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**.

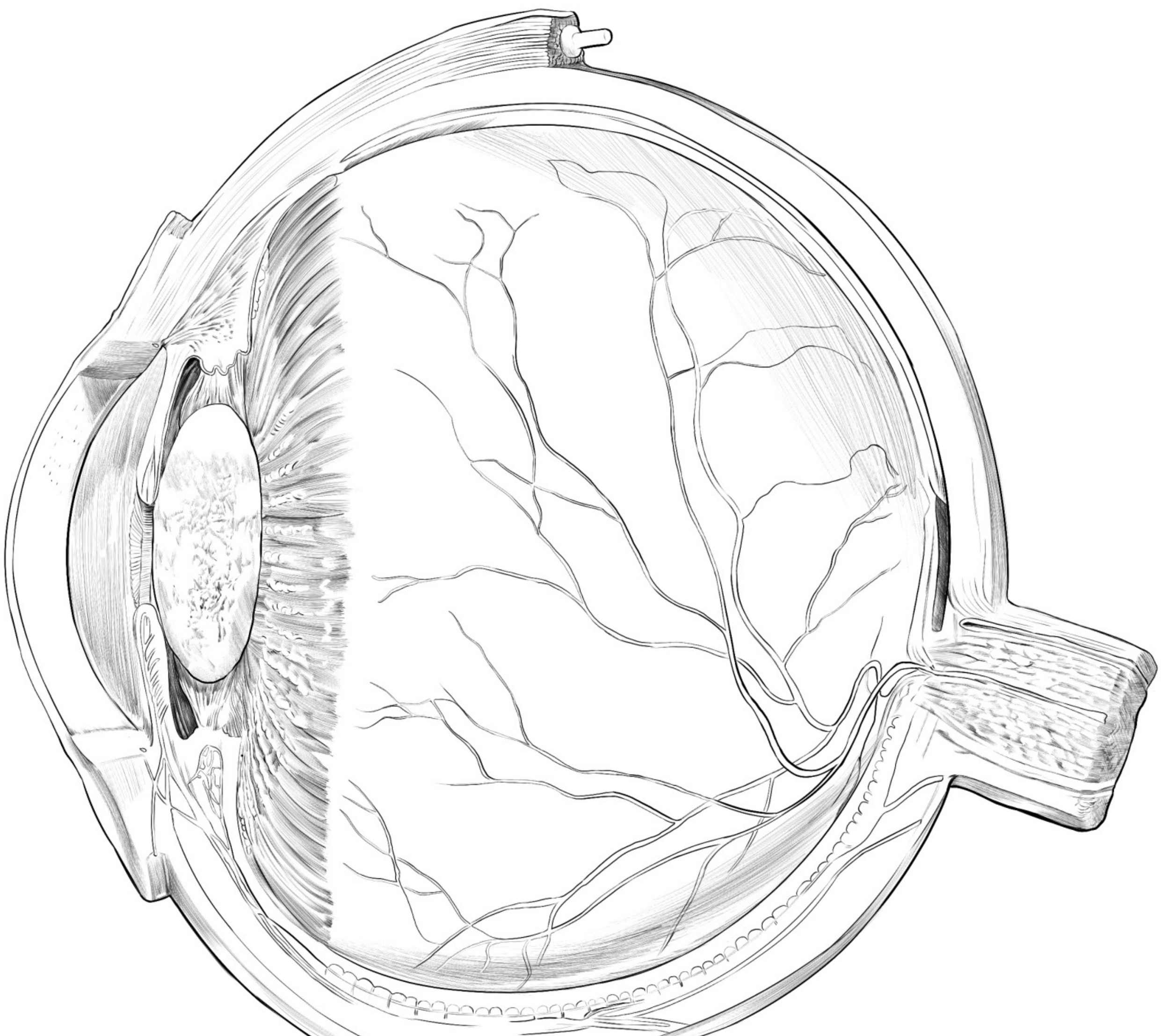
Activity:

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.

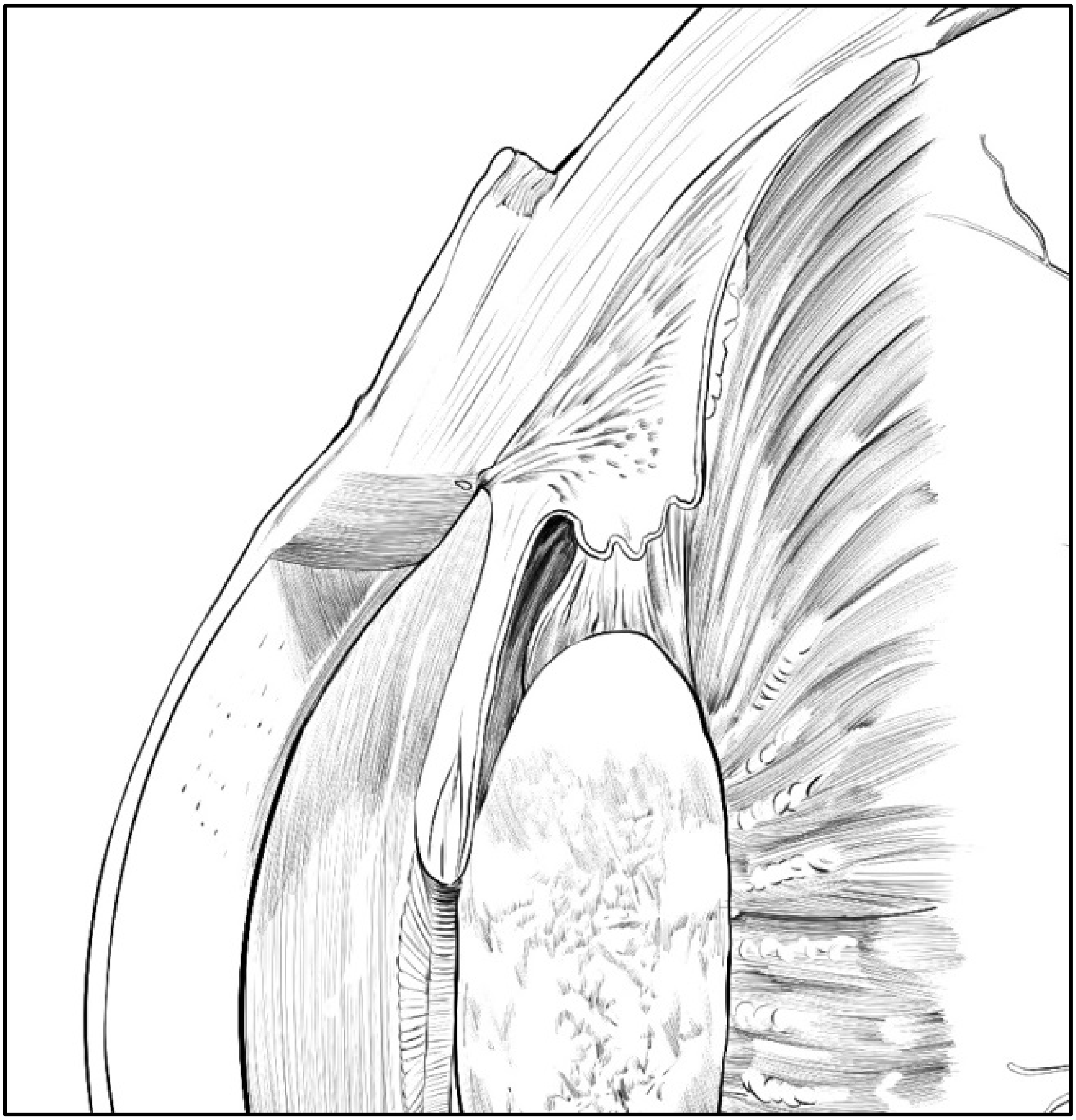
Behind the lens is the **posterior segment** of the eye, which contains **vitreous humor**. Unlike aqueous humor, which is constantly produced, vitreous humor is produced just once prior to birth.

Activity:

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.

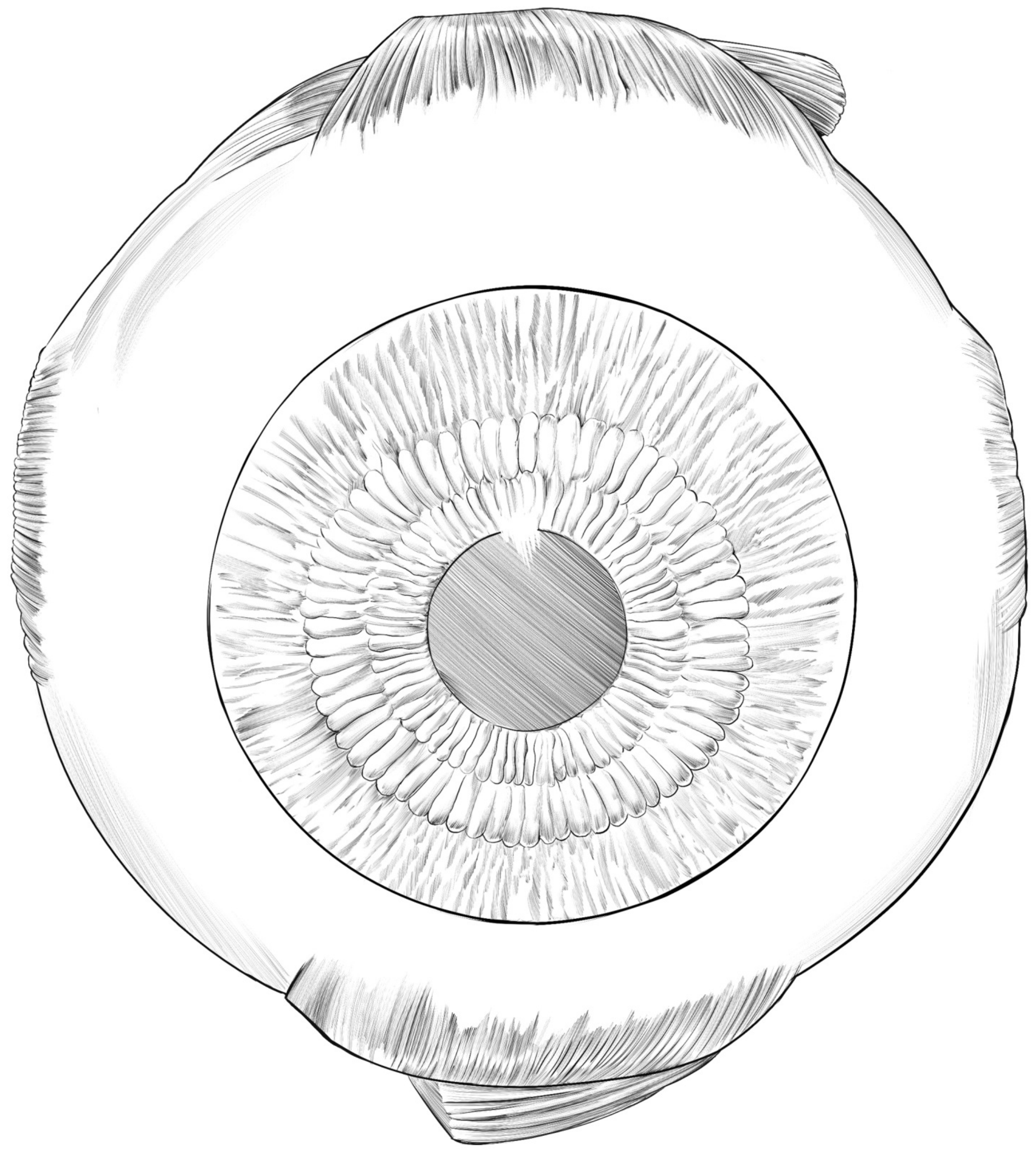
Activity:

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.

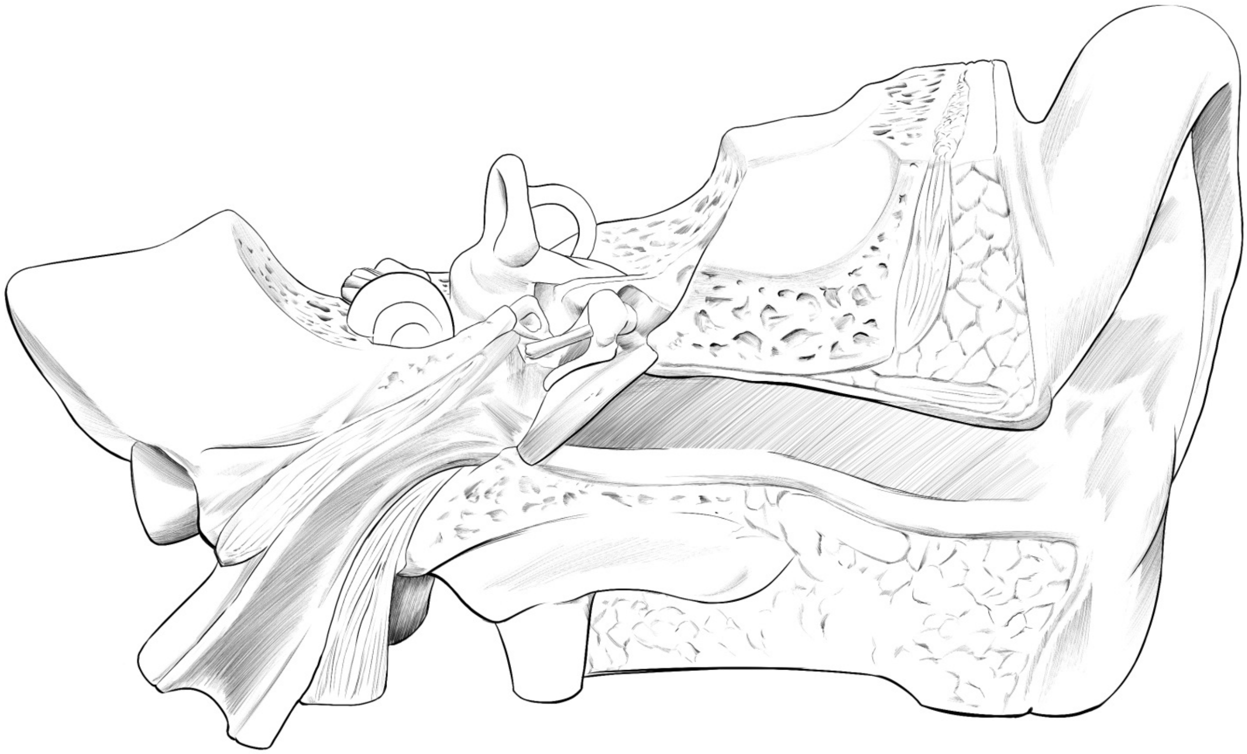
Activity:

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).

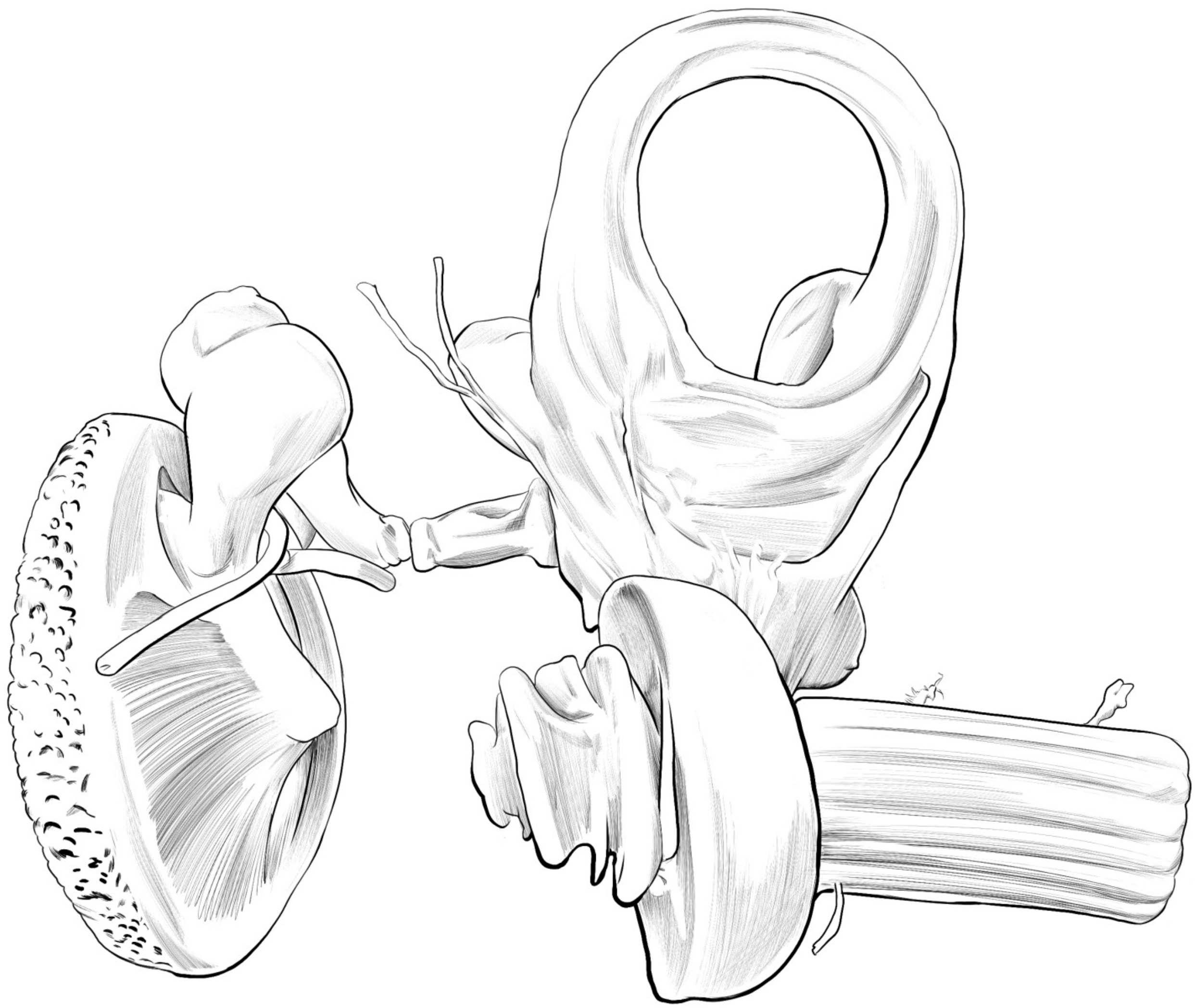
Activity:

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.

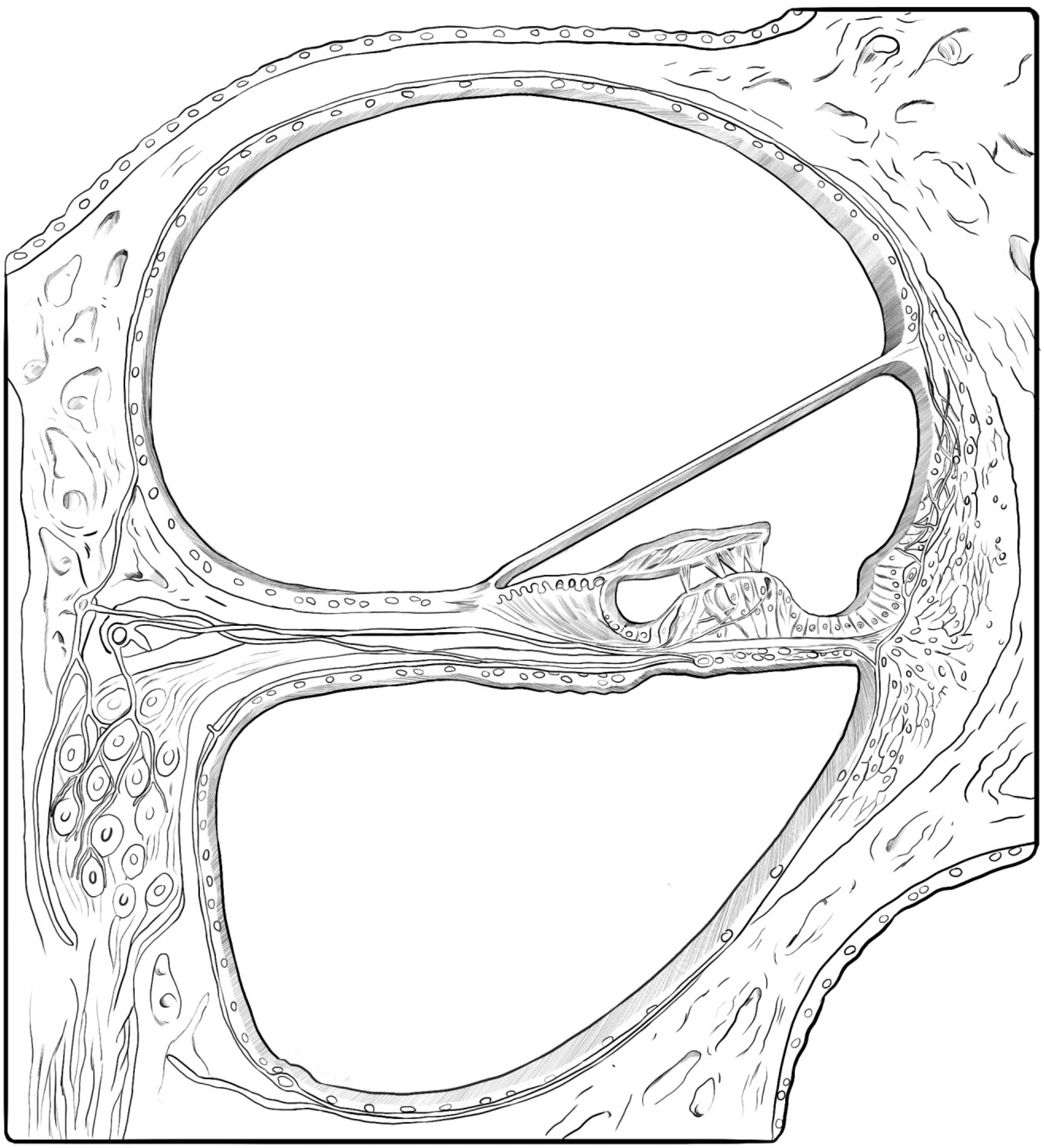
Activity:

1. Identify the following structures:

☐	Cochlear duct (scala media)	☐	Scala tympani
☐	Organ of Corti	☐	Tectorial membrane
☐	Basilar membrane	☐	Vestibular membrane
☐	Scala vestibuli	☐	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)

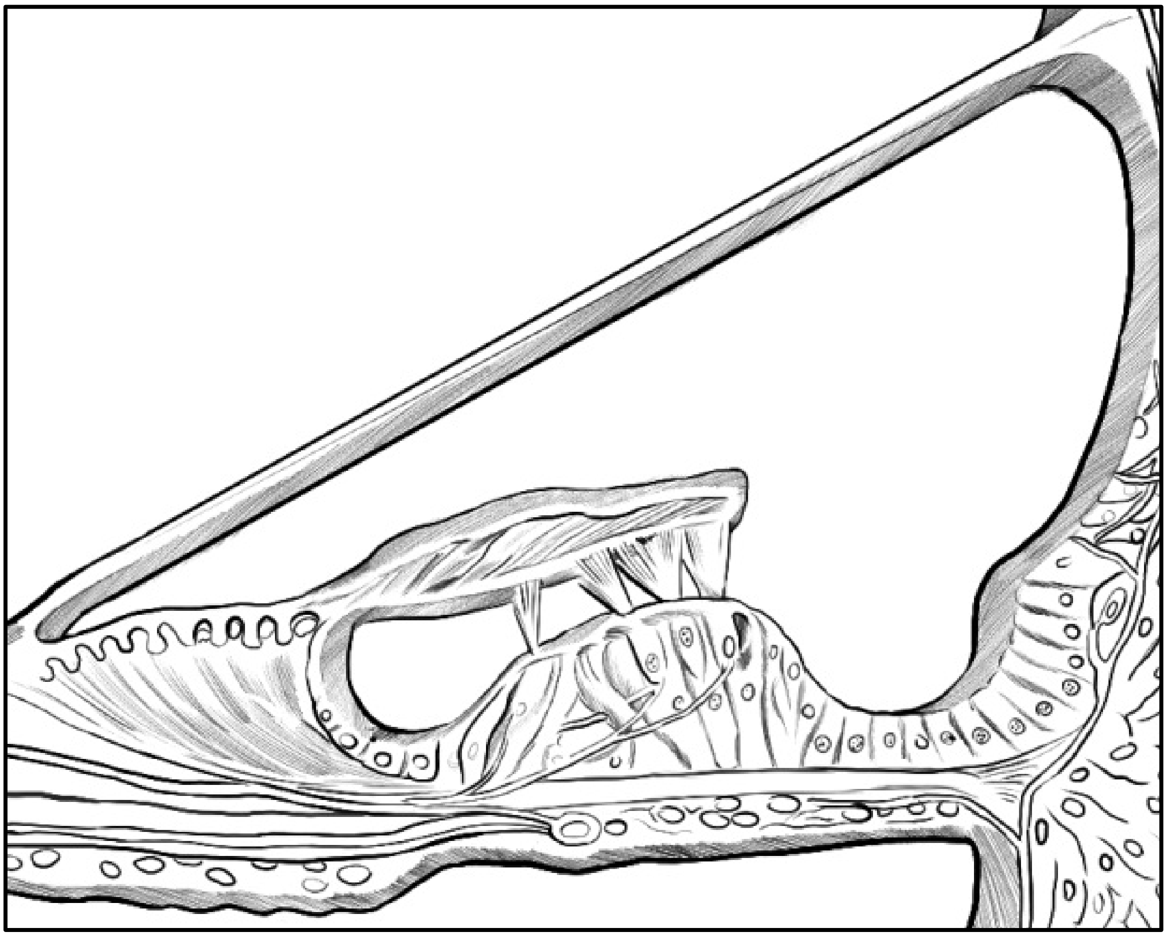
This drawing gives a closer perspective of the organ of Corti. You can see the **vestibular membrane**, separating the scala vestibuli from the cochlear duct, and the **basilar membrane**, supporting the structures of the organ of Corti. Resting on the basilar membrane are the **supporting cells** and 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)

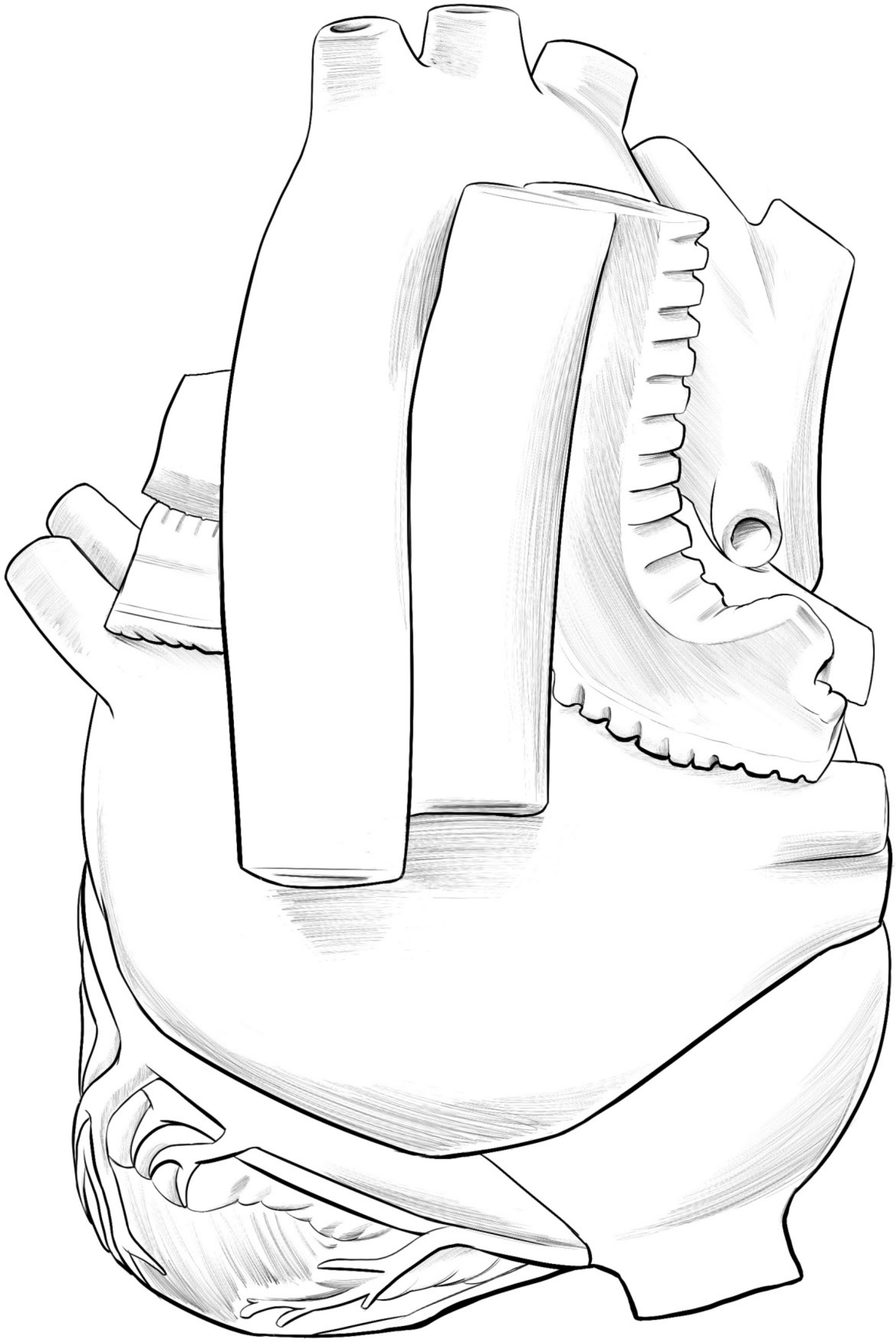
Looking at the posterior side of the heart, you can see many of the same structures as the anterior side. The four chambers (**right atrium**, **right ventricle**, **left atrium**, **left ventricle**) are visible. The major vessels can also be seen, including the **superior and inferior vena cavae**, 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 artery	☐	Right pulmonary artery
☐	Apex	☐	Left pulmonary veins	☐	Right pulmonary veins
☐	Inferior vena cava	☐	Left ventricle	☐	Right ventricle
☐	Left atrium	☐	Right atrium	☐	Superior vena cava

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.

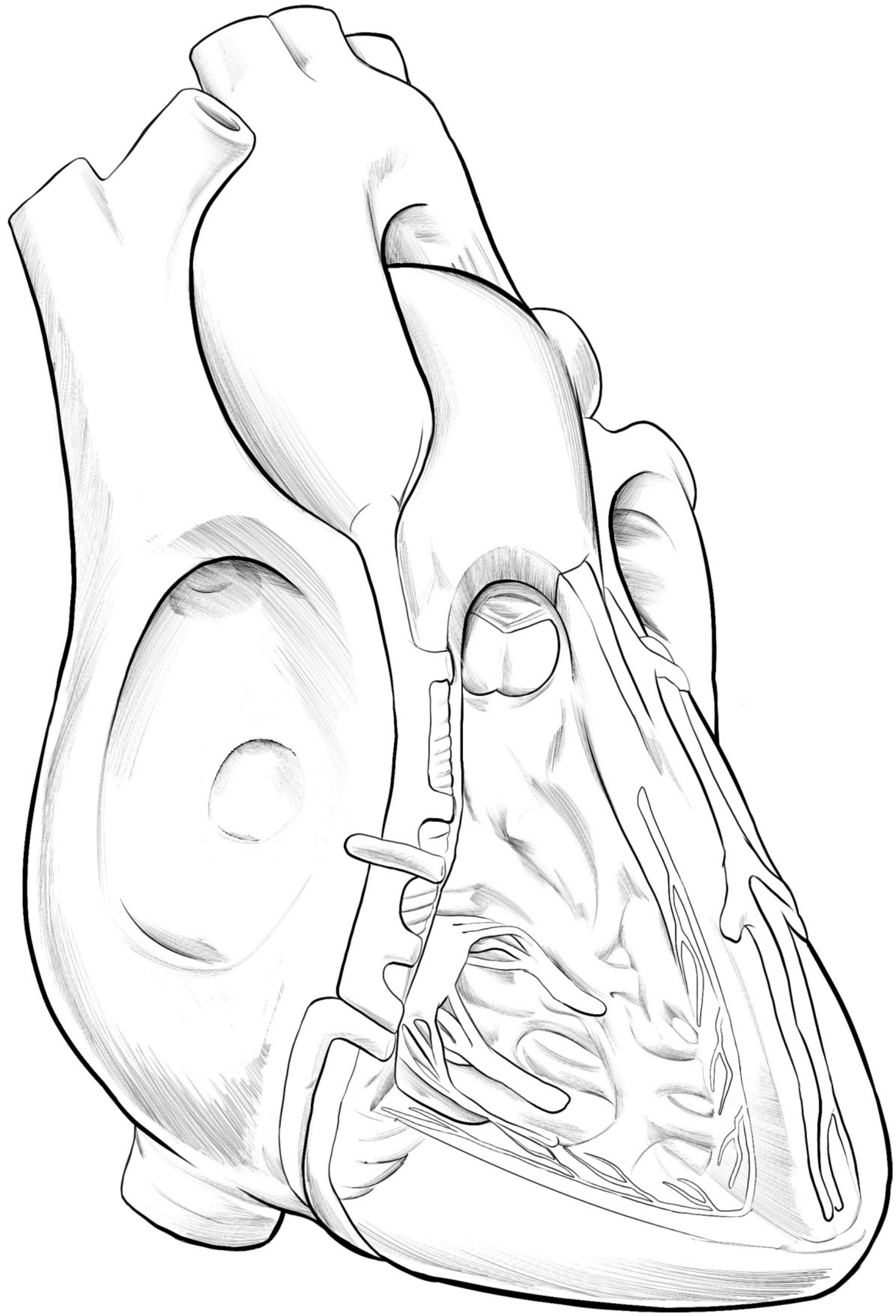
<u>Activity:</u>

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.

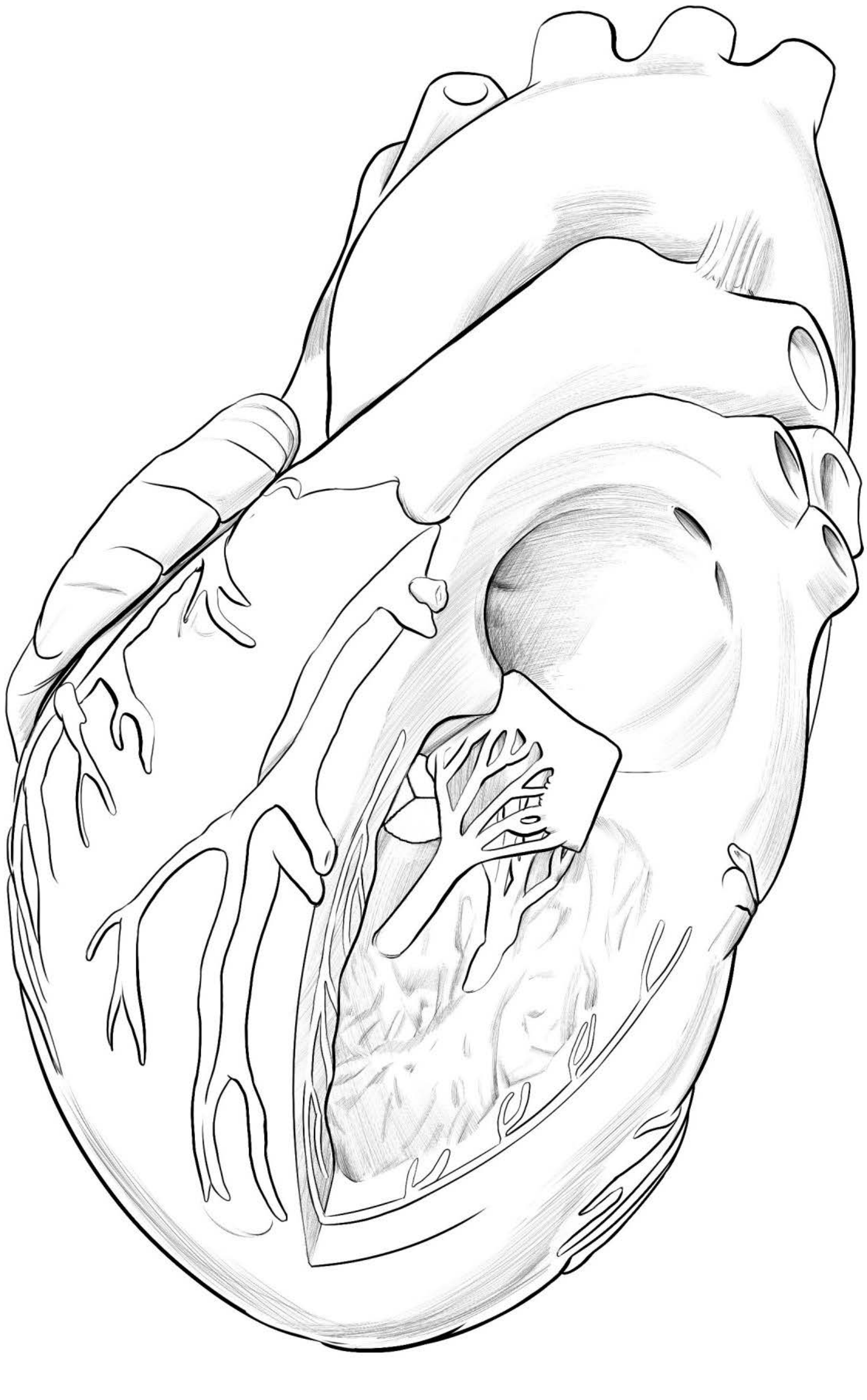
<u>Activity:</u>

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.

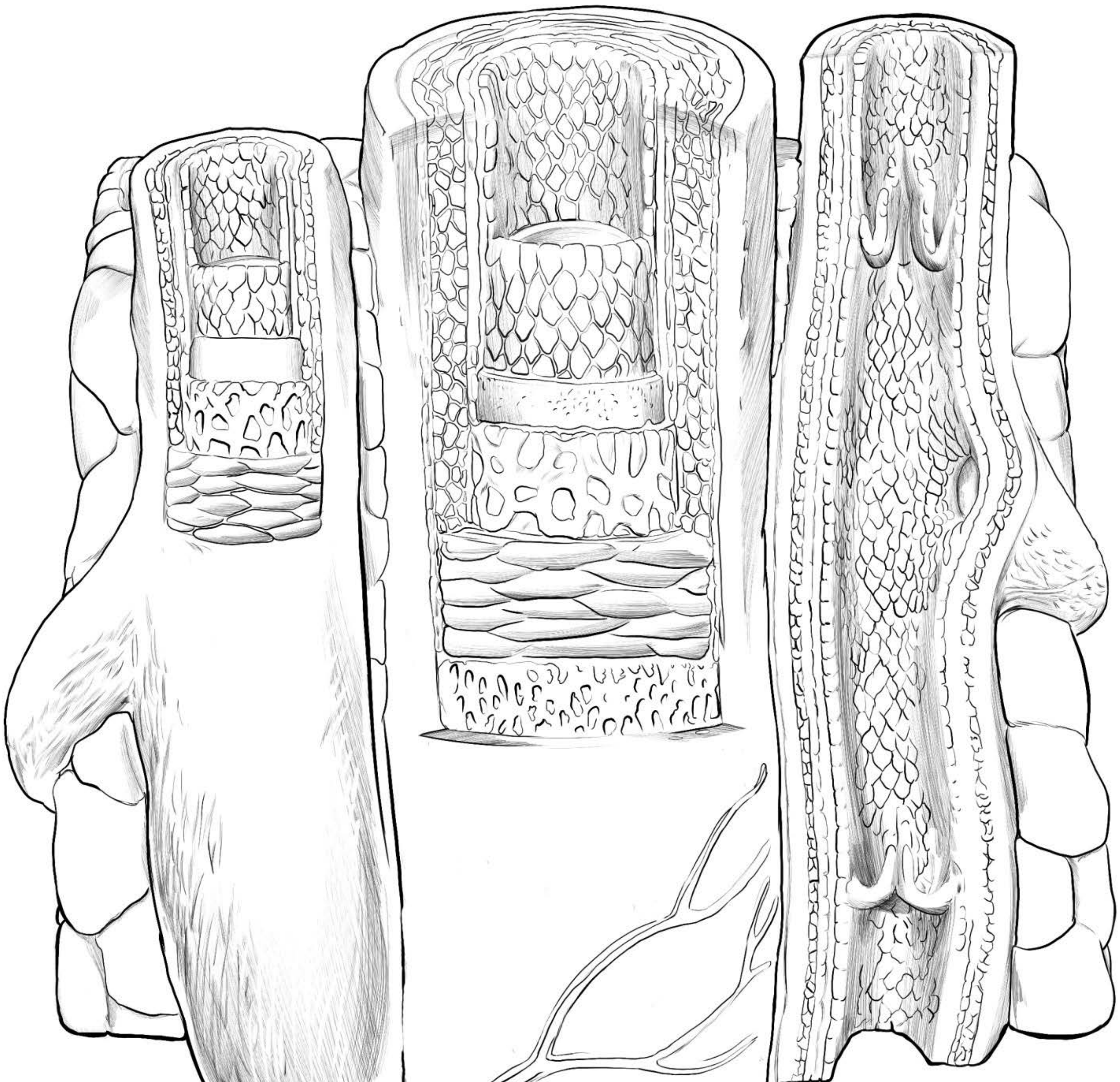
Activity:

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 on the right side of the diagram, while the veins are shown on the left.

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**.

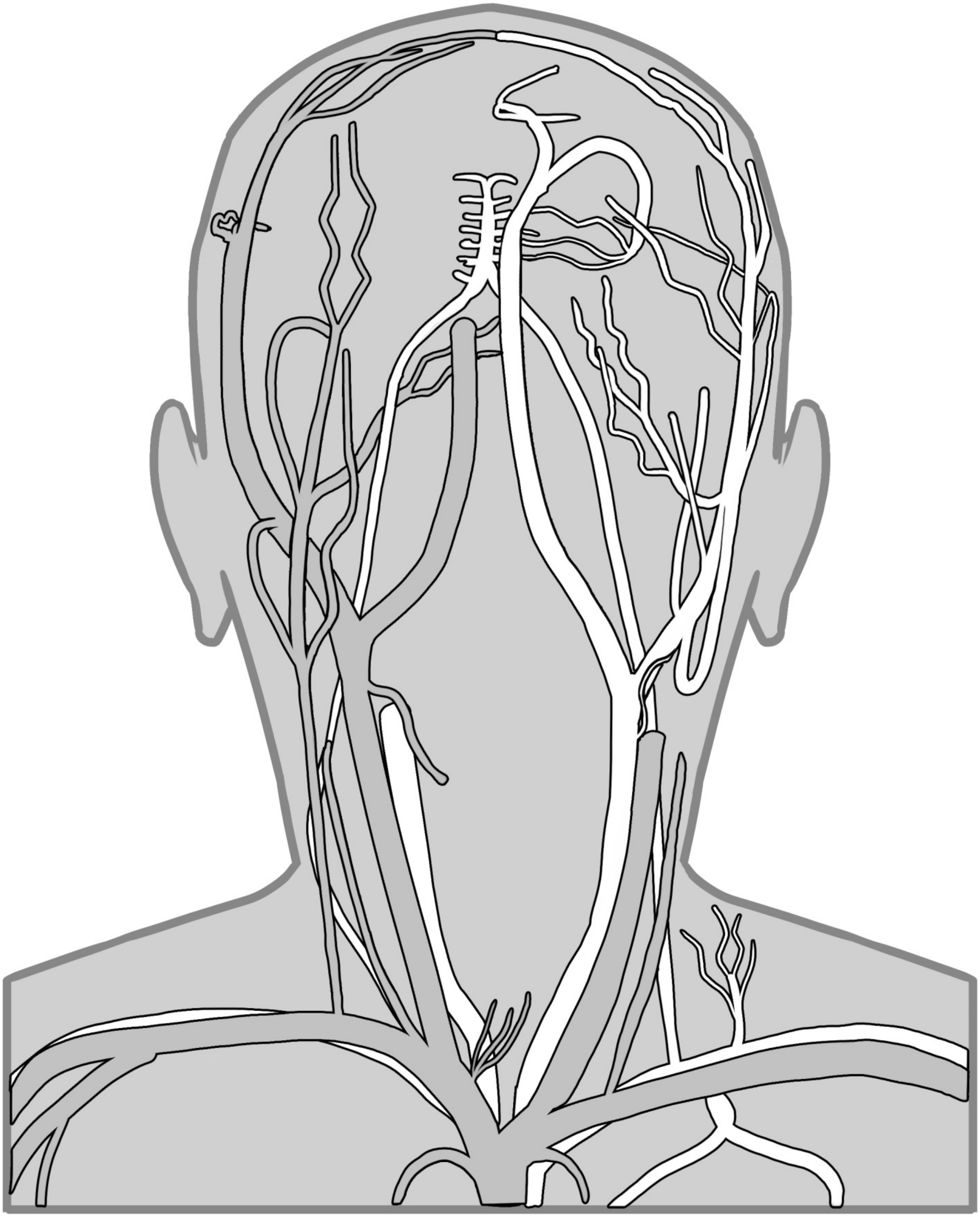
Activity:

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** medially, which supplies the medial forearm, and the **ulnar artery** laterally, which supplies the lateral forearm. These two arteries rejoin to supply blood to the hand.

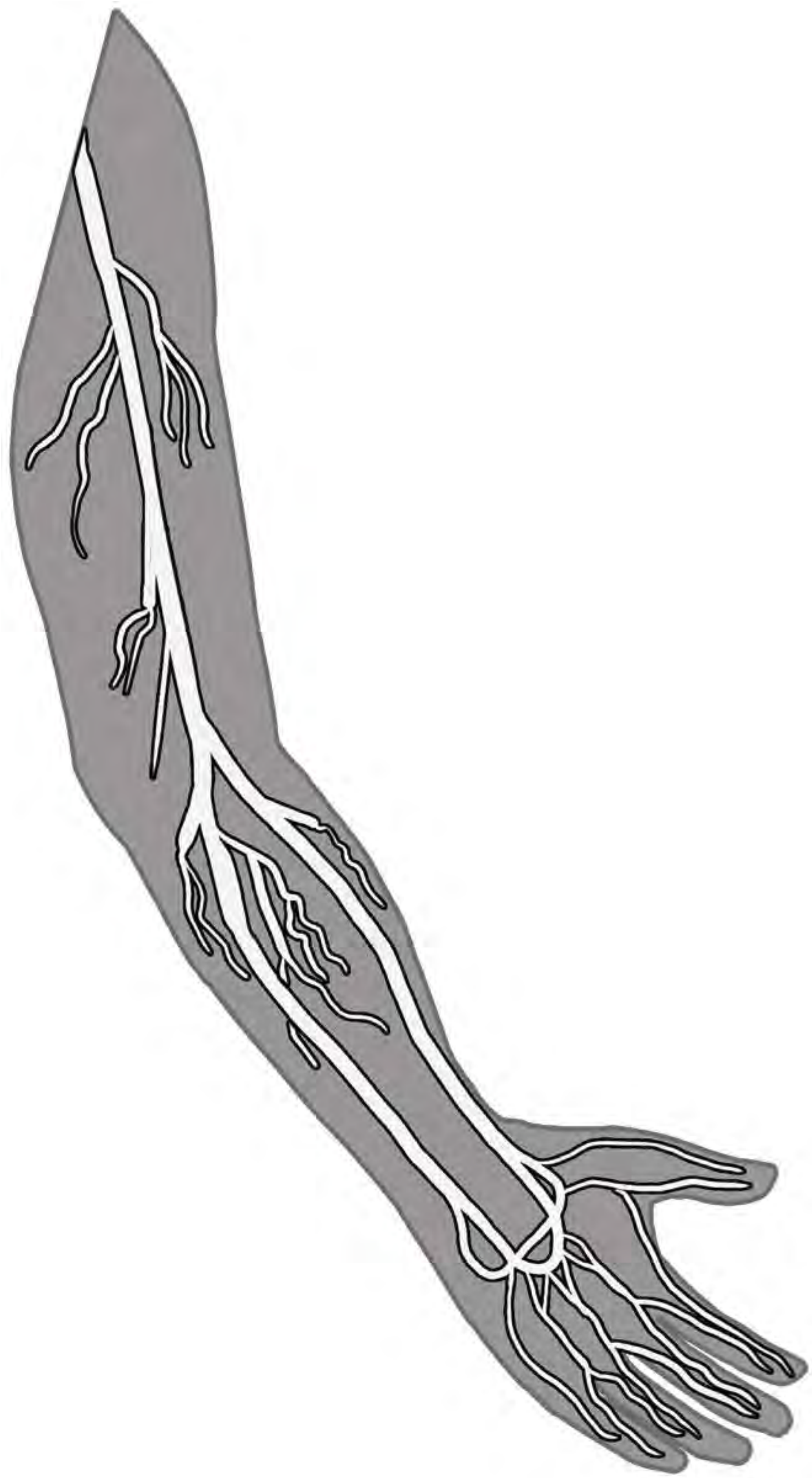
<u>Activity:</u>

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 medial forearm) and the **ulnar vein** (which drains the lateral 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 **medial cubital vein**. In our model, the median cubital vein is replaced by two short veins: the **median cephalic vein** laterally and the **medial basilic vein** medially. These two short veins receive blood from the **median vein of the forearm**, which drains the forearm.

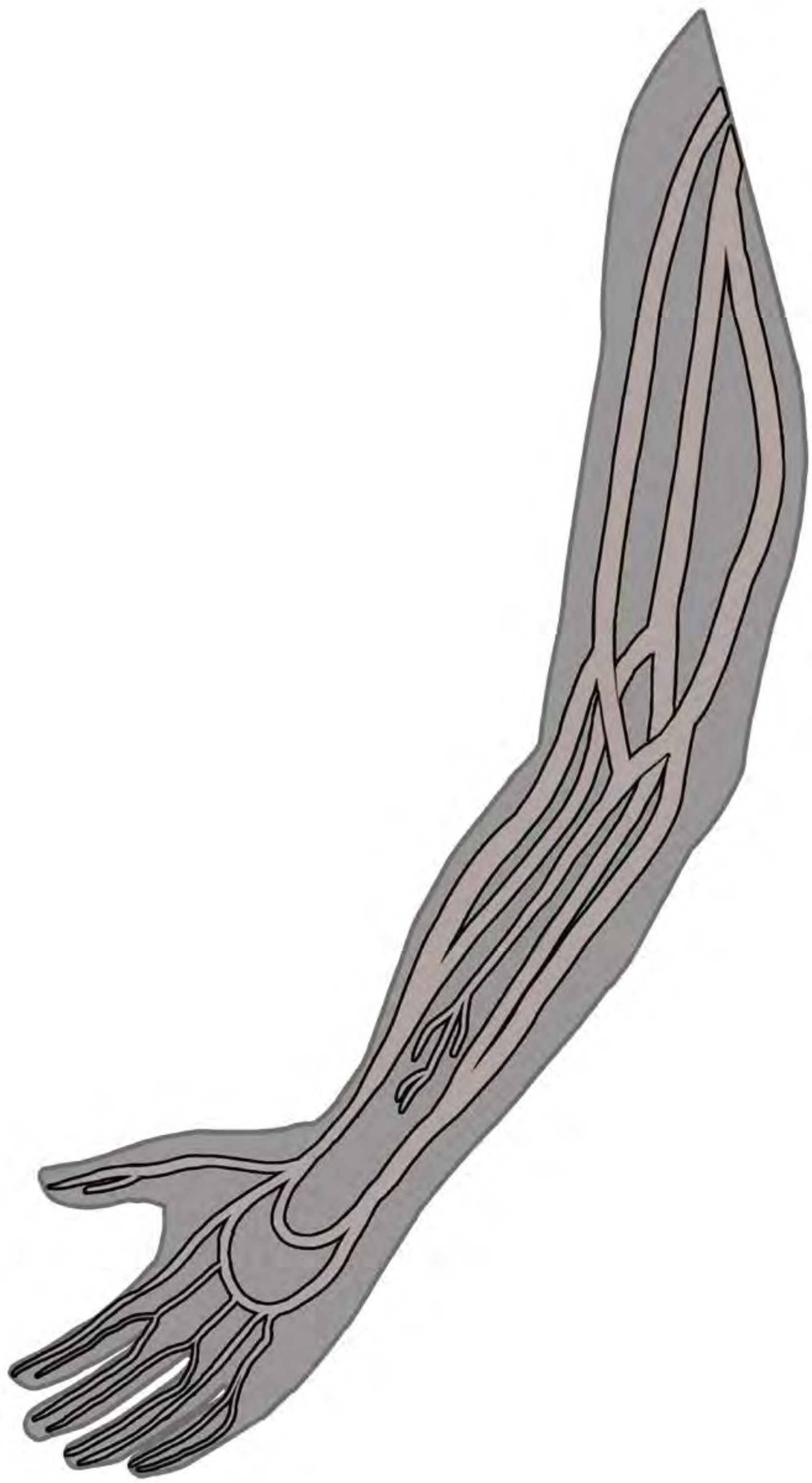
Activity:

1. Identify the following veins:

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

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**.

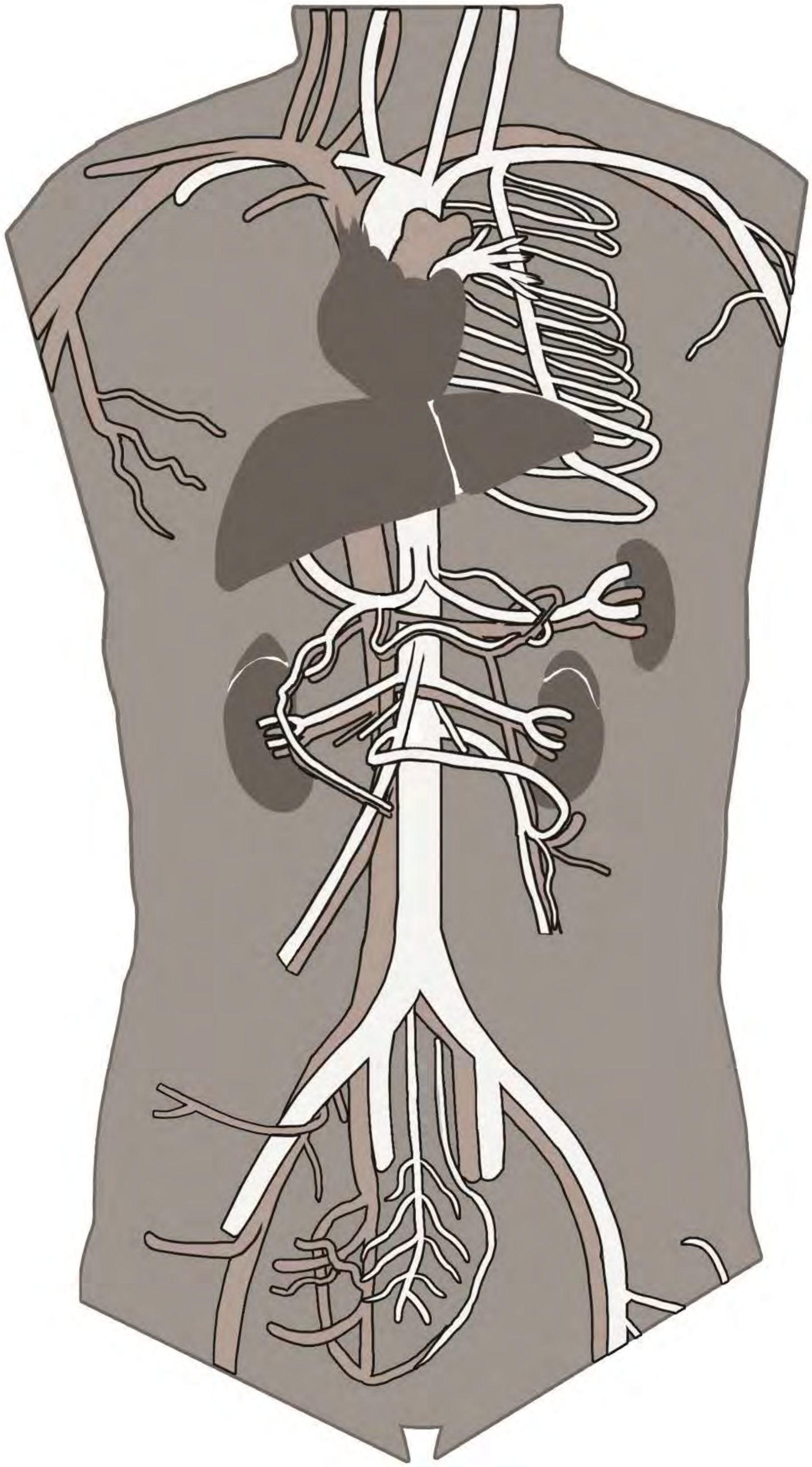
Activity:

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.

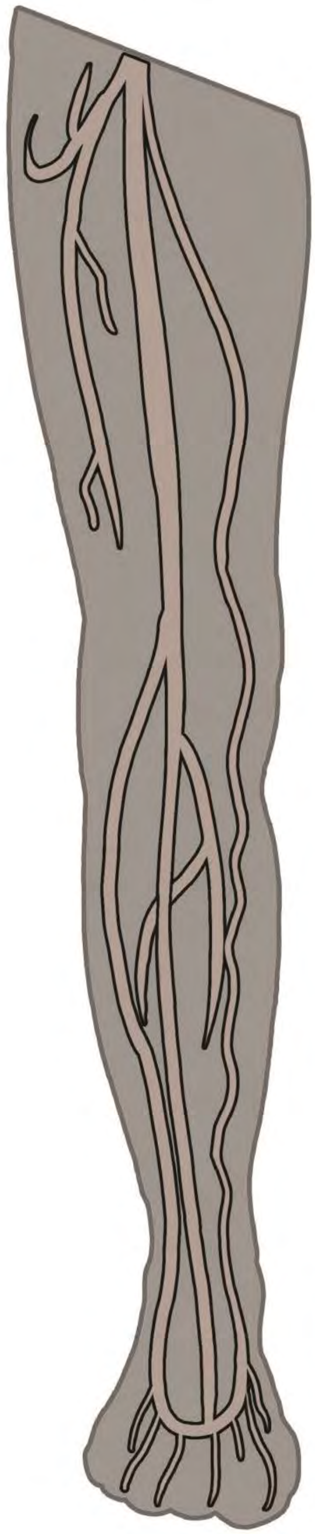
Activity:

1. Identify the following veins:

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

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.

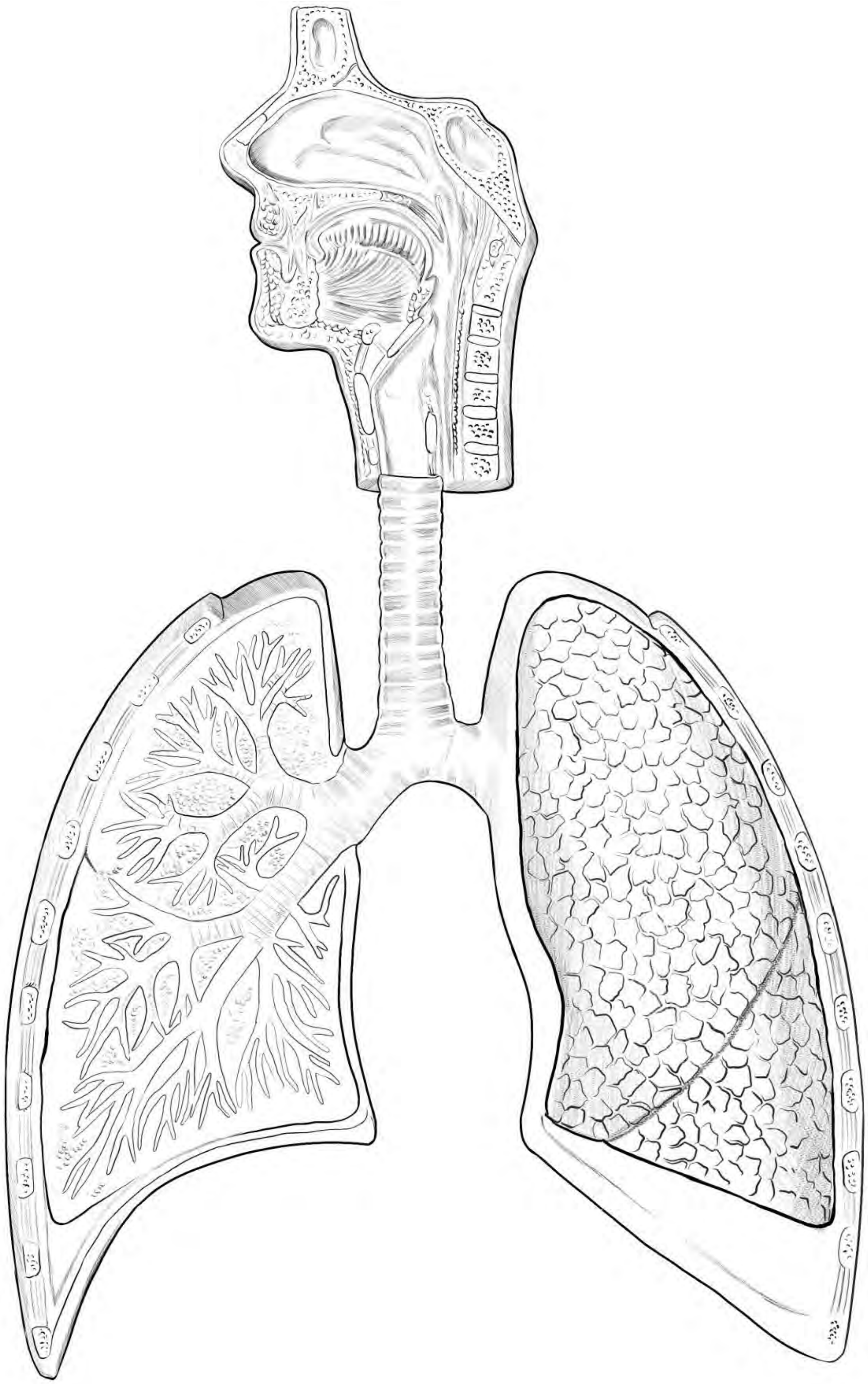
Activity:

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.

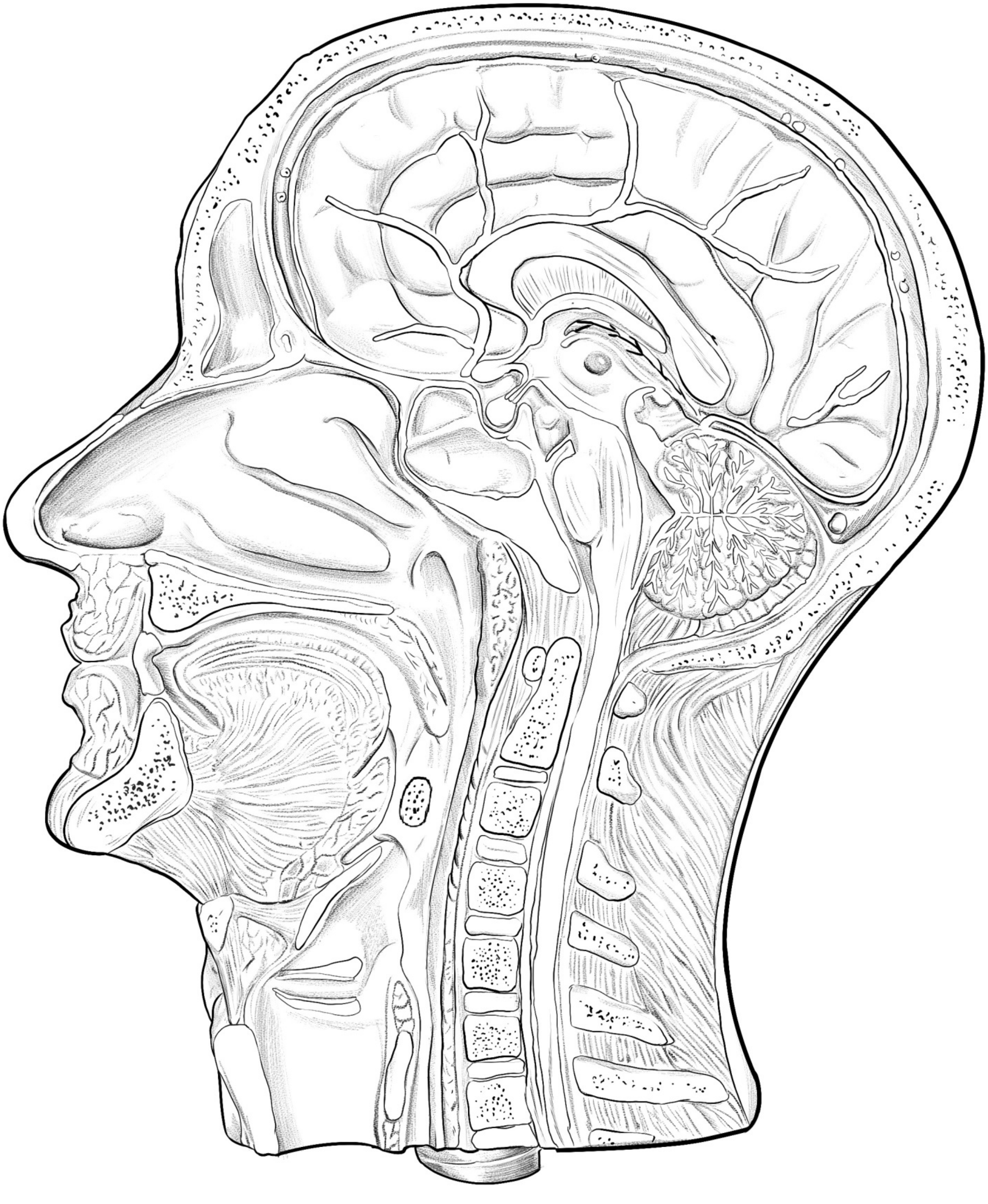
The nasopharynx should not have any food in it, only air. During swallowing the **uvula** of the soft palate rises and closes the oropharynx from the nasopharynx, thereby preventing food from entering the nasopharynx. The oropharynx and laryngopharynx, however, both allow for the passage of food and 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.

<u>Activity:</u>

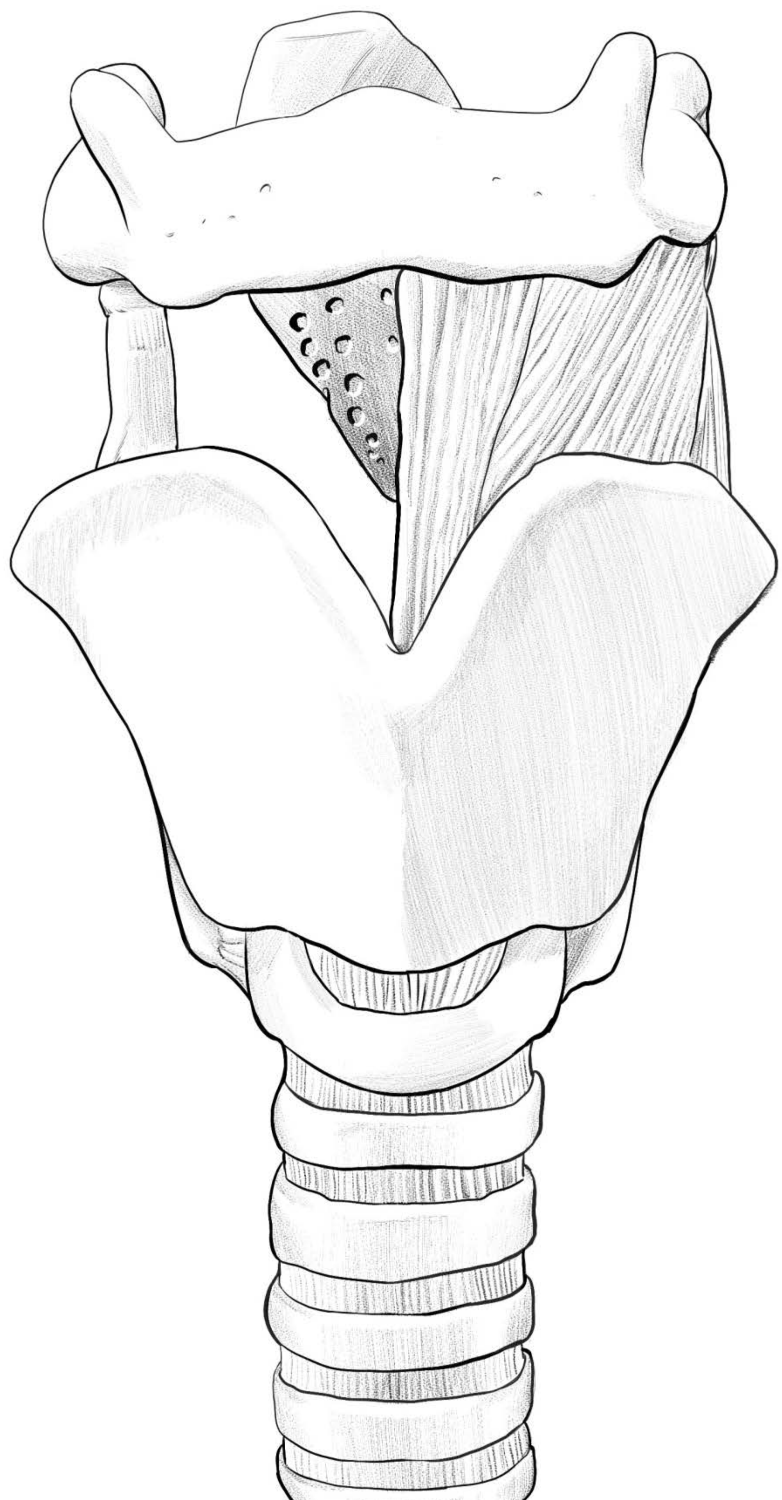
1. Identify the following structures:

☐ 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>

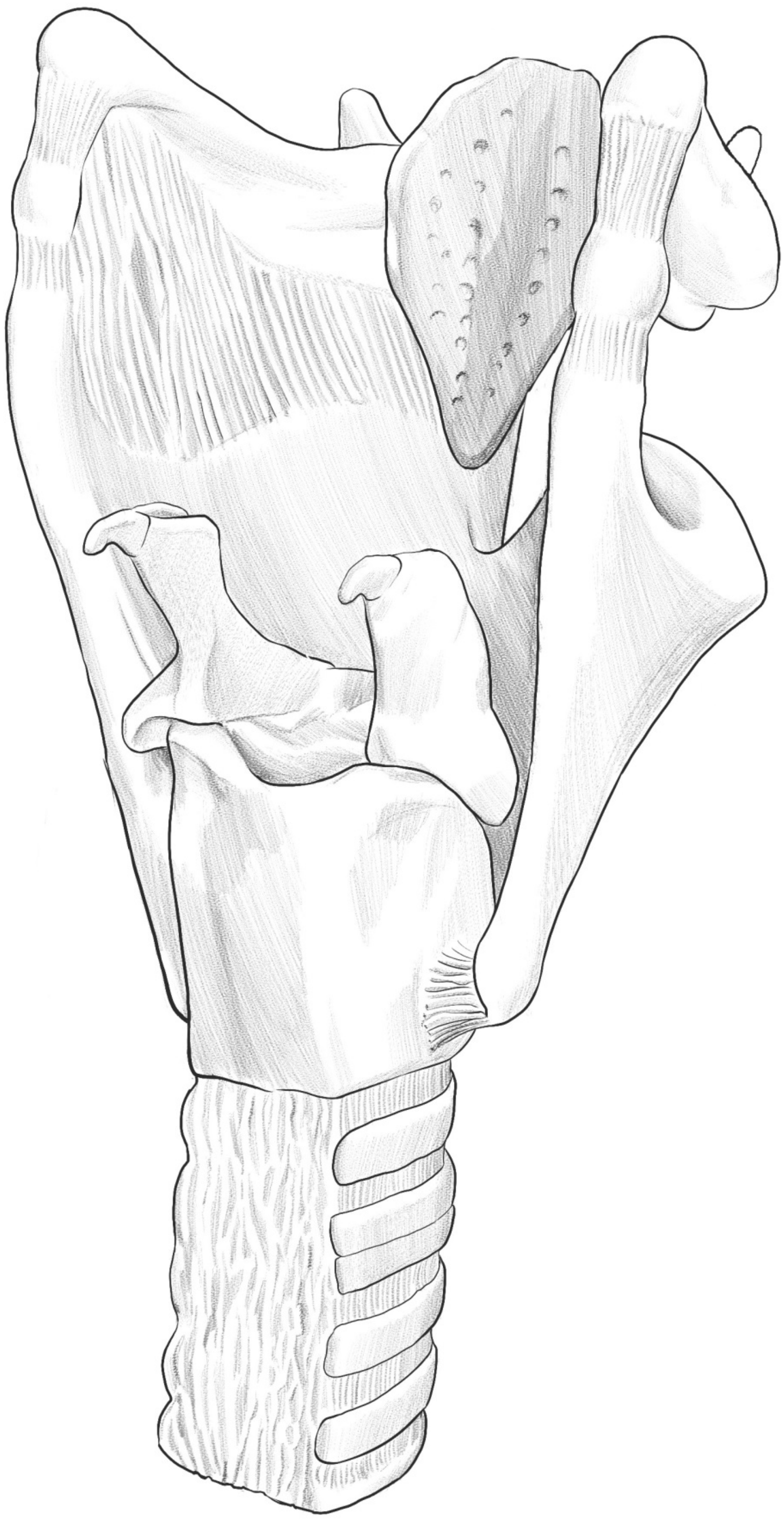
1. Identify the following structures:

☐	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.

<u>Activity:</u>

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.

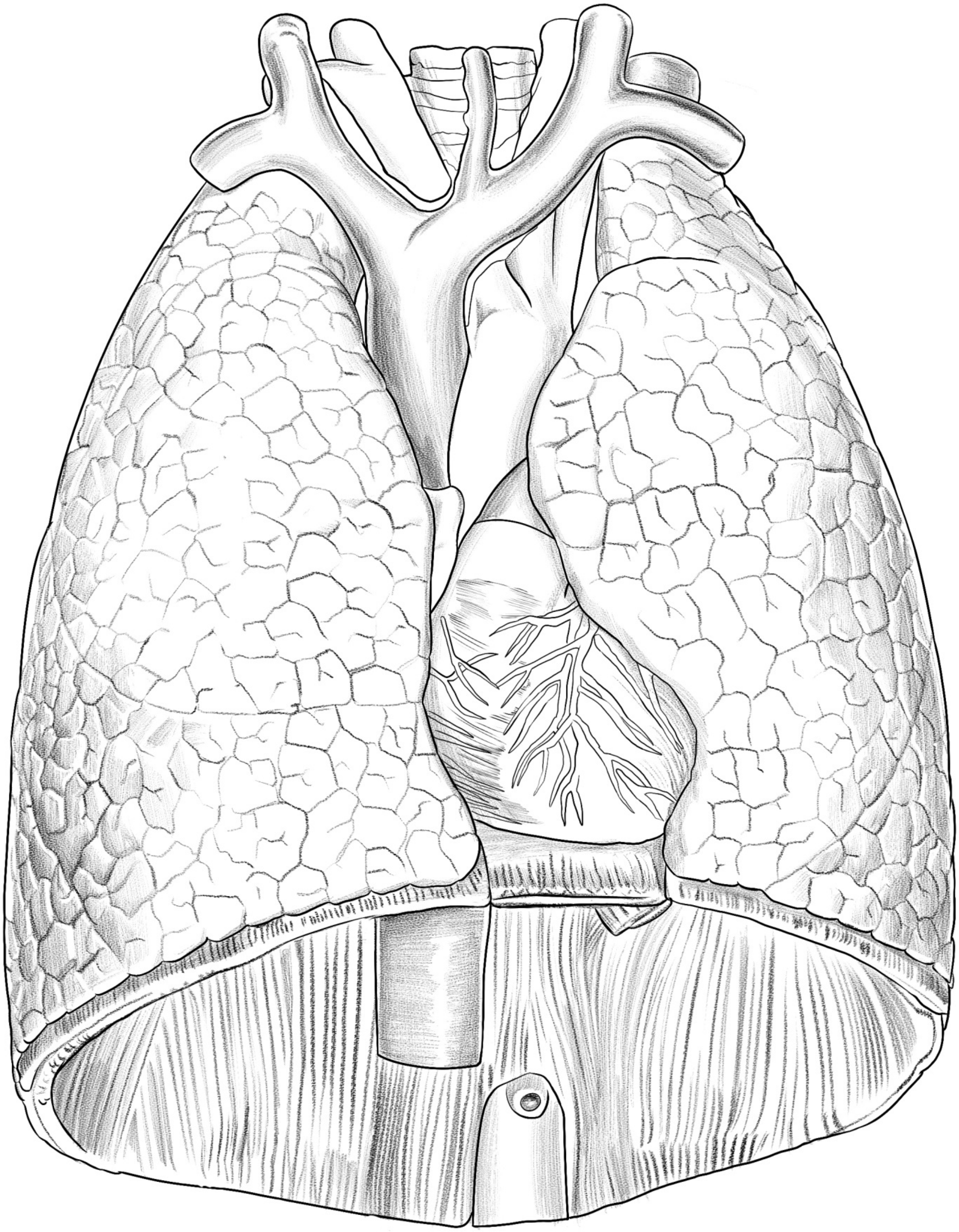
Activity:

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.

<u>Activity:</u>

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