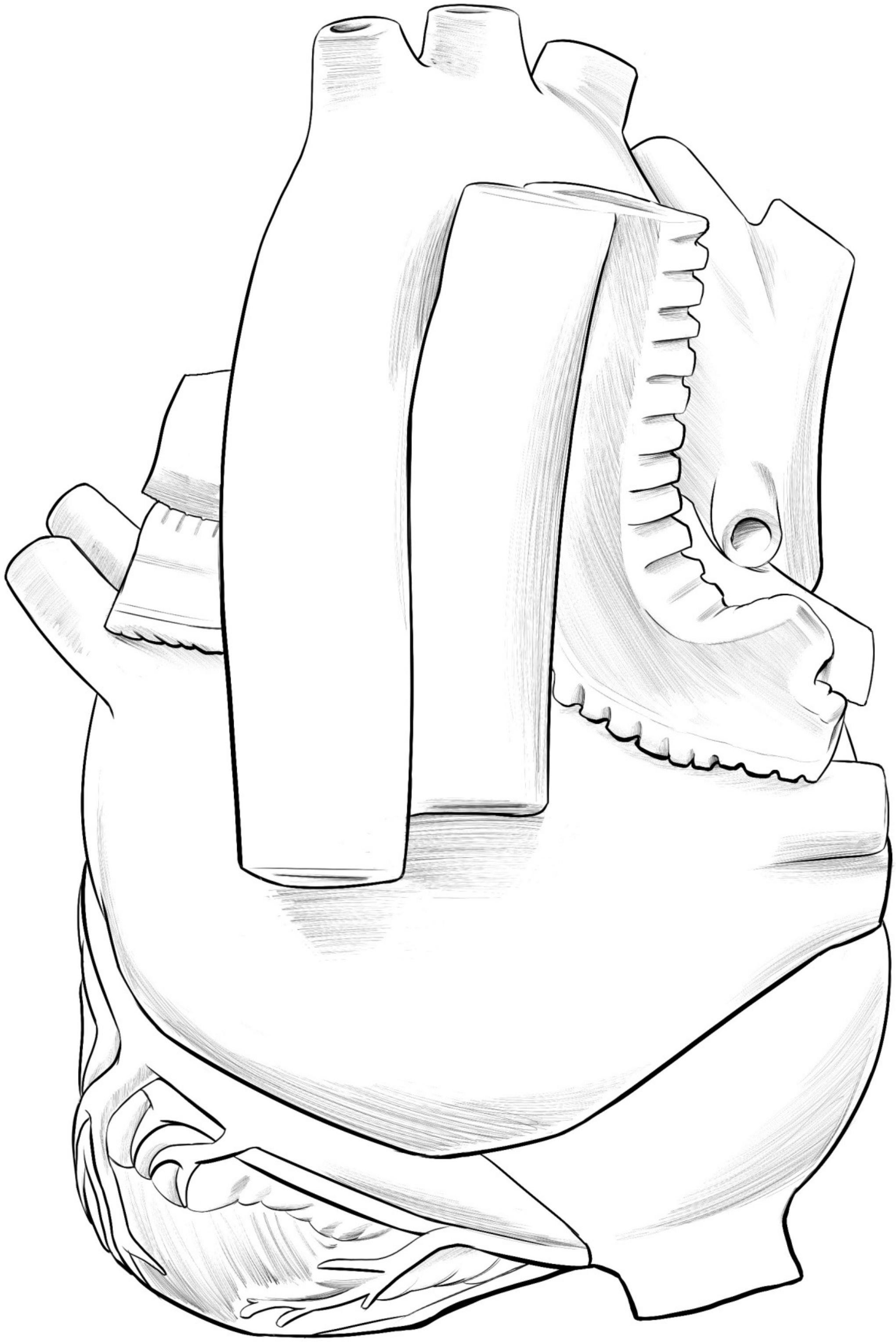
Looking at the posterior side of the heart, you can see many of the same structures as the anterior side. The four chambers (**right atrium**, **right ventricle**, **left atrium**, **left ventricle**) are visible. The major vessels can also be seen, including the **superior and inferior vena cavae**, the **right and left pulmonary arteries**, the **right and left pulmonary veins** and the **aortic arch**.

Activity:

1. Identify the following structures:

☐ Aortic arch	☐ Left pulmonary veins	☐ Right pulmonary veins
☐ Apex	☐ Left ventricle	☐ Right ventricle
☐ Inferior vena cava	☐ Right atrium	☐ Superior vena cava
☐ Left pulmonary artery	☐ Right pulmonary artery	

The Heart
(Posterior View)



The Heart
(Interior View, Right Side)

This drawing shows the interior chambers of the right side of the heart. You can see the openings through which the **superior and inferior vena cavae** empty their deoxygenated blood into the **right atrium**. On the left wall of the **interatrial septum** (the tissue that separates the right and left atria), there is an oval shaped depression called the **fossa ovalis**. This is a remnant from the fetus; prior to birth a hole in this location called the **foramen ovale** allows blood to move from the right atrium to the left atrium, bypassing the lungs. Deoxygenated blood moves from the right atrium, down into the **right ventricle**, through one of four of the heart's valves, the **right atrioventricular**, or **tricuspid valve**. This valve prevents the backflow of blood from the right ventricle to the right atrium; when the ventricles contract, pressure forces the blood upward, filling the cusps of the tricuspid valve with blood and closing it. A large amount of pressure is created through this contraction, so to prevent the valve from inverting and failing, tendons called **chordae tendineae** connect the underside of the valve to **papillary muscles** within the ventricular wall. When the right ventricle contracts and closes the tricuspid valve, the blood is forced upward into the **pulmonary trunk** through the second of the four valves, the **pulmonary semilunar valve**. The pulmonary valve prevents the backflow of blood from the artery back to the right ventricle; when the ventricle relaxes, the blood trickles backward, filling the cusps and closing the valve. Note that the semilunar valves do not have chordae tendineae. The right ventricle is separated from the left ventricle by the **interventricular septum**, which along with the interatrial septum, ensures that deoxygenated blood on the right side of the heart remains separate from oxygenated blood on the left side.

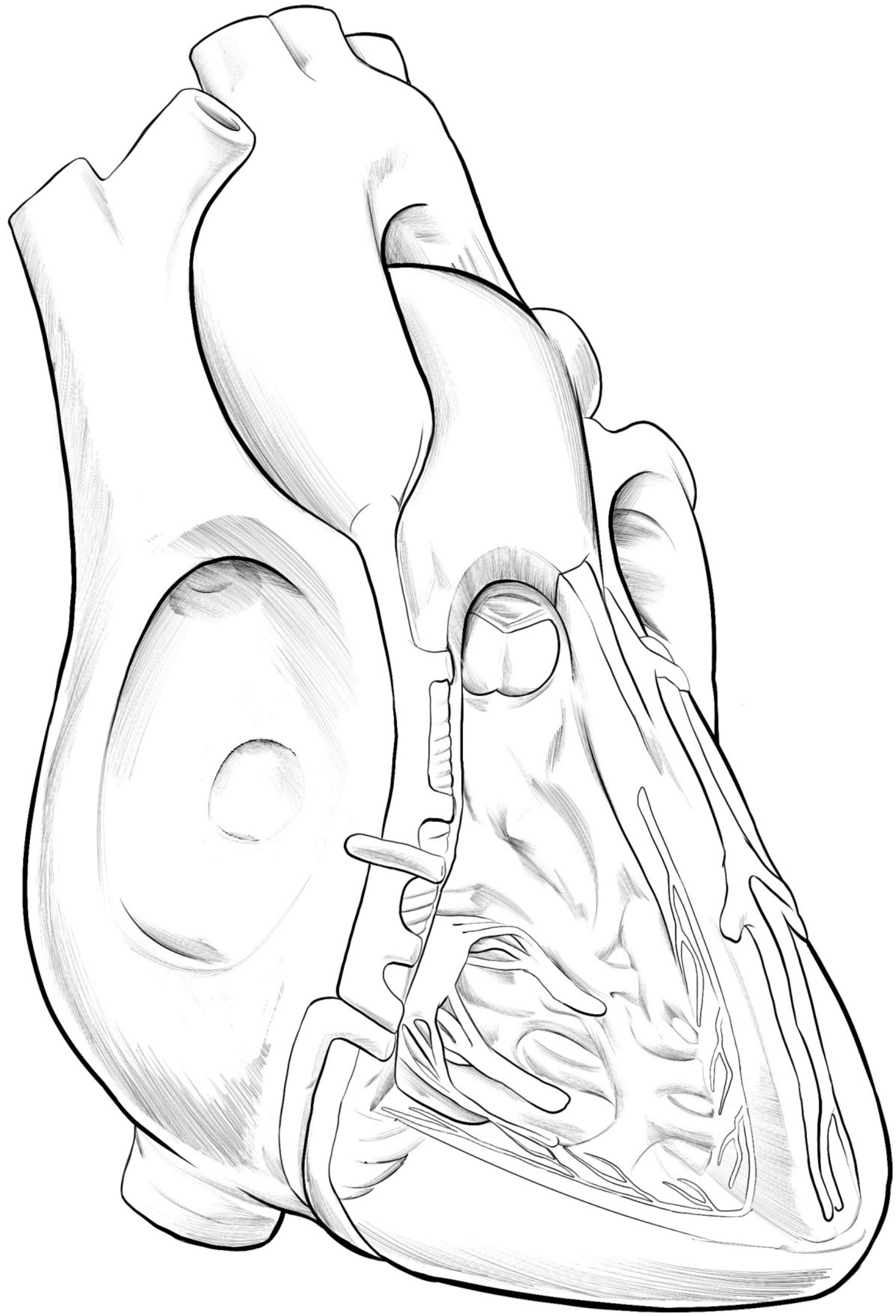
Activity:

1. Identify the following structures:

☐	Chordae tendineae	☐	Interventricular septum	☐	Right atrium
☐	Fossa ovalis	☐	Papillary muscles	☐	Right ventricle
☐	Inferior vena cava	☐	Pulmonary trunk	☐	Superior vena cava
☐	Interatrial septum	☐	Pulmonary valve	☐	Tricuspid valve

2. What type of blood is found within this side of the heart?
3. Using arrows, trace the pathway of blood through the right side of the heart and its major vessels.

The Heart
(Interior View, Right Side)



The Heart
(Interior View, Left Side)

This drawing shows you the interior chambers of the left side of the heart. You can see the openings through which the right and left **pulmonary veins** empty their oxygenated blood into the **left atrium**. Oxygenated blood moves from the left atrium down into the **left ventricle**, through the **left atrioventricular/tricuspid**, or **mitral valve**. This valve works in the same way as the tricuspid valve, preventing backflow of blood from the ventricle to the atrium; note the presence of **chordae tendineae** and **papillary muscles** associated with the mitral valve. When the left ventricle contracts and closes the mitral valve, the blood is forced upward into the **aorta** through the last of the four valves, the **aortic semilunar valve**. The aorta delivers the blood to all of the body's systems. In this drawing, you can also see the **ligamentum arteriosum**, the vestige from the fetal ductus arteriosus.

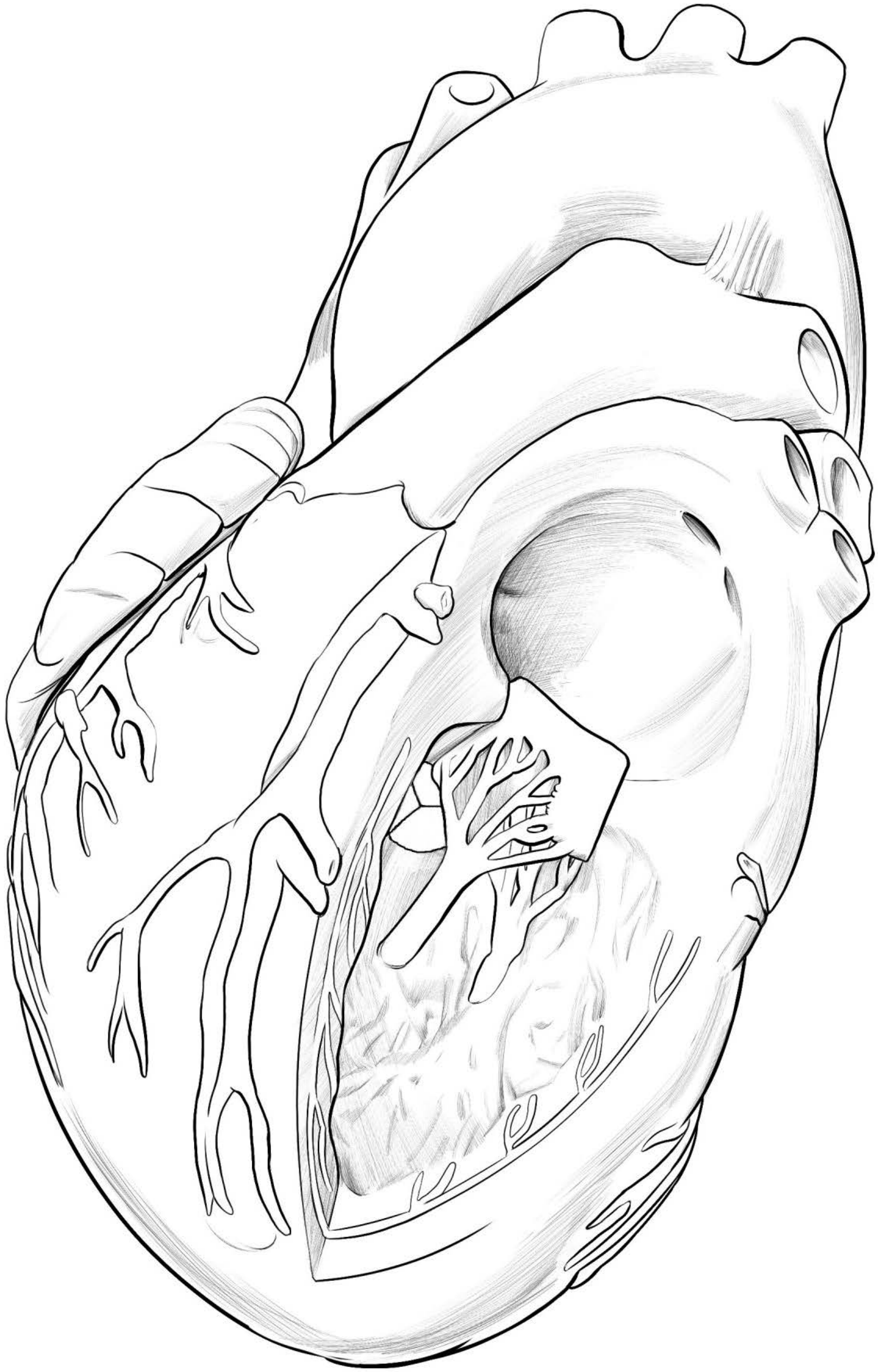
Activity:

1. Identify the following structures:

☐ Aorta	☐ Left atrium	☐ Mitral valve
☐ Aortic valve	☐ Left ventricle	☐ Papillary muscles
☐ Chordae tendinae	☐ Ligamentum arteriosum	☐ Pulmonary veins

2. What type of blood is found within this side of the heart?
3. Using arrows, trace the pathway of blood through the left side of the heart and its major vessels.
4. Why is the wall of the left ventricle so much thicker than the right?

The Heart
(Interior View, Left Side)



Artery and Veins

Blood is circulated throughout the body by way of **blood vessels**. **Arteries**, the vessels that carry blood away from the heart, branch into smaller **arterioles**, which feed into **capillaries**, our exchange vessels. Capillaries then feed into **venules**, which combine to form **veins**, the vessels that return blood to the heart.

Arteries and veins are composed of three layers of tissue, called tunics. The innermost layer, called the **tunic intima** (also called tunica interna), is composed of simple squamous epithelium called **endothelium**. Larger arteries and veins have a delicate layer of loose connective tissue outside of the endothelium, called the **subendothelial layer**. The middle layer, the **tunica media**, is composed of smooth muscle with collagen and elastic fibers throughout. The smooth muscle can contract or relax to change the size of the **lumen** of the blood vessel. The outer layer, the **tunica externa** (also called tunica adventitia), is composed of collagen and elastic fibers, which hold the blood vessel together.

Arteries have thicker walls than veins. The tunica media of arteries is thicker, containing more smooth muscle. Larger arteries have two additional membranes within the tunics: a layer of elastic fibers called the **internal elastic membrane** outside of the subendothelial layer of the tunica intima, and a layer of elastic fibers called the **external elastic membrane** outside of the smooth muscle of the tunica media. These two extra membranes provide additional elasticity to arteries, which are under great pressure as the blood passes through them with every heartbeat. As a result of this difference in thickness, veins tend to collapse when empty.

Veins have an additional modification – **valves** – which are composed of the same tissue as the tunica intima. Like the valves of the heart, venous valves prevent the backflow of blood. This is really important in veins because blood pressure in our veins is very low and throughout most of the body the blood needs to travel against the force of gravity upward to the heart.

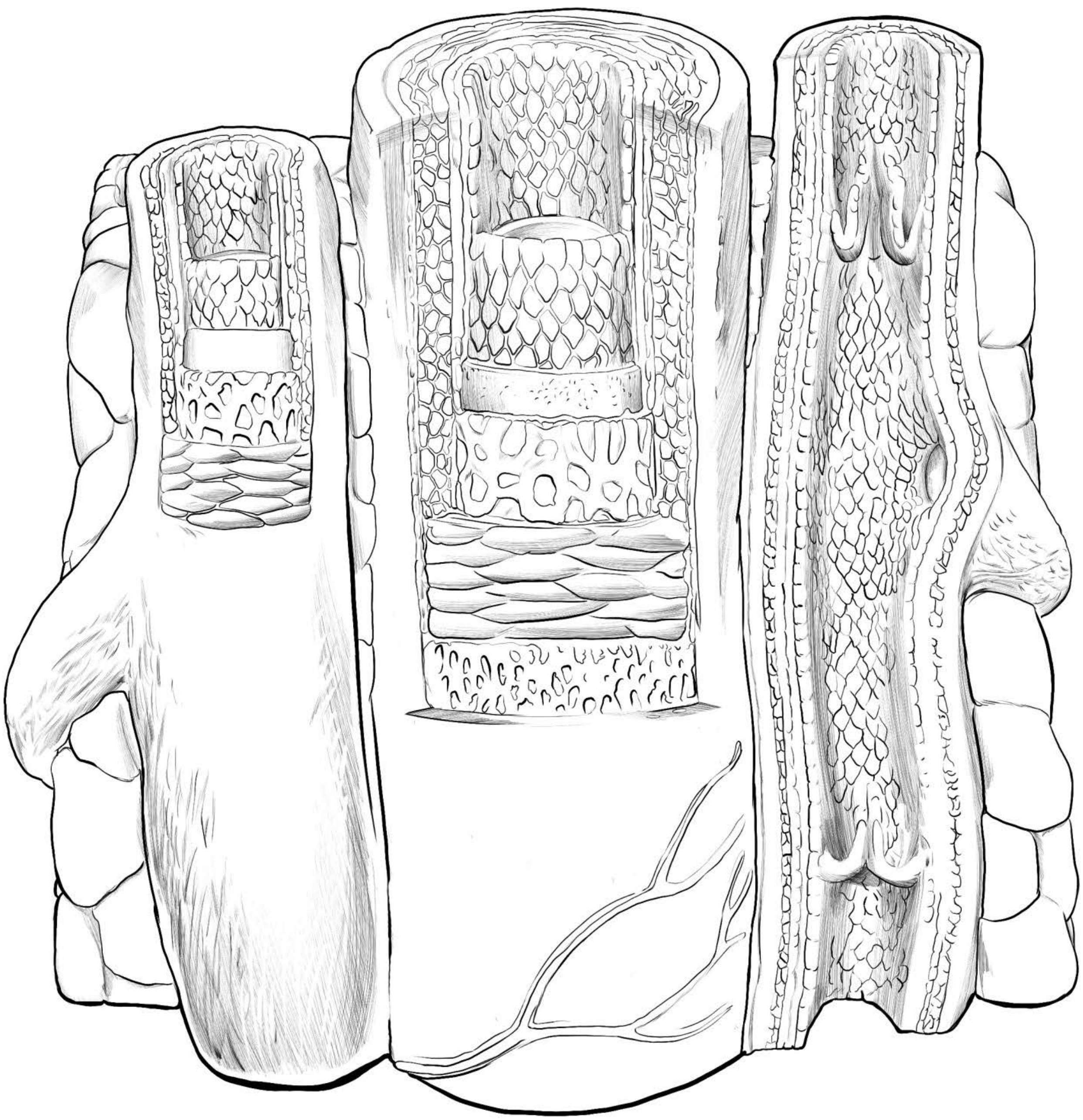
Activity:

1. Identify the following structures:

☐	Artery	☐	Tunica externa
☐	Endothelium	☐	Tunica intima
☐	External elastic membrane	☐	Tunica media
☐	Internal elastic membrane	☐	Valve
☐	Subendothelial layer	☐	Vein

2. What differences are there between arteries and veins, in terms of structure and function?

Artery and Veins



Artery and Vein Histology

Once you are familiar with the generalized microscopic structure of arteries and veins, you should be able to differentiate between arteries and veins on prepared and stained sections of blood vessels.

This slide is of a cross section of an artery, vein and nerve.

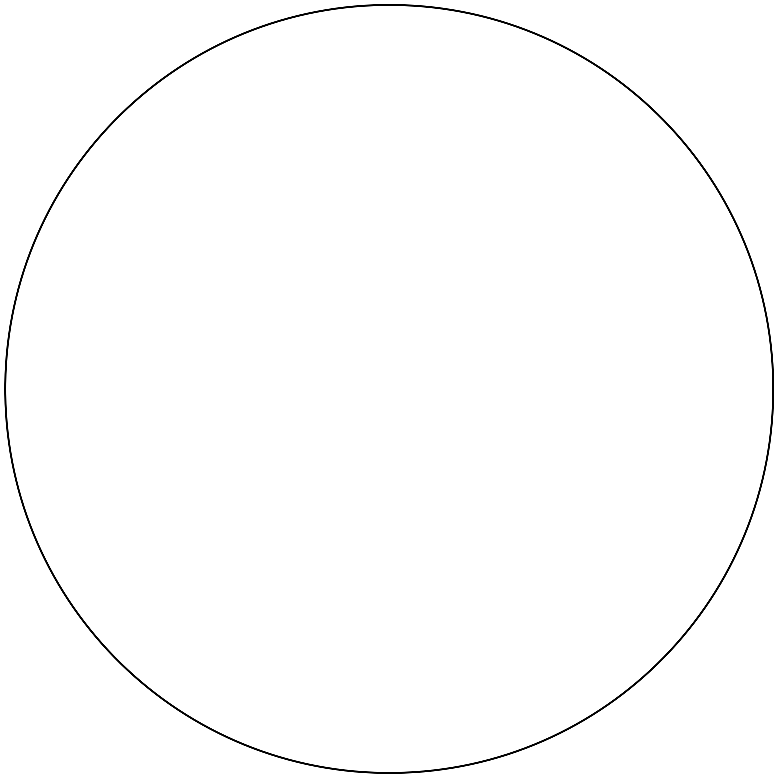
Activity:

1. Obtain slide number 62 from your slide box.
2. Using the 4X objective lens, locate the following:

   Artery
   Vein

3. Draw what you see on the following page, labelling the structures listed above.

Artery and Vein Histology



Vessels of the Heart
(Anterior View)

Recall that the **superior vena cava** and **inferior vena cava** bring deoxygenated blood to the right atrium. Feeding into the superior vena cava are the **right and left brachiocephalic veins**, which receive blood from the head and upper limbs. The **pulmonary trunk**, and its branches, the **right and left pulmonary arteries,** take deoxygenated blood from the right ventricle to the lungs. The four **pulmonary veins** carry oxygenated blood from the lungs to the left atrium. The **ascending aorta** carries oxygenated blood from the left ventricle to all of the body's systems. The ascending leads to the **aortic arch**, which has three branches**.** The first branch is the **brachiocephalic trunk**, which heads to the right side of the body. The second branch is the **left common carotid**, which ascends to the head. The final branch is the **left subclavian**, which goes on to supply the left upper limb.

The coronary circuit also branches off the aorta. The **left coronary artery** comes off the left side of the aorta. It then branches into the **anterior interventricular artery**, which supplies the anterior side of the ventricles, and the **circumflex artery**, which supplies the left atrium and posterior side of the left ventricle. The **right coronary artery** comes off the right side of the aorta, then branches into the **marginal artery**, which supplies the right atrium and ventricle, and the **posterior interventricular artery** , which will be discussed shortly. In terms of veins, the **great cardiac vein**, which runs next to the anterior interventricular artery, drains the left atrium and right and left ventricles. Over the right ventricle are the **anterior cardiac veins**, which drain the anterior surface of the right ventricle, and the **small cardiac veins**, which drain the posterior surface of the right atrium and ventricle.

<u>Activity:</u>

1. Identify the following vessels:

☐	Anterior cardiac V.	☐	Inferior vena cava	☐	Pulmonary A.
☐	Anterior interventricular A.	☐	Left brachiocephalic V.	☐	Pulmonary trunk
☐	Aortic arch	☐	Left common carotid A.	☐	Pulmonary V.
☐	Ascending aorta	☐	Left coronary A.	☐	Right brachiocephalic V.
☐	Brachiocephalic A.	☐	Left subclavian A.	☐	Right coronary A.
☐	Circumflex A.	☐	Marginal A.	☐	Small cardiac V.
☐	Great cardiac V.	☐	Posterior interventricular A	☐	Superior vena cava

2. What regions of the body do the arteries supply, and from what regions do the veins drain blood?

Vessels of the Heart

(Anterior View)

Vessels of the Heart
(Posterior View)

Many of the large vessels of the heart can be identified from the posterior view, including the **superior and inferior vena cavae**, the **right and left pulmonary arteries,** the four **pulmonary veins**, and the **aortic arch**. The three branches of the arch – **brachiocephalic, left common carotid and left subclavian arteries** – can be seen. The aorta then continues down the posterior of the heart as the **descending aorta**. You can see the **right and left brachiocephalic veins** feeding into the superior vena cava, as well as another vein on its posterior surface called the **azygous vein**, which receives blood from the posterior thorax and abdomen.

Posterior coronary arteries can also be identified. The **right coronary artery**, which originated on the anterior side of the heart, branches into the **posterior interventricular artery**; this artery supplies the posterior ventricles. The **middle cardiac vein**, which runs in parallel with the posterior interventricular artery, drains blood from the right ventricle. Over the left ventricle is the **posterior cardiac vein**, which received blood from the left ventricle. With the exception of one vein (anterior cardiac, which drains directly into the right atrium), all veins from the anterior and posterior side of the heart empty into the **coronary sinus**, a large vein that returns blood to the right atrium.

<u>Activity:</u>

1. Identify the following vessels:

☐	Aortic arch	☐	Left subclavian A.
☐	Azygous V.	☐	Middle cardiac V.
☐	Brachiocephalic A.	☐	Posterior cardiac V.
☐	Brachiocephalic V.	☐	Posterior interventricular A.
☐	Coronary sinus	☐	Pulmonary A.
☐	Descending aorta	☐	Pulmonary V.
☐	Inferior vena cava	☐	Right coronary A.
☐	Left common carotid A.	☐	Superior vena cava

2. What regions of the body do the arteries supply, and from what regions do the veins drain blood?

Vessels of the Heart
(Posterior View)

Arteries and Veins of the Head and Neck

The arteries of the head and neck are shown in white on the diagram, while the veins are shown in gray.

Recall that the second branch off the arch of the aorta is the left **common carotid**. This artery ascends up the neck and branches into the left **internal carotid artery** (which supplies the brain) and the left **external carotid artery** (which supplies the left side of the head, external to the brain). The third branch, the left **subclavian artery** branches into the left **vertebral artery** (which supplies the brain) and the **axillary artery** (which supplies the left axilla). Though not all vessels are shown on the diagram, the **brachiocephalic artery** branches into the right **common carotid** and right **subclavian arteries**, which then follow the same branching pattern as the left side.

Blood from the brain empties into the **dural venous sinuses**, large veins found within the dura mater of the brain. Blood from the brain also drains into the **internal jugular veins**, which descend through the neck. From the upper limbs, deoxygenated blood is entering the **subclavian veins**, which also receive blood from the scalp and face via the **external jugular veins**. The subclavian veins join the internal jugular veins to become **brachiocephalic veins**.

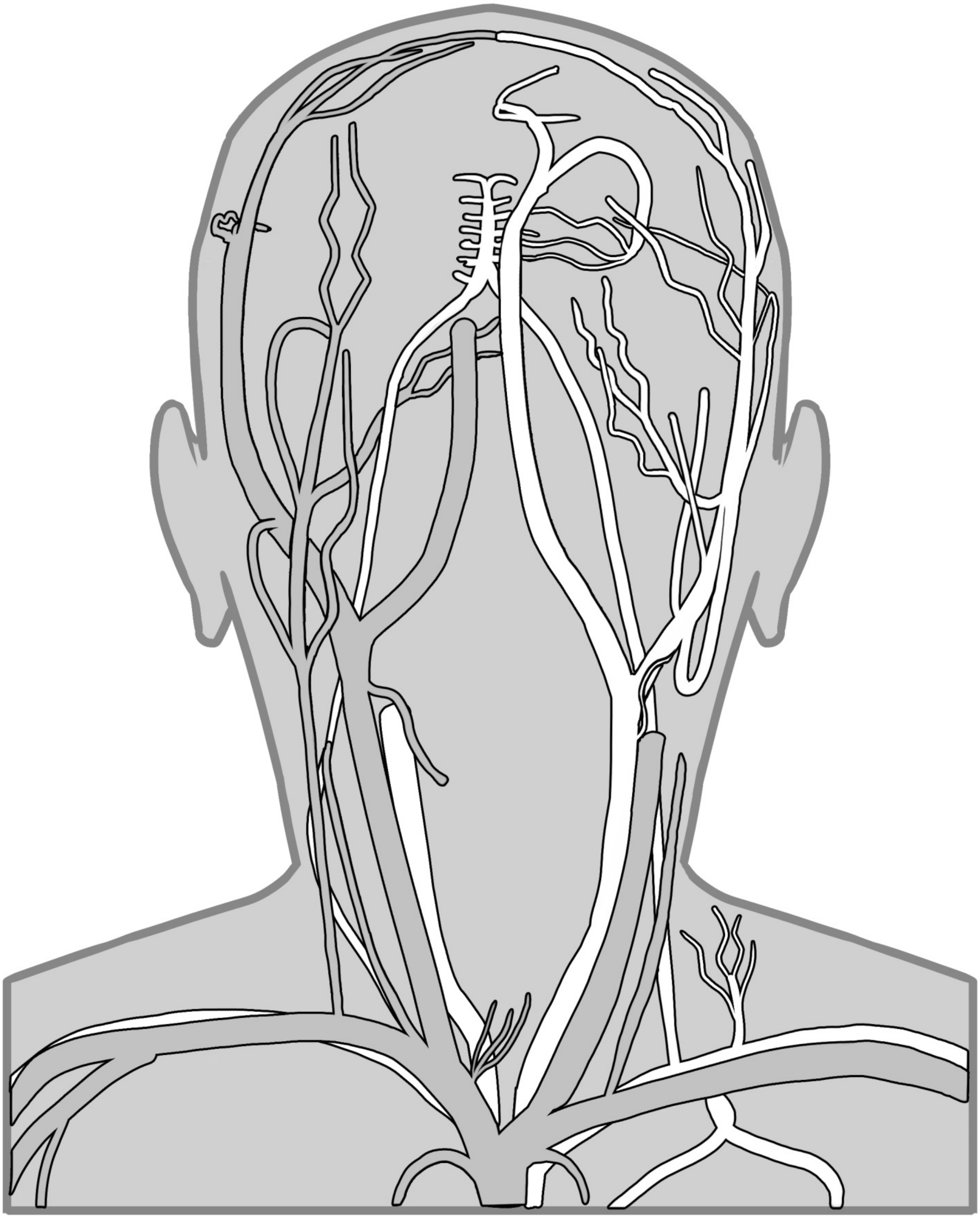
Activity:

1. Identify the following vessels:

☐	Axillary A.	☐	Internal carotid A.
☐	Brachiocephalic V.	☐	Internal jugular V.
☐	Common carotid A.	☐	Subclavian A.
☐	Dural venous sinus	☐	Subclavian V.
☐	External carotid A.	☐	Vertebral A.
☐	External jugular V.		

2. What structures do the arteries supply, and from which structures do the veins receive blood?

Arteries and Veins of the Head and Neck



Arteries of the Upper Limb

Recall that the subclavian artery has two branches: the vertebral artery, which runs superiorly to the brain, and the **axillary artery**, which goes to the upper limb to supply the axilla (underarm). The axillary artery then leads to the **brachial artery**, which supplies the arm. Just below the elbow, the brachial artery branches into the **radial artery** laterally, which supplies the lateral forearm, and the **ulnar artery** medially, which supplies the medial forearm. These two arteries rejoin to supply blood to the hand.

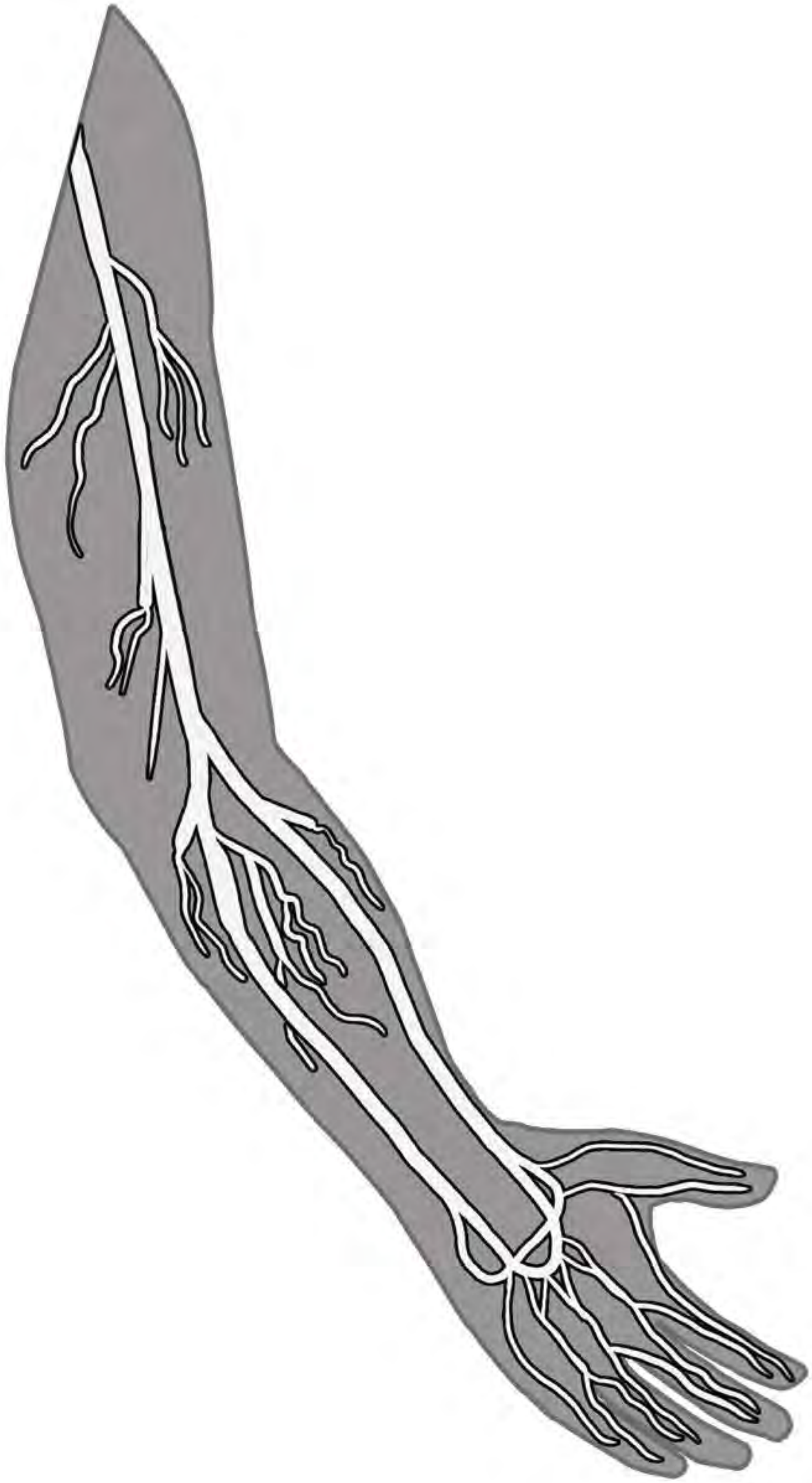
<u>Activity:</u>

1. Identify the following arteries:

☐ Axillary	☐ Radial
☐ Brachial	☐ Ulnar

2. What regions of the upper limb do the arteries supply?

Arteries of the Upper Limb



Veins of the Upper Limb

The deep veins of the upper limb, which are found deep within the limb compartment, are very similar to the arteries in terms of location and name. The **radial vein** (which drains the lateral forearm) and the **ulnar vein** (which drains the medial forearm) combine to form the **brachial vein**, which drains the arm. The brachial vein then becomes the axillary vein as it enters the axilla. The **axillary vein** feeds into the subclavian vein.

The upper limb also contains superficial veins, running closer to the surface of the skin. The **cephalic vein** begins on the lateral side of the hand and extends up the anterior surface of the upper limb to the shoulder, where it drains into the axillary vein. The **basilic vein** begins on the medial side of the hand and extends up the posterior surface of the forearm, then the anterior surface of the arm, before feeding into the top of the brachial vein. There are two alternate arrangements of the remaining superficial veins of the forearm. Commonly, the cephalic and basilic veins are connected by a single, obliquely oriented vein called the **median cubital vein**. In our model, the median cubital vein is replaced by two short veins: the **median cephalic vein** laterally and the **median basilic vein** medially. These two short veins receive blood from the **median vein of the forearm**, which drains the forearm.

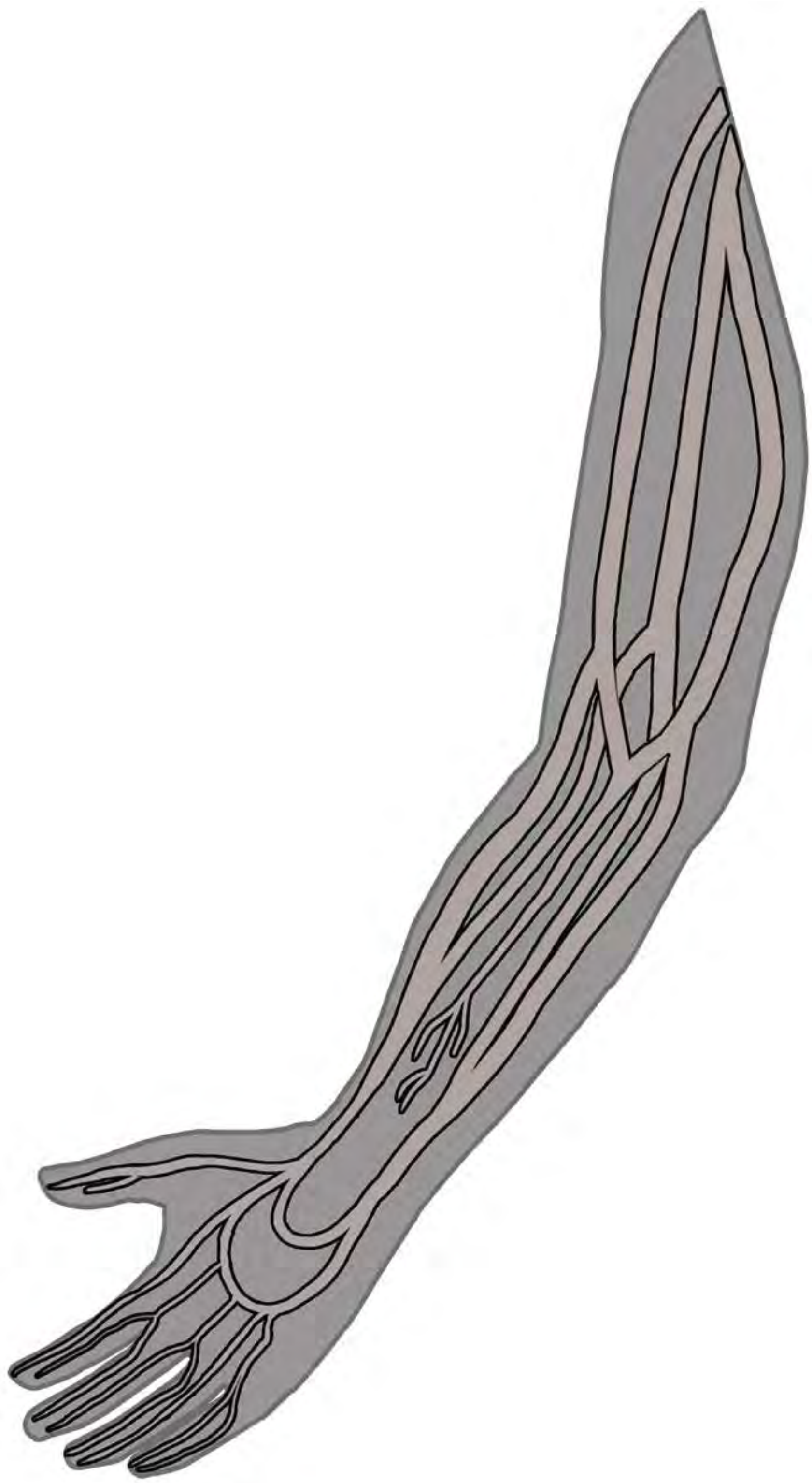
Activity:

1. Identify the following veins:

- ☐ Axillary
- ☐ Basilic
- ☐ Brachial
- ☐ Cephalic
- ☐ Median basilic
- ☐ Median cephalic
- ☐ Median vein of the forearm
- ☐ Radial
- ☐ Ulnar

2. From what regions of the upper limb do the following veins drain blood?

Veins of the Upper Limb



Arteries and Veins of the Thorax and Abdomen

The arteries of the thorax and abdomen are shown in white. The **thoracic aorta** has branches called the **intercostal arteries**, which supply the intercostal muscles. The thoracic aorta becomes the **abdominal aorta** through the abdomen. The first artery off the abdominal aorta is the **celiac trunk**, which has many branches including the **left gastric artery**, which supplies the stomach and esophagus, the **splenic artery**, which supplies the spleen, and the **common hepatic artery**, which supplies the liver, stomach, duodenum and pancreas. The **right gastric artery**, which supplies the stomach, connects the common hepatic to the left gastric artery. The next branch is the **superior mesenteric artery**, which supplies the small intestine, pancreas and part of the large intestine. The **renal arteries** branch next; they bring blood to the kidneys. Next, the **gonadal arteries** supply the ovaries and testes. Just below is the **inferior mesenteric artery**, which supplies the remainder of the large intestine. The final branches of the abdominal aorta are the **common iliac arteries**, which then split into the **internal iliac arteries**, to supply the pelvic organs, and the **external iliac arteries**, to supply the lower limbs.

The veins of the abdomen, which are shown in gray, are very similar to the arteries in their name, location and organs from which they receive blood. The **internal iliac veins** and **external iliac veins** feed into the **common iliac veins**. The common iliac veins combine to form the **inferior vena cava**, into which all of the abdominal veins drain. There are three main veins that drain into the inferior vena cava (from inferior to superior): **gonadal**, **renal**, and **hepatic veins**. The **hepatic portal vein** is a large vein that delivers blood from the digestive system to the liver. It receives blood from the **superior mesenteric**, **splenic**, and **inferior mesenteric veins**.

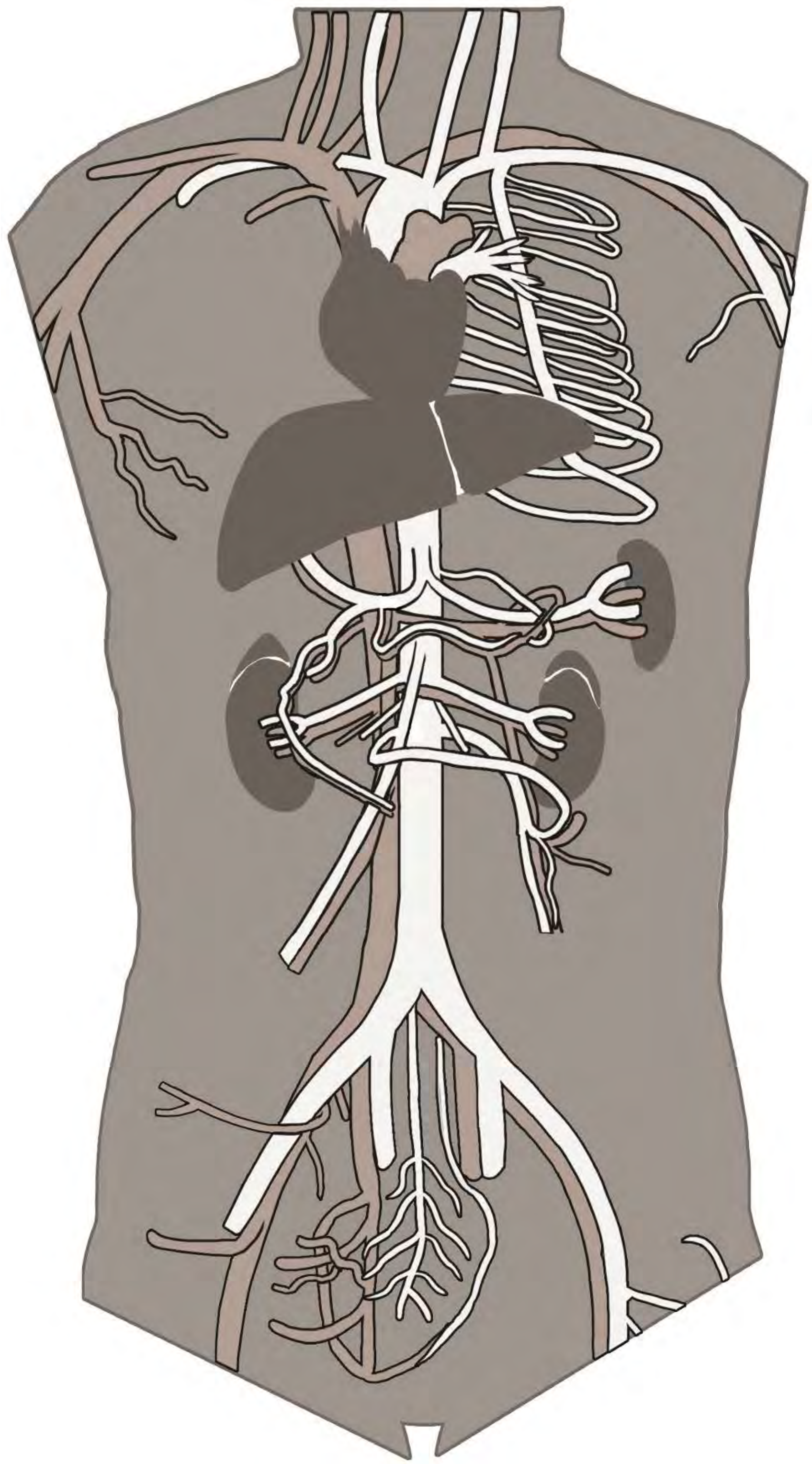
Activity:

1. Identify the following vessels:

☐	Abdominal aorta	☐	Hepatic portal V.	☐	Renal A.
☐	Celiac trunk	☐	Hepatic V.	☐	Renal V.
☐	Common hepatic A.	☐	Inferior mesenteric A	☐	Right gastric A.
☐	Common iliac A.	☐	Inferior mesenteric V	☐	Splenic A.
☐	Common iliac V.	☐	Inferior vena cava	☐	Splenic V.
☐	External iliac A.	☐	Intercostal A.	☐	Superior mesenteric A
☐	External iliac V.	☐	Internal iliac A.	☐	Superior mesenteric V
☐	Gonadal A.	☐	Internal iliac V.	☐	Thoracic aorta
☐	Gonadal V.	☐	Left gastric A.		

2. What structures do the arteries supply, and from which do the veins receive blood?

Arteries and Veins of the Thorax and Abdomen



Arteries of the Lower Limb

Recall that in the pelvis the common iliac artery branches into the internal iliac artery, which supplies the pelvic organs, and the external iliac artery, which delivers blood to the lower limbs. Once the external iliac artery passes through the pelvis, it is called the **femoral artery**, which supplies the thigh. The femoral artery descends down the thigh, behind the knee within the popliteal fossa, to form the **popliteal artery**, which supplies the knee. Just after the knee, the popliteal artery branches into the **anterior tibial artery**, which supplies the anterior medial portion of the leg, and the **posterior tibial artery**, which supplies the posterior medial portion of the leg. At the ankle, the anterior tibial artery becomes the **dorsalis pedis** muscle, which supplies the foot. The posterior tibial artery, shortly after it branched from the anterior tibial artery, has a large branch called the **fibular artery**, which supplies the lateral leg.

Activity:

1. Identify the following arteries:

☐	Anterior tibial	☐	Fibular
☐	Dorsalis pedis	☐	Popliteal
☐	Femoral	☐	Posterior tibial

2. What regions of the lower limb do the arteries supply?

Arteries of the Lower Limb

Veins of the Lower Limb

The deep veins of the lower limb are very similar to the arteries in terms of location and name. The **dorsalis pedis vein**, which drains the foot, leads to the **anterior tibial vein**, which drains the anterior/medial portion of the leg. The **fibular vein**, which drains the lateral leg, leads to the **posterior tibial vein**, which drains the posterior/medial portion of the leg. Both anterior and posterior tibial veins come together to form the **popliteal vein**, which drains the knee. The popliteal vein leads to the **femoral vein**, which drains the thigh. The femoral vein then leads to the external iliac vein as it enters the pelvis.

The **great saphenous vein** is a superficial vein, running closer to the surface of the skin. This very long vein extends the entire length of the lower limb, and empties into the femoral vein near the pelvis.

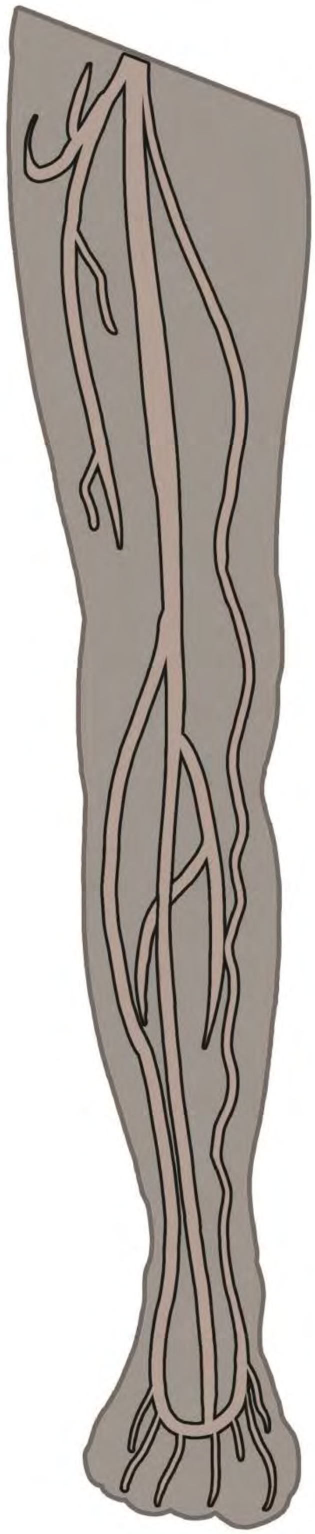
Activity:

1. Identify the following veins:

- ☐ Anterior tibial
- ☐ Dorsalis pedis
- ☐ Femoral
- ☐ Fibular
- ☐ Great saphenous
- ☐ Popliteal
- ☐ Posterior tibial

2. From what regions of the lower limb do the following veins drain blood?

Veins of the Lower Limb



Organs of the Respiratory System

The organs of the respiratory system can be categorized based on location; they are part of either the upper or the lower respiratory tract. The upper respiratory tract begins with the **nose**, which allows us to breathe in and out; the **oral cavity** can technically serve the same purpose, but the nose is better designed for this function (to be discussed shortly). Air is then conducted to the **pharynx**, the throat. The junction of the upper and lower respiratory tracts is located at the **larynx**, the voice box. (Because of disagreement between anatomists about which category to place the larynx in, we will say that it is both upper and lower.) The air is then conducted to the **trachea**, the windpipe. At its base, the trachea branches into the **right primary bronchus**, which provides air to the **right lung**, and the **left primary bronchus**, which provides air to the **left lung**. The primary bronchi then split into **secondary (lobar) bronchi**; there are five secondary bronchi, three on the right side and two on the left (the left lung is smaller because of the position of the heart). The secondary bronchi then split into **tertiary (segmental) bronchi**; the bronchi continue to branch into smaller and smaller bronchi, ultimately becoming microscopic **bronchioles**, which deliver air to the alveoli of the lungs.

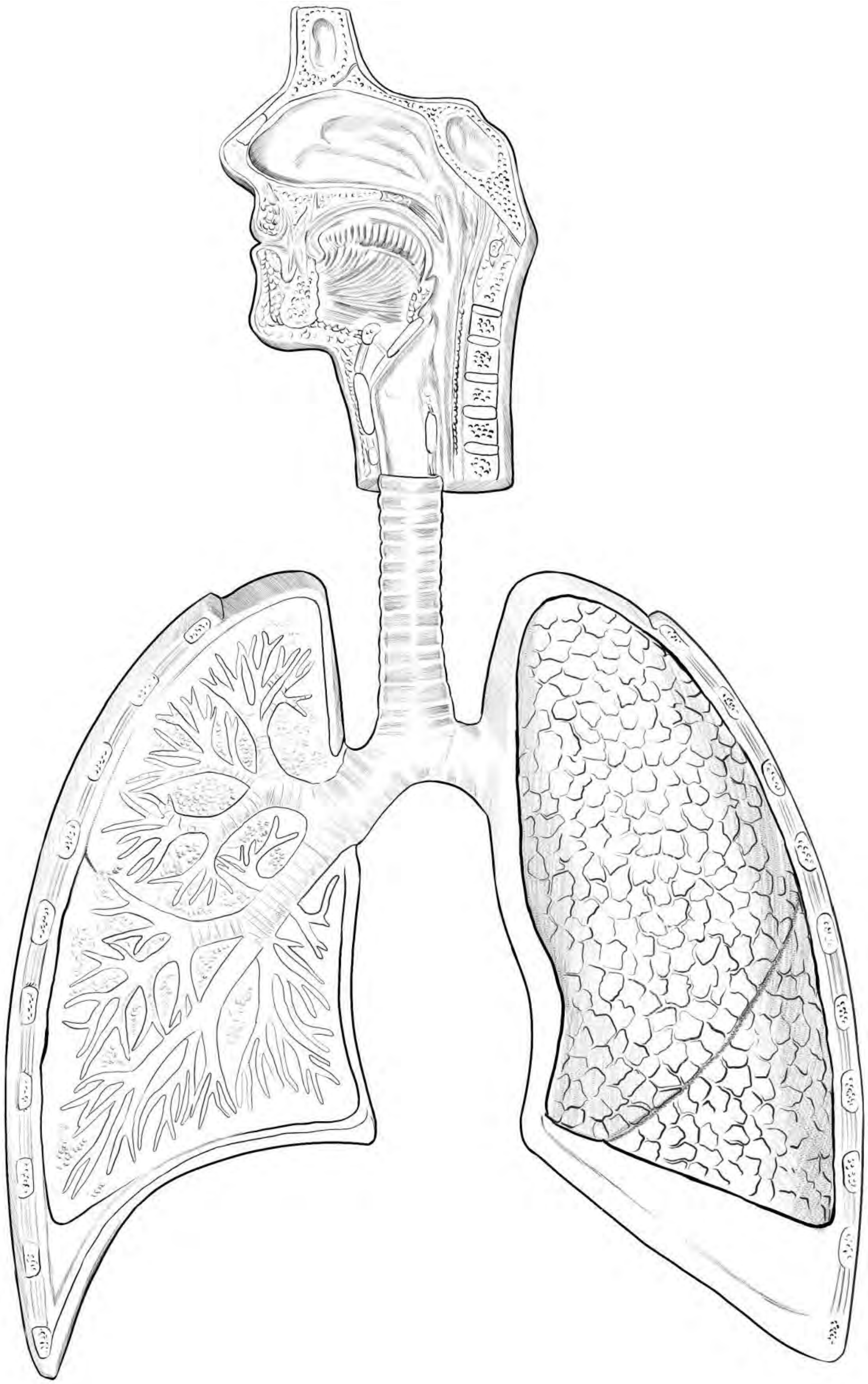
<u>Activity:</u>

1. Identify the following structures:

- ☐ Larynx
- ☐ Left lung
- ☐ Left primary bronchus
- ☐ Nose/nasal cavity
- ☐ Oral cavity
- ☐ Pharynx
- ☐ Right lung
- ☐ Right primary bronchus
- ☐ Right secondary bronchi
- ☐ Right tertiary bronchi
- ☐ Trachea

2. Which structures are part of the upper respiratory tract? Lower?

Organs of the Respiratory System



The Upper Respiratory Organs

The upper respiratory tract extends from the **nose** or **oral cavity** to the larynx. The nose is the ideal organ for breathing. Hairs and ciliated epithelial cells inside the nose filter the air we breathe, and mucus in the nose traps dust and microbes. Further, the **superior, middle and inferior nasal conchae** and their associated **superior, middle and inferior nasal meatuses** act as turbines, causing the air to swirl around the nasal cavity, warming and humidifying the air before it enters the pharynx.

The first segment of the pharynx, the **nasopharynx**, sits just posterior to the nasal cavity. It contains a mass of lymphatic tissue called the **pharyngeal tonsil** (the adenoid). The opening to the **pharyngotympanic tube** can also be found here. Recall that the nasal and oral cavities are separated by the palate; the anterior **hard palate** is formed by bone while the posterior **soft palate** is composed of muscle. At the level of the **soft palate**, the second segment of the pharynx – the **oropharynx** – begins; this region sits just posterior to the oral cavity. The oropharynx contains the **palatine tonsils** near the soft palate and the **lingual tonsils** on the posterior surface of the tongue. The third segment of the pharynx – the **laryngopharynx** – is just posterior to the larynx. It is continuous with both the larynx and the esophagus.

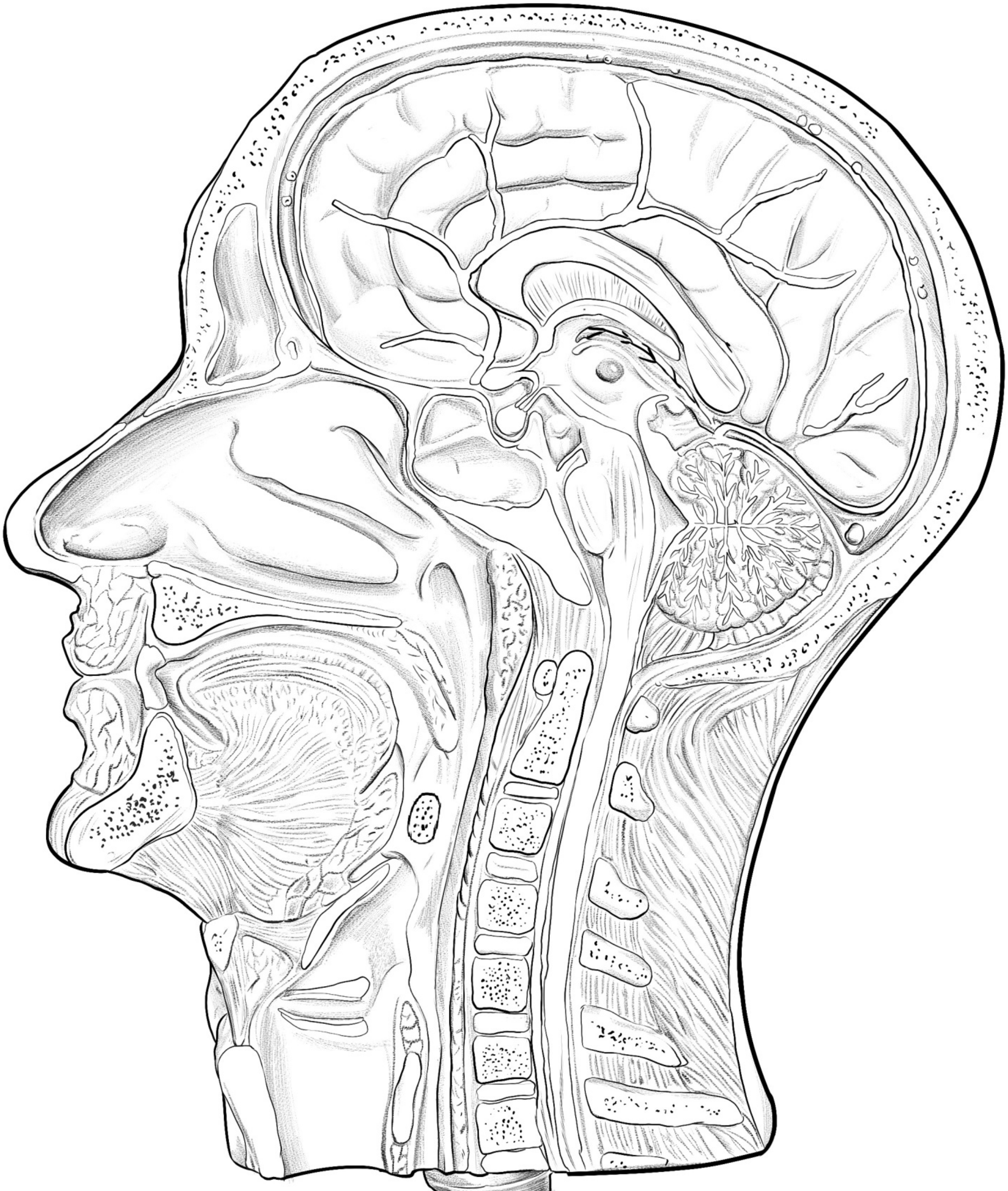
The nasopharynx should not have any food in it, only air. During swallowing the **uvula** of the soft palate rises and closes the oropharynx from the nasopharynx, thereby preventing food from entering the nasopharynx. The oropharynx and laryngopharynx, however, both allow for the passage of food and air. From the laryngopharynx, food should be directed posteriorly into the **esophagus** and air should be diverted anteriorly to the **larynx**.

Activity:

1. Identify the following structures:

☐	Epiglottis	☐	Lingual tonsil	☐	Pharyngeal tonsil
☐	Hard palate	☐	Middle nasal concha	☐	Pharyngotympanic tube
☐	Inferior nasal concha	☐	Middle nasal meatus	☐	Soft palate
☐	Inferior nasal meatus	☐	Nasopharynx	☐	Superior nasal concha
☐	Laryngopharynx	☐	Oropharynx	☐	Superior nasal meatus
☐	Larynx	☐	Palatine tonsil	☐	Uvula

The Upper Respiratory Organs



The Larynx and Trachea
(Anterior view)

The **larynx** is continuous with the laryngopharynx, and is attached to the hyoid bone superiorly and the trachea inferiorly. It is commonly referred to as the voice box because this is where the vocal cords are located. In addition, the cartilaginous structure of the larynx keeps the airway open for efficient breathing.

The larynx is composed of nine cartilages, several of which can be viewed from the anterior perspective; all of the cartilages, except one, are composed of hyaline cartilage. The largest cartilage is the **thyroid cartilage**. It contains a ridge on its anterior surface called the **laryngeal prominence** ("Adam's apple"). Below it is the **cricoid cartilage**; its shape resembles a signet ring with the narrow part of the ring on the anterior surface. The last cartilage that can be seen is the **epiglottis**, which is composed of elastic cartilage. The epiglottis attaches to the tongue on its posterior surface, and meets the thyroid cartilage on its anterior surface. During swallowing, the epiglottis moves downward to cover the airway to prevent choking. When not swallowing, it points superiorly, keeping the airway open so we can breathe. The remaining cartilages will be discussed with posterior view of the larynx.

The **trachea,** colloquially referred to as the windpipe, extends from the larynx to the bronchial tree. It runs through the mediastinum, just anterior to the esophagus. Hyaline cartilage rings, which are shaped like a C, surround the trachea with the open part of the C facing posteriorly. The rings keep the trachea open, thereby reducing any resistance to airflow.

Activity:

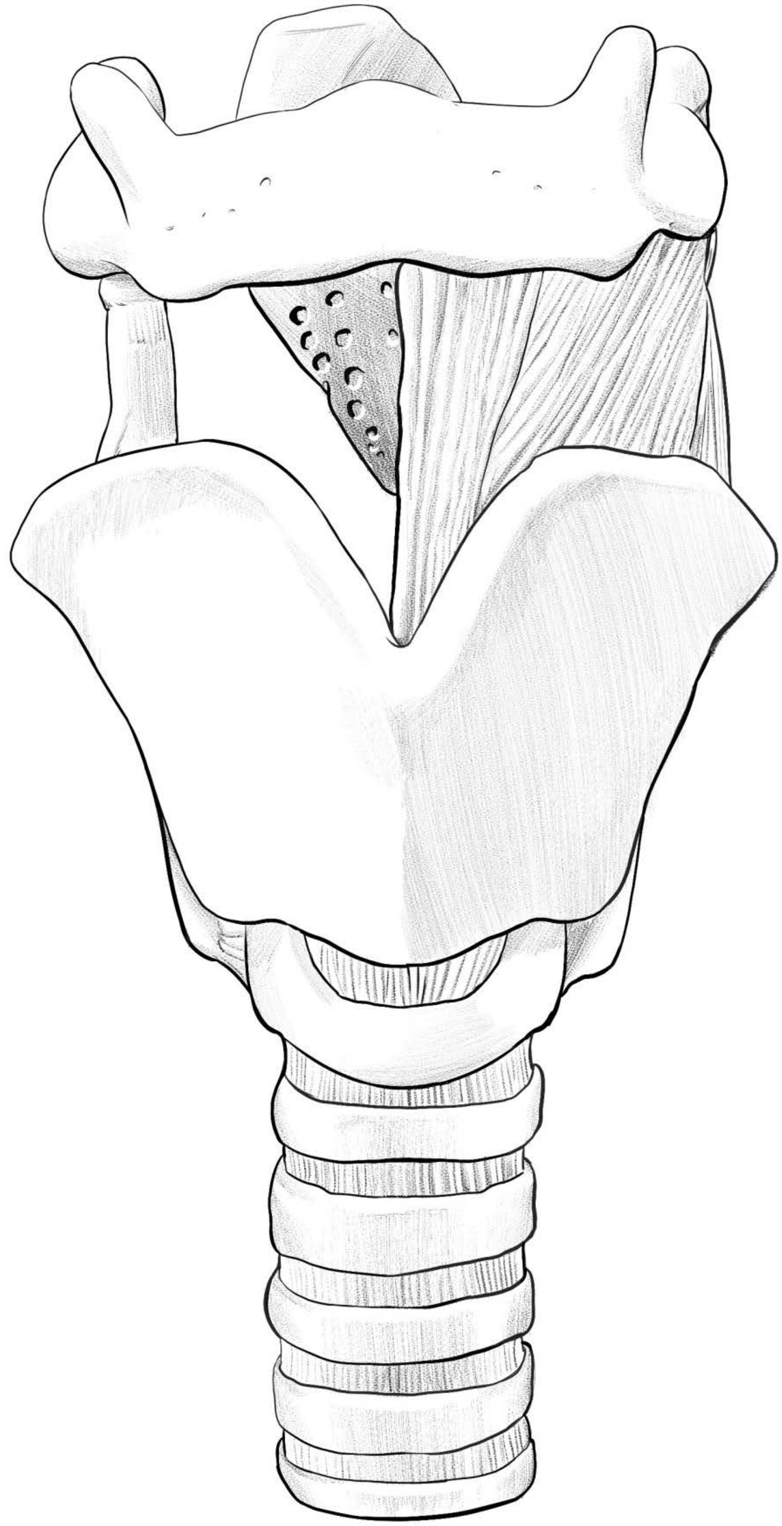
1. Identify the following structures:

☐ Cricoid cartilage	☐ Laryngeal prominence
☐ Epiglottis	☐ Thyroid cartilage
☐ Hyoid bone	☐ Tracheal rings

2. Label on the figure where the larynx ends and the trachea begins.

The Larynx and Trachea

(Anterior view)



The Larynx and Trachea
(Posterior view)

Observing the larynx from the posterior perspective, the sides of the **thyroid cartilage** can be seen. Additionally, the wide, flat portion of the signet ring-shaped **cricoid cartilage** can be seen. The full shape of the **epiglottis** can be viewed from this perspective. The paired, pyramid-shaped **arytenoid cartilages** are just above the cricoid cartilage. These cartilages provide an attachment site for the vocal cords. Resting on top of the arytenoid cartilages are the paired, horn-shaped **corniculate cartilages**. The last two cartilages, the **cuneiform cartilages**, form the lateral walls of the laryngeal opening, and cannot be seen on any of our models.

The posterior view of the **trachea** allows you to see the open portion of the C-shaped cartilaginous rings. The opening allows for expansion of the esophagus, which sits behind the trachea, during swallowing.

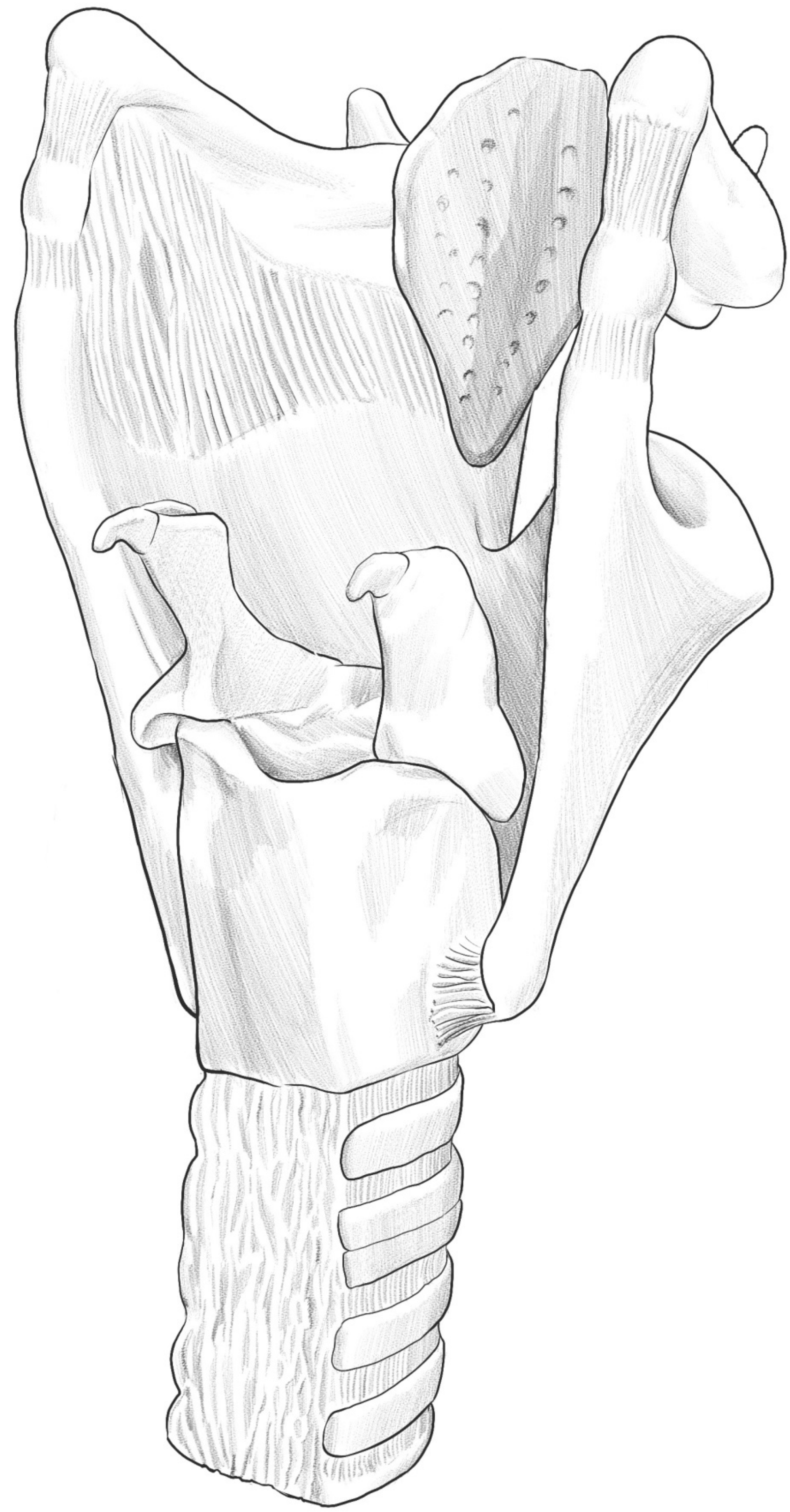
<u>Activity:</u>

1. Identify the following structures:

☐	Arytenoid cartilage	☐	Epiglottis
☐	Corniculate cartilage	☐	Thyroid cartilage
☐	Cricoid cartilage	☐	Tracheal rings

2. Why are the cartilaginous rings not continuous around the posterior surface of the trachea?

The Larynx and Trachea
(Posterior view)



Tracheal Histology

Once you are familiar with the generalized structure of the trachea, you should be able to identify many of the features on prepared and stained sections. Like many organs of the respiratory system, the mucosa (innermost layer) of the trachea is lined by **pseudostratified ciliated epithelium**. The cilia trap microbes and dust, and push them toward the throat to be coughed out or swallowed. The submucosa outside of the mucosa contains connective tissue with **seromucous glands** that secrete mucus to help trap microbes and dust. Outside of the submucosa are the **hyaline cartilage rings**.

This slide is a cross section of the trachea, taken from a human.

Activity:

1. Obtain slide number 66 from your slide box.
2. Using the 4X objective lens, locate the following:

    Hyaline cartilage ring
    Pseudostratified ciliated epithelium
    Seromucous gland

3. Draw what you see on the following page, labelling the structures listed above.

Tracheal Histology

The Lungs

This figure shows you the gross anatomy of the lungs in their entirety, and provides perspective with respect to the location of the lungs relative to the heart and its major vessels. The lungs take up the majority of the thoracic cavity; they are located just lateral to the **mediastinum** within the **pleural cavities**. The **apex** (top) of the lungs begins just behind the clavicle and the **base** of the lungs rests on top of the **diaphragm**.

The heart is lateralized toward the left side of the body. As a result the **left lung** is much smaller than the right lung, only containing two lobes instead of three. The two lobes are the **superior lobe** and the **inferior lobe**, which are separated by the **oblique fissure**. The superior lobe has a **cardiac notch**, an indentation on its medial border to make room for the heart.

The **right lung** has three lobes: **superior lobe**, **middle lobe** and **inferior lobe**. The superior and middle lobes are separated by the **horizontal fissure**; whereas the middle and inferior lobes are separated by the **oblique fissure**.

Each lung is independent of one another and is surrounded by its own **pleural membrane**. As a result, if one lung collapses (e.g. due to puncture), the other one will remain inflated as long as its pleural membrane is undisturbed.

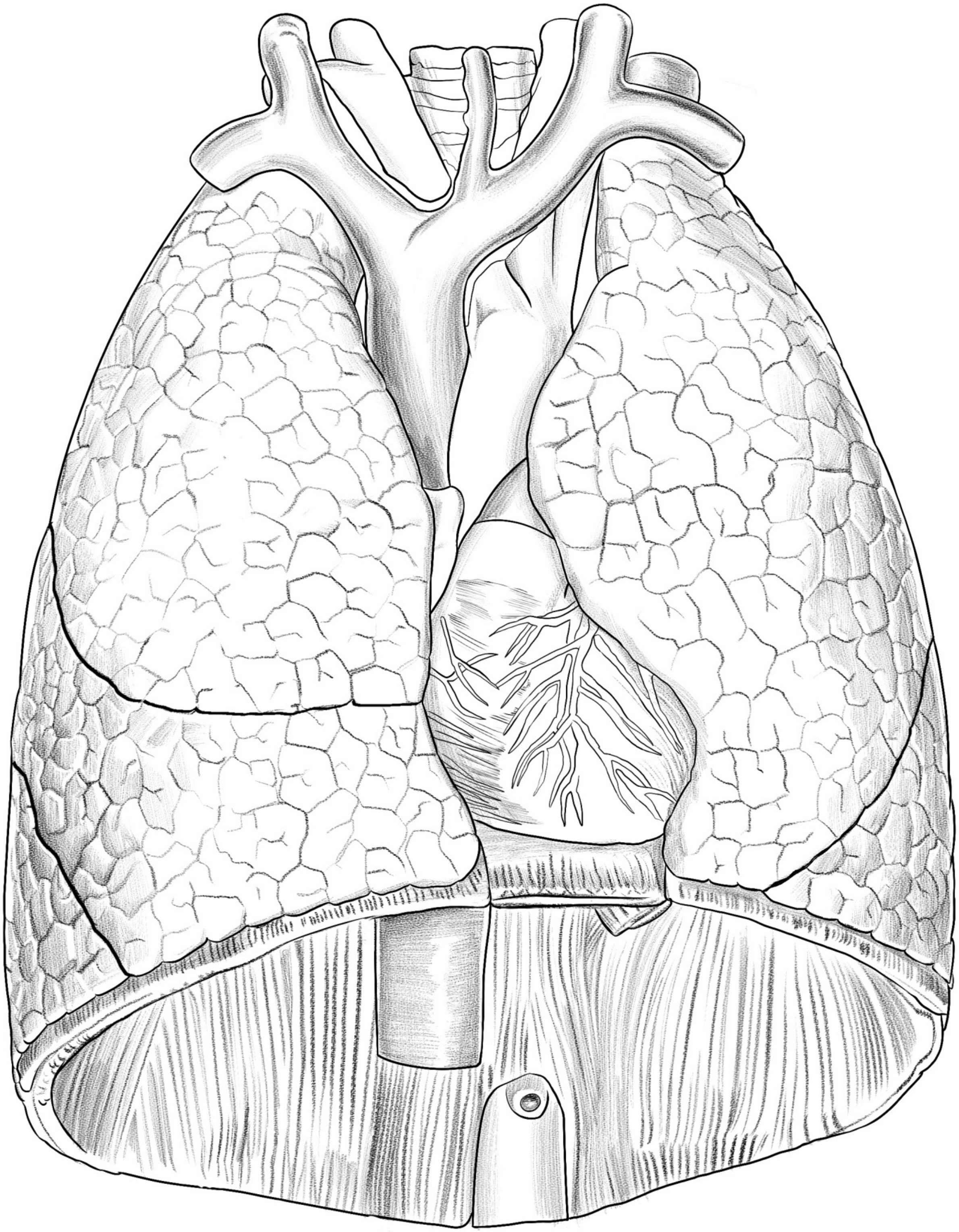
Activity:

1. Identify the following structures:

☐ Apex	☐ Horizontal fissure	☐ Right inferior lobe
☐ Base	☐ Left inferior lobe	☐ Right middle lobe
☐ Cardiac notch	☐ Left oblique fissure	☐ Right oblique fissure
☐ Diaphragm	☐ Left superior lobe	☐ Right superior lobe

2. What is the serous membrane of the lungs called? What is its purpose?
3. Which lung is smaller? Why?

The Lungs



The Respiratory Zone

The organs of the respiratory system can be categorized based on function: the **conducting zone** and the **respiratory zone**. The structures of the conducting zone simply conduct, or move, the air toward the functional unit of gas exchange, the **alveolus**. Through this process, the air is also filtered and humidified. The structures of the respiratory zone, on the other hand, all contain alveoli and are therefore responsible for gas exchange. Thus far, we have been focusing on the conducting organs. In this diagram, you will be looking at structures that are part of the respiratory zone.

Recall that the bronchi branch into microscopic bronchioles. The smallest of the bronchioles, which are still part of the conducting zone, are the **terminal bronchioles**. Terminal bronchioles then branch into **respiratory bronchioles**, which are the first of the respiratory zone structures. Respiratory bronchioles are distinguished from terminal bronchioles because they have alveoli embedded in their walls. Respiratory bronchioles are not shown on this diagram. The respiratory bronchioles then feed into the **alveolar ducts** (also with alveoli on their walls, also not shown), which then become clusters of alveoli called **alveolar sacs**. This figure shows one example of an alveolar sac.

Note is the presence of **smooth muscle cells** around the bronchioles. These muscle cells, which first appeared around the trachea, contract to cause bronchoconstriction and relax to cause bronchodilation. Also note the close association between the alveoli and the **capillaries** that supply them. This close association forms the **respiratory membrane**, across which oxygen and carbon dioxide are exchanged.

Activity:

1. Identify the following structures:

- ☐ Alveolus
- ☐ Capillaries
- ☐ Terminal bronchiole
- ☐ Alveolar sac
- ☐ Smooth muscle cells

The Respiratory Zone

Lung Histology

Once you are familiar with the generalized structure of the lungs, you should be able to identify lung tissue on prepared and stained sections.

This slide is of smoker's lungs. You can see the delicate walls of the alveoli, lined by simple squamous epithelium. Note the carbon deposits amongst the alveoli.

Activity:

1. Obtain slide number 64 from your slide box.
2. Using the 10X objective lens, draw what you see on the following page, labelling an example of an alveolus.

Lung Histology

The Digestive System

The organs of the digestive system fall into two categories: the gastrointestinal tract organs and accessory organs. The gastrointestinal tract is a continuous tube that extends from the oral cavity to the anus, and includes the mouth, pharynx, esophagus, stomach, small intestine and large intestine. The accessory organs include the teeth, tongue, salivary glands, liver, gallbladder, and pancreas. The digestive system has many functions including ingestion (intake of food), digestion (mechanically or chemically with enzymes), absorption of nutrients, and defecation (waste elimination).

Ingestion, mechanical and chemical digestion, and deglutition (swallowing) are all accomplished in the **oral cavity**. These processes are assisted by several accessory organs, including the tongue, teeth, and salivary glands. Swallowing is also accomplished in the **pharynx** and the **esophagus**. Once inside the **stomach**, the food is mixed with acidic gastric juice, and chemical digestion continues. The stomach empties its contents into the **small intestine**. The small intestine, assisted by secretions from the liver, gallbladder and pancreas, is the site of most chemical digestion, and is also where most absorption occurs. The **liver** is the largest gland in the body, and assists lipid digestion through the secretion of bile, an emulsifier. The **gallbladder** is the liver's accessory, storing and concentrating bile. The **pancreas**, also a gland, secretes pancreatic juice, which has enzymes to chemically digest food in the small intestine, and bicarbonate to buffer the acids from the stomach. The small intestine empties into the **large intestine**, which is mainly responsible for the absorption of water from feces and the elimination of waste.

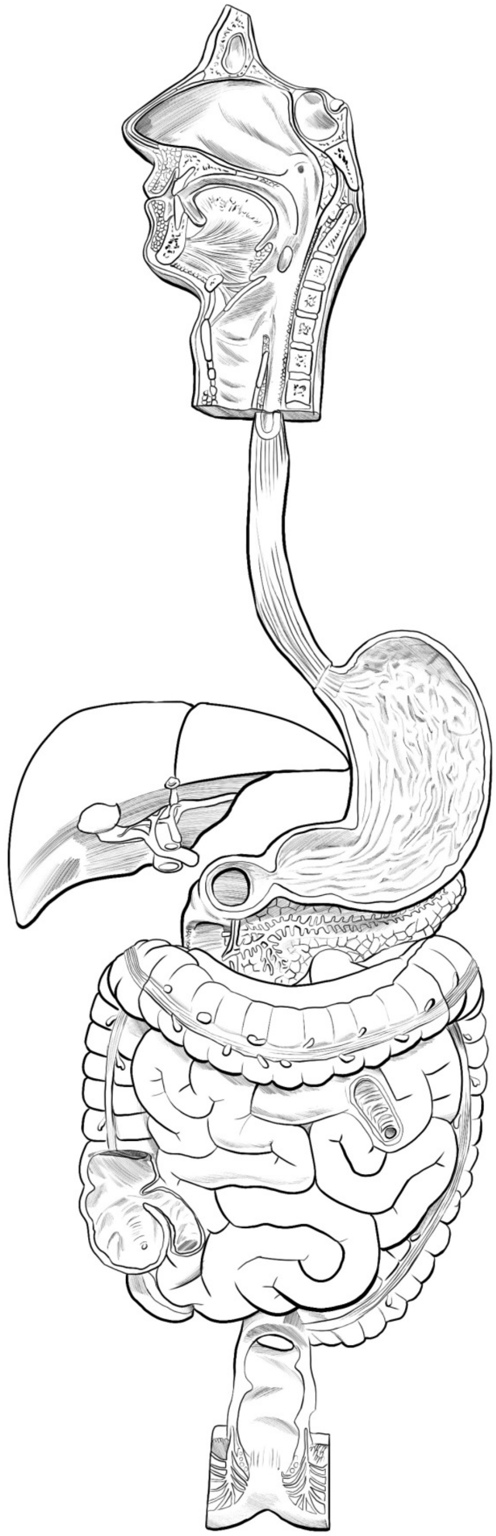
Activity:

1. Identify the following structures:

☐	Esophagus	☐	Liver	☐	Pharynx
☐	Gallbladder	☐	Oral cavity	☐	Small intestine
☐	Large intestine	☐	Pancreas	☐	Stomach

2. Which of the structures above are part of the gastrointestinal tract?
3. Which of the structures above are accessory organs?
4. What are the three regions of the small intestine?

The Digestive System



The Oral Cavity and Pharynx

The digestive process begins in the **oral cavity** (the mouth), when we ingest food. The food gets dissolved by saliva from the salivary glands, and is chewed by the **teeth**. This process leads to the formation of a ball of food, called a bolus. The oral cavity is separated from the nasal cavity by the palate, which forms the roof of the mouth. Recall that the anterior portion, the **hard palate**, is formed by four different bones (two palatine processes of the maxillae and two palatine bones). Posterior to the hard palate is the **soft palate**, which is composed of muscle. A portion of the soft palate, the **uvula**, rises during swallowing to prevent food from entering the **nasopharynx**, the region of the pharynx behind the nose. The **tongue** assists with chewing, and is also involved in swallowing, pushing the bolus of food into the **oropharynx**, the region of the pharynx behind the mouth. Next, the food enters the **laryngopharynx**, the region of the pharynx just posterior to the larynx. Food moves posterior from the laryngopharynx, into the **esophagus**. The **epiglottis** of the larynx closes the glottis, thereby preventing the food from entering the larynx and trachea.

The oral cavity and pharynx have the same layers of tissue as all mucous membranes of the gastrointestinal tract do (from superficial to deep: mucosa, submucosa, muscularis mucosa and serosa/adventitia). Because the oral cavity and pharynx are subject to hard food that could damage the mucosa, they are both lined by protective, wear-and-tear, stratified squamous epithelium. These regions of the GI tract also contain skeletal muscle in their muscularis externa.

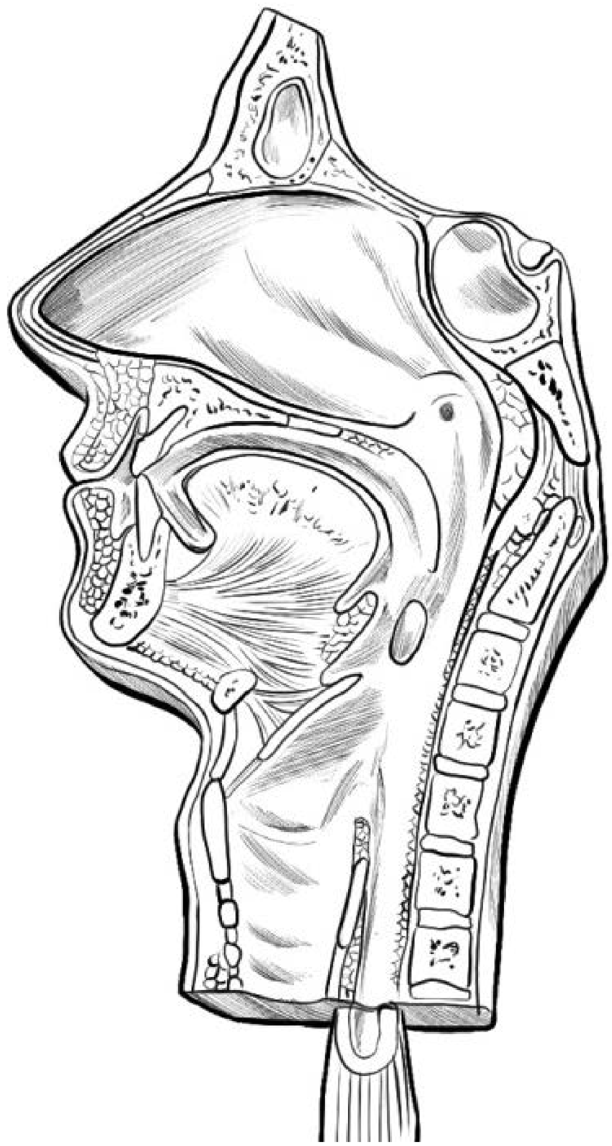
Activity:

1. Identify the following structures:

☐ Epiglottis	☐ Oropharynx
☐ Esophagus	☐ Soft palate
☐ Hard palate	☐ Teeth
☐ Laryngopharynx	☐ Tongue
☐ Nasopharynx	☐ Uvula
☐ Oral cavity	

2. What type of epithelial tissue lines the oral cavity and pharynx?
3. What type of muscle tissue is found in the muscularis externa of these organs?

The Oral Cavity and Pharynx



The Salivary Glands

The salivary glands are responsible for secreting saliva into the oral cavity. Saliva, which contains water, mucus and enzymes, dissolves the food we eat so we can taste and swallow it better, and also contains an enzyme that initiates the digestion of starch. We have intrinsic salivary glands throughout the mucosa of the oral cavity which constantly produce saliva. We also have three pairs of extrinsic salivary glands, which are much larger and are located outside of the mouth. Saliva is produced in large quantities by these glands during a meal. The saliva is secreted into the oral cavity by way of their associated ducts.

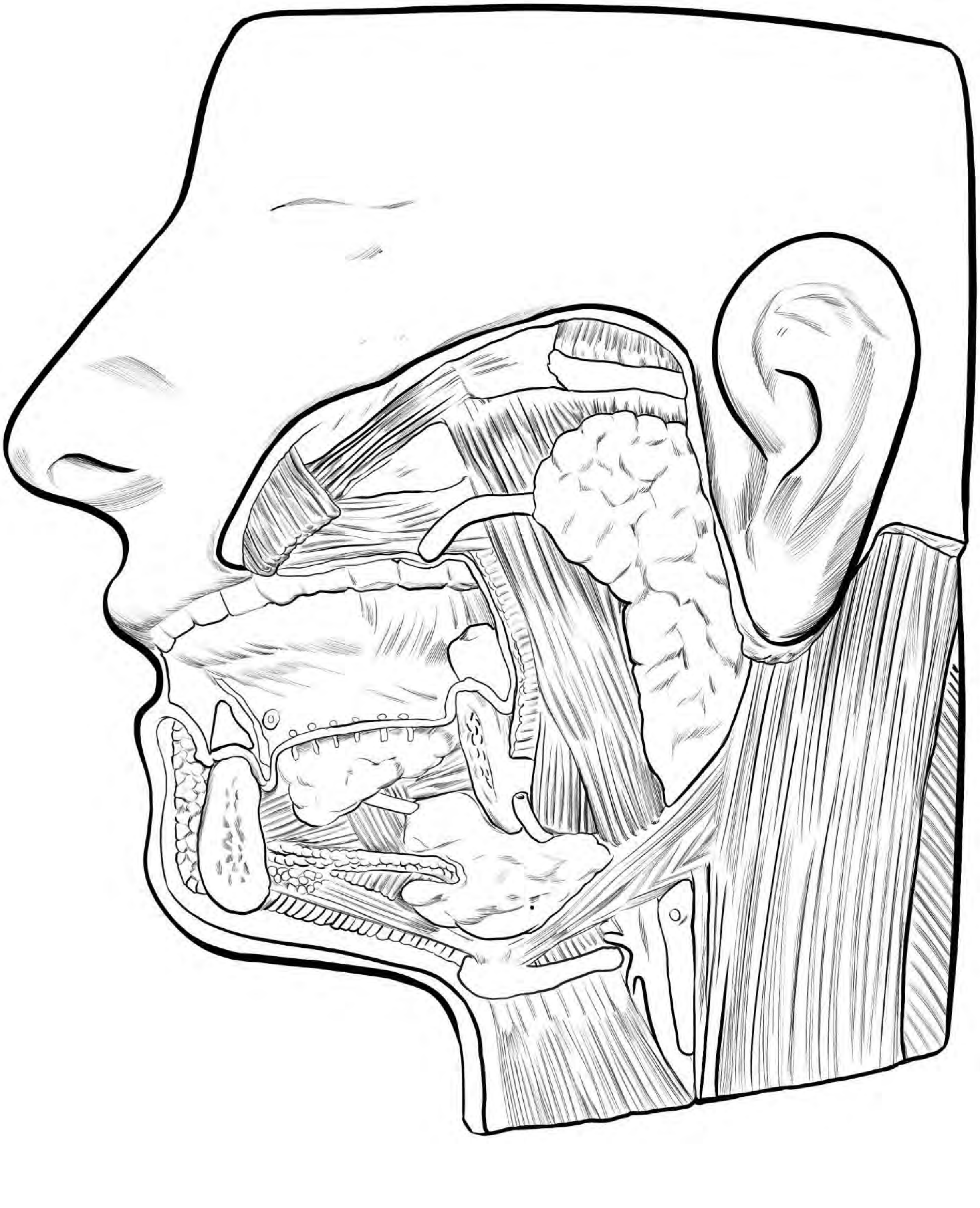
The **parotid glands** are the largest of the three extrinsic salivary glands. They are located superficial to the masseter muscles, and secrete saliva via the **parotid ducts**, which open near the upper molars on both sides of the mouth. The **submandibular glands** are the second largest of the three extrinsic glands. As their name implies, they are located near the mandible. The **submandibular ducts** secrete saliva onto the floor of the mouth, lateral to the tongue. The smallest of the extrinsic glands are the **sublingual glands**. As their name implies, they are located just underneath the tongue. Unlike the other two glands, each of the sublingual glands have about a dozen small **sublingual ducts**, which secrete saliva up into the mouth, just under the tongue.

Activity:

1. Identify the following structures:

☐	Parotid duct	☐	Sublingual gland
☐	Parotid gland	☐	Submandibular duct
☐	Sublingual ducts	☐	Submandibular gland

The Salivary Glands



Microscopic Anatomy of the Esophagus

Similar to the rest of the gastrointestinal tract, the esophagus has four layers of tissue. The **mucosa** has a superficial **epithelium**, which is composed of stratified squamous epithelium, except at the junction with stomach where the epithelium become simple columnar. The **lamina propria** (areolar connective tissue) is deep to the epithelium and the **muscularis mucosa** (smooth muscle) is the deepest layer of the mucosa. The **submucosa** is composed of a special type of connective tissue which has a combination of properties from areolar and dense irregular connective tissues. **Mucous glands** are found in the submucosa; the mucus secreted by these glands helps to move the bolus of food through the esophagus during swallowing. The type of muscle tissue found in the **muscularis externa** varies; the top third is skeletal muscle, the middle third is skeletal and smooth muscle and the bottom third is entirely smooth muscle. The last third has two layers of smooth muscle, an inner circular and an outer longitudinal, which work together to cause peristalsis. Because the esophagus is found in the thoracic cavity, it is extraperitoneal and is surrounded by the **adventitia** (rather than the serosa, found around most other GI organs). The adventitia is composed of loose connective tissue with collagen and elastin fibers.

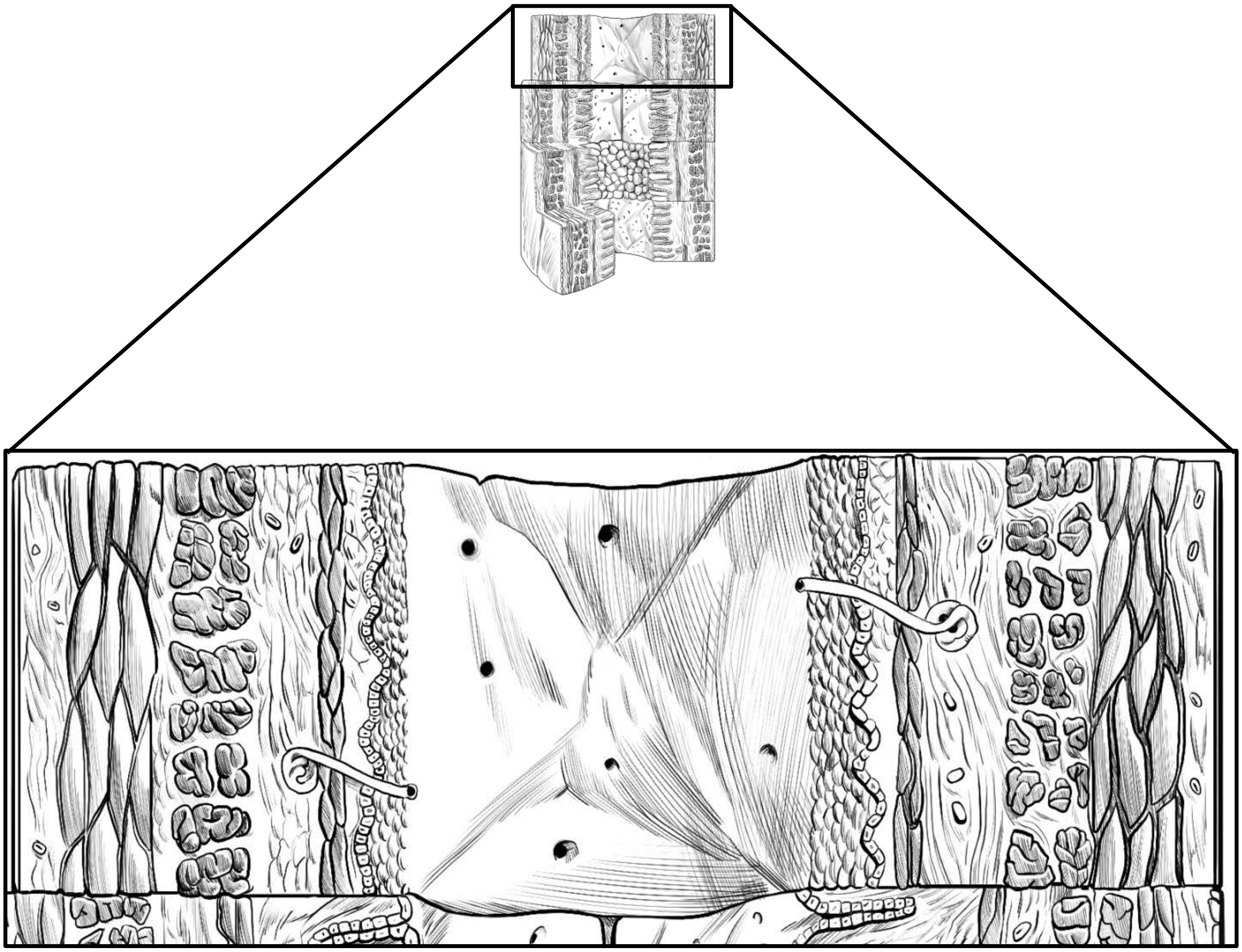
Activity:

1. Identify the following structures/layers:

- ☐ Adventitia
- ☐ Epithelium
- ☐ Lamina propria
- ☐ Mucosa
- ☐ Mucous gland
- ☐ Muscularis externa
- ☐ Muscularis mucosa
- ☐ Submucosa

2. What type of tissue is found in the lamina propria of all GI organs?
3. What type of tissue is found in the muscularis mucosa of all GI organs?
4. What type of tissue is found in the submucosa of all GI organs?
5. What type of epithelial tissue is found in the mucosa of the esophagus?
6. What type of muscle tissue is found in the muscularis externa of the esophagus?
7. What is the name of the layer of tissue that surrounds the esophagus? What type of tissue is the layer composed of?

Microscopic Anatomy of the Esophagus



Esophagus Histology

Once you are familiar with the microscopic structure of the esophagus, you should be able to identify many of the features on prepared and stained sections of the esophagus.

This slide is of a cross section of the esophagus, in which you will be able to identify the different layers of tissue.

Activity:

1. Obtain slide number 68 from your slide box.
2. Using the 10X objective lens, locate the following:

   Mucosa
   Submucosa
   Muscularis externa
   Adventitia

3. Draw what you see on the following page, labelling the structures listed above.

Esophagus Histology

The Stomach

Once food enters the stomach, it is stored for a short time and then mixed with gastric juice to form chyme. Protein digestion begins in the stomach, and any carbohydrate digestion that began in the mouth is now inhibited by the acids of the stomach.

The esophagus and stomach are separated by a circular muscle called the **lower esophageal sphincter** (LES). This muscle remains contracted at all times, except during swallowing, thereby preventing the acidic gastric juice from rising into the esophagus and damaging its lining. During swallowing, the LES relaxes and food enters the **cardiac region** of the stomach. Next, the food enters the **fundus**, a small pouch on the left side of the stomach, where it is stored. After about an hour of storage, the food enters the **body** of the stomach, which is the largest region. Here, the muscles of the stomach mix and churn the food with gastric juice. Finally, the chyme enters the **pylorus** of the stomach. This narrower region of the stomach connects to the duodenum of the small intestine. Controlling the movement of chyme from the pylorus to the duodenum is another sphincter muscle called the **pyloric sphincter**.

The stomach has a characteristic J shape. The smaller, concave surface of the stomach is called the **lesser curvature**, while the larger, convex surface is called the **greater curvature**.

This figure shows you a coronal section of the stomach so that you can see the different regions, as well as inside of the stomach. Notice that the inside of the stomach is not flat; instead it has ridges called **rugae**, which increase the storage capacity of the stomach. When the stomach is empty the folds are larger and when the stomach is full, the folds flatten. The stomach has a tremendous capacity for stretch; it can hold up to 4 liters in extreme cases!

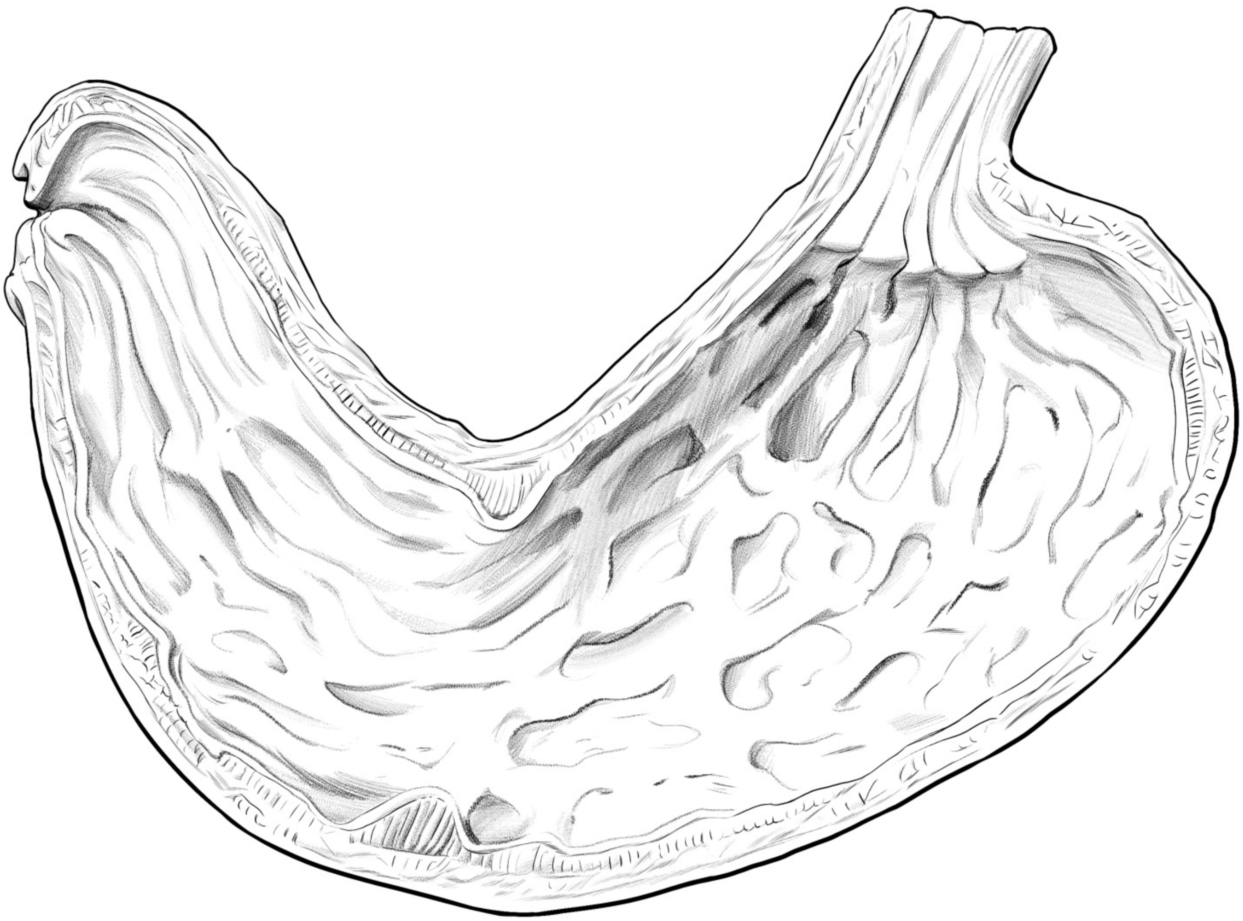
Activity:

1. Identify the following structures:

☐	Body	☐	Lesser curvature
☐	Cardiac region	☐	Pylorus
☐	Fundus	☐	Pyloric sphincter
☐	Greater curvature	☐	Rugae

2. What is the name of the sphincter that separates the esophagus and stomach?
3. What is the name of the sphincter that separates the stomach and small intestine?
4. What is the purpose of rugae?

The Stomach



Microscopic Anatomy of the Stomach

The stomach has the same layers of tissue as the rest of the gastrointestinal tract. The **mucosa** has a superficial **epithelium**, composed of simple columnar epithelium, with the **lamina propria** (areolar connective tissue) deep to that and the **muscularis mucosa** (smooth muscle) as the deepest layer. The mucosa is not flat; rather, it has **gastric pits** which lead to **gastric glands**. The cells lining the pits secrete a thick layer of mucus that protects the lining of the stomach. The cells lining the glands secrete the different components of gastric juice, such as pepsinogen and hydrochloric acid. The **submucosa** is composed of the same connective tissue as the esophagus. The **muscularis externa** is entirely smooth muscle. What is unique about the stomach is that there are three layers of smooth muscle: circular, longitudinal and oblique. This modification allows for greater mixing and churning of food during digestion. Unlike the esophagus, the stomach is surrounded by a **serosa** since it is an intraperitoneal organ. The serosa is composed of mesothelium (simple squamous epithelium) and areolar connective tissue.

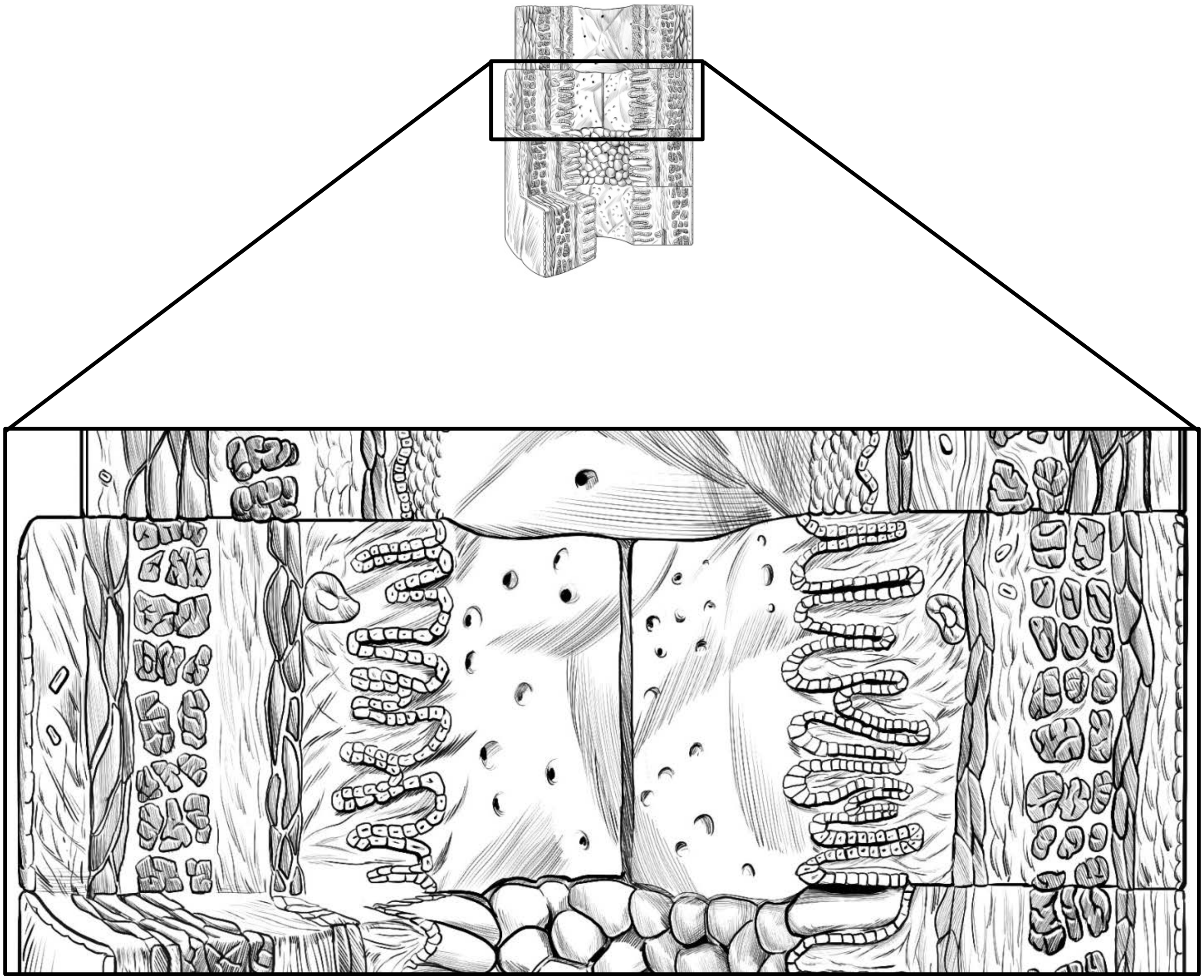
Activity:

1. Identify the following structures/layers:

☐	Epithelium	☐	Muscularis externa
☐	Gastric pit/gland	☐	Muscularis mucosa
☐	Lamina propria	☐	Serosa
☐	Mucosa	☐	Submucosa

2. What type of epithelial tissue lines the mucosa of the stomach?
3. What type of muscle tissue is found in the muscularis externa of the stomach?
4. How many layers of muscle tissue are found in the muscularis externa of the stomach?
5. What type of tissue is found in the serosa?

Microscopic Anatomy of the Stomach



Stomach Histology

Once you are familiar with the microscopic structure of the stomach, you should be able to identify many of the features on prepared and stained sections of the stomach.

This slide is of a cross section of the stomach, in which you will be able to identify the different layers of tissue.

Activity:

1. Obtain slide number 70 from your slide box.
2. Using the 10X objective lens, locate the following:

   - Mucosa
     - Epithelium
     - Lamina propria
     - Muscularis mucosa
   - Submucosa
   - Muscularis externa
   - Serosa

3. Draw what you see on the following page, labelling the structures listed above.

Stomach Histology

The Small Intestine

The small intestine, the site of most chemical digestion and absorption, has three regions. The first region, which attaches to the pylorus of the stomach, is the **duodenum.** Recall that the **pyloric sphincter** of the stomach controls how much chyme is entering the duodenum from the pylorus. This duodenum, which accounts for the first 10 inches of the small intestine, is retroperitoneal. The duodenum begins at the pylorus of the stomach, heads to the left side of the body, past the pancreas, and makes a sharp turn back toward the middle of the abdomen. It receives acidic chyme from the stomach, bile from the liver and gallbladder, and pancreatic juice from the pancreas. The bicarbonate from pancreatic juice buffers the acidic chyme. Pancreatic juice also contains digestive enzymes that the small intestine uses to chemically digest carbs, proteins and fats. To assist in fat digestion, bile from the liver and gallbladder emulsifies fat.

Of the remaining length of the small intestine, roughly the first 40% is the **jejunum** and the remaining 60% is the **ileum**. Both of these regions are within the peritoneum. The ileum attaches to the first segment of the large intestine, called the **cecum**. A sphincter, called the **ileocecal valve**, controls the movement of chyme from the ileum to the cecum.

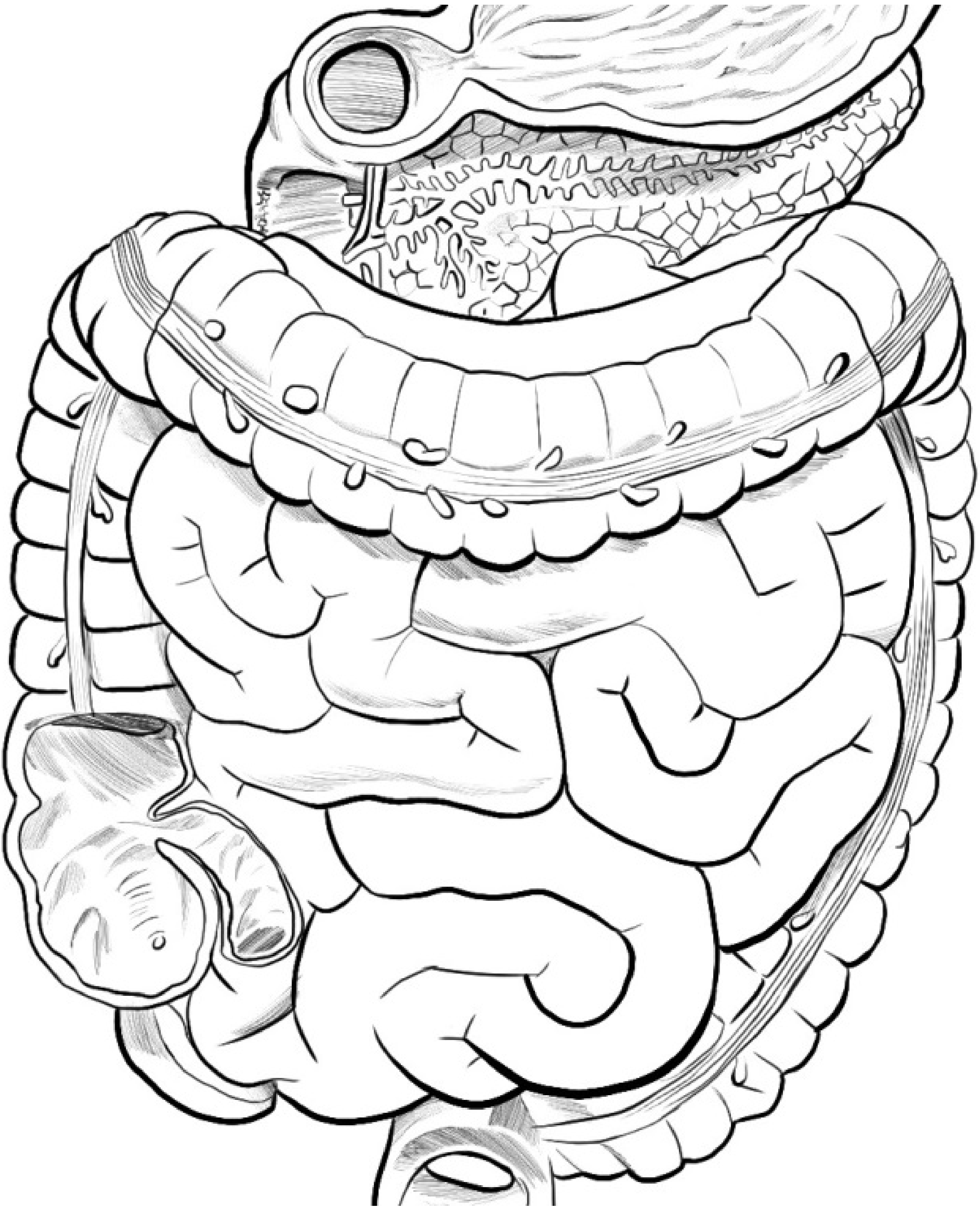
Note that you can identify the duodenum and ileum based on their attachment points to the stomach and large intestine, respectively, but it is difficult to distinguish where one region ends and another begins when looking at the gross structure of the small intestine. The jejunum is found mostly in the umbilical region of the abdominopelvic cavity; whereas the ileum is found mainly in the pubic region.

<u>Activity:</u>

1. Identify the following structures:

- [ ] Cecum
- [ ] Ileocecal valve
- [ ] Jejunum
- [ ] Duodenum
- [ ] Ileum
- [ ] Pyloric sphincter

The Small Intestine



Microscopic Anatomy of the Small Intestine

The small intestine has the same layers of tissue as the rest of the gastrointestinal tract. The **epithelium** of the **mucosa** is composed of simple columnar epithelium. These absorptive cells have a structural modification on their apical surface, called **microvilli**, which are microscopic projections of the plasma membrane. The **lamina propria** and **muscularis mucosa** are the same as the esophagus and stomach. The mucosa is not flat; rather, it has finger-like extensions called **villi** as well as small invaginations called **intestinal crypts**. Both the villi and microvilli create a tremendous amount of surface area, which is important for the small intestine since most nutrient absorption occurs here. We will take a closer look at villi and intestinal crypts shortly. The **submucosa** is composed of the same connective tissue as the other organs, the **muscularis externa** is composed of two layers of smooth muscle, and the small intestine is surrounded by a **serosa**.

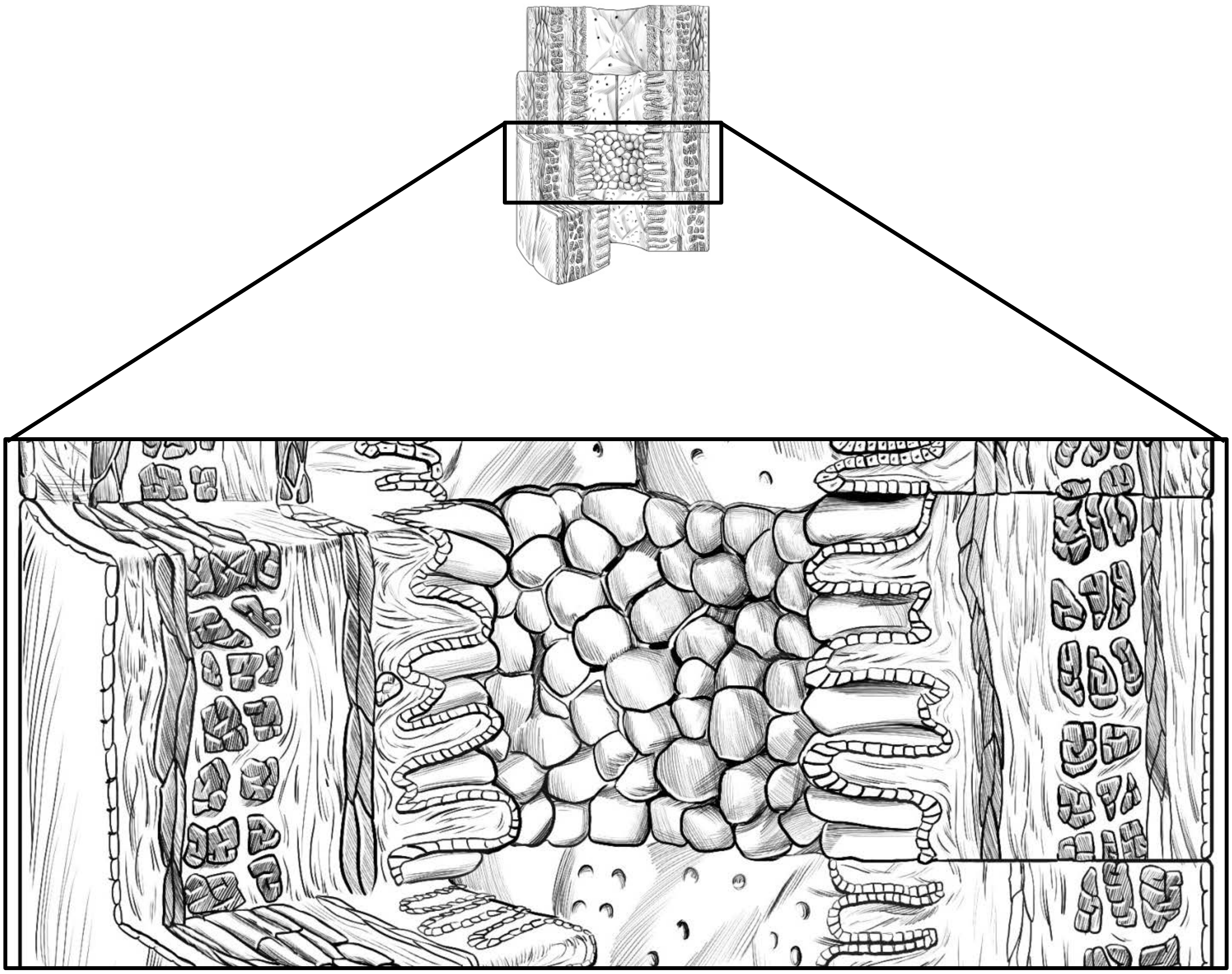
Activity:

1. Identify the following structures/layers:

☐	Epithelium	☐	Muscularis mucosa
☐	Lamina propria	☐	Serosa
☐	Mucosa	☐	Submucosa
☐	Muscularis externa	☐	Villi

2. What type of epithelial tissue lines the mucosa of the small intestine?
3. What type of muscle tissue is found in the muscularis externa of the small intestine?
4. How many layers of muscle tissue are found in the muscularis externa of the small intestine?

Microscopic Anatomy of the Small Intestine



Small Intestine Villi

As you have learned previously, the mucosa of the small intestine is not flat. Instead, it has finger-like projections called **villi** which increase its surface area. This figure shows you a closer perspective of villi. Simple columnar epithelial cells line the mucosa of the villus. Some of the cells are **absorptive cells**, with microvilli on their apical surface. These cells create digestive enzymes called brush border enzymes and are also responsible for the absorption of nutrients. The rest of the cells are **goblet cells**, which secrete mucus to lubricate the chyme and also protect the lining of the small intestine. Inside the **lamina propria** of each villus is a lymphatic capillary, called a **lacteal**, which aids in the absorption of fat. A thin layer of smooth muscle – the **muscularis mucosa** – lies underneath the lamina propria. Between the villi, there are small invaginations of the mucosa called intestinal crypts. The cells lining the crypts secrete intestinal juice, which aids in digestion. In the duodenum, the submucosa contains **duodenal glands**, which secrete buffers to neutralize the acidic chyme coming from the stomach.

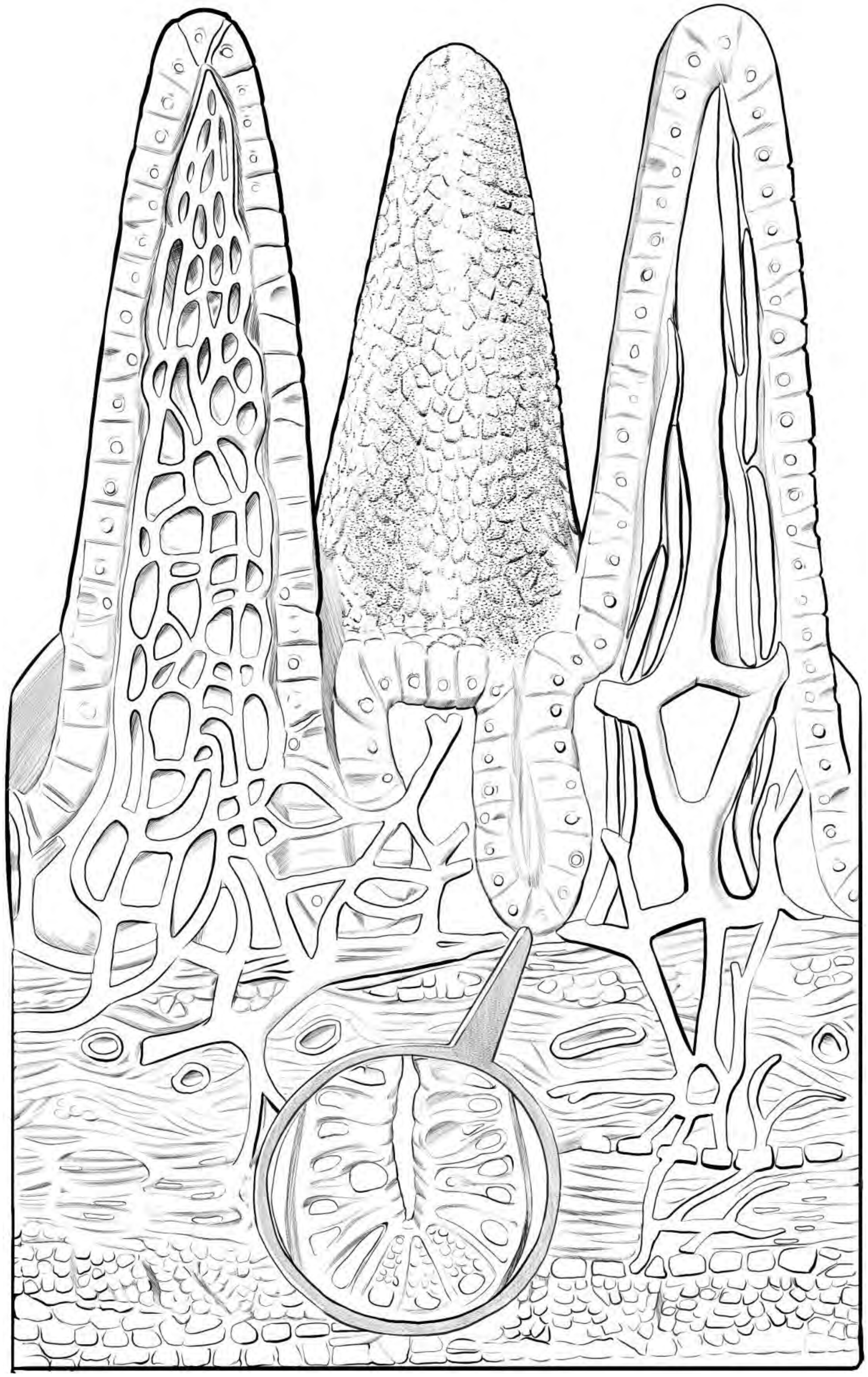
Activity:

1. Identify the following structures/layers:

☐	Absorptive cell	☐	Lamina propria
☐	Duodenal gland	☐	Muscularis mucosa
☐	Goblet cell	☐	Submucosa
☐	Intestinal crypt	☐	Villus
☐	Lacteal		

2. What is the purpose of the villi?
3. What is the purpose of the intestinal crypts?

Small Intestine Villi



Small Intestine Histology

Once you are familiar with the microscopic structure of the small intestine, you should be able to identify many of the features on prepared and stained sections of the small intestine.

This slide is of a cross section of the duodenum, in which you will be able to identify the different layers of tissue.

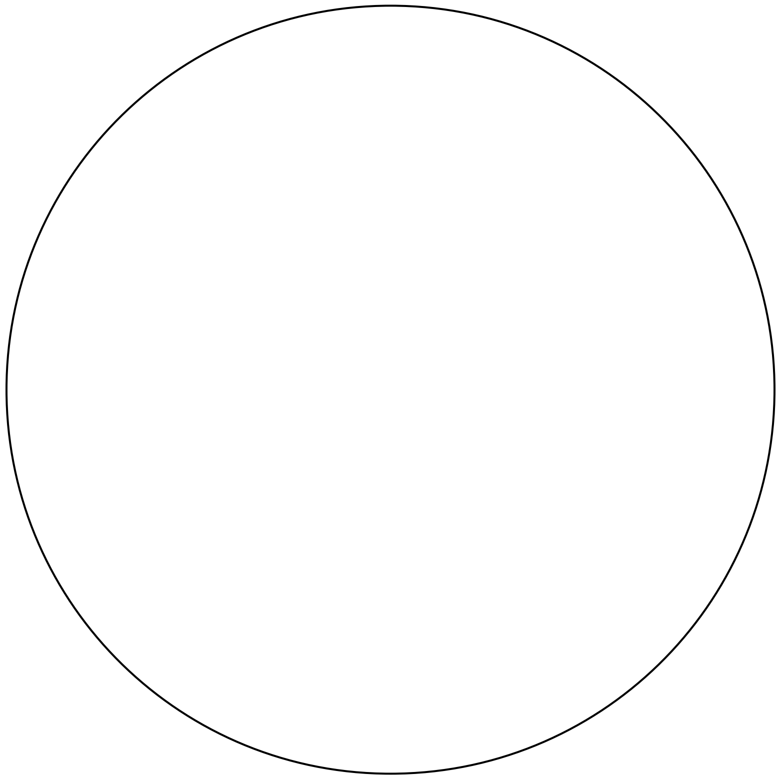
Activity:

1. Obtain slide number 72 from your slide box.
2. Using the 10X objective lens, locate the following:

    Mucosa
        Epithelium
        Lamina propria
        Muscularis mucosa
    Muscularis
    Serosa
    Submucosa
    Villi

3. Draw what you see on the following page, labelling the structures listed above.
4. What type of epithelial tissue is found in the mucosa?
5. What type of muscle tissue is found in the muscularis?
6. What is the purpose of villi?

Small Intestine Histology



The Large Intestine

The large intestine is so named because its diameter is larger than the small intestine; however, it is significantly shorter than the small intestine. The **cecum** of the large intestine is connected to the **ileum** of the small intestine. Recall that the **ileocecal valve** controls the movement of chyme from the small intestine to the large intestine. Attached to the cecum is the **vermiform appendix**, a small pouch that contains lymphatic tissue. The cecum then leads to the colon, which has several segments. The **ascending colon**, which directly attaches to the cecum, ascends up the abdominopelvic cavity toward the liver. It then makes a turn at the **hepatic flexure** to become the **transverse colon**. The transverse colon transcends across the abdominal cavity toward the spleen, until it makes another turn at the **splenic flexure**. This leads to the **descending colon**, which descends down the abdominopelvic cavity toward the left pelvis. As the colon enters the pelvis, it becomes an S-shaped **sigmoid colon**. Note that the ascending and descending colon are both retroperitoneal. Also, note that the hepatic flexure is lower in the abdomen than the splenic flexure because the position of the liver is lower in the abdominopelvic cavity than the spleen. The colon leads to the retroperitoneal **rectum**, which descends down the middle of the pelvis. As the rectum passes through the pelvic floor, it becomes the final region of the large intestine, the **anal canal**.

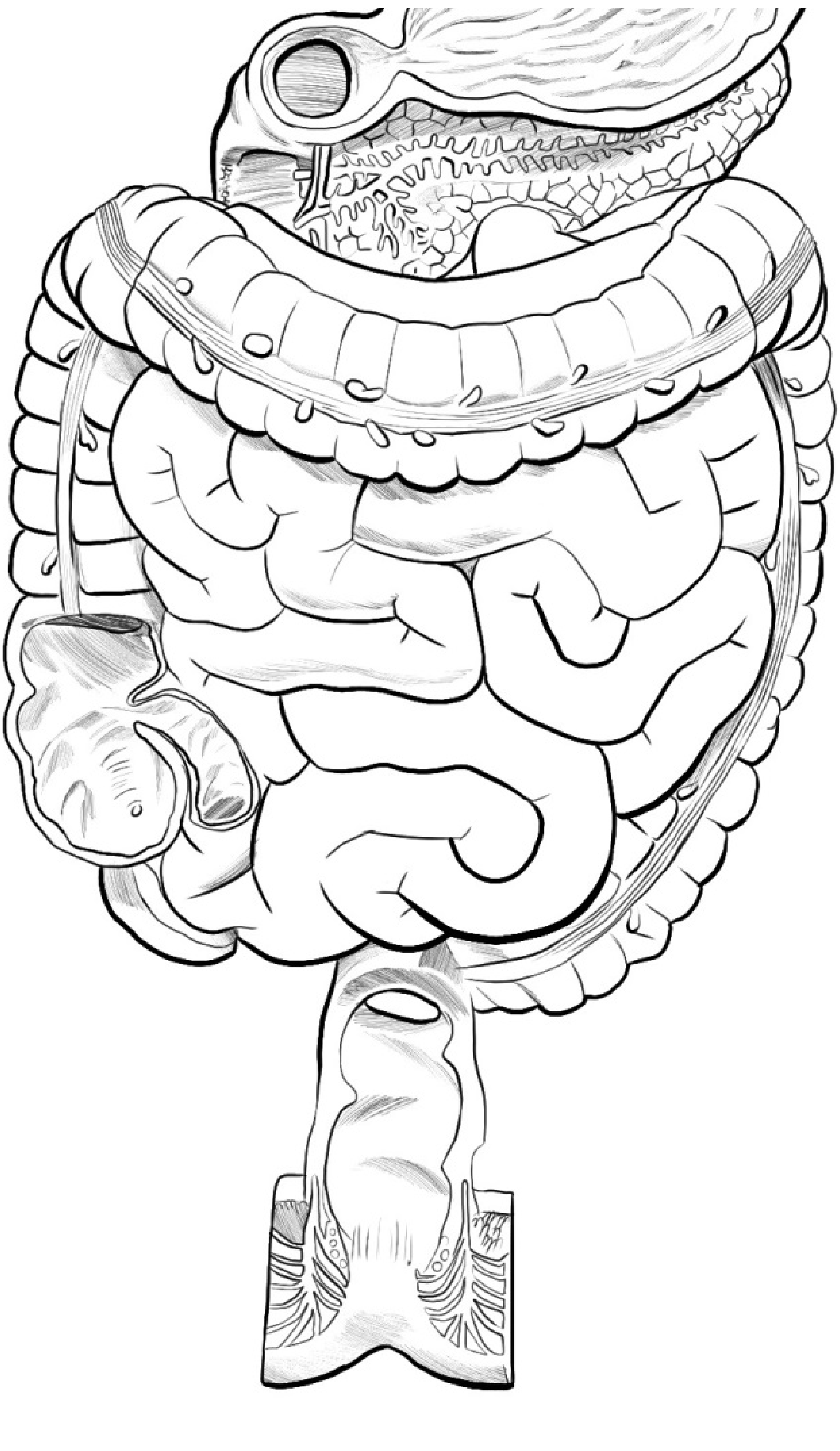
There are three structural modifications associated with the cecum and colon of the large intestine. Longitudinal bands of thickened smooth muscle, called **teniae coli**, are found on the outside of the cecum and colon. They create tone in the large intestine and, as a result, the cecum and colon bulge into structures called **haustra**. These pouches allow small amounts of chyme to move through the colon in segments through a type of movement called haustral contractions. Finally, there are fat filled sacs of visceral peritoneum, called **epiploic appendages**, which are hanging from the outside of the large intestine. Their purpose is not known, but they can be problematic if they become inflamed.

Activity:

1. Identify the following structures:

☐ Anal canal	☐ Hepatic flexure	☐ Splenic flexure
☐ Ascending colon	☐ Ileocecal valve	☐ Teniae coli
☐ Cecum	☐ Ileum	☐ Transverse colon
☐ Descending colon	☐ Rectum	☐ Vermiform appendix
☐ Epiploic appendages	☐ Sigmoid colon	

The Large Intestine



Microscopic Anatomy of the Large Intestine

The large intestine has the same layers of tissue as the rest of the gastrointestinal tract. The **epithelium** of the **mucosa** is composed of simple columnar epithelium along the majority of the large intestine, except in the anal canal where the epithelium changes into stratified squamous. The **lamina propria** and **muscularis mucosa** are the same as the three other organs. The mucosa is not flat; rather, it has invaginations called **intestinal crypts**. There are many mucus secreting goblet cells lining the crypts. The **submucosa** is composed of the same connective tissue as the other organs, except that it has more lymphatic tissue associated with it. The **muscularis externa** is composed of two layers of smooth muscle, and there is a **serosa**.

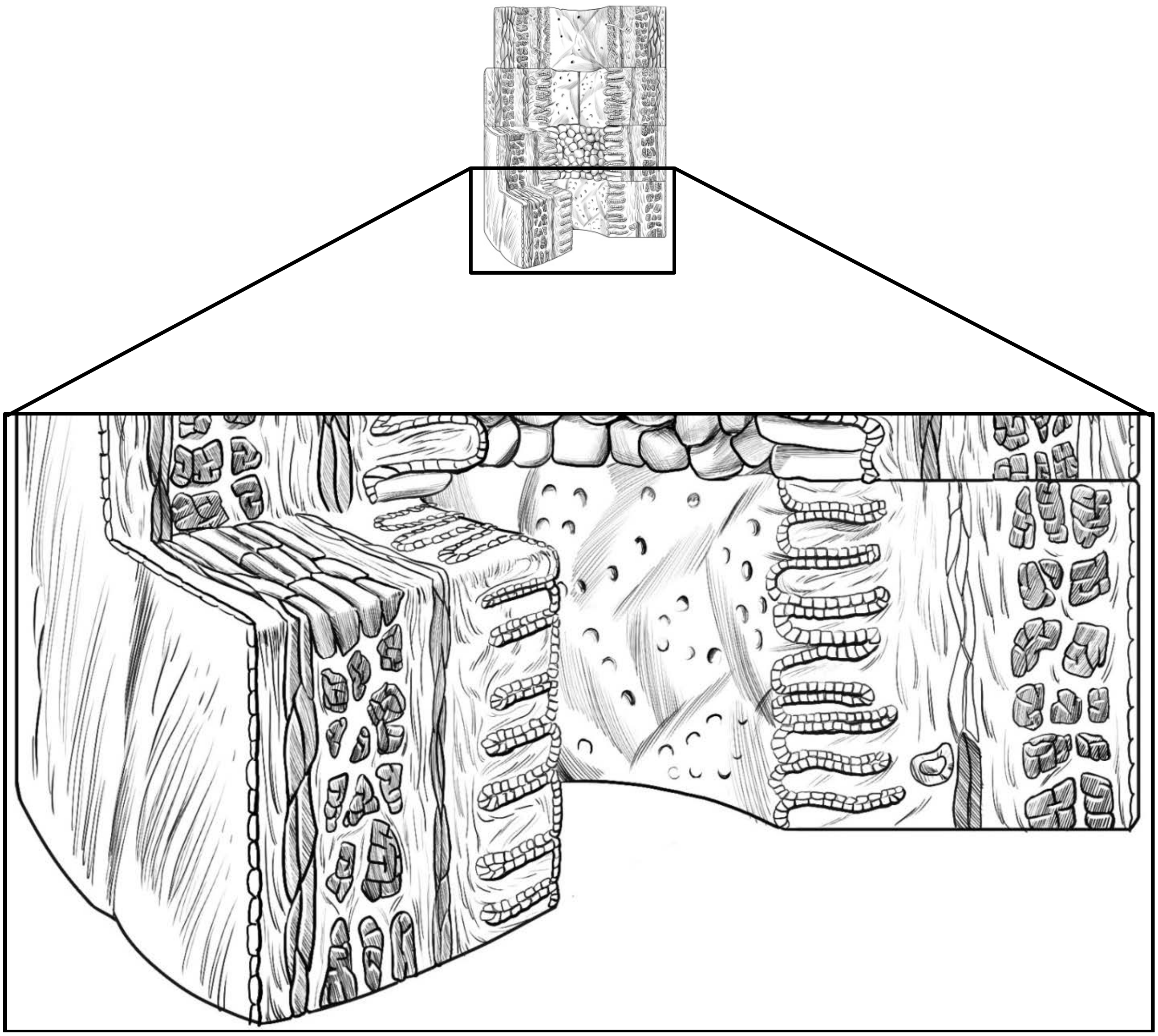
Activity:

1. Identify the following structures/layers:

☐	Epithelium	☐	Muscularis externa
☐	Intestinal crypt	☐	Muscularis mucosa
☐	Lamina propria	☐	Serosa
☐	Mucosa	☐	Submucosa

2. What type of epithelial tissue lines the mucosa of the large intestine?
3. What type of muscle tissue is found in the muscularis externa of the small intestine?
4. How many layers of muscle tissue are found in the muscularis externa of the large intestine?

Microscopic Anatomy of the Large Intestine



Large Intestine Histology

Once you are familiar with the microscopic structure of the large intestine, you should be able to identify many of the features on prepared and stained sections of the large intestine.

This slide is of a cross section of the large intestine, in which you will be able to identify the different layers of tissue as well as intestinal glands.

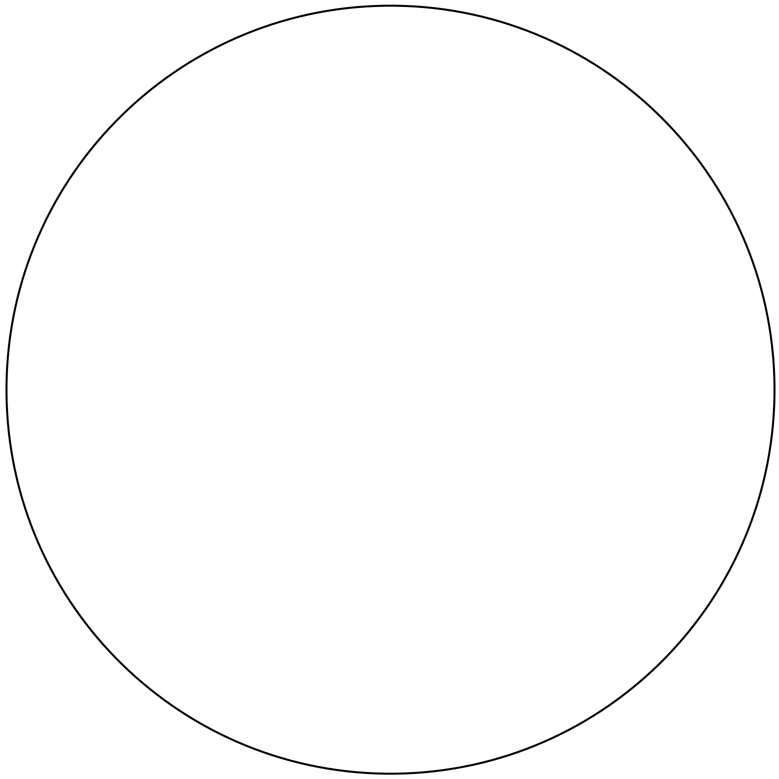
Activity:

1. Obtain slide number 74 from your slide box.
2. Using the 10X objective lens, locate the following:

    Intestinal glands
    Mucosa
    Muscularis
    Serosa
    Submucosa

3. Draw what you see on the following page, labelling the structures listed above.
4. What type of epithelial tissue is found in the mucosa?
5. What type of muscle tissue is found in the muscularis?

Large Intestine Histology



The Liver and Gallbladder
(Visceral surface)

The liver, the largest gland in the body, is located on the right side of the abdominal cavity. It is an accessory organ to the digestive system; it aids in the digestion of fat by producing bile, an emulsifier, which is secreted into the duodenum of the small intestine.

This figure shows the visceral surface of the liver, which faces posterior and inferior, toward the other abdominal viscera. The liver has two lobes. The **right lobe**, the larger of the two, is located (as its name implies) on the right side of the liver. The **left lobe**, the smaller lobe, is on the side facing the stomach. The right and left lobes are divided by a **fissure;** within the fissure is the **ligamentum teres,** which is a developmental remnant of the umbilical vein. The left lobe has two smaller lobes with which it shares blood vessels and nerves; these lobes, called the **caudate lobe** and **quadrate lobe**, are located just to the right of the fissure.

There are three types of blood vessels supplying the liver. All three major vessels enter and leave the liver at an area called the **porta hepatis**. The **hepatic artery** delivers oxygenated blood to the liver, while the **hepatic vein** carries deoxygenated blood away from the liver. A third vessel – called the **hepatic portal vein** – carries blood from the intestines to the liver. After a meal, the hepatic portal vein is rich with nutrients; those nutrients are delivered to the liver so they can be processed.

The **gallbladder**, which is the liver's accessory, is located near the right lobe of the liver. It stores and concentrates the bile produced by the liver.

Activity:

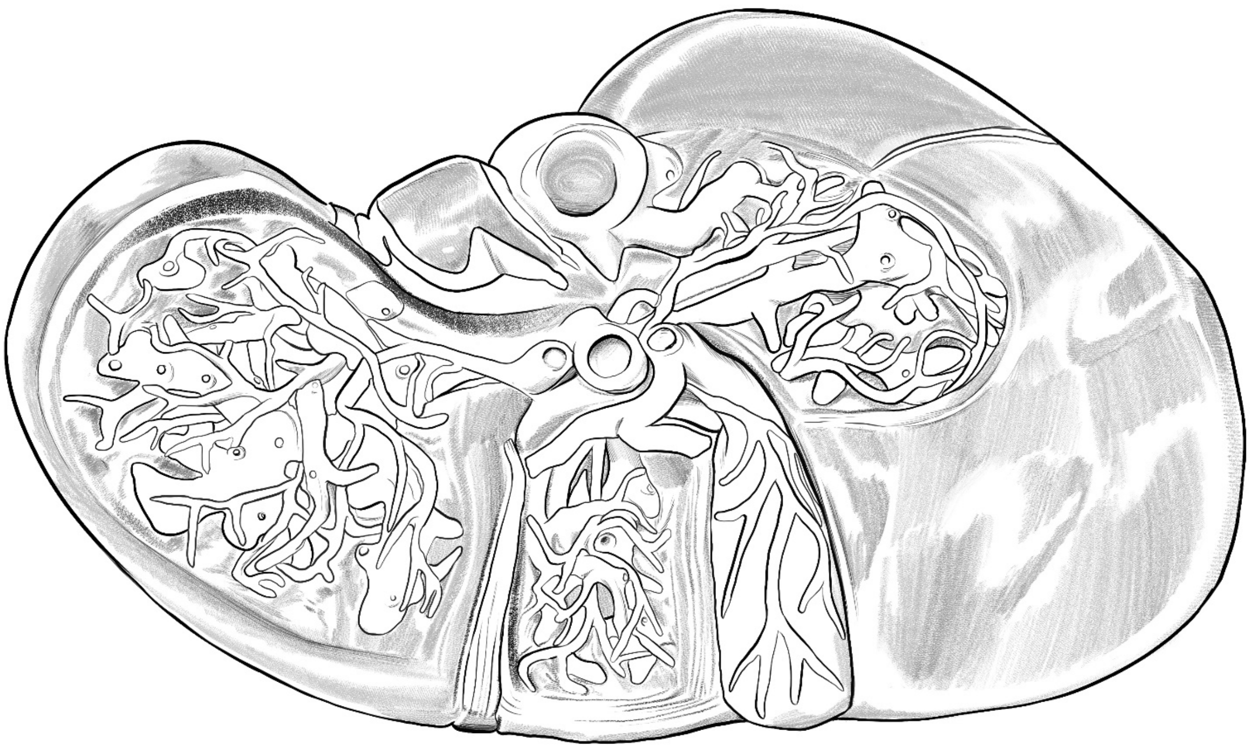
1. Identify the following structures:

☐	Caudate lobe	☐	Hepatic veins
☐	Fissure	☐	Left lobe
☐	Gallbladder	☐	Ligamentum teres
☐	Hepatic artery	☐	Quadrate lobe
☐	Hepatic portal vein	☐	Right lobe

2. Circle the porta hepatis on the figure.

The Liver and Gallbladder

(Visceral surface)



Liver Histology

Once you are familiar with the generalized structure of the liver, you should be able to identify many of the features on prepared and stained sections of the liver.

The functional unit of the liver is called the **lobule**. These microscopic structures are shaped like hexagons. In the center of the lobule is a **central vein**; these veins ultimately drain blood into the hepatic veins. At the corners of the hexagon there are **portal triads**, which consist of an **arteriole** (branch of the hepatic artery), a **portal venule** (branch of hepatic portal vein), and a **bile duct**. The remainder of the lobule is composed of **hepatocytes**, liver cells, and **sinusoids**, leaky capillaries that drain into the central vein.

This slide is of a section of the liver, in which you will be able to identify the lobules and their central veins.

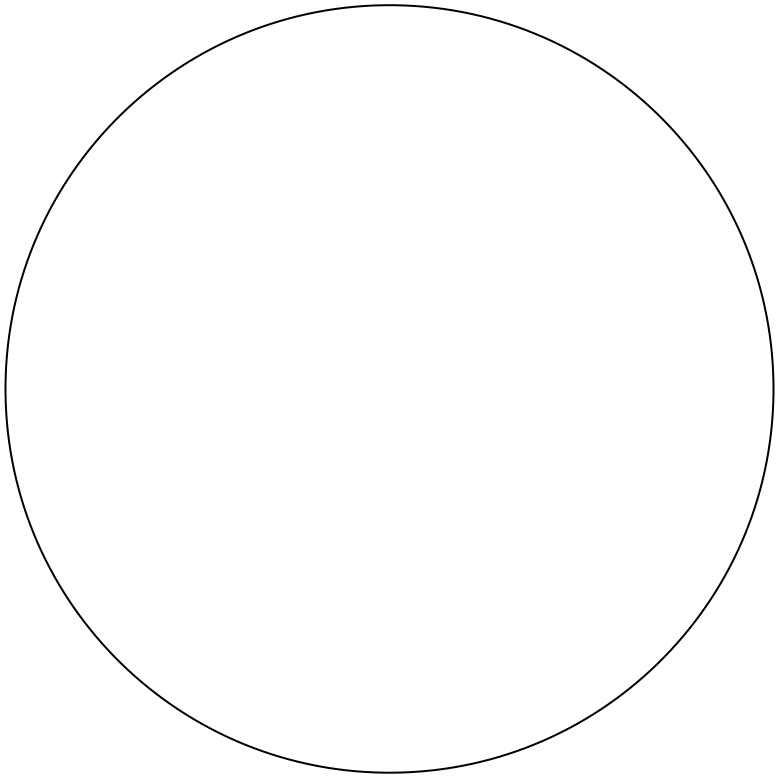
Activity:

1. Obtain slide number 76 from your slide box.
2. Using the 4X objective lens, locate the following:

   Central vein
   Lobule

3. Draw what you see on the following page, labelling the structures listed above.
4. What are liver cells called?

Liver Histology



The Pancreas

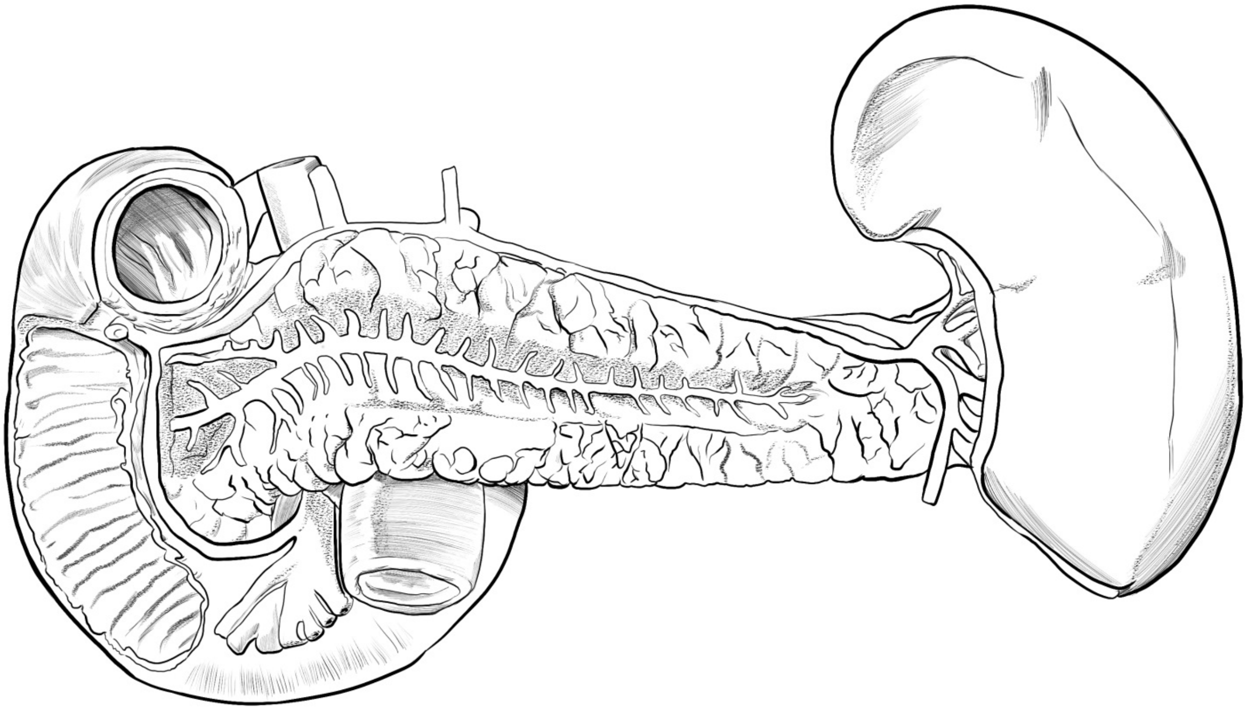
This figure shows you the position of the **pancreas**, relative to the **spleen** and the **duodenum**. The pancreas sits in the upper region of the abdominal cavity, just behind the stomach. It is a retroperitoneal organ, with three regions. The **head** fits in the C-shaped turn of the duodenum, the **tail** points toward the spleen, and the **body** lies between the head and the tail. The pancreas is both an endocrine and exocrine organ; the endocrine function will be discussed later. The exocrine secretions – digestive enzymes and buffers – are released from the exocrine cells into the **main pancreatic duct**. This duct extends the entire length of the pancreas, from head to tail. Within the head there is an additional, smaller duct, called the **accessory pancreatic duct**. The pancreatic ducts ultimately release the exocrine secretions into the duodenum, to assist with digestion. The intricate duct system involving both the liver and the pancreas will be discussed shortly.

Activity:

1. Identify the following structures:

- [ ] Accessory pancreatic duct
- [ ] Body
- [ ] Duodenum
- [ ] Head
- [ ] Main pancreatic duct
- [ ] Spleen
- [ ] Tail

The Pancreas



The Hepatopancreatic Duct System

Recall that the duodenum of the small intestine receives pancreatic juice (enzymes and buffers) from the pancreas and bile from the liver and gallbladder. These exocrine glands deliver their respective secretions to the duodenum by a network of ducts.

The right lobe of the liver secretes bile into the **right hepatic duct**. The left lobe of the liver secretes bile into the **left hepatic duct**. These two ducts then combine to form the **common hepatic duct**. Meanwhile, the gallbladder secretes bile into the **cystic duct**. The common hepatic and cystic ducts combine to form the **common bile duct**.

Most of the pancreatic secretions leave the pancreas via the **main pancreatic duct**. The main pancreatic duct meets with the common bile duct at the wall of the duodenum; these two ducts combine to form an opening to the duodenum, called the **hepatopancreatic ampulla**.

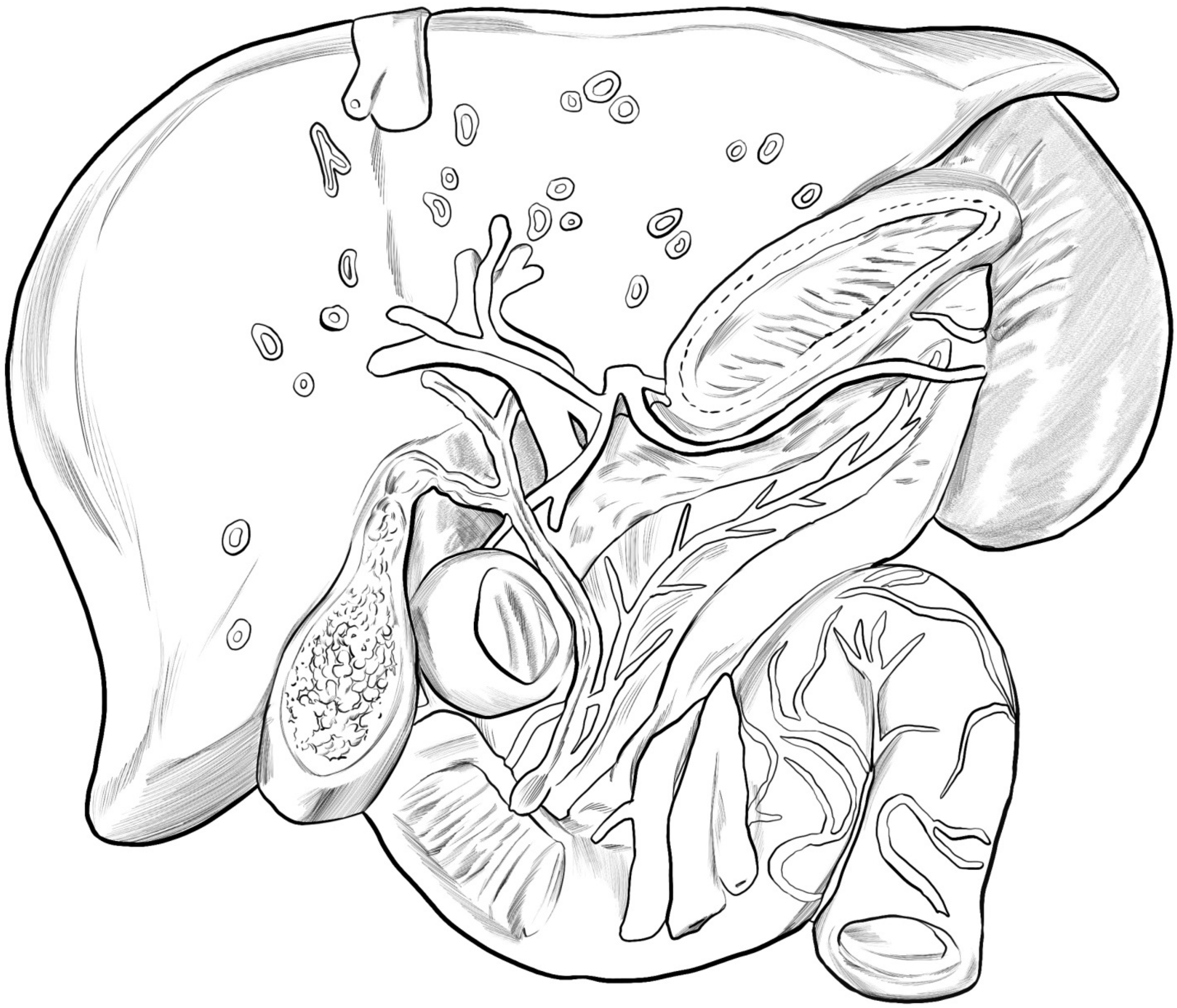
In some people, the head of the pancreas has an additional duct, called the **accessory pancreatic duct**. This duct drains directly into the duodenum, without first combining with the main pancreatic or common bile ducts.

Activity:

1. Identify the following structures:

☐	Accessory pancreatic duct	☐	Gallbladder
☐	Body	☐	Head
☐	Common bile duct	☐	Left hepatic duct
☐	Common hepatic duct	☐	Main pancreatic duct
☐	Cystic duct	☐	Right hepatic duct
☐	Duodenum	☐	Tail

The Hepatopancreatic Duct System



Pancreas Histology

Once you are familiar with the generalized structure of the pancreas, you should be able to identify many of the features on prepared and stained sections of the pancreas.

Recall that the pancreas is both an endocrine and exocrine organ. The exocrine portion forms the majority of the pancreas, with small clusters of endocrine cells throughout. The exocrine cells are called **acinar** cells. These glandular cells secrete digestive enzymes and buffers to aid the chemical digestion that occurs within the small intestine. The clusters of endocrine cells are called the islets of Langerhans (pancreatic islets); these cells will be discussed during the endocrine system unit.

This slide is of a section of the pancreas, in which you will be able to identify the acinar cells. You will also see the islets of Langerhans, but you don’t need to identify them during this activity.

Activity:

1. Obtain slide number 78 from your slide box.
2. Using the 10X objective lens, locate the following:

   Acinar cells

3. Draw what you see on the following page, labelling the structures listed above.
4. What is the purpose of acinar cells?

Pancreas Histology

The Urinary System

The urinary system serves the vital purpose of ridding the blood of waste products and balancing different variables of blood (e.g. volume, pressure, pH, osmolality). The **kidneys** perform these functions of the urinary system. These retroperitoneal organs are located in the posterior abdomen, extending from about T12 to L3. Note that the left kidney is slightly higher than the right kidney, because of the position of the liver on the right side. The kidneys are bean-shaped, with a lateral convex surface and medial concave surface. The medial surface has a large fissure, called the **hilum**, where the **renal artery** enters the kidney and the **renal vein** and **ureter** leave the kidney.

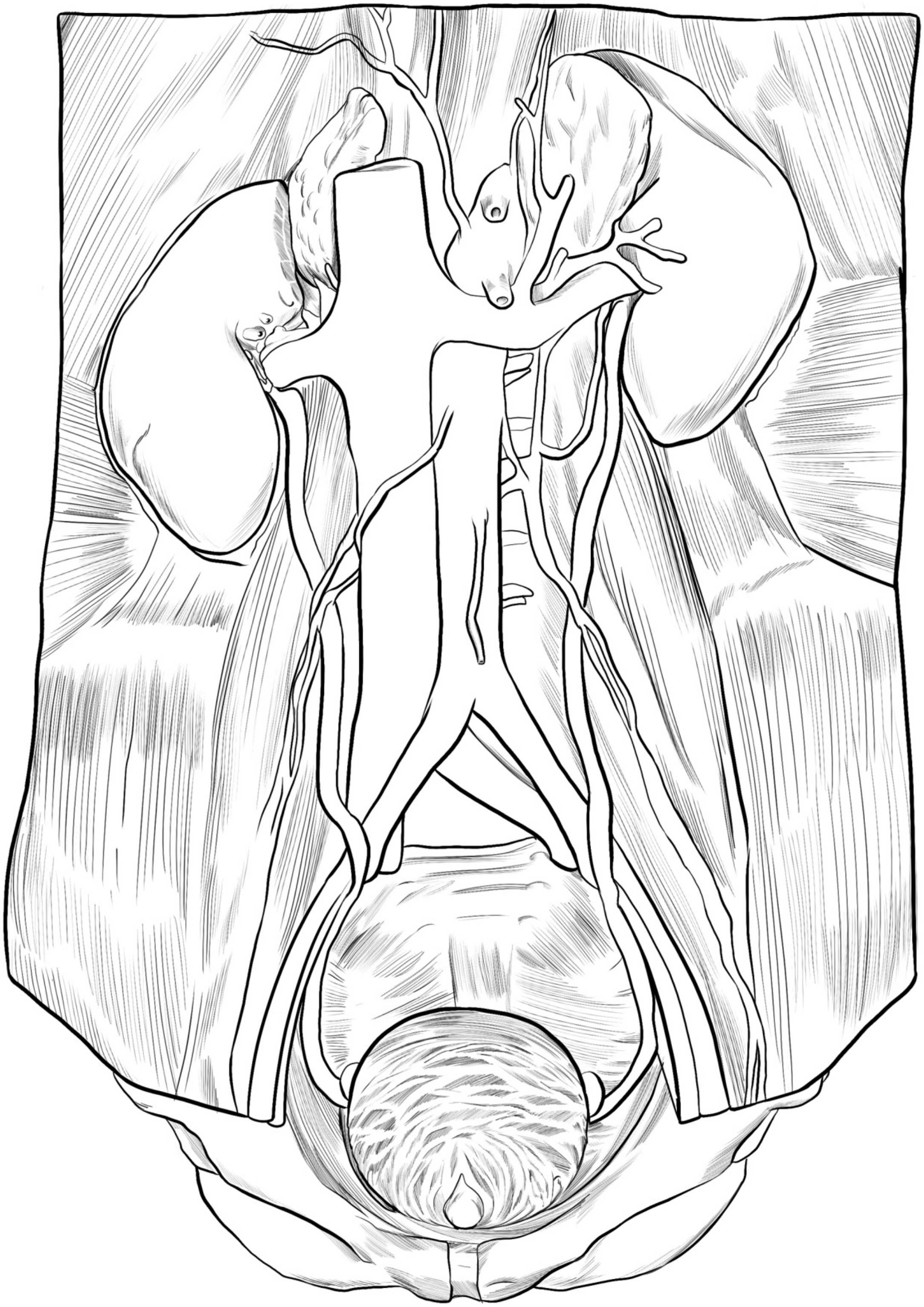
Once urine is produced by the kidneys, it is drained from the kidneys by the ureters. These long tubes extend retroperitoneal down the abdominopelvic cavity, and empty into the **urinary bladder**. The muscular urinary bladder stores urine, and then expels it during micturition. The bladder is shaped like an upside down pyramid. The lateral points are attached to the two ureters. The anterior point is a fibrous structure called the **urachus**; during fetal development this was a tube (the allantois) that drained the fetal bladder into the umbilical cord. The inferior point connects to the **urethra**, the tube that drains urine from the bladder.

Activity:

1. Identify the following structures:

☐	Kidney	☐	Urachus
☐	Renal artery	☐	Ureter
☐	Renal hilum	☐	Urethra
☐	Renal vein	☐	Urinary bladder

Urinary System



Gross Kidney Structure

This figure shows you the gross structure of a kidney, which has been sliced along the coronal section. There is a **fibrous capsule** surrounding the kidney, which is composed of collagen and elastin fibers. This capsule holds the structures of the kidney together and protects it from trauma. Within the kidney, there are two regions: the outer cortex and inner medulla. The **cortex** contains millions of nephrons, the functional units of urine production. The **medulla** contains some nephrons, but is mostly composed of structures that conduct the urine away from the kidney. **Renal pyramids** are found within the renal medulla. These cone-shaped, striped structures contain the ducts that drain urine from the nephrons; the broad portion faces the cortex and the apex, called the **renal papilla**, faces the interior of the kidney. Columns of cortex tissue, called **renal columns**, extend between the renal pyramids.

The urine from each renal papilla drains into a **minor calyx**. Two to three minor calyces combine to form a **major calyx**. Two to three major calyces combine to form the **renal pelvis**. The **ureter** attaches to the renal pelvis, and transports urine from the kidney to the bladder.

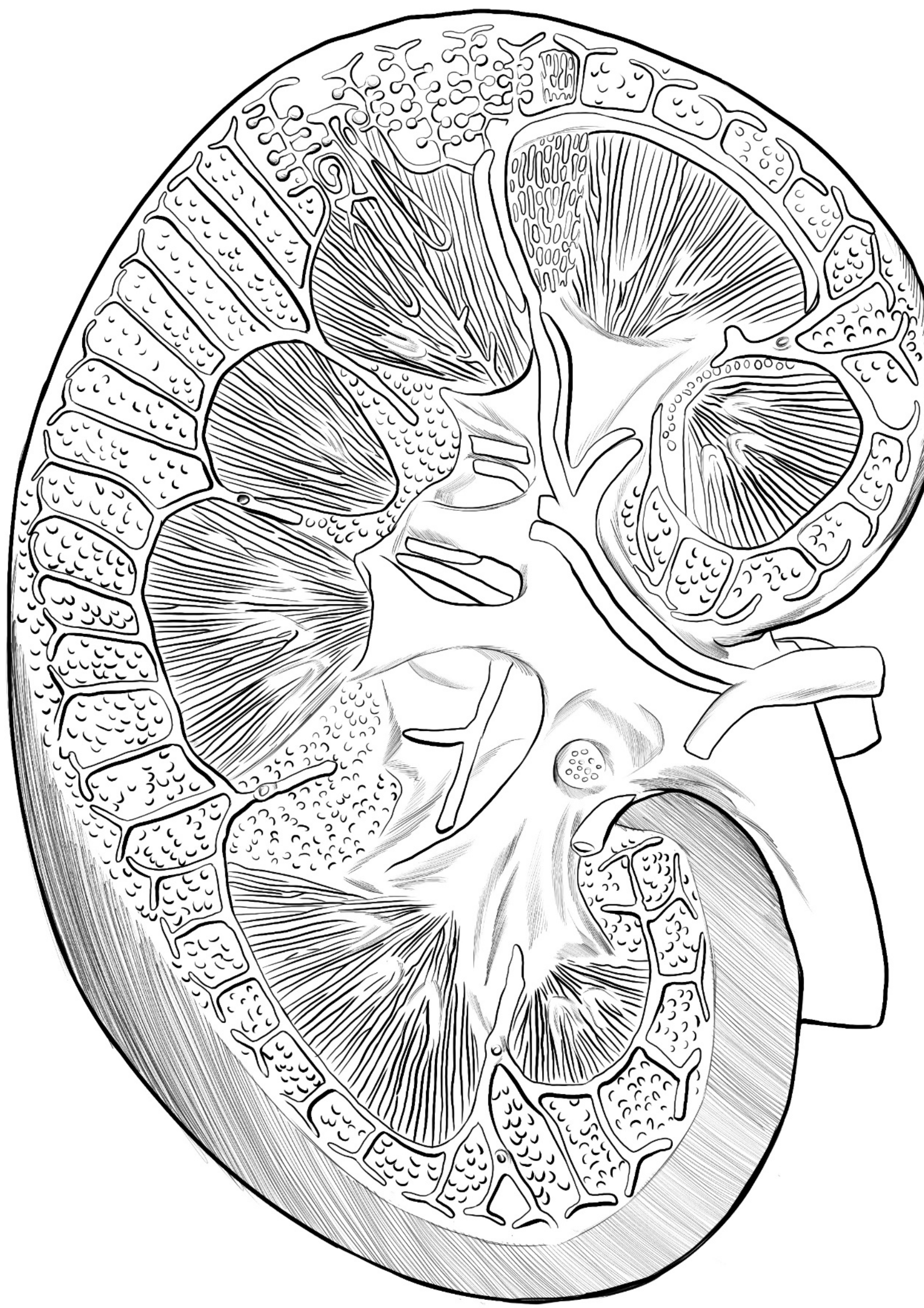
Activity:

1. Identify the following structures:

☐	Fibrous capsule	☐	Renal column
☐	Major calyx	☐	Renal pelvis
☐	Minor calyx	☐	Renal pyramid
☐	Renal papilla	☐	Ureter

2. Label which region is the cortex, and which region is the medulla.

Gross Kidney Structure



Blood Vessels of the Kidney

The kidneys are highly vascular organs, containing large volumes of blood at all times. The **renal artery** delivers blood to the kidney. The renal artery then splits into five segmental arteries, which enter the kidney at the hilum. Once inside the renal medulla, the segmental arteries then split into **interlobar arteries**; these arteries are found within the renal columns. Where the medulla meets the cortex, the interlobar arteries become **arcuate arteries**. These arteries are found arching over the base of the renal pyramids. The arcuate arteries then give rise to the **cortical radiate arteries**. These small arteries, which radiate toward the outer surface of the kidney, feed into the microcirculation of the nephron, the functional unit of the kidney.

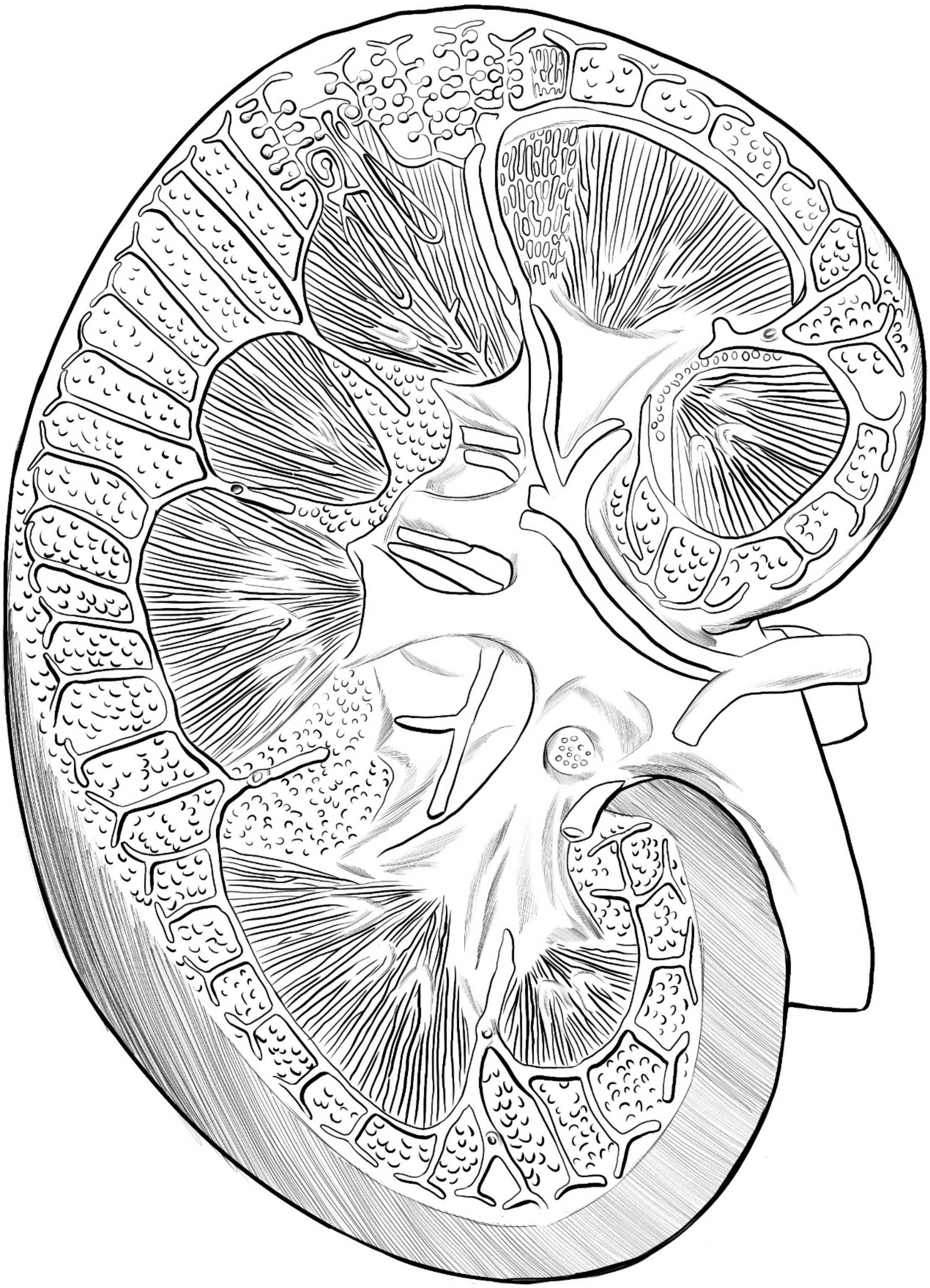
The veins of the kidney are very similar to the arteries, in terms of name and location. The microcirculatory vessels of the nephron feed deoxygenated (but cleaner!) blood into the **cortical radiate veins**. The cortical radiate veins then feed into **arcuate veins**, which become **interlobar veins**. The interlobar veins drain directly into the **renal vein**; note that there are no segmental veins.

Activity:

1. Identify the following vessels:

- ☐ Arcuate artery
- ☐ Arcuate vein
- ☐ Cortical radiate artery
- ☐ Cortical radiate vein
- ☐ Interlobar artery
- ☐ Interlobar vein
- ☐ Renal artery
- ☐ Renal vein
- ☐ Segmental artery

Blood Vessels of the Kidney



The Nephron
(Tubules)

Each of the kidneys contains more than a million nephrons, the function unit of the urinary system. The nephron is composed of tubules and blood vessels, which are closely associated. The tubules remove wastes from the blood, and also selectively retain nutrients and other chemicals in the blood.

Urine formation begins at the **renal corpuscle** of the nephron. **Bowman's capsule** surrounds a cluster of capillaries called the **glomerulus**. A filtration membrane lies between them, allowing certain blood constituents (selected based on size) to leave the blood, thereby forming a fluid called filtrate. The filtrate moves into the remaining tubules of the nephron, and is modified along the way through the processes of reabsorption and secretion until urine is formed. The regions of the tubule, in order, are: the **proximal convoluted tubule**, the **descending limb of the loop of Henle**, the **ascending limb of the loop of Henle**, and the **distal convoluted tubule**. The distal convoluted tubule then empties into the **collecting duct**, which collects urine from several different nephrons and sends it through the renal pyramids of the medulla to ultimately be excreted by the kidney.

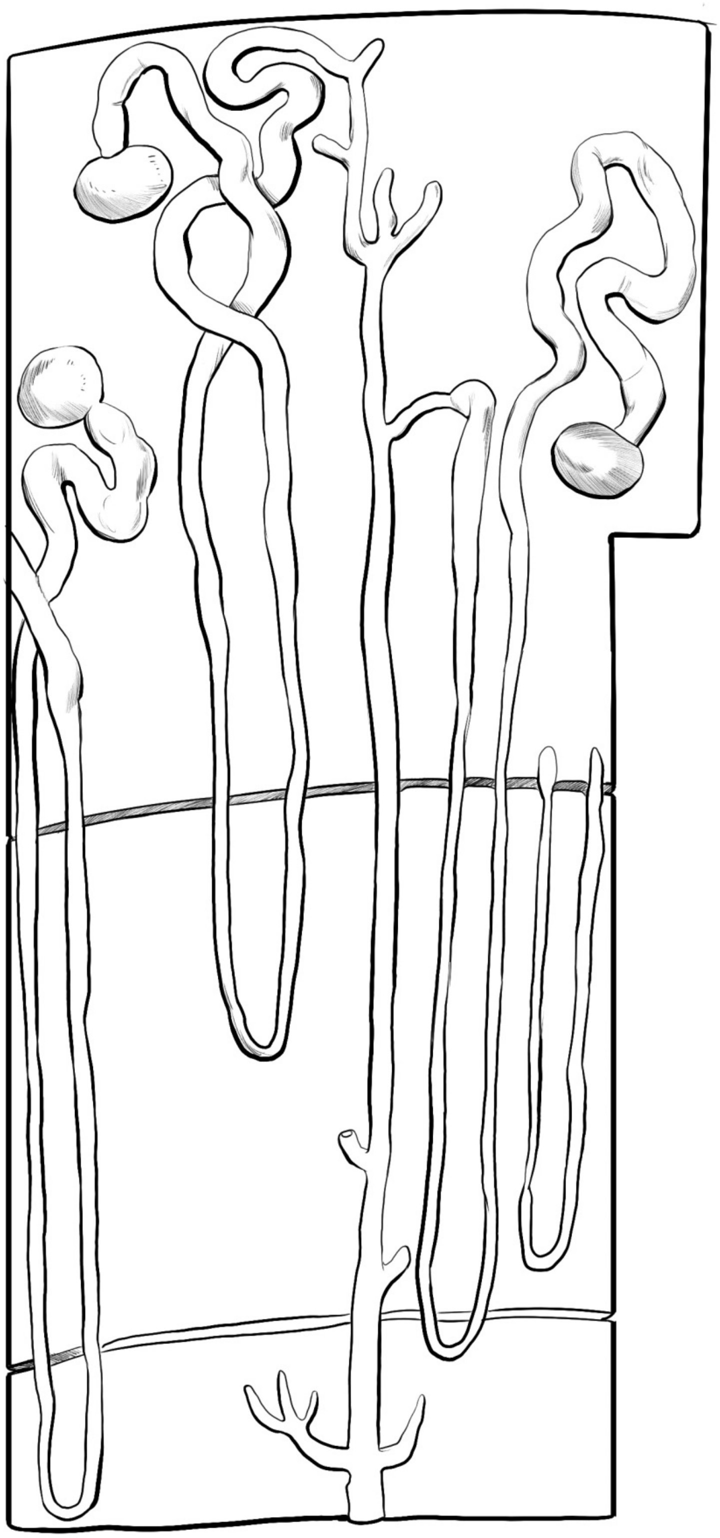
This image is focusing on the tubules of the nephron; we will look at the microscopic blood vessels shortly.

<u>Activity:</u>

1. Identify the following regions of the tubule:

- ☐ Ascending limb of loop of Henle
- ☐ Bowman's capsule
- ☐ Collecting duct
- ☐ Descending limb of loop of Henle
- ☐ Distal convoluted tubule
- ☐ Proximal convoluted tubule

The Nephron
(Tubules)



The Nephron
(Blood Vessels)

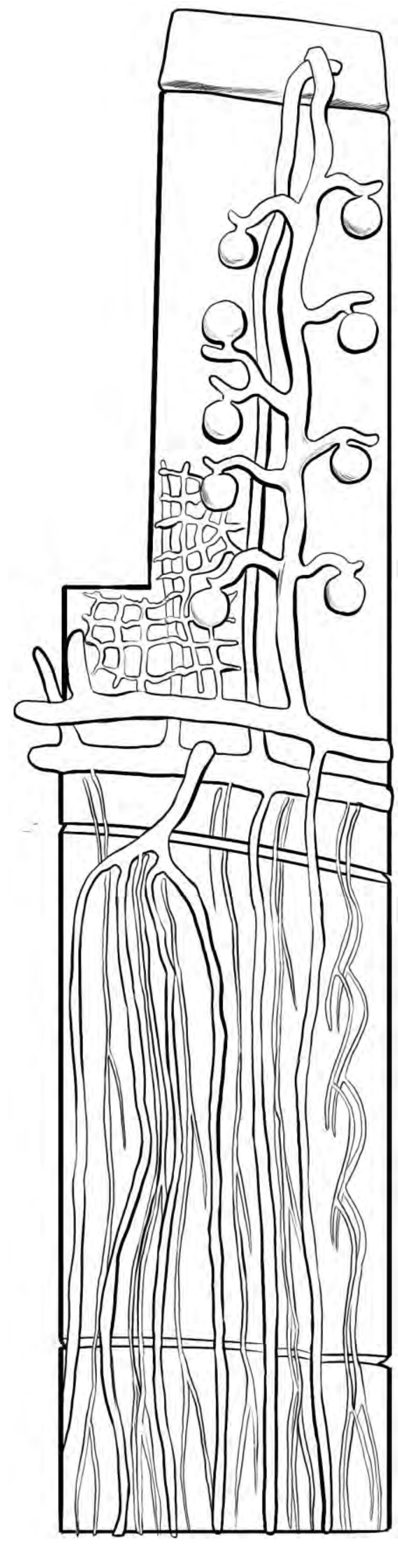
This image provides greater detail of the blood vessels that supply the nephron. Recall that the **arcuate arteries** feed into the **cortical radiate arteries**. A small arteriole, called the **afferent arteriole**, branches off the cortical radiate artery. The afferent arteriole feeds into the **glomerulus**, the cluster of capillaries found within the renal corpuscle, where filtration occurs. Blood then leaves the glomerulus through the **efferent arteriole**, which then gives rise to **peritubular capillaries**. This capillary bed intertwines amongst the tubules of the nephron, allowing for the reabsorption of substances from filtrate to blood, and the secretion of wastes from blood to filtrate. Here, the blood transitions from oxygenated to deoxygenated. The peritubular capillaries empty into the **cortical radiate veins**, which then empty into the **arcuate veins**. The deoxygenated, but cleaner, blood continues on through the venous system.

Activity:

1. Identify the following blood vessels:

☐	Afferent arteriole	☐	Cortical radiate vein
☐	Arcuate artery	☐	Efferent arteriole
☐	Arcuate vein	☐	Glomerulus
☐	Cortical radiate artery	☐	Peritubular capillaries

The Nephron
(Blood Vessels)



The Renal Corpuscle

This figure shows you a close up perspective of the **renal corpuscle**. Recall that the renal corpuscle includes an outer **Bowman's capsule** surrounded by a cluster of capillaries called the **glomerulus**. The first step of urine formation – filtration – occurs here. The glomerulus is lined by a single layer of endothelial cells which have fenestrations, or pores. Blood comes to the glomerulus via the **afferent arteriole**, and leaves via the **efferent arteriole**. The radius of the afferent arteriole is larger than the efferent; this keeps the blood pressure in the glomerulus relatively high to promote filtration.

Bowman's capsule has two layers. The outer, **parietal layer** is composed of simple squamous epithelium and serves no purpose other than to hold the renal corpuscle together. The inner, **visceral layer** is composed of a special type of epithelial cell called a podocyte, so named because they have foot-like processes, called pedicels. The podocytes wrap themselves around the capillary tubes, creating a filtration membrane. The space in between the parietal and visceral layers of Bowman's is the **capsular space**; filtrate is found here. Filtrate then enters the first region of the nephron tubules: the **proximal convoluted tubule**.

Closely associated with the afferent arteriole is a specialized region of the ascending loop of Henle called the **macula densa**. Whereas most of the loop of Henle is lined by simple cuboidal epithelium, the macula densa contains simple columnar epithelium. These cells sit near specialized cells of the afferent arteriole, called **granular cells**. The granular cells and macula densa cells are collectively referred to as the **juxtaglomerular apparatus**, which is a region that is important in blood pressure regulation.

Activity:

1. Identify the following structures:

☐	Afferent arteriole	☐	Macula densa
☐	Capsular space	☐	Parietal layer of capsule
☐	Efferent arteriole	☐	Podocytes
☐	Glomerulus	☐	Proximal convoluted tubule

2. Circle the general location of the juxtaglomerular apparatus.

The Renal Corpuscle

Kidney Histology

Once you are familiar with the structure of the nephron, you should be able to identify many of the features on prepared and stained sections of the kidney.

This slide is of a cross section of the kidney, in which you will be able to identify the different regions of the kidney, as well as some structures of the nephron.

Activity:

1. Obtain slide number 82 from your slide box.
2. Using the 4X objective lens, locate the following:

   Cortex
   Medulla

3. Draw what you see on the following page, labelling the structures listed above.
4. Using the 10X objective lens, locate the following:

   Bowman's capsule
   Capsular space
   Glomerulus
   Tubules

5. Draw what you see on the following page, labelling the structures listed above.

Kidney Histology

Male Reproductive System

This image is of a sagittal section through the male pelvis. It allows you to identify the internal reproductive organs, as well as the external genitalia. The male gonads are the **testes**, which are located outside of the body within the **scrotum**. The sperm created by the testes then travel through several ducts. The first duct is the **epididymis**, which is located on the posterior side of the testes. The epididymis then drains into the **ductus deferens**, a long tube that begins at the base of the testis, up through the spermatic cord, then through the inguinal canal and the abdominal wall, and then over and behind the **urinary bladder**. The ductus deferens leads to the short **ejaculatory duct** that is found within a gland called the prostate gland. The ejaculatory duct empties into the urethra, which transports both urine and semen. The urethra has three regions: the **prostatic urethra** through the prostate, the **membranous urethra** through the urogenital diaphragm, and the **spongy urethra** through the penis.

The ducts are closely associated with three different glands, all of which contribute to the fluid portion of semen. Behind the bladder are the paired **seminal vesicles**; these glands secrete their product into the ejaculatory duct at the same point as the ductus deferens. Under the bladder is the **prostate gland**; this gland empties its secretions into the prostatic urethra. Finally the paired **bulbourethral glands** are located in the urogenital diaphragm and empty their secretions into the spongy urethra.

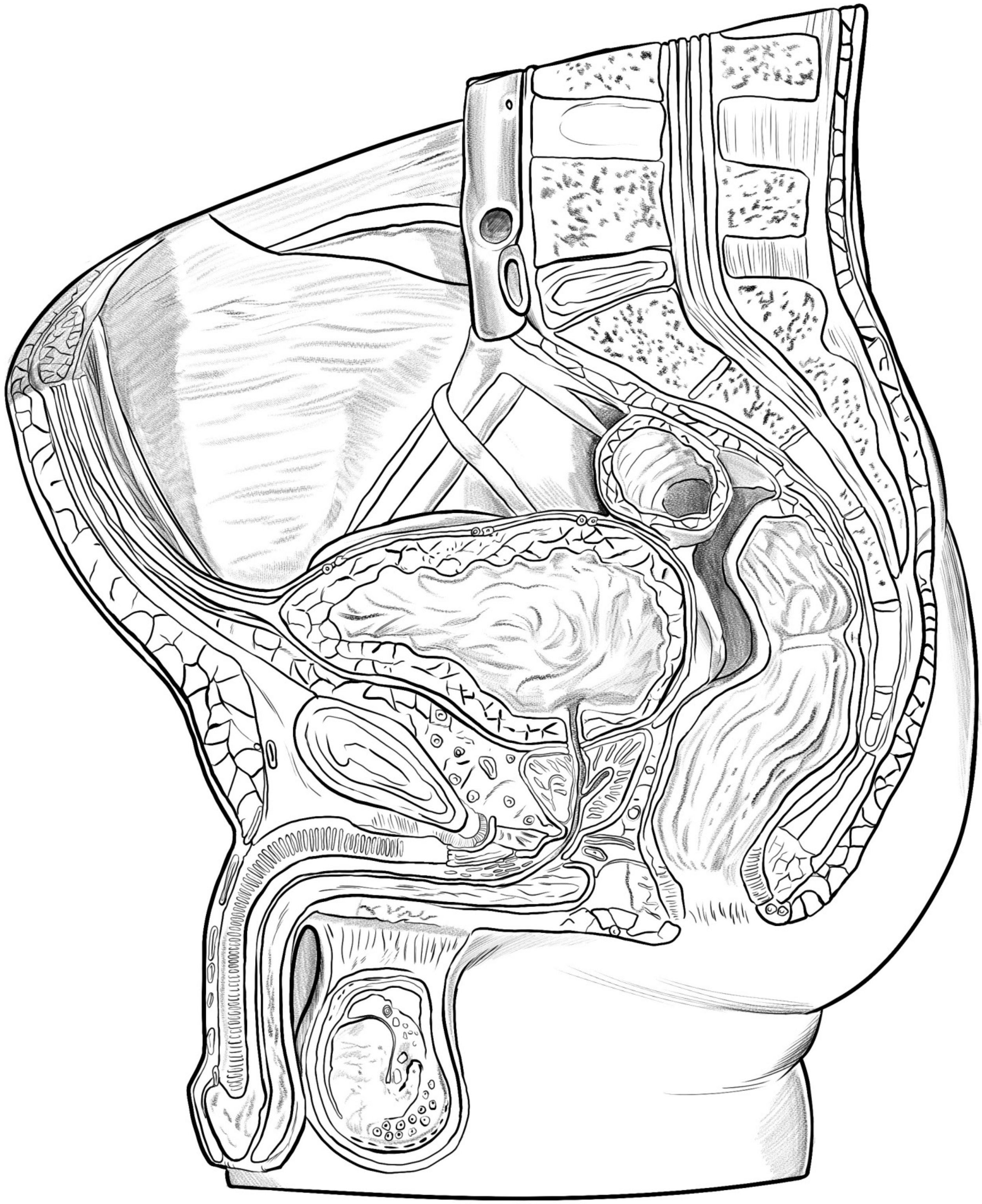
The male external genitalia include the scrotum and penis. The penis is a dual purpose organ; it allows for the expulsion of urine during micturition, and also delivers semen to the female tract during intercourse. It attaches to the pelvis at the **root**; the shaft is referred to as the **body**, which ends at the **glans penis**. There are three columns of tissue that run through the penis. There are two **corpora cavernosa** and a single **corpus spongiosum**, through which the spongy urethra runs.

<u>Activity:</u>

1. Identify the following structures:

☐ Body of penis	☐ Epididymis	☐ Scrotum
☐ Bulbourethral gland	☐ Glans penis	☐ Seminal vesicle
☐ Corpus cavernosum	☐ Membranous urethra	☐ Spongy urethra
☐ Corpus spongiosum	☐ Prostate	☐ Testis
☐ Ductus deferens	☐ Prostatic urethra	☐ Urinary bladder
☐ Ejaculatory duct	☐ Root of penis	

Male Reproductive System



Male Reproductive Histology

Once you are familiar with the structure of the male reproductive organs, you should be able to identify many of the features on prepared and stained slides.

The first slide is of the testis, which contains tubes called **seminiferous tubules**. You will be able to see cross sections of the seminiferous tubules, which are lined by cells in various stages of spermatogenesis called **spermatogenic cells**. In between the seminiferous tubules are **interstitial cells**, which are the endocrine cells that secrete testosterone.

The second slide is of the epididymis. Here you can see the pseudostratified columnar epithlium that lines the mucosa of the epididymis, as well as the surrounding smooth muscle that causes peristaltic contractions to propel the sperm through the male duct system.

The final slide is a cross section of the penis. The different corpora, as well as the spongy urethra, can be observed.

Activity:

1. Obtain slide number 86 from your slide box.
2. Using the 10X objective lens, locate the following:

    Interstitial cells
    Seminiferous tubules
    Spermatogenic cells

3. Draw what you see on the following page, labelling the structures listed above.
4. Obtain slide number 88 from your slide box.
5. Using the 40X objective lens, locate the following:

    Pseudostratified columnar epithelium
    Smooth muscle

6. Draw what you see on the following page, labelling the structures listed above.
7. Obtain slide number 84 from your slide box.
8. Using the 4X objective lens, locate the following:

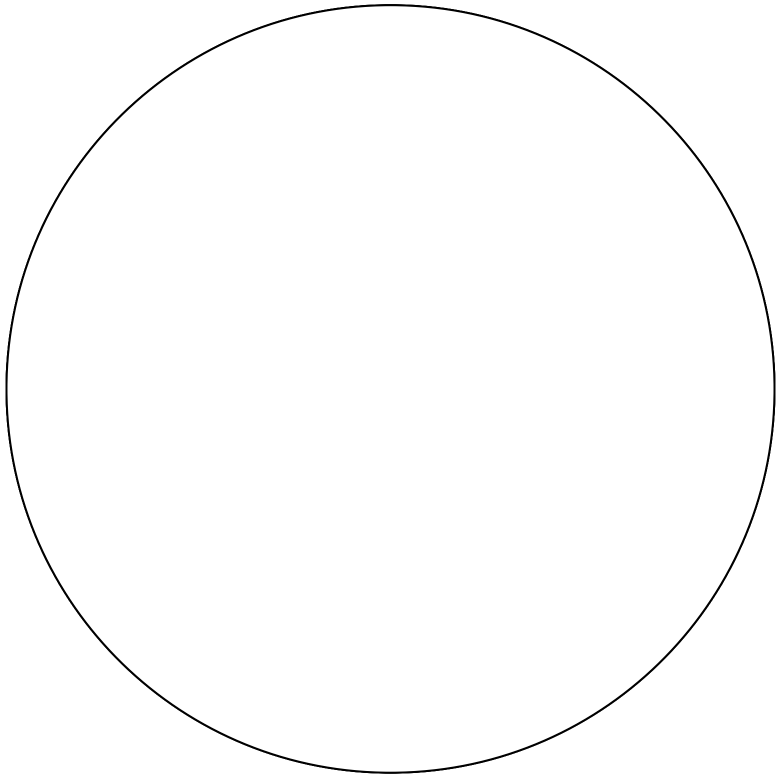
    Corpora cavernosa
    Corpus spongiosum
    Urethra

9. Draw what you see on the following page, labelling the structures listed above.

Male Reproductive Histology

Male Reproductive Histology

Male Reproductive Histology



Female Reproductive System

This image is of a sagittal section through the female pelvis. It allows you to identify the internal reproductive organs, as well as the external genitalia.

The female reproductive organs are found within the pelvic cavity, posterior to the urinary organs and anterior to the digestive organs. The female gonad is the **ovary**. In close association with the ovary is the **uterine tube** (also called oviduct and fallopian tube), which partially connects the ovary to the **uterus** (the womb). The uterus is tilted forward, resting on the urinary bladder. The bottom, neck region of the uterus, called the **cervix**, extends into the **vagina** (birth canal). In the superior-most regions of the vagina, where the cervix extends into it, there are two arch-like areas: the smaller **anterior fornix** and larger and deeper **posterior fornix**.

The female reproductive organs are held in place by several different ligaments, a few of which can be seen on this image. The **round ligament** connects the anterior side of the uterus to the anterior pelvic wall. The remaining ligaments will be discussed shortly.

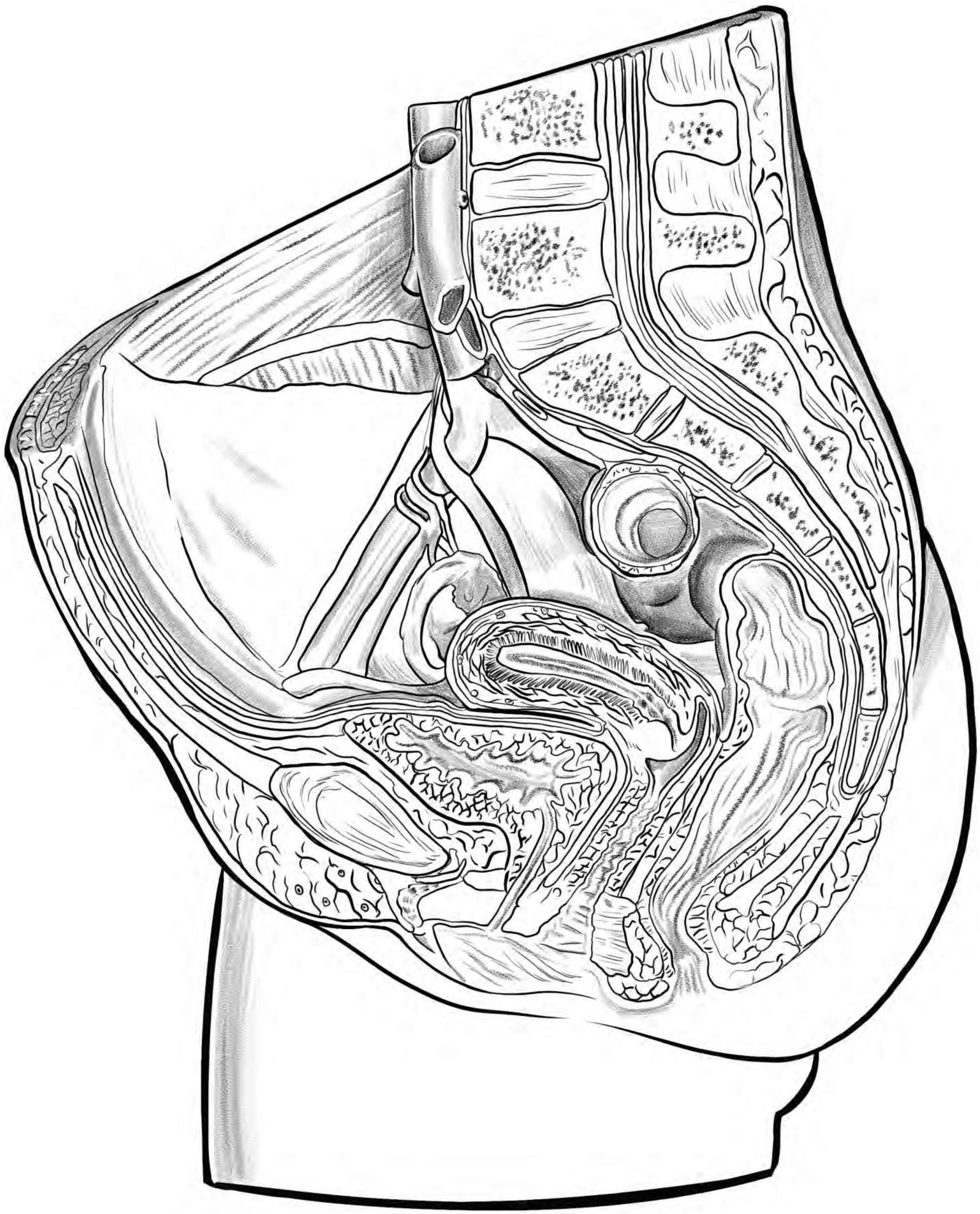
The vagina opens to the exterior at the **vaginal orifice**. The external genitalia are collectively referred to as the **vulva**. This includes the **labia majora** and **labia minora** on the lateral sides, the **clitoris**, which is just anterior to the urethra opening, and the **mons pubis**, a fatty pad that sits in front of the pubic symphysis.

Activity:

1. Identify the following structures:

☐	Anterior fornix	☐	Posterior fornix
☐	Cervix	☐	Round ligament
☐	Clitoris	☐	Uterine tube
☐	Labium majora	☐	Uterus
☐	Labium minor	☐	Vagina
☐	Mons pubis	☐	Vaginal orifice
☐	Ovary		

Female Reproductive System



The Internal Female Reproductive Organs

These figures show the internal organs of the female reproductive system. A large sheet of peritoneum, called the **broad ligament**, which is shown in the first figure, covers all internal reproductive organs and holds them in place. In the second figure, the broad ligament has been removed so you can identify features of the uterus and uterine tube.

The rounded top of the **uterus** is called the **fundus**. The **body** forms the majority of the uterus; it narrows inferiorly to become the **isthmus**. The neck of the uterus is the **cervix**, which projects into the **vagina**. The opening of the cervix superiorly to the uterine body is called the **internal os**, while the opening to the vagina is called the **external os**. The uterus has three layers of tissue. The outermost layer is the **perimetrium**, which is pertineum. The middle layer, the **myometrium**, is composed of smooth muscle. The innermost layer is called the **endometrium**; this highly vascular layer composed of epithelial tissue changes throughout the menstrual cycle and supports the developing fetus.

The **uterine tubes** (also called oviducts and fallopian tubes) extend laterally from the uterus, and partially connect the ovary to the uterus. There are three regions to the uterine tube. The **isthmus** connects the uterine tube to the uterus. Laterally, to the isthmus is the **ampulla**, which is the most common site for fertilization. The lateral-most region is the **infundibulum** which opens to the pelvic cavity. At the very end of the infundibulum are finger-like extensions called **fimbriae**, which help to draw an oocyte into the uterine tube after ovulation.

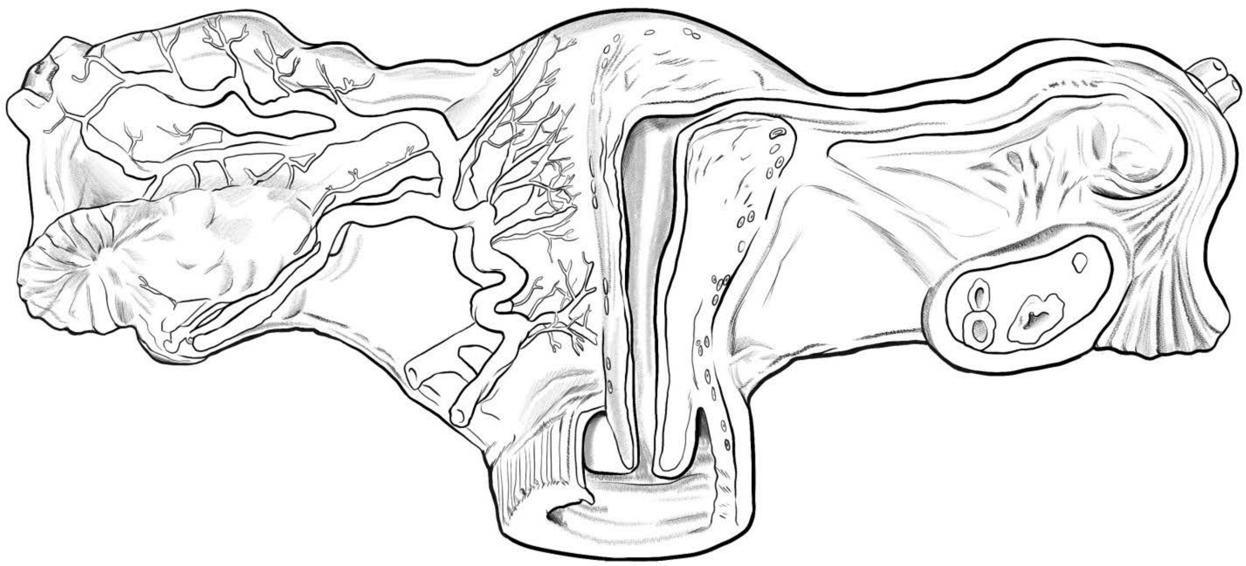
Supporting the uterus, uterine tubes and ovaries are several ligaments. The **ovarian ligament** connects the medial side of the ovary to the uterus. The **suspensory ligament** connects the lateral side of the ovary to the lateral pelvic wall. The round ligament attaches the uterus to the anterior pelvic cavity; this ligament is not shown in these figures.

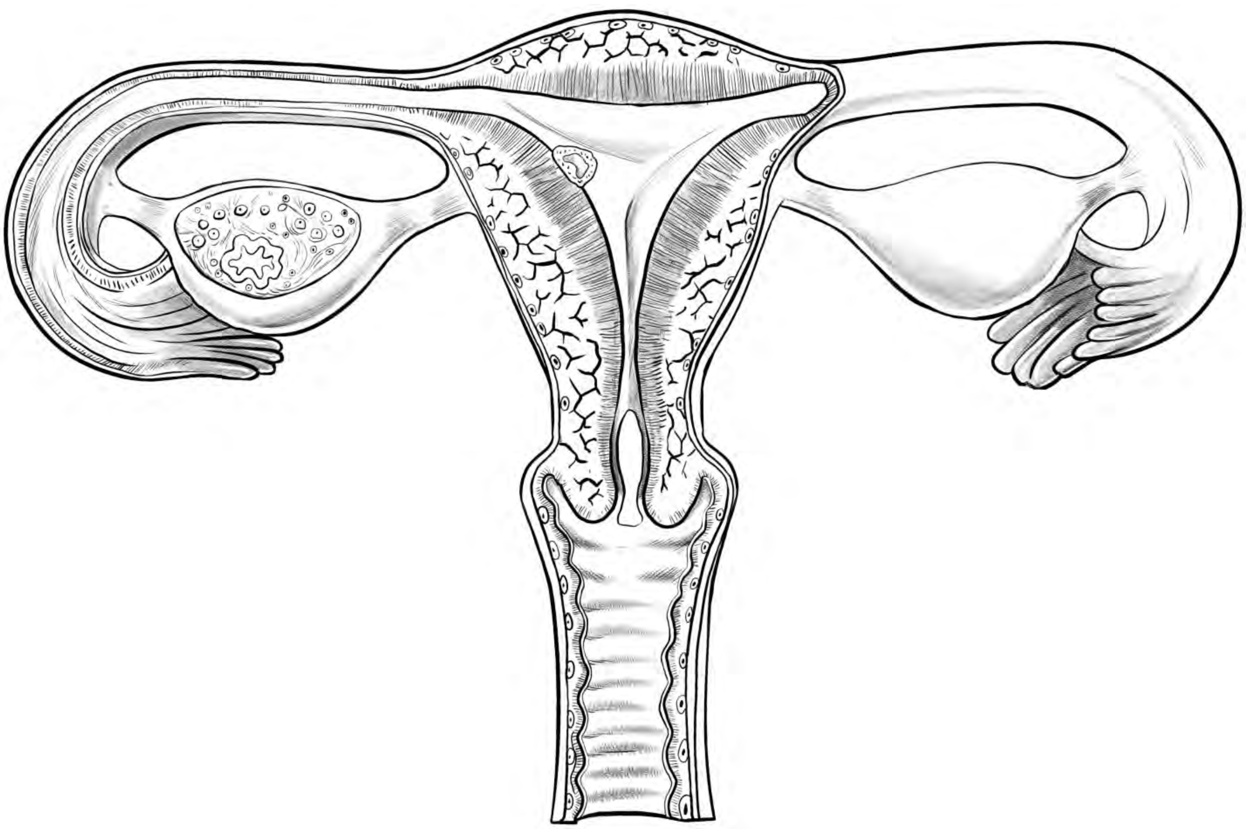
Activity:

1. Identify the following structures:

☐ Ampulla	☐ Fundus	☐ Ovary
☐ Body	☐ Infundibulum	☐ Perimetrium
☐ Broad ligament	☐ Internal os	☐ Suspensory ligament
☐ Cervix	☐ Isthmus, uterine tube	☐ Uterine tube
☐ Endometrium	☐ Isthmus, uterus	☐ Uterus
☐ External os	☐ Myometrium	☐ Vagina
☐ Fimbriae	☐ Ovarian ligament	

The Internal Female Reproductive Organs





The Ovary

This figure is of a coronal section of the ovary, which shows the internal structures of the ovary. The ovary has an outer **cortex**, where the follicles and developing oocytes are located, and an inner **medulla**, which contains highly vascular connective tissue. The ovary is surrounded by the **tunica albuginea**, a layer of fibrous connective tissue that holds the ovary together. Oocytes develop within structures called follicles. The smallest follicles, **primordial follicles**, contain an **oocyte** surrounded by one layer of follicular cells. At the beginning of the ovarian cycle each month, several primordial follicles grow larger to become **primary follicles** as the oocyte and its surrounded follicular cells get larger. Next, the follicular cells begin to multiple until the oocyte is surrounded by several layers of follicular cells; the follicle at this stage is called a **secondary follicle**. The follicle then begins to accumulate fluid on the inside, and begins to grow even larger. The largest of these follicles is the **Graafian follicle**. It is the Graafian follicle that ruptures during **ovulation** to release the oocyte into the pelvic cavity. The empty follicle now becomes an endocrine structure called the **corpus luteum**, which is responsible for secreting the hormones that will support a pregnancy for several months. If a pregnancy does not occur, the corpus luteum will begin to degenerate a little less than two weeks after ovulation to become a scar, called the **corpus albicans**.

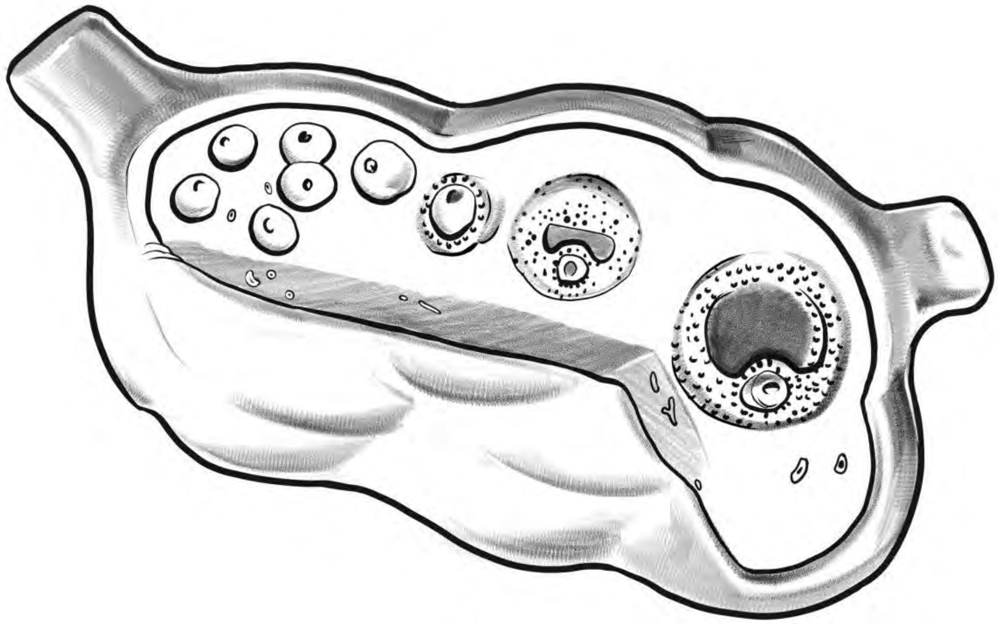
Activity:

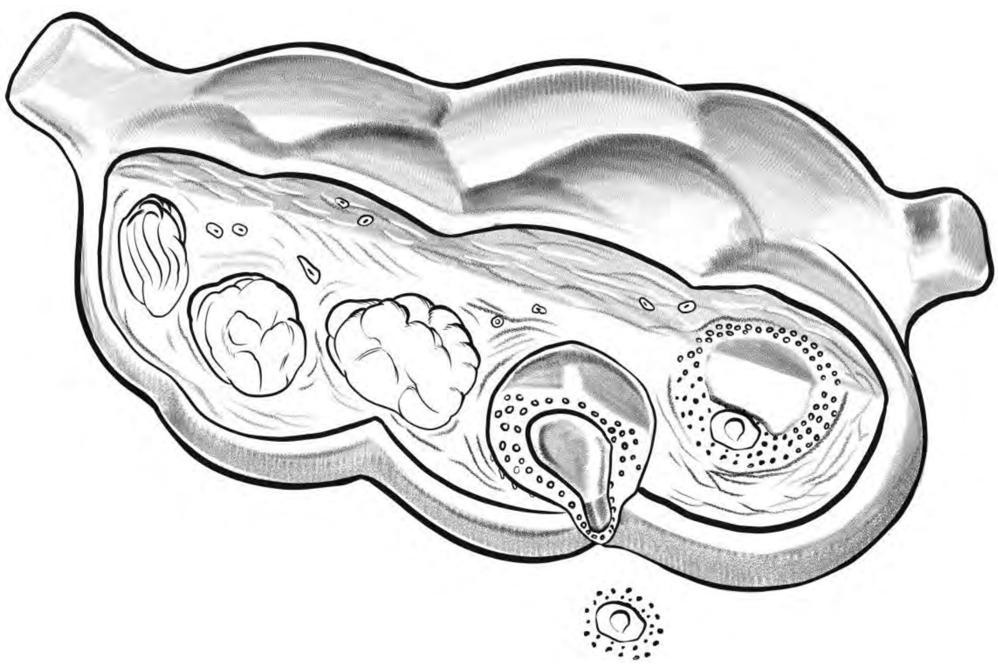
1. Identify the following structures:

☐	Corpus albicans	☐	Primary follicle
☐	Corpus luteum	☐	Primordial follicle
☐	Graafian follicle	☐	Secondary follicle
☐	Oocyte	☐	Tunica albuginea

2. Label the cortex and medulla.
3. Circle the region of the image representing ovulation.

The Ovary





Female Reproductive Histology

Once you are familiar with the structure of the female reproductive organs, you should be able to identify many of the features on prepared and stained slides.

The uterine wall has three layers of tissue. The outer layer, called the **perimetrium**, is composed of peritoneum. The middle layer, called the **myometrium**, is composed of smooth muscle. The inner layer, called the **endometrium**, is the mucosal layer of the uterus which contains simple columnar epithelium and an underlying lamina propria. There are two layers within the endometrium, the innermost **stratum functionalis** and the underlying **stratum basalis**. The stratum functionalis is subject to hormonal influences and changes in thickness throughout the month; this layer is shed during menstruation. The stratum basalis contains cells that re-form the stratum functionalis after menstruation. The first slide that you will be viewing is of the uterus, in which you can see the different layers of endometrial tissue.

The second slide is of the ovary. You should be able to identify the two regions – cortex and medulla – as well as the follicles and oocytes.

Activity:

1. Obtain slide number 92 from your slide box.
2. Using the 4X objective lens, locate the following:

    Stratum basalis
    Stratum functionalis

3. Draw what you see on the following page, labelling the structures listed above.
4. Obtain slide number 90 from your slide box.
5. Using the 4X objective lens, locate the following:

    Cortex
    Graafian follicle
    Medulla
    Oocyte
    Primary/secondary follicle
    Primordial follicle

6. Draw what you see on the following page, labelling the structures listed above.

Female Reproductive Histology

The Pituitary

The **pituitary gland**, also called the **hypophysis**, is the master gland of the endocrine system. This gland rests in the sella turcica of the sphenoid bone, just inferior to the **hypothalamus**. It is connected to the hypothalamus via a stalk of tissue called the **infundibulum**. There are two regions within the pituitary gland; the anterior pituitary is called the adenohypophysis and the posterior pituitary is called the neurohypophysis.

The **adenohypophysis** is composed of glandular tissue, which secretes seven different hormones. Four of these hormones are considered tropic hormones, because they stimulate other endocrine glands to produce their hormones. Thyroid hormone (TH) stimulates the thyroid gland; adrenocorticotropic hormone (ACTH) stimulates the adrenal gland; and follicle stimulating (FSH) and luteinizing hormones (LH) stimulate the gonads. The remaining three hormones have non-endocrine gland target tissues. Prolactin (PRL) stimulates milk production in mammary glands. Growth hormone (GH) stimulates body cells to grow. Finally, melanocyte stimulating hormone (MSH) stimulates the production of melanin by melanocytes, and also influences appetite

The **neurohypophysis** is composed of nervous tissue. The neurons arise in the hypothalamus, and the axons extend down through the infundibulum, into the neurohypophysis. This is called the hypothalamic-hypophyseal tract. This portion of the pituitary gland does not produce any hormones; rather, it secretes hormones produced by the hypothalamus. Antidiuretic hormone (ADH) stimulates the kidneys to retain water during dehydration. Oxytocin (OXY) stimulates uterine contractions during childbirth, milk ejection during lactation, and affiliative behaviors.

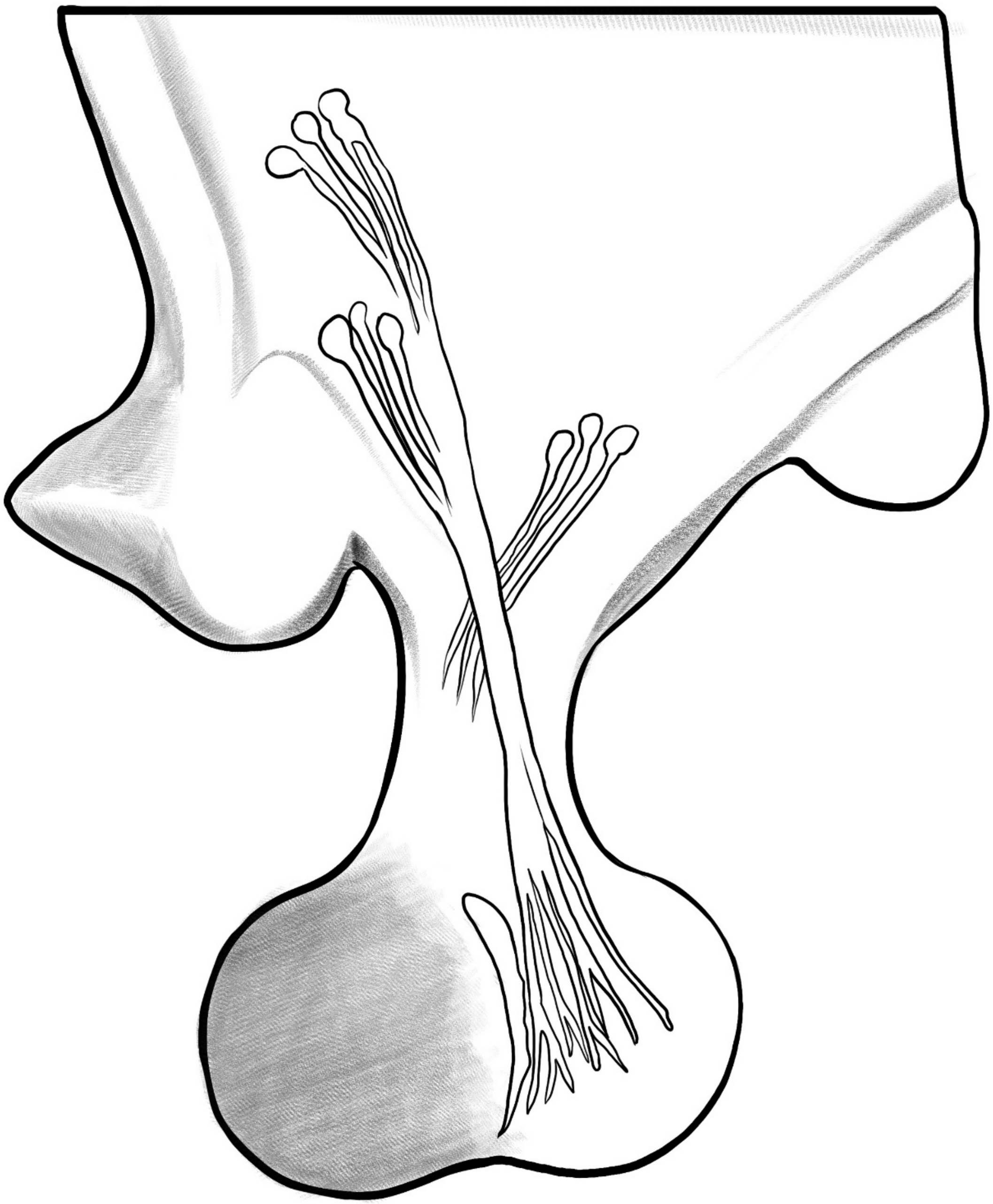
Activity:

1. Identify the following structures:

- [ ] Adenohypophysis
- [ ] Infundibulum
- [ ] Hypothalamus
- [ ] Neurohypophysis

2. Why is the anterior pituitary called the adenohypophysis?
3. Why is the posterior pituitary called the neurohypophysis?

The Pituitary



The Thyroid Gland
(Anterior View)

The **thyroid gland** is found in the neck, just below the larynx, on the anterior surface of the trachea. It has two lobes, a **left lateral lobe** and a **right lateral lobe**, which are connected by a piece of tissue called the **isthmus**. The thyroid is the largest of all the endocrine glands, and can be felt by palpating the trachea just below the larynx.

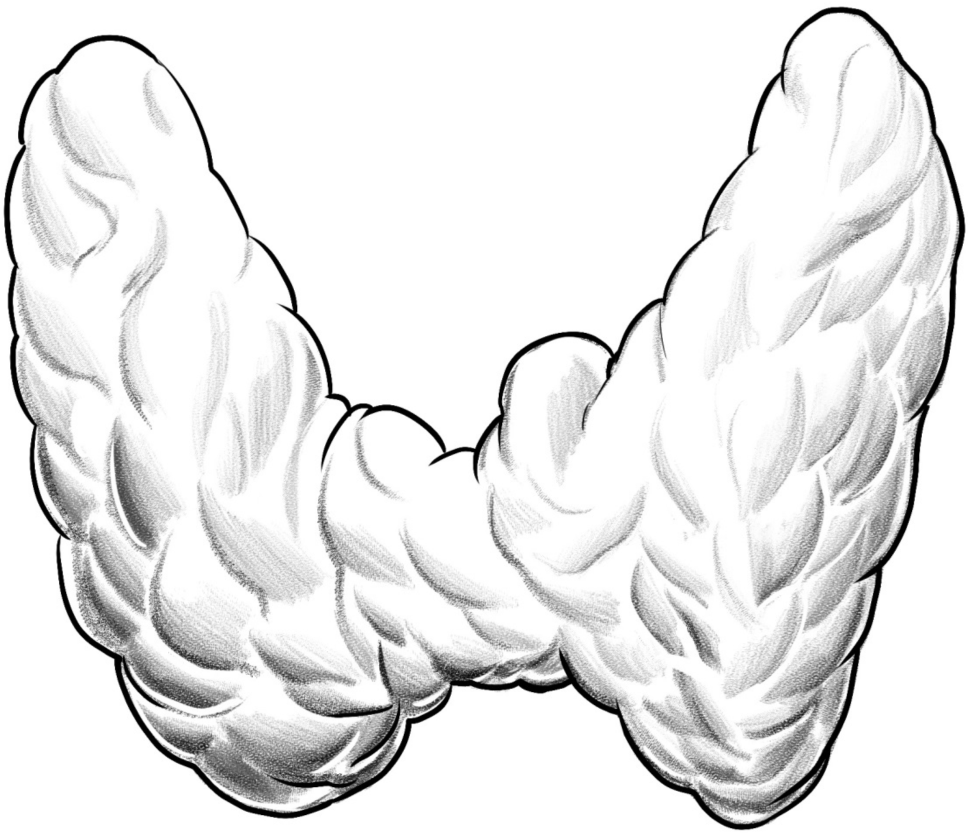
The thyroid gland secretes two hormones: thyroid hormone (also called thyroxine) to increase metabolism and calcitonin to reduce blood calcium concentration.

Activity:

1. Identify the following structures:

☐ Isthmus ☐ Left lateral lobe ☐ Right lateral lobe

The Thyroid Gland
(Anterior View)



The Thyroid and Parathyroid Glands

(Posterior View)

This figure shows you the posterior surface of the **thyroid gland**. The **lobes** and **isthmus** can be observed from this perspective. Note that the **parathyroid glands** are attached to the posterior surface of the thyroid. Even though they are attached to the thyroid gland, they are completely distinct in structure and function. There are normally 4 total glands present, though some individuals can have more or less. These glands secrete a very important hormone called parathyroid hormone, which raises blood calcium level. Recall that calcium is required for nerve impulse generation and muscle contraction. Removal of these glands would result in sudden death due to a lack of neuromuscular function.

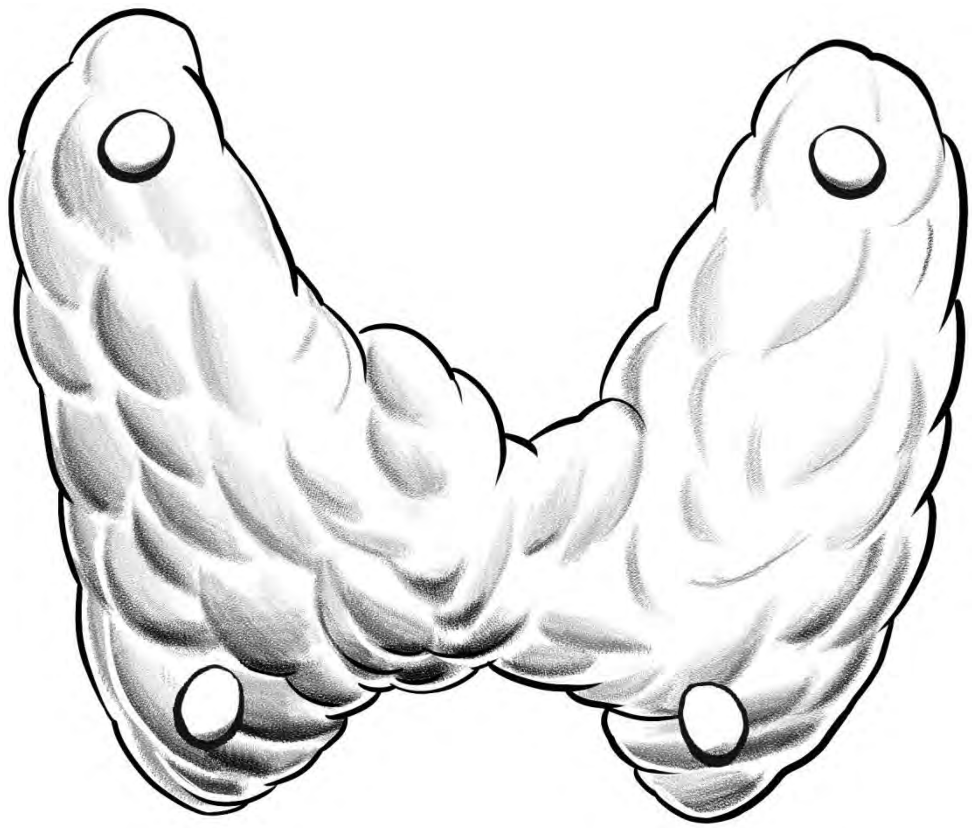
Activity:

1. Identify the following structures:

☐	Isthmus	☐	Parathyroid glands
☐	Left lateral lobe	☐	Right lateral lobe

The Thyroid and Parathyroid Glands

(Posterior View)



The Adrenal Glands and the Pancreas

The **adrenal glands** are also called the suprarenal glands because of their location on the superior surface of the kidney. These pyramid-shaped glands are composed of two types of tissue which almost behave as two distinct glands. The outer cortex is composed of glandular tissue, whereas the inner medulla is composed of nervous-like tissue. The cortex secretes several different hormones, collectively referred to as the corticoids. The mineralocorticoid aldosterone causes the kidneys to retain water in order to increase blood pressure. The glucocorticoid cortisol increases blood glucose level to help the body fight stressors. The medulla secretes the hormones epinephrine and norepinephrine, which are part of the sympathetic response.

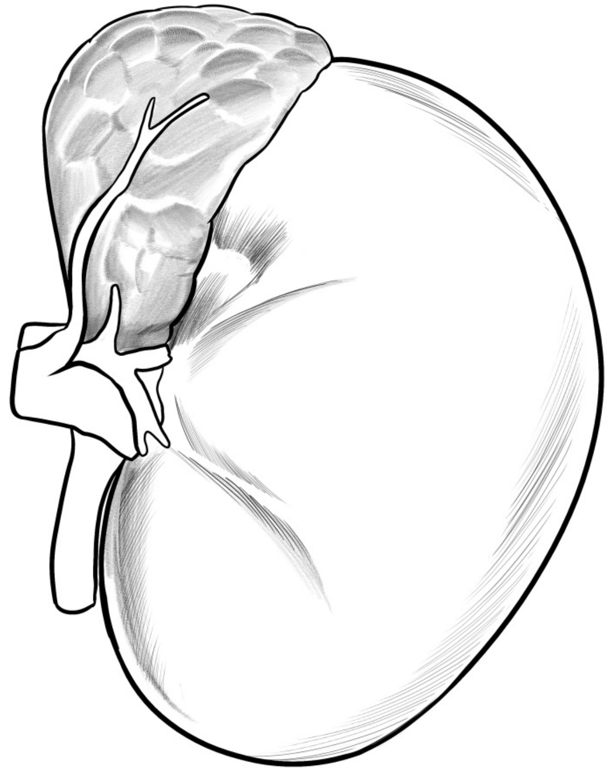
Recall that the **pancreas** is both an exocrine and endocrine gland. The exocrine function was previously discussed with the digestive system. The endocrine portion will be the focus of this section. The endocrine region, which is called the pancreatic islets of Langerhans, contains different cell types that are responsible for secreting various hormones. The two most common are insulin, which lowers blood glucose level, and glucagon, which raises blood glucose level.

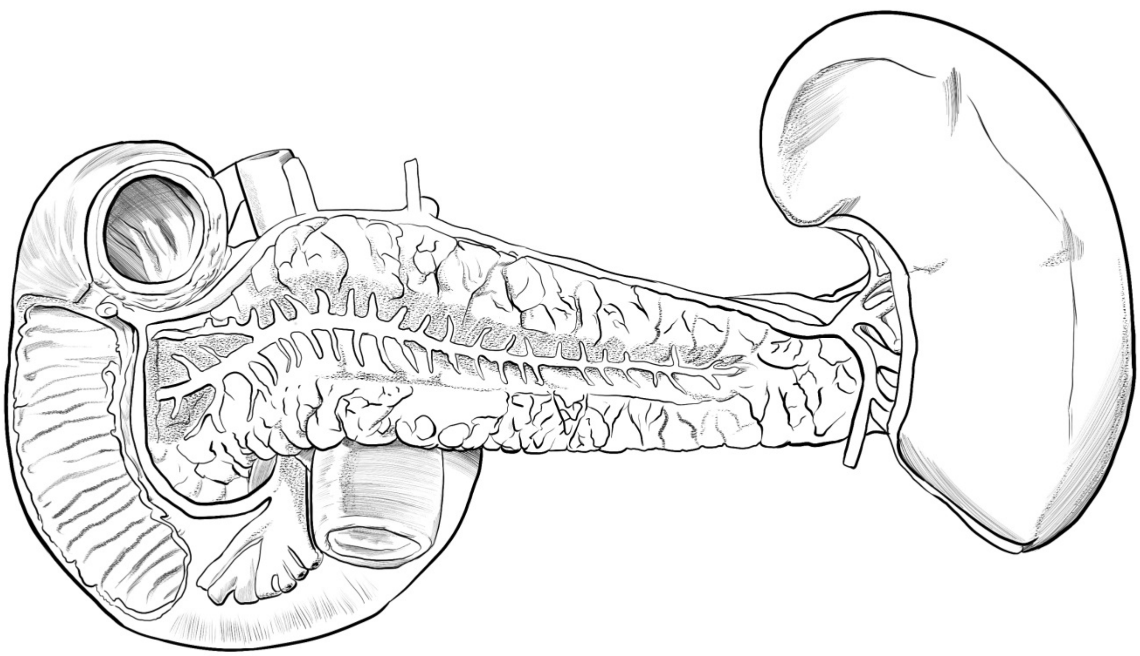
Activity:

1. Identify the following glands:

☐ Adrenal ☐ Pancreas

The Adrenal Glands and the Pancreas





Endocrine Histology

Once you are familiar with the microscopic structure of the endocrine glands, you should be able to identify the different glands by observing prepared and stained sections, and in some cases you should be able to identify different regions or cell types within the glands.

Recall that the **pituitary gland** has two regions: the posterior **neurohypophysis** and the anterior **adenohypophysis**. The neurohypophysis is composed of nervous tissue that secretes ADH and OXY. The adenohypophysis is composed of glandular tissue, which secretes FSH, LH, TH, GH, ACTH, PRL, and MSH. Within the **thyroid gland** are many small bubble-like structures called **follicles**. These fluid filled sacs are surrounded by epithelial cells called **follicular cells,** which secrete thyroid hormone. In between the follicles are **parafollicular cells**, which secrete the hormone calcitonin. The **parathyroid gland** is composed mostly of cells called **chief (parathyroid) cells**, which secrete parathyroid hormone. Rarely there are large cells called oxyphil cells, whose function is not known. Recall that the **adrenal gland** has two layers: the outer **cortex** and inner **medulla**. The cortex has three layers of glandular tissue (zona glomerulosa, zona fascuculata and zone reticularis), which secrete the corticoid hormones. The medulla is composed of chromaffin cells, which secrete norepinephrine and epinephrine. Within the **pancreas** there are two cell types: the acinar cells, which are the exocrine cells, and the **pancreatic islets of Langerhans**, which are the endocrine cells. The majority of the tissue falls into the exocrine category, with clusters of islet cells dispersed throughout. Within the islets there are β cells, which secrete insulin, and α cells, which secrete glucagon, D cells, which secrete somatostatin and PP cells, which secrete pancreatic polypeptide. Most of the cells are α and β cells.

Activity:

1. Obtain the pituitary slide (number 94) from your slide box.
2. Using the 4X objective lens, locate the following:

   Adenohypophysis
   Neurohypophysis

3. Draw what you see, labelling the structures listed above.
4. Obtain the thyroid slide (number 96) from your slide box.
5. Using the 40X objective lens, locate the following:

   Follicles
   Follicular cells
   Parafollicular cells

6. Draw what you see, labelling the structures listed above

Endocrine Histology

7. Obtain the parathyroid slide (number 98) from your slide box.
8. Using the 40X objective lens, locate the following:

    Chief (parathyroid) cells

9. Draw what you see, labelling the structures listed above.
10. Obtain the adrenal slide (number 100) from your slide box.
11. Using the 40X objective lens, locate the following:

    Cortex
    Medulla

12. Draw what you see, labelling the structures listed above.
13. Obtain the pancreas slide (number 78) from your slide box.
14. Using the 10X objective lens, locate the following:

    Islets of Langerhans

15. Draw what you see, labelling the structures listed above.

Endocrine Histology

Endocrine Histology