Human Anatomy Lab Manual

Human Anatomy Lab Manual

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Contents

Banner image for 333 syllabus page. Excerpt from colored woodcut cover of Vesalius' historic text "De humani corporis fabrica libri septem", from 1543.

Welcome to Human Anatomy Laboratory, the study of the structures of the human body. Our goal is to make this one of the most relevant courses you will take in college. Our anatomy is made up of the structures derived from our skin, our skin (integument), and the structures under our skin that allow us to move, consume and distribute nutrients, send signals throughout the body, and much, much more. An understanding of human anatomy is essential for those entering health careers and other relevant fields, such as biomedical engineering and medical research. Most importantly, understanding your anatomy can help you make informed decisions about your health.

This anatomy lab course is designed to provide a foundation of knowledge in human anatomy and identification of anatomical structure through engaging activities and clinical application. The course will take a regional approach, beginning with a brief introduction to histology, radiology, and body systems followed by three sections covering different body regions: thorax, abdomen, and pelvis; head and neck; and the lower and upper extremities.

We will use human cadaveric specimens, radiology, virtual dissection programs, hands-on-activities, models, and palpation to help understand structural and functional anatomy. We will apply this information with case studies of injury and pathology. By the end of this course, you will have developed a thorough understanding of the anatomy of the human body, be able to apply that knowledge to make informed decisions about your health and be prepared for future studies and practice as a clinician in a variety of health settings.

COURSE LEARNING OUTCOMES

Upon completing this course, students will:

1. Identify key structures of the human body, including muscles, organs, and bones, and their characteristics.
2. Explain how structure governs function.
3. Recognize how structures work together in normal function.
4. Use anatomical terminology in communication with others in the health field.
5. Apply anatomical knowledge and identification skills in preparation for practice as a clinician in a variety of health fields.

PART I

UNIT 1: THORAX, ABDOMEN, AND PELVIS

Lab 1: Course Introduction | Introduction to Anatomy

LEARNING OBJECTIVES:

- Explain how the course is set up and where to find important information about the course.
- Describe anatomical position and properly use directional terminology with respect to that position.
- Associate how the basic principles of common radiological methods are used clinically.
- Interpret how cross-sectional anatomy relates to 3D anatomy.
- Explain the function of various bony markings.

TERMS TO KNOW

Positions and Planes

- Anatomical position
- Coronal (frontal) plane
- Transverse (horizontal) plane
- Sagittal plane
- Midsagittal (median) plane
- Prone / Supine

Axes of Rotation

- Anteroposterior axis
- Vertical axis
- Transverse axis

Terms of Motion

- Flexion / Extension
- Dorsiflexion / Plantar flexion
- Abduction / Adduction
- Circumduction
- Pronation / Supination
- Medial rotation / Lateral rotation

Terms of Direction

- Anterior / Posterior
- Superior / Inferior
- Medial / Lateral
- Proximal / Distal

Radiology Terms

- Radiograph (X-Ray)
- Computed Tomography (CT)
- Magnetic Resonance Imaging (MRI)

Bone markings

- Sites of muscle attachment
    - Tuberosity
    - Crest
    - Trochanter
    - Line
    - Tubercle
    - Epicondyle
    - Spine
    - Process
- Articular surfaces
    - Head
    - Facet
    - Condyle
- Depressions, openings, passageways
    - Foramen
    - Groove
    - Sulcus
    - Fissure
    - Notch
    - Fossa
    - Meatus
    - Sinus

INTRODUCTION

Welcome to Anatomy & Physiology 338: Human Anatomy Laboratory! Today we will begin with an introduction to this human anatomy lab course. We will discuss the logistics of the course, and you can ask any questions you might have. We also ask that you review the course Canvas website for additional details about the course. We put great effort into providing you with all of the information you need in a user-friendly way on the website. In the future, we ask that you look at the website before emailing questions to TAs or Professors.

After the introduction to the course, we will view a presentation on radiology methods. Following that exercise, we will break up into groups and go through four stations: a review planes of motion, movement, axes, and directional terminology; an introduction to cross-sectional principles; an introduction to the Navigator; and an introduction to bones and bony markings.

RADIOLOGY PRESENTATION

The most common way you will interact with anatomy in the clinic is through **surface anatomy.** Surface anatomy is the anatomy that we can see from the surface of the body. For example, if you look at your knee, you can see where the patella (or kneecap) is. We will explore surface anatomy throughout the course. Palpation is the part of a medical examination in which the clinician uses their hands to touch or feel the anatomy. For example, if you touch your patella and feel its anatomy, you are palpating the surface anatomy of that structure. We will also explore anatomy through palpation.

Another common way you will interact with anatomy in the clinical setting is through radiological imaging. Your TAs will give a presentation describing the different types of radiological images that you may see in the clinic. The key take-aways that you should get from the presentation are in the questions below. A PDF copy of the questions can be found in the worksheet posted on the Lab 1 Canvas page.

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https://wisc.pb.unizin.org/humananatomylabmanual/?p=52#h5p-2

LAB ACTIVITY 1: ANATOMICAL TERMINOLOGY, PLANES, MOTION, AND AXES

For this activity, you will work in small groups to answer anatomical terminology, planes, and motion questions. You can find the questions in the worksheet posted on Canvas and in the interactive modules below.

ANATOMICAL TERMINOLOGY

Anatomical terminology is the language used to describe the structures and functions of the human body. It is also the language used in medicine. You can use the [Glossary of Anatomical Terms] to learn these terms. This document is also posted on the course Canvas page. You are not required to know all terms and word parts in the glossary, though they may be helpful to reference when you are learning new terms. You are expected to know the terms of direction on the second page of the glossary and all terms listed at the beginning of this lab guide.

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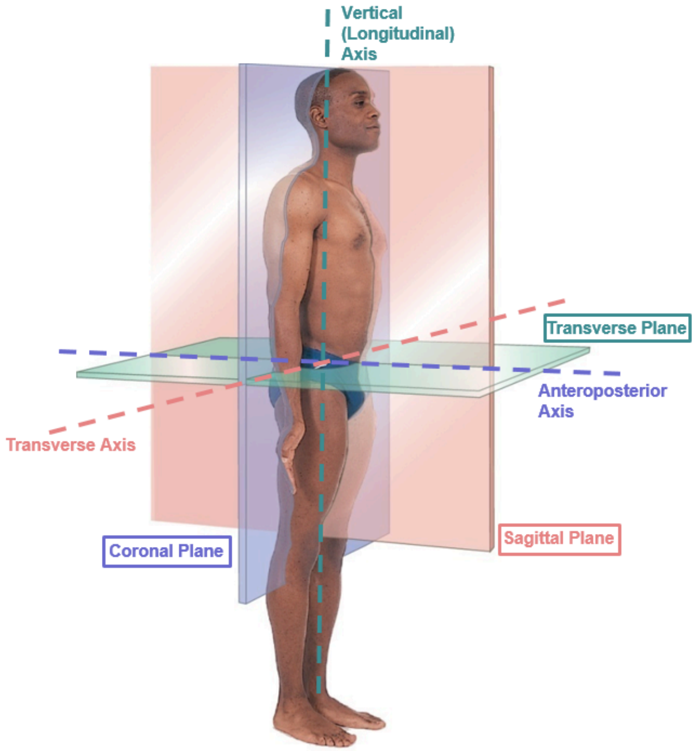
Why is it important to use the anatomical terms of direction from the activity above and the list of terms in your lab guide? Discuss this with your classmates and provide your answer.

ANATOMICAL PLANES AND MOTIONS

Our muscles produce movements at our joints. Those movements occur around axes and within planes of motion. Specific movements usually only occur within certain planes. The planes of motion and their associated axes and movements are described in the table below.

Plane	Axis	Description
Sagittal	Transverse	Bisects the body from front to back, dividing it into **left and right portions**. Flexion and Extension movements usually occur in this plane.
Coronal / Frontal	Anterior-posterior	Bisects the body laterally from side to side, dividing it into **front and back portions**. Abduction and Adduction movements occur in this plane.
Transverse / Horizontal	Vertical	Divides the body horizontally into **superior and inferior portions**. Rotational movements usually occur in this plane.

Completing the movements yourself can be a great way to learn motions. With a classmate, actively complete the following motions and identify the associated plane.



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Elbow flexion and extension

- Ankle dorsiflexion and plantar flexion
- Abduction and adduction of the hip
- Abduction and adduction of the shoulder
- Horizontal abduction and adduction of the shoulder (raise your arm to the side and reach across your body)
- Trunk rotation
- Lateral bending of the trunk (bend to the side)
- Internal and external rotation of the glenohumeral joint (shoulder)

- Cervical (neck) rotation to the right
- Flexion of the trunk
- Extension of the cervical spine
- Flexion and extension of the knee
- Hip extension

Work with a partner to answer the questions in the following activities and/or the worksheet (posted here and on Canvas). Some of the questions in the activities and worksheet overlap, while some differ. You are encouraged to use both resources as practice when learning these anatomical terms.

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For more practice, work with a partner to complete the following table (also in the worksheet).

Exercise	Joint	Movement	Plane	Axes
Squat / Standing up from a chair	Knee			
	Hip			
Push-up (lifting up from the ground)	Elbow			
	Shoulder			
Jumping Jack (moving your arm over head and your feet outwards)	Hip			
	Shoulder			

LAB ACTIVITY 2: CROSS-SECTIONS

In this activity, you will work through a PowerPoint on the computers in the lab. You will view cross-sectional images of objects, and you will be asked to guess what the objects are. You will be prompted to think about a few questions as you go through the activity.

LAB ACTIVITY 3: BONY MARKINGS

Review the bony markings in the activity below before working through the activities and markings exercises. ***You do not need to know the names of specific markings on specific bones at this time** (e.g. lesser trochanter, deltoid tuberosity).* For now, you should understand the general names for different bony markings and the purpose of each marking (e.g., attachment site, passageway, space a structure runs through). Understanding the terminology and purpose of these bony markings, in general, will help you when you learn specific bony markings later in the course.

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Look at the bones on display and note the areas marked with a star or an arrow. The markings at these stations will match up with the letters indicated below. Complete the following questions below. A

PDF copy of the questions can be found in the worksheet posted on the Lab 1 Canvas page.

When reviewing bony markings, ask yourself:

- Why might these areas exist on bones? Specifically, why are there holes within the skull?
- Why are there locations on long bones that are rough, smooth, protruding, grooved, or depressed?

Bony markings on the humerus:

A. This is a tubercle (greater tubercle). What is the purpose of this protrusion?

B. This is a groove (bicipital groove). What is the purpose of this groove?

C. This is an epicondyle (medial epicondyle). What is the purpose of this protrusion?

Bony markings on the scapula:

A. This is a fossa (supraspinous fossa). What is the purpose of this area?

B. This is a spine (scapular spine). What is the purpose of this area?

C. This is a process (Coracoid process). What is the purpose of this projection?

Bony markings on the skull:

A. This is a foramen (Foramen Magnum). Why are there holes like this in the skull?

Bony markings on the femur:

A. This is a trochanter (Greater trochanter). What is the purpose of this structure?

B. This is the head of a bone (Femoral head). Why does it have a smooth surface?

C. This is a condyle (Medial condyle). Why does it have a smooth surface?

LAB ACTIVITY 4: THE NAVIGATOR

In this activity, students will learn how to use the Anatomage Navigator. This tool includes a 3D printed model, a digital rendering of the model, and cross-sectional images of the human cadaver that the model was created from. The tool allows you to see the different levels of the body in cross-section. Layers and structures can be added or removed in the digital model so that you can examine specific structures.

- The TAs or PLAs will lead you through a demonstration of how to use the navigator.
- When working on your own, you can use the "Using the Navigator" instructions next to the computer to practice using the Navigator for reference. Be sure to practice using every tool on the instructions sheet. For now, you will be using the torso model. There is also a head and neck model that we will use later in class.
- We will begin using the Navigator to explore specific structures in the lab starting in Lab 2. It is important to use this lab activity to familiarize yourself with the tool to get the most out of the tool in the upcoming labs. While the computer interface technology is not as intuitive as we would like it to be, the tool itself is incredibly valuable. One of the most challenging skills to attain in anatomy (and medicine) is understanding how the 3D anatomy you view in the lab relates to the 2D image you will see in radiology and cross-sections. The Navigator is an excellent tool for helping you gain that skill.

Lab 2: Spinal Cord | Vertebral Column | Trunk Wall Part I

LEARNING OBJECTIVES:

- Describe the gross anatomy of the spinal cord and identify its regional variations.
- Identify the level and gray and white matter regions of the spinal cord on the cross-sectional images.
- Identify the anatomical features of the vertebrae and sacrum.
- Identify the bones of the thoracic cage and their anatomical features.
- Identify and describe the function of the muscles of the back and abdominal wall.

TERMS TO KNOW

Spinal Cord Gross Anatomy

- Cervical region
- Thoracic region
- Lumbar region
- Sacral region
- Cervical enlargement
- Lumbar enlargement
- Conus medularis
- Cauda equina
- Meninges
    - Dura mater
    - Arachnoid mater
    - Pia mater
        - Denticulate ligament
        - Filum terminale
- White matter
    - Dorsal column
    - Ventral column
    - Lateral column
- Grey matter
    - Posterior horn
    - Lateral horn
    - Anterior horn
- Central canal
- Dorsal root ganglion
- Dorsal root and rootlets
- Ventral root and rootlets
- Spinal nerves
- Dorsal rami
- Ventral rami

Muscles of the Trunk Wall

- External Oblique
- Erector Spinae
    - Iliocostalis
    - Longissimus
    - Spinalis

Bones of the Thoracic Cavity

- Ribs
    - True
    - False
    - Floating
    - Costal cartilage
    - Articular (Costal) facet of the transverse process
    - Head
- Sternum
    - Manubrium
    - Body
    - Xiphoid process
    - Sternal angle
    - Suprasternal notch
    - Clavicular notch

Vertebral Column

- Spinous process
- Transverse process
- Superior articular process
    - Superior articular facet
- Inferior articular process
    - Inferior articular facet
- Vertebral foramen
- Intervertebral foramen
- Body
- Cervical vertebrae
- Transverse foramen
- Atlas
    - Occipital condyles
    - Anterior Arch
    - Posterior Arch
- Axis
    - Dens
- Thoracic vertebrae
    - Superior costal demifacet
    - Inferior costal demifacet
- Lumbar vertebrae
- Sacrum
- Coccyx

- Intervertebral discs
- Ligaments
    - Anterior longitudinal ligament
    - Posterior longitudinal ligament

INTRODUCTION

In this lab, you will be examining the spinal cord, vertebral column, bones of the thoracic cage, and the abdominal wall. The spinal cord serves as the connection between our peripheral nervous system and the brain. The central region of gray matter is primarily composed of cell bodies and unmyelinated axons. The outer region of white matter is composed mainly of myelinated axons ascending, carrying sensory information, to the brain, or descending, carrying motor information, from the brain to the target tissues.

The vertebral column supports the body's weight and helps transmit forces between the upper and lower extremities. The muscles of the abdominal wall act on the vertebral column to create movements such as lateral bending, rotation, flexion, and extension at the trunk. These muscles are also constantly working to stabilize the trunk and vertebral column both with movement and at rest. The bones of the thoracic cage connect directly or indirectly to the thoracic vertebrae and together form a protective "cage" around the thoracic and some abdominal organs.

This is the first lab during which we will examine human cadaveric tissue. In this lab, you will examine spinal cord. You will also view abdominal wall musculature on a cadaver. **Please be respectful and appreciative of the gift our donors have given. Handle the tissue with great care!!! Be *very* gentle when moving the tissue to examine the various structures.**

LAB ACTIVITY 1: SPINAL CORD ANATOMY

WET SPINAL CORD SPECIMENS

We have three wet human spinal cord specimens for you to view in this lab. You should view all three by the end of the lab. Anatomical variation is common, and each spinal cord is slightly different. You could be asked to identify structures on any of the spinal cords on an exam. Some of the spinal cords have been sectioned. This tissue came from UW Hospital, and these cuts were made as part of the autopsy. **Be very careful and gentle when handling these specimens!**

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- Observe the spinal cord as a whole. Is it shorter or longer than you expected it to be? Though our vertebral column extends down from the skull to our coccyx, the spinal cord only extends down to the L1 vertebral level. The **conus medullaris** is the somewhat cone-shaped inferior end of the spinal cord at this level. Identify this structure on the spinal cord. Notice all of the string-like extensions of nerves hanging off of the conus medullaris. Because the spinal cord ends at L1, the nerve roots exiting the vertebral column below that level have to leave the spinal cord at this level and travel through the vertebral column to get to the level that they will exit the vertebral column. This group of spinal nerves is called the **cauda equina** (Latin for "horse's tail").

- Observe the cervical region of the spinal cord. Notice that part of this region is larger (wider) than the rest. The wider section is the **cervical enlargement**. Now observe the region just above the conus medullaris, and notice that it is also larger than the area just above or below it. This larger region is the **lumbar enlargement**.

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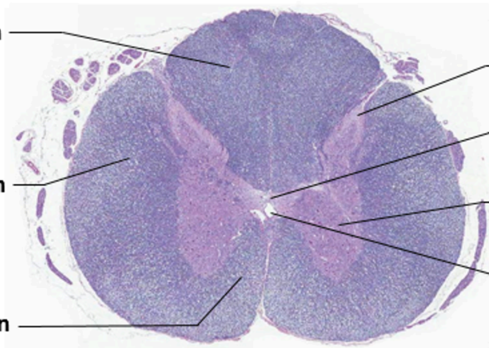
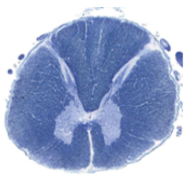
- The **meninges** are the layers of tissue that surround the brain and spinal cord. You can see them on the spinal cords in the lab. The **dura mater** is the tough outer layer. The **arachnoid mater** is the thin, transparent layer, deep to the dura mater. It can be seen on the spinal cord itself. The final layer, directly touching the spinal cord, is the **pia mater**. You cannot see the pia mater directly surrounding the spinal cord (or brain), as it is too thin. However, there are two places where you can observe the pia mater without magnification.

    - The **filum terminale** is an extension of the pia mater that anchors the spinal cord from the conus medullaris to the coccyx. Gently move the nerve roots of the cauda equina to the side to view the very tip of the conus medullaris. You will see a string-like projection off of the conus medullaris that is lighter in color than the nerve roots of the cauda equina. This is the **filum terminale.**
    - *Gently* move the dura mater to see the space between the dura and lateral aspect of the spinal cord. Look along the length of the spinal cord in this lateral region, and you will see a few triangular-shaped sections of tissue. The base of the triangle is coming from the spinal cord, and the tip is connecting to the dura mater. These are the **denticulate ligaments,** and they function to anchor the spinal cord laterally to keep it centrally located within the vertebral column.
- Observe the roots exiting the spinal cord. The smaller branches immediately leaving the spinal cord are called rootlets, and the rootlets merge to form roots. This tissue is dissected so that the dura mater is cut anteriorly, making the anterior or ventral portion of the spinal cord more easily visible. Therefore, the branches that you most easily see exiting the spinal cord are the **ventral roots (**and **rootlets)**. These carry motor information from the spinal cord out to the muscles. In this view, the **dorsal**

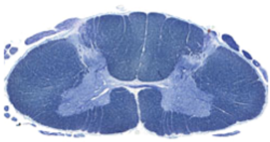
roots (and **rootlets**) are deep to the ventral roots, but you may be able to see them in some cases. These carry sensory information, including fine touch, pain, and proprioception from the periphery to the spinal cord.

- Follow the dorsal and ventral roots to the dura mater, and on the outer aspect of the dura mater, you will see a small ball-like swelling at a few levels. This is the **dorsal root ganglion**, which houses the cell bodies of the sensory neurons traveling through the dorsal root.
- Just past the dorsal root ganglion, you may be able to observe that the dorsal and ventral roots merge for a short distance. This is called the **spinal nerve.** Motor and sensory information mix in the spinal nerve, and then two branches extend out into the periphery. The **dorsal ramus** runs dorsally to innervate the muscles and skin of the back. The **ventral ramus** runs anteriorly to innervate the muscles and skin of the extremities and anterior trunk. Most of the other nerves we will observe in this course originate from the ventral rami. *While it is unlikely that you will see the rami on the spinal cord tissue, you can observe these structures in images in the Netter's atlas.*

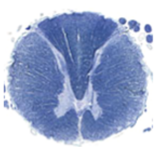




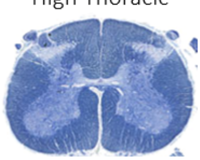
High Cervical



Cervical Enlargement



High Thoracic



High Lumbar

- On the cut spinal cords, gently examine the cross-sections. You can see the white matter and gray matter at the gross level without special preparation and staining. In this case, the white matter looks darker, and the gray matter looks lighter. This is because of the preservative used on this tissue. Review the parts of the spinal cord in cross-section. Observe different levels along the spinal cord to see how the white and gray matter changes in cross-section from superior to inferior. You can also review the spinal cord regions and regional variations in grey and white matter using the cross-sectional image at the right.

PLASTINATED SPINAL CORD

We have one plastinated human spinal cord for you to observe in this lab. This spinal cord is sitting within the vertebral column. The vertebrae have been cut at the lamina, and the spinous process has been removed. This procedure is called a laminectomy, and it allows you to view the spinal cord *in situ* within the **vertebral foramen**.

- Observe the spinal cord as a whole, and compare its length to the vertebral column. Notice how the dorsal and ventral roots run more horizontally in the cervical region but tend to leave the spinal cord and run downward to reach their exit point (intervertebral foramen) at the lower thoracic and lumbar levels. Observe **cervical and lumbar enlargements** as well as the **conus medullaris** and **cauda equina.**
- Though the *meninges* are difficult to see here, you can observe the **filum terminale** within the cauda equina, anchoring the spinal cord to the coccyx. You can also see a few **denticulate ligaments** anchoring the spinal cord

laterally.

- Follow the **dorsal and ventral roots** and observe the small swelling, or **dorsal root ganglion**, near the intervertebral foramen. Just past the dorsal root ganglion, you may be able to observe that the dorsal and ventral roots merge for a short distance. This is called the **spinal nerve.**

LAB ACTIVITY 2: PLASTIC SPINAL CORD MODEL

We have two plastic spinal cord models for you to observe in this lab. The spinal cord models are 5-times life-size. To orient yourself, when looking at the spinal cord, the cross-sectional images will be on the right, and the *3B* symbol will be on the top left of the base. While looking at the spinal cord model in this position, the side closest to you is ventral. The side furthest away from you is dorsal.

- Review the spinal cord models using the laminated images and key to identify structures from the terms to know list above. (The terms on the key in light gray are numbered on the laminated images, but you are **NOT** responsible for knowing them for the lab, although they might help you for the lecture course.)

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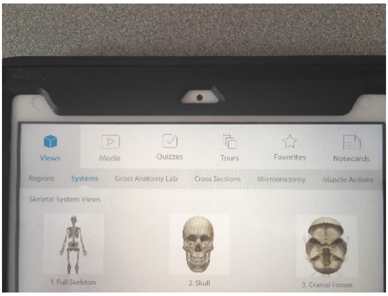
LAB ACTIVITY 3: TRUNK WALL AND THORACIC CAGE – DIGITAL HUMAN ANATOMY ATLAS

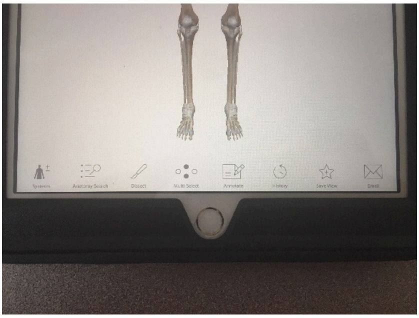
Today you will have the opportunity to learn how to use the Human Anatomy Atlas app by *Visible Body* on the iPad while examining the trunk wall. From the home screen on the iPad, click on the Atlas app. You will now be on the home page of the app (if it asks you to continue where you left off, select "No").

Under the **Views** icon, you will see Regions, Systems (the preset), Gross Anatomy Lab, Cross-Sections, Microanatomy, and Muscle Actions on the top bar. Take a



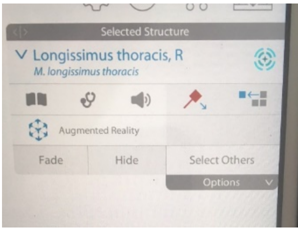
minute to get a feel for the icons in the app and where they will take you. You will not need to use other icons aside from the views for the majority of this class.

Under the **Systems** tab, scroll down to the **Muscular System Views.** You can expand this region by clicking the carrot at the bottom of the system, saying “Show More….”



Once you click on a specific structure/ area, there will be new icons at the bottom of the screen:

- For the time being, you should be familiar with the **multi-select** button only. If at any time you have moved the image too much or made a mistake and want to reset the view, click the **reset** button.

- 

Another feature to learn is how to use the **Selected Structure** box. When you have selected a structure, for example, a muscle or a bone, the selected structure box will appear in the upper right corner of the app. The structure will appear in light blue, and there are a few icons you should be able to use. The book will provide you further information on the structure and muscles. This will provide you the origin, insertion, innervation, action, and blood supply. The speaker icon will provide you the annunciation of the term. Finally, the isolate button (looks like four blocks) can isolate the structure. The **Fade** tab will allow you to fade the selected structure. The **Hide** button will remove selected structures.

The other intuitive features of the app are common amongst all smartphones; pinch to zoom out, separate your fingers to zoom in, rotate left to right, and up or down.

Now examine the muscles of the trunk wall.

- Click on the systems icon, then find the **Muscular System Views.** Now find the files marked **14. Upper Back**, **15.**

Lower Back and **16. Abdomen**. Using the features of the app (fade, hide, zoom, rotate), identify the following muscles and tissue (work from superficial to deep):

- **External Oblique**
- **Internal Oblique**
- **Transversus Abdominis**
- **Rectus Abdominis**
  Erector spinae: Iliocostalis, Longissimus, Spinalis.
- **Anterior longitudinal ligament** of the spine. This ligament helps to prevent hyperextension of the vertebral column.
- **Supraspinous ligament** of the spine

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- Highlight each muscle and look at the box on the upper right-hand side of the screen and review the action of each muscle (click the book icon for the muscle description, including origin, insertion, innervation, action, and blood supply). *In addition to identifying these muscles, you are only responsible for* *knowing their name and action(s)*. Be sure to look at each muscle from various angles to appreciate the architecture and orientation of the muscle fibers. This is important when considering the action of the muscle. For example, look at the fibers of the external oblique. This can be considered the "pocket muscle" as the fibers run in the same direction as your fingers when you put your hands in your pockets. A muscle will contract and "pull" in the direction that its fibers are running. *Therefore, what do you think the function of the external oblique muscle may be?*

- At the top of the home page on the app, there is a Muscle Actions file that, when you click, you will be able to see the motions of spine flexion, spine extension, spine lateral flexion, and spine rotation. Explore these movements of the trunk. Observe each movement and how each of the muscles listed above contributes.

Now explore the bones of the thoracic cage. Under **Systems** and **Skeletal System Views**, click on **9. Thoracic Cage.**

- Click on the second rib, then click on bony landmarks (the small pelvis icon with colors on it). From here, you can see more bone features, including the head, neck, shaft, and costal cartilage.
- Continue to isolate a few other ribs (2, 8, 11) to see some differences between the true, false, and floating ribs.

- You can also isolate the sternum and its segments the same way you did the ribs. Become familiar with the parts of the sternum from the list of terms to know above.
- Lastly, isolate a thoracic vertebra as you did with the ribs & sternum. Observe the bony landmarks on the vertebrae, specifically where the ribs articulate (Costal facet of the transverse process, superior costal demifacet, inferior costal demifacet).

LAB ACTIVITY 4: TRUNK WALL

Today you will be able to view some of the structures of the trunk wall on the cadaver. The cadaver will be in the prone position, so only posterior and a portion of the lateral structures will be visible in this lab. In lab 3, the cadaver will be in the supine position, and you will be able to view the other structures of the trunk wall at that time.

Observe the **erector spinae** muscles. These muscles are deep to the latissimus dorsi and trapezius muscles. **Spinalis** is relatively thin and medial, closest to the spine. **Longissimus** is the longest of the erector spinae muscles. **Iliocostalis** is the most lateral of the three erector spinae muscles and runs from the iliac crest of the pelvis to the ribs (costals). When these muscles contract bilaterally, they extend the spine and help to maintain upright posture against gravity. Unilateral contraction contributes to lateral flexion. You can also observe the **external oblique** running anteriorly on the lateral aspect of the abdominal wall. This muscle rotates the trunk to the opposite side and assists with lateral flexion.

LAB ACTIVITY 5: SPINAL COLUMN AND VERTEBRAE

Bony landmarks of the vertebrae: For each vertebra, identify the following landmarks:

- Spinous process
- Transverse process
- Superior articular facet
- Inferior articular facet
- Vertebral foramen
- Intervertebral foramen
- Body
- Intervertebral foramen (observed by stacking two adjacent vertebrae together)

Spinal column regions: Identify the following structures/ landmarks specific to vertebrae from different spinal cord regions.

- **Cervical vertebrae**
    - Transverse foramen

- Atlas
  - Anterior Arch
  - Posterior Arch
- Axis
  - Dens

- **Thoracic vertebrae**
  - Costal facets/demifacets
  - **Note**: *If demi means half and a demifacet is a half facet, what has to happen for a whole facet to be created*? Think about the arrangement of vertebrae. We will look at these facets more closely in the next lab.
- **Sacrum**
  - Anterior/posterior sacral foramina
  - Sacral Canal
  - Superior articular facet
  - Five fused bodies of vertebrae/transverse ridges
  - Median sacral crest
- **Coccyx**
  - Three to five fused vertebrae

Compare the superior and inferior articular processes and facets of a thoracic and lumbar vertebra. Notice that these facets of the thoracic vertebrae are oriented more within the coronal plane, while the facets of the lumbar vertebrae are oriented more within the sagittal plane.

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BONUS ACTIVITY!

If you have time, try carefully arranging the vertebrae in anatomical order from superior to inferior. First, separate the vertebrae into the appropriate groups by examining them and observing their unique features. Try to make your first attempt without looking at the atlas. Do not worry about having each vertebra in the exact spot it belongs. For example, you won't be able to distinguish T9 from T10. Just do your best to put them in the correct order based on shape and size.

LAB ACTIVITY 6: RIBS & STERNUM

Using the bones and the standing articulated skeleton, examine the **true, false, & floating ribs**. Also, observe the **costal cartilage** connecting the sternum and ribs. This is best seen on the standing skeleton.

Examine the following bony landmarks:

- **Ribs**
  - **Head**
  - **Articular facet of the transverse process (**on the thoracic vertebrae**)**
- **Sternum**
  - **Manubrium**
  - **Body**
  - **Xiphoid process** (may not be present in the set of bones)
  - **Suprasternal notch**
  - **Clavicular notch**
  - **Sternal Angle**

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These structures may be difficult to identify on the isolated sternum. Try to palpate these structures on your own sternum. At the superior aspect, palpate the **suprasternal notch**. As you move about two inches inferiorly, you can feel the **sternal angle**, where the manubrium meets the body. Just lateral to the sternal notch, you can palpate the sternoclavicular joint and **sternoclavicular notch**, where the sternum articulates with the clavicle (collarbone).

Take a rib and two adjacent thoracic vertebrae & examine the articulations of these three bones. Notice how the superior demifacet of the inferior vertebrae & inferior demifacet of the superior vertebrae form one full facet articulating with the rib head. Notice the costal facet on the transverse processes of the thoracic vertebrae.

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LAB ACTIVITY 7: RADIOLOGY OF THE VERTEBRAL COLUMN, THORACIC CAGE, AND SPINAL CORD

View the slideshow on the computers identifying the anatomy of the vertebral column, thoracic cage, and spinal cord in radiology images. The unlabeled images are also provided on canvas as a study tool.

Lab 3: Trunk Wall Part II | Heart | Respiratory System

LEARNING OBJECTIVES:

- Identify the muscles of the thoracic cage involved in respiration and describe their functions.
- Identify the components of the respiratory system, including the trachea, bronchi, and lungs.
- Identify the great vessels transporting blood to and from the heart and outline the pattern of blood through the heart and lungs.
- Identify the internal and external anatomical features of the heart.
- Identify the valves of the heart and understand how valves regulate blood flow through the heart.

- Identify and describe the location and branches of the coronary blood vessels.
- Identify structures of the thoracic cavity using various imaging modalities, including X-Ray, CT, and Echo.

TERMS TO KNOW

Muscles of Respiration

- Internal intercostal
- External intercostal
- Serratus posterior inferior
- Serratus posterior superior
- Diaphragm
  - Phrenic nerve

Trunk Wall

- External oblique
- Internal oblique
- Rectus abdominis
- Transversus abdominis

Respiratory System Structures

- Trachea
  - Carina
  - Trachealis muscle
- Bronchi
- Lungs
  - Alveoli
  - Oblique fissure
  - Horizontal fissure
  - Superior lobe
  - Middle lobe
  - Inferior lobe
  - Hilum

Great Vessels

- Aorta
  - Ascending aorta
  - Aortic arch
  - Descending aorta
- Superior vena cava
- Inferior vena cava
- Pulmonary Trunk
  - Right and left pulmonary arteries
- Pulmonary Vein

Heart Anatomy

- Atria
  - Auricle
- Ventricles
- Right atrioventricular (tricuspid) valve
- Left atrioventricular (bicuspid, mitral) valve
- Pulmonary semilunar valve
- Aortic semilunar valve
- Interventricular septum
- Trabeculae carneae
- Papillary muscles
- Chordae tendineae
- Fossa ovalis

Coronary Circulation

- Right coronary artery
  - Right marginal artery
  - Posterior interventricular artery
- Left coronary artery
  - Anterior interventricular artery
  - Circumflex artery
- Great cardiac vein
- Middle cardiac vein
- Small cardiac vein
- Coronary sinus

INTRODUCTION

In this lab, you will examine the muscles of respiration, lungs, heart, and roots of the great vessels. The lungs function for the exchange of oxygen and carbon dioxide between the alveoli and the blood. Our muscles of respiration allow us to inhale and exhale by expanding and diminishing the space in our thoracic cavity and, in turn, our lungs. The heart pumps blood throughout our body, carrying oxygen and nutrients to our tissues, carrying waste products away from our tissues, and much more.

You will have the opportunity to examine preserved human heart and lung tissue in this lab. We have this great opportunity thanks to the Pathology Department at UW hospital. ***Treat these specimens with care and respect.*** *As with all of the human specimens that we will view in this lab, we have the opportunity to examine them because the donors and their families were generous enough to allow us to learn from them. Appreciate how great this opportunity is, and give them the respect that they deserve.*

LAB ACTIVITY 1: MUSCLES OF RESPIRATION – DIGITAL ATLAS

Utilize the digital atlas to explore the muscles of respiration.

- Open the Atlas app and go to **Muscular System Views**.
    - Under the muscular system views, click on **9. Inhalation** and **10. Exhalation**.

- Identify the following muscles of respiration (work from superficial to deep). Highlight each muscle. The box on the upper right side of the screen shows the action of each muscle, and those actions are listed below as well. You are only responsible for the actions of these muscles (not the origin or insertion, for example). Be sure to look at the muscle from various angles and zoom levels to appreciate the architecture and orientation of the muscle fibers. This is important when considering the action of the muscle.
    - **External intercostals:** Elevate ribs with passive inhalation
    - **Internal intercostals:** Depress the ribs with forced exhalation
    - **Serratus posterior superior:** Elevate the ribs with forced inhalation
    - **Serratus posterior inferior:** Depress the ribs with forced exhalation
    - **Diaphragm:** Expands and increases the vertical dimension of the thoracic cavity, Increases pressure in the abdominopelvic cavity

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- Go back to the menu of the Atlas App and now go into the **Muscle Actions** tab.
    - Under the muscle actions, click on **Ribs elevation** and **Ribs depression.**
    - While in these views, the virtual cadaver will be moving. You can still touch each of the muscles listed above to see their role in either rib elevation or depression (inhalation or exhalation).

LAB ACTIVITY 2: TRUNK WALL AND MUSCLES OF RESPIRATION – CADAVER

In Lab 2 you viewed the posterior musculature of the trunk on the cadaver. In this lab you will view the anterior musculature of the trunk and thoracic cage.

Observe the **external oblique** on the lateral aspect of the abdominal region. Fibers of this muscle run anteriorly and inferiorly. Unilateral contraction of the external oblique rotates the trunk to the opposite side and assists with lateral flexion to the same side. Gently reflect the external oblique to observe the **internal oblique**. Fibers of this muscle run posteriorly and inferiorly. As a result, unilateral contraction rotates the trunk to the same side and assists with lateral flexion to the same side. Bilateral contraction of both the internal and external oblique contributes to trunk flexion.

Medial to the obliques, observe the **rectus abdominis** muscle.

This muscle appears as two flat muscles running vertically parallel to each other, separated by connective tissue called the linea alba. The linea alba has been cut here to reveal the abdominal organs. Additional horizontal lines of connective tissue separate portions of the muscle, giving the “six pack” appearance. The rectus abdominis flexes the trunk.

Deep to the obliques and rectus abdominis, observe the **transversus abdominis**. Fibers of transversus abdominis run relatively horizontally around the trunk. Contraction of this muscle bilaterally compresses the abdominal cavity, and unilateral contraction causes trunk rotation to the same side. On the left side of the cadaver the internal oblique has been separated from the transversus abdominus. On the right the fascia connecting the two muscles remains intact, and you can observe the superior portion of the transversus abdominus emerging deep to the internal oblique.

Observe the thoracic cage. The ribs have been cut to the left of the sternum in order to view the contents of the thoracic cage. However, you can move them back into anatomical position. View the sternum in the center of the thoracic cavity. Palpate the manubrium, body, and xiphoid process. Also palpate the sternal angle and suprasternal notch.

Between the ribs, observe the external and internal intercostals. You will need to open the thoracic cage to observe the internal intercostals on the internal aspect.

LAB ACTIVITY 3: HEART AND RESPIRATORY TISSUE – CADAVER AND ADDITIONAL DONOR

TISSUE

Full Cadaver

Observe the heart *in situ* in the cadaver. Observe its orientation. The right ventricle is inferior, resting on the diaphragm. The great vessels (aorta and pulmonary trunk) are visible superiorly. The right atrium is to the right, and the left ventricle is to the left. This heart is moderately enlarged compared to a typical heart.

The coronary arteries supply the heart with blood, and some are visible on the cadaver's heart. Notice the **anterior interventricular artery**, which is a branch off of the the left coronary artery. The **right coronary artery** can be seen branching off of the ascending aorta and traveling in the coronary sulcus. A small portion of the **right marginal artery** can be seen traveling along the right margin, or border, of the heart. The right coronary artery travels to the posterior aspect of the heart and gives of the **posterior interventricular artery**, which can be seen by *gently* lifting the heart to view its posterior aspect.

Observe the lungs in the cadaver. They are much smaller than usual, and the reason for this is unclear. Notice that the diaphragm is quite domed in shape and extends unusually superiorly into the thoracic cavity. The abdominal organs (which will be viewed in the next lab) also extend unusually far into the thoracic cavity (e.g. liver, hepatic flexure, spleen, etc.). The donor's cause of death was non-small cell lung cancer, but evidence if the disease is not evident by viewing the external aspect of the lungs. It is also unlikely to be the primary cause of the small lung size. The patient was a smoker, but that is also unlikely to cause the lungs to be this small and the abdominal organs and diaphragm to move this high into the thoracic cavity.

It is possible that the donor was born with smaller lungs, and the enlargement of the heart may have been compensatory to ensure the body received the oxygenated blood it needed. It is also possible that smoking or cancerous changes made the already small lungs even smaller. This likely would have been observed with imaging as part of the cancer diagnosis, but we do not have access to additional medical records for our donor.

Additional Donor Heart and Lungs

We also have heart and lung tissue (as well as abdominal and pelvic organs) from a second donor. The two coronary arteries and four primary branches arteries can be seen on this heart. ***Be extremely gentle when handling and turning this tissue.***

- **Right coronary artery** – Brach off of the aorta traveling to the right in the coronary sulcus
    - **Right marginal artery** – branching from the right coronary artery and traveling along the right margin of the heart
        - Supplies the right border (margin) of the right ventricle
    - **Posterior interventricular artery –** on the posterior aspect of the heart traveling between the right and left ventricles. This vessel is often called the posterior descending artery (PDA) in the clinical setting.
        - Supplies the posterior aspect of the right and left ventricles
- **Left coronary artery** – Brach off of the aorta traveling to the left in the coronary sulcus
    - **Anterior interventricular artery** – on the anterior aspect of the heart traveling between the right and left ventricles. This artery is often

called the left anterior descending artery (LAD) in the clinical setting.

    - Supplies the anterior aspect of the right and left ventricles as well as the interventricular septum

  - **Circumflex artery** – travels around the left aspect of the heart in the coronary sulcus between the left atrium and left ventricle
    - Supplies portions of the left atrium and ventricle

- *Note*** You can observe the left marginal artery along the left margin of this heart. You will not be asked to identify this artery.*

The **middle cardiac vein** can also be seen next to the posterior interventricular artery. It drains blood from the same area supplied by the posterior interventricular artery. The great cardiac vein, which travels with the anterior interventricular artery, and small cardiac vein, which runs with the marginal artery, cannot be observed here, but you can view these veins on the laminated images or with the visible body atlas. The great cardiac vein drains blood from the area supplied by the anterior interventricular artery, and the small cardiac vein drains blood from the same area supplied by the right marginal artery. These veins drain into the coronary sinus on the posterior aspect of the heart in the coronary sulcus.

Observe the great vessels. The **ascending aorta** leaves the left ventricle, and then the **aortic arch** arches to the left. The **descending aorta** descends through the thoracic cavity and continues into the abdominal cavity, carrying blood to the body tissues. The **pulmonary trunk** leaves the right ventricle and branches into the **right and left pulmonary arteries**. You can follow the pulmonary arteries to the hilum of the lung.

Observe the size of the lungs from this donor compared to the full cadaver donor. They are substantially larger and more typical in size. The right lung has three **lobes**: **Inferior, superior**, and **middle**. The **oblique** and **horizontal fissures** separate the lobes. The left lung only has two lobes due to the space taken up on the left side of the thoracic cavity. The two lobes of the left lung are separated by an oblique fissure.

Darkened spots may be observed occasionally throughout the lung. This can be evidence of smoke inhalation in some cases, and it can also occur with frequent inhalation of polluted air.

Also observe the trachea and the bronchi branching from the trachea and traveling to the hilum of the lungs.

LAB ACTIVITY 4: HEART TISSUE FROM PATHOLOGY AT UW HOSPITAL

The organs from pathology at UW hospital were cut at autopsy to allow the pathologists to search for disease in the tissues. Smaller cuts sequentially along the outside surface of the heart were made to investigate the condition of the coronary arteries. The coronary arteries are usually surrounded by adipose tissue.

The following provides some background on the hearts we have in our lab. Case A and Case C were both males with enlarged hearts (**cardiomegaly**). The heart in Case C is particularly enlarged. For reference, the typical male human heart weighs between 240-380g. (***Note: All cases tested negative for COVID-19**)

- **Case A:** This heart is from a male patient in his mid-50s. It is enlarged, with a weight of 500 g. The chambers are somewhat dilated, meaning the atria and ventricles have more space than they typically should. The valves were dilated, meaning the opening that blood travels through to enter or exit a ventricle was enlarged, increasing the risk for regurgitation of blood backward through the valve. The coronary arteries have mild atherosclerosis with calcification, with up to 50% stenosis (narrowing) of the anterior interventricular (left anterior descending, LAD) artery. You may be able to feel the calcification along these arteries in some locations.

- **Case B**: This heart is from a female patient in her early 60s. It is mildly enlarged at 400 g. The patient had a clinical history of hypertension. The left ventricle walls were borderline hypertrophic (thickened) to accommodate the increased force needed to push blood out of the heart and through the vessels of the body. There is evidence of a subendocardial (below the endocardium, or inner layer of the heart) hemorrhage resulting from refractory hemorrhagic shock in the left ventricle. All four valves of the heart are dilated, and the left atrioventricular (mitral, bicuspid) valve is fibrotic (thickening and loss of flexibility that can lead to valvular dysfunction). This heart also has a patent foramen ovale. The foramen ovale never closed at birth, so instead of a fossa ovalis being present on the interatrial wall, the foramen ovale passageway remains between the atria. See below for more information on the foramen ovale and fossa ovalis.

- **Case C**: This heart is that of a man in his early 60s. The patient suffered a sudden cardiac arrest following cirrhotic cardiomyopathy, a cardiac condition observed in patients with cirrhosis of the liver. Cardiomegaly was severe, with the heart weighing 740 g. The ventricles are hypertrophied (thickened walls), and all four chambers are dilated. These open spaces would not be this large in a healthy heart. The aortic valve is calcified, and atherosclerosis is present in the anterior interventricular artery (left anterior descending, LAD).

As you examine the hearts, you should identify several of these structures on most or all of the specimens. Not all structures will be clearly visible on every specimen, and that is OK.

- Observe the external features of the heart. In the region of the atria, notice a pouch-like structure. This is called the auricle, and there is one present on each atrium. It is visible on both the wet tissue and the plastinated hearts.
- Look inside the right atria and view the septum between

the left and right atria. Observe a small oval indent on the septum. This is the **fossa ovalis**. Before birth, there is no need for blood to go to the lungs because the fetus receives oxygen from the mother's circulation. The fossa ovalis is an opening in the fetus, then called the foramen ovalis. As a result, blood can bypass pulmonary circulation and go straight from the right atrium to the left and into systemic circulation. It closes shortly after birth, but the small oval indent, the fossa ovalis, remains. Notice that the foramen ovale never closed in case B. This is called a patent foramen ovale.

- Observe the ventricles. Notice that the left ventricle is thicker than the right. The left ventricle pumps blood out to the whole body, while the right ventricle pumps blood to the lungs.
- Observe the structures of the internal features of the heart from the list of terms.
    - The **right (tricuspid) and left (bicuspid, mitral) atrioventricular (AV) valves** prevent backflow from the ventricles into the atria. The **pulmonary** and **aortic semilunar valves** prevent backflow from the pulmonary arteries and aorta into the right and left ventricles. You should note whether or not it appears that the valve is near an artery or separating the atria and ventricles. You can also differentiate an AV valve from a semilunar valve by determining if the **chordae tendineae** are attached to it. The chordae tendineae prevent the AV valves from prolapsing (collapsing backward) into the atria.
    - The projections from the heart wall that attach to the chordae tendineae are the **papillary muscles**. They provide support to prevent

prolapse of the AV valves.

    - The muscular ridges on the walls of the ventricles are called the trabeculae carneae. Their function is not well-understood.
    - Also, observe the interventricular septum separating the right and left ventricles.

- Observe the great vessels entering and leaving the heart. The **aorta** leaves the left ventricle, while the **pulmonary trunk** leaves the right ventricle. The aorta has thicker walls than the pulmonary trunk. It may be difficult to distinguish the aorta from the other vessels in the laminated images taken from a superior view. The **superior and inferior vena cava** carry deoxygenated blood to the right atrium, while the pulmonary veins carry oxygenated blood to the left atrium. They will appear as holes in the right atrium.
- Some of the coronary vessels can be seen on the wet heart tissue, but note that not all of these vessels are readily identifiable. On this tissue, they have been sectioned as part of the pathological examination. Refer to the laminated images or digital atlas for a clear view of these vessels.
    - Note that the **left and right coronary arteries** branch off the **ascending aorta** just after it leaves the heart. The other vessels do not have any immediate branches. This is one way to identify the aorta in the wet specimens, as this structure has been cut open. You can usually see dark “holes” near the base of the aorta on its internal aspect. These holes are the origins of the coronary arteries. This vessel also arches upwards and to the left.

Be sure to view all of the hearts. Everyone has slightly different anatomy, so it is always good to observe multiple examples. Any of them could be used on an exam.

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LAB ACTIVITY 5: PLASTINATED HEART TISSUE

The plastinated tissue is human tissue that has been preserved in a way that hardens it. While studying this tissue, you can touch it without gloves. However, please try to limit how much you are handling it. This is because the oils and dirt on your hands can degrade the plastinated tissue over time. One of the plastinates has been cut through the right ventricle and atrium. The other has been cut through the left ventricle and right atrium. *Note: The vessel coloring is indicating arteries in red and veins in blue. The colors do not necessarily indicate oxygenated or deoxygenated blood.

When examining the plastinates, use the laminated images and/or digital atlas to help you identify structures in the list of terms and described in the previous activities.

LAB ACTIVITY 6: RESPIRATORY SYSTEM TISSUE FROM PATHOLOGY AT UW HOSPITAL

The lung tissue from pathology at UW hospital has been cut to search for pathological changes. The way that the lungs are cut makes it difficult to see the fissures and lobes. The lungs in Case A have evidence of acute bronchopneumonia. In Case C, the lungs are congested and heavy and have evidence of alveolar inflammation or fibrosis.

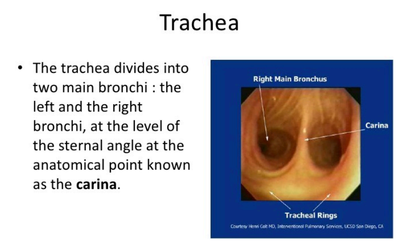
Observe the **hilum** on the medial aspect of the lungs. By the end of the unit, you will observe several organs that have a hilum. This is where neurovascular structures, and sometimes other structures, enter or leave an organ. In the lungs, you can observe bronchi, arteries, and veins in this location. The bronchi will feel hard as a result of the cartilage in their walls. Arteries have thicker walls than veins, and this will be evident in the hilum as well.

The orientation of these structures as they enter/leave the hilum is consistent and can tell you if you are looking at a right or left lung. You can use the mnemonic "**RALS**."

- In the *R*ight lung, the **pulmonary artery** will be **A**nterior to the main **bronchi**.
- In the *L*eft lung, the **pulmonary artery** is located **S**uperior to the main **bronchi**.

Observe a cut internal section of a lung and examine the appearance of the alveoli. The lungs will look somewhat like a very condensed sponge, which is a result of the **alveoli**.

Observe the **trachea** and primary (main) **bronchi**. Feel these specimens and notice the hard cartilage. Cartilaginous rings help maintain this tube's lumen (open portion) so that our airway does not collapse. Also, notice the point where the trachea splits into the primary bronchi. The point at which the split is called the **carina**. The image at the right is taken from within the trachea, looking down at the bronchi.



In Case A, the trachea is preserved with its relation to the esophagus and aortic arch. Notice how the trachealis muscle is on the posterior aspect of the trachea, just anterior to the esophagus.

LAB ACTIVITY 7: PLASTINATED RESPIRATORY TISSUE

Observe the lobes and fissures of the lungs. Notice the orientation of the pulmonary arteries and bronchi as they enter the lungs at the hilum. You should see that the pulmonary artery is anterior to the bronchus on the right, while it is superior to the bronchus on the left.

Observe the diaphragm. This thin muscle is the primary muscle of respiration. Notice how it is dome-shaped, extending upward into the thoracic cavity, though not as far as in the full cadaver. It is innervated by the phrenic nerve, which cannot be seen on our tissue but can be seen in laminated images or in the visible body atlas. The **phrenic nerve** descends through the thoracic cavity and innervates the diaphragm. It originates from the C3, C4, and C5 spinal roots. *Remember, C3, C4. C5 keeps the diaphragm alive.* A portion of the diaphragm is also present with the trachea in Case A.

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LAB ACTIVITY 8: HEART AND LUNGS – ANATOMAGE NAVIGATOR TOOL

The Navigator program will be open and ready for you to use. Ask your TA if you need any help or if it is not open. Zoom in on the heart and lungs, and center them on the screen.

- Using this tool, explore the cross-sectional and internal anatomy of the heart and lungs. Hover the cursor over one of the cross-section images at the top of the screen and scroll. Compare what you see on the 3D digital model and cross-sectional images to better understand the relationship between the 3D anatomy that we typically see and how the structure appears in cross-section. For example, you will be able to see the chambers of the heart labeled as you move superiorly and inferiorly along the model. You will also see the different structures visible in the same section at different levels. The cross-sections are essentially a color version of the black and white images that you will see in radiology images. Spend some time exploring the structures in the digital model and cross-section. Be sure to view the cross sections in all three planes.

- Observe the heart, lungs, and trachea on the 3D model. Only a few structures will be visible on the 3D model, but between the digital model and the 3D model, you should identify most of the structures in the list of terms.
- You will be asked to identify structures in the cross-sectional images on the exams. A helpful method for orienting yourself to the cross-section is to identify structures that you know are surrounding a given structure. Understanding what other tissues look like around the target tissue can help you understand whether you are superior or inferior, medial or lateral, etc.

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LAB ACTIVITY 9: THORACIC RADIOLOGY

View the radiology presentation in Canvas on a lab computer. You will see X-Ray imaging, Echo imaging, and CT imaging of the thoracic cavity. Identify the following structures:

X-Ray

- Lungs
- Heart
- Liver
- Ribs
- Vertebrae

Echocardiogram (echo) – Heart

- Atria
- Ventricles
- Right atrioventricular (tricuspid) valve
- Left atrioventricular (bicuspid/mitral) valve

- Pulmonary semilunar valve
- Aortic semilunar valve
- Interventricular septum
- Papillary muscles

CT

- Lungs
- Heart
- Aorta
- Liver
- Vertebrae

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https://wisc.pb.unizin.org/humananatomylabmanual/?p=84#h5p-19

Lab 4: Abdominal Quadrants, Digestive System, and Abdominal Radiology

LEARNING OBJECTIVES:

- Identify the vasculature of the digestive system and accessory organs, including the great vessels and associated branches.
- Identify the structures of the alimentary canal and the accessory organs of the digestive system.
- Identify the ducts carrying bile from the liver and gallbladder to the duodenum.
- Identify the quadrants of the abdomen and list the organs found in each quadrant.

- Identify structures of the abdominal cavity using various imaging modalities.

TERMS TO KNOW

Vasculature

- Inferior vena cava
- Hepatic portal vein
- Celiac trunk
    - Splenic artery
    - Common hepatic artery
    - Left gastric artery
- Superior mesenteric artery
- Inferior mesenteric artery

Digestive Tract

- Esophagus
- Stomach
    - Cardia
    - Fundus
    - Body
    - Pyloris
    - Pyloric sphincter
    - Rugae (gastric folds)
    - Greater curvature
    - Lesser curvature
- Small Intestine
    - Duodenum
    - Ileum
    - *you are not responsible for specifically identifying the jejunum in the images or on a specimen
- Large Intestine
    - Cecum
    - Ascending colon
    - Transverse colon
    - Descending colon
    - Sigmoid colon
    - Rectum
    - Appendix

Accessory Digestive Organs

- Liver
    - Right lobe
    - Left lobe
    - Caudate lobe
    - Quadrate lobe
- Gall Bladder
    - Common hepatic duct
    - Cystic duct
    - Common bile duct
- Pancreas
    - Pancreatic duct
- Mesentery
    - Greater omentum

Other Abdominal Organs

- Spleen

Abdominal Quadrants

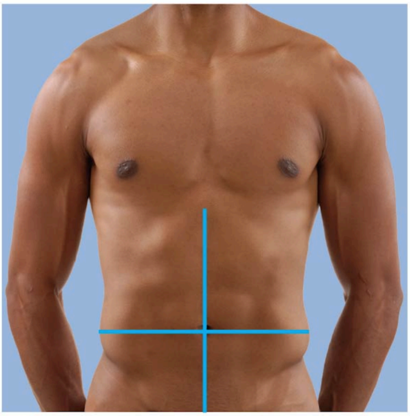
- Upper right quadrant
- Upper left quadrant
- Lower right quadrant
- Lower left quadrant

INTRODUCTION

In this lab, you will learn about the organs of the digestive system located in the thorax, abdomen, and pelvis. This includes both the organs of the alimentary canal or digestive tract and the accessory digestive organs. Though the spleen is not part of the digestive tract, we will discuss it today due to its location in the abdomen. You will also organize the organs into their abdominal quadrants and observe them in cross-sections and radiology.

As you use the various tools and specimens in the lab today, keep in mind that not all structures will be visible using all tools. Try to identify the structures on the specimens. If they are not visible on the specimens, observe them using atlas images or the Navigator.

LAB ACTIVITY 1: ABDOMINAL QUADRANTS EXERCISE



Howdo you evaluate the location of internal organs when you can't see them? It is of critical importance for clinicians in various health science fields to navigate the location of these organs when looking at the abdomen. Where to palpate (feel with your hands), what type of pain is produced, and does pain move or extend into other quadrants are all key questions a clinician may want to know. The umbilicus (aka your belly button) is the center of a grid or intersection of two lines that form the abdominal quadrants. We orient by designating the quadrants by anatomical location (not the way YOU look at them), Upper Right Quadrant (URQ), Upper Left Quadrant (ULQ), Lower Left Quadrant (LLQ), and Lower Right Quadrant (LRQ).

There will be a grid on a table in the lab, like the one shown above. Each organ, or part of an organ (hint: some are in more than one quadrant), is listed on laminated cards. Your task is to properly label each quadrant and then place each organ (label) into the quadrant where it is found in the abdominal cavity. For example, the appendix card goes in the lower right quadrant, etc.

LAB ACTIVITY 2: DIGESTIVE ORGANS – DIGITAL ATLAS

Open the Atlas app on the iPad and go to the **Digestive System Views. Click** on **11. Regional Vasculature**. From this view, you will be able to identify all of the vasculatures from the list of structures to know for this lab; Inferior Vena Cava, Hepatic Portal Vein, Celiac Trunk, Splenic Artery, Common Hepatic Artery, and Left Gastric Artery. You will have to rotate the figure around, zoom, zoom out, and tap on the structures to find exactly what you are looking for.

Back to the systems view, open the **Digestive System View** again, and click on **7. Alimentary Canal**. From this view, you will identify the following digestive structures; **Esophagus, Stomach, Cardiac Sphincter, Pyloric Sphincter, Duodenum, Cecum, Appendix, Ascending Colon, Transverse Colon, Descending Colon, Sigmoid Colon,** and

Rectum. (**NOTE: You cannot see some of the stomach features on the app, but you will be able to see these on the wet specimen. The app does have the muscular layers of the stomach that are pretty cool to see.) You will have to rotate the figure around, zoom, zoom out and tap on the structures to find exactly what you are looking for.

Back to the systems view, open the **Digestive System View** again, and click on **10. Accessory Organs**. From this view, you will be able to identify the following accessory digestive organs; **Liver** (***NOTE you cannot identify the lobes well using the app aside from the **Caudate Lobe**), **Common Hepatic Duct, Gall Bladder, Cystic Duct, Common Bile Duct, Pancreas** (you can find the **Pancreatic Duct**if you hide part of the Duodenum). Again you will have to rotate the figure around, zoom in, zoom out, and tap on the structures to find exactly what you are looking for.

Back to the systems view, open the **Digestive System View** again and click on **2. Lower Digestive System**. From this view, you will be able to identify the **Greater Omentum**. As with all of the structures, feel free to click on the book icon to read a little further on the function of the structure.

LAB ACTIVITY 3: DIGESTIVE SYSTEM ORGANS – ANATOMAGE NAVIGATOR

First, ensure that the Navigator is on the correct settings. You should be able to see all of the internal organs present in the 3D model. If this is not the case, click on the eye (view) icon on the toolbar and choose another preset.

Observe the abdominal organs in cross-section. You should observe each structure in cross-sectional images based on the spatial relationships between structures. Be sure to view the cross sections in all three planes. *In the coronal cross-sectional image, you are looking at the individual as if they are laying on their back, and you are looking up at them from their feet.*

Go to the level of the heart and observe that the **esophagus** sits directly anterior to the vertebral column and posterior to the trachea (in the superior thorax). The aorta sits just anterior and slightly to the left of the esophagus.

Move inferiorly and notice that the **liver**takes up a large portion of the superior abdominal cavity. Continue moving inferiorly. Examine the cross-sectional images with respect to where in the 3D image you are, and explore the digestive structures you can see in cross-section.

Use the advanced view to observe structures on the “List of Structures” for this lab. You can choose to view gastrointestinal structures. You can also unclick that box and instead view the great vessels by clicking on Cardiovascular in the system column, for example, and narrowing down the structures using the Category and Structure columns. Keep in mind that some structures are better viewed in an atlas or on the bones or specimens.

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LAB ACTIVITY 4: DIGESTIVE SYSTEM – CADAVERIC SPECIMENS FROM PATHOLOGY

We have three sets of digestive organs and spleens from Pathology that you will view in the lab today. These are from the same cases as the hearts and lungs from the previous lab. Keep in mind that not all structures are visible on each specimen. Be sure to observe all of the cases, as there is some anatomical variation, and some structures are only visible in certain cases. **As a reminder, treat these organs with care and respect.**

Your group should have an atlas or iPad with you as a reference when examining these organs.

Observe the **spleen** tissue. We only have sections of the spleen, but you can view the sections to appreciate the tissue that makes up this organ. This structure is part of the lymphatic system, not the digestive system, but we will examine it today due to its location in the superior abdomen, surrounded by digestive organs. This organ recycles old blood cells, kills bacteria and other foreign particles, and plays an important role in the immune system.

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Observe the sections of the **liver**. (We do not have an intact whole liver in this lab). Observe that one section of the liver in Case A has the majority of the **gall bladder** attached to it, and you can observe the **cystic duct** and **common**

hepatic duct that merge to form the **common bile duct.** (More on this later). These structures appear green because bile is green in color. The livers in Case A and Case B are enlarged and contain excessive amounts of fat. In Case B, the liver is soft and has diffuse yellow discoloration.

The liver is involved in many functions, including bile production; detoxification of drugs, metabolites, and poisons; storage of certain vitamins and nutrients; and synthesis of blood plasma proteins.

Use atlas images to identify the lobes of the liver. There is usually a thin layer of tissue that separates the right and left lobes. You can identify the caudate (posterior) and quadrate (anterior) lobes on the inferior aspect. The vasculature is located on the posterior and inferior aspects of the liver. The largest, thin-walled vessel is the **inferior vena cava**. This vessel ascends through the abdomen and carries blood from the lower extremities and trunk back to the heart. It picks up blood that has been processed in the liver along its path.

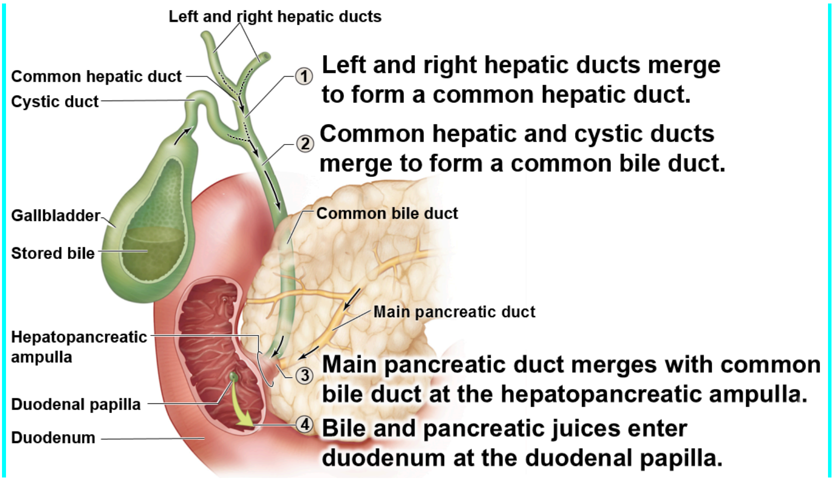
Observe the organ group that includes the **esophagus, stomach,** and **proximal duodenum** (the esophagus is not with this tissue group in Case A, but you can view it in the organ group containing the trachea and diaphragm). The **esophagus** is located along the midline, just to the right of the descending aorta, and just anterior to the vertebral column. You can see it just posterior to the trachea in the plastinated cadaver and Case A tissue. The **esophagus** has to pass through the posterior aspect of the **diaphragm** to reach the **stomach**. In case A, you can see the relationship between the esophagus and the diaphragm. In Case B, feel where the **esophagus** meets the **stomach**and notice a subtle thickening in this area. This sphincter works to prevent regurgitation of stomach contents back into the esophagus.

Now observe the **stomach**. It has been opened, and the **rugae,** or folds on the interior surface, are clearly visible. Use the digital atlas as a reference and try to identify the different regions of the **stomach**. (These regions are best viewed in Cases B and C, though the body and pyloric region are visible in Case A.) The **cardiac region** is nearest the esophagus, and the **fundus** is the most superior, dome-shaped region. Though the borders are difficult to ascertain, the central region of the stomach can be considered the **body**. Near the entrance to the **duodenum** is the **pyloric region** of the **stomach**. As the **stomach** approaches the **duodenum**, feel the very thick **pyloric sphincter**. This regulates the passage of digested materials from the stomach to the **small intestines**.

Examine the structure of the proximal **duodenum**, the first part of the **small intestines**. Notice folds within the small intestines, which help to increase surface area for nutrient absorption. You may be asked to identify the duodenum on these specimens.

Observe the **gallbladder**, which is green in color because it stores the bile that the liver has produced. Bile plays an important role in fat digestion. The gallbladder is attached to a portion of the liver in Case A, and it has been separated from the digestive tissue in Case B.

Bile is carried from the liver through the **common hepatic duct**. The **cystic duct** connects the common hepatic duct to the gallbladder. The duct formed by the merging of the common hepatic duct and cystic duct is the **common bile duct**. When food enters the small intestines, bile travels from the liver via the common hepatic duct and gall bladder through the cystic duct, then through the common bile duct to the duodenum. The common bile duct is visible in all three cases, and the cystic duct and common hepatic duct are visible in Case A with the liver.



Two vessels travel alongside the common bile duct to the liver. The smaller but thicker-walled vessel is the **common hepatic artery**. This artery supplies oxygenated blood to the tissue of the liver. This is a branch of the celiac trunk, which you can observe in Cases A and C. The larger but thin-walled vessel is the **hepatic portal vein**. This vein carries blood from the digestive tract to the liver to be processed and detoxified before entering general circulation. In all cases, the common hepatic artery, hepatic portal vein, and common bile duct can be viewed with the specimen containing the stomach and duodenum, as described below.

Observe the **pancreas**. It is light yellow in color and more granular than nearby adipose (fat) tissue. It has been sectioned in all cases. Pancreatic endocrine cells secrete insulin and glucagon into the blood to regulate blood sugar levels. Pancreatic exocrine cells produce enzymes and bicarbonate that are key for digestion in the **small intestines**. The **pancreatic duct** joins the **common bile duct** at the **hepatopancreatic ampulla** before emptying its contents into the duodenum. Follow the common bile duct to the duodenum. From there, you can follow the pancreatic duct a short distance into the pancreas. Notice how the hepatopancreatic ampulla, where these ducts meet, is very short and somewhat enlarged. On the internal aspect of the duodenum in this region, you can look carefully and try to observe the duodenal papilla, where these ducts empty their contents into the duodenum.

Observe the artery that is twisting and winding near and in the pancreas. This is the **splenic artery**. It is a branch of the celiac trunk, and it supplies the spleen, part of the stomach, and part of the pancreas. In Case B, this artery is calcified and particularly tortuous. It branches towards the most lateral portion of the pancreas.

The **left gastric artery** is the third branch off of the celiac trunk,and it supplies the rest of the stomach and inferior esophagus. All three branches, the common hepatic, left gastric, and splenic arteries, can also be observed with the digestive organs in Cases A and C. You can tell which artery is which based on where it is traveling.

Observe the **greater omentum** both on the stomach and duodenum organ group and in an atlas image. It sits anterior to the abdominal organs. The **greater omentum** is one of the **mesenteries** of the abdominal cavity. The mesenteries hold organs in place, store fat, and provide a route for vessels and nerves to reach the organs.

Use the digital atlas or another atlas image in the lab to observe the regions of the large intestines: the **cecum, ascending colon, transverse colon, descending colon, and sigmoid colon**. The primary function of the large intestines is the absorption of water. All cases contain sections of the large intestines, including the cecum. Observe the small section of the ilium attached to the cecum, and feel the ileocecal junction. The ilium has more folds in the walls than the large intestine. In Case A, the patient had ileitis or inflammation of the ileum. Notice how thick the walls of the ileum are in this case compared to the other cases. There is an additional section of the ilium included with Case A. The cecum is larger in diameter and somewhat pouch-like. It also has a small tube-like structure extending from it. That is the **appendix**. In Case A, the appendix has been cut, and you can view it separately from the cecum. Though its function was misunderstood for a long time, we now know that the appendix has lymphatic and immune functions.

LAB ACTIVITY 5: DIGESTIVE ORGANS AND SPLEEN – DONOR CADAVERIC TISSUE

Ensure that you are viewing the anterior aspect of the tissue, as if the individual was supine. Observe the organs in anatomical position. Notice the spatial relationships between the organs. In the full cadaver, notice how superior some of the abdominal organs are located into the thoracic cavity, such as the liver, stomach, and transverse colon. This is unusual and likely a congenital anomaly.

In the full cadaver, observe the greater omentum overlying the abdominal organs.

Superiorly, observe the esophagus. In the full cadaver, you may only be able to observe a small portion of the esophagus. In digestive donor tissue, as the esophagus approaches the cardiac portion of the stomach, notice the small portion of connective tissue around the diaphragm just superior to the stomach. This tissue balloons outward somewhat, likely due to a previous hiatal hernia in which the cardiac portion of the stomach goes through the esophageal hiatus in the diaphragm and into the thoracic cage.

Now observe the stomach in anatomical position, and notice the **lesser curvature** to the donor's right and the **greater curvature** to the donor's left. Notice the location of the stomach with respect to the surrounding organs. The liver sits just superior and to the right of the stomach, while the spleen is to the left (and somewhat posterior in anatomical position). Feel the pyloric sphincter. You may need to move lift the liver slightly to access the pyloric sphincter. In the digestive donor tissue there appears to be a somewhat excessive thickening of the pyloric sphincter for an unknown reason.

Observe the small intestine. The duodenum is the first portion of the small intestine leaving the stomach. The ilium is the last portion of the small intestine that meets the large intestine, and the jejunum is in between. Notice the mesentery holding the small intestine in place and providing a pathway for the neurovascular to reach the organ. Some of the mesentery has been dissected so that you can view the neurovasculature, which is coming from the superior mesenteric artery (you will view this artery in the next lab). On the digestive donor tissue, notice the small nodules scattered along part of the small intestine. We do not have a medical history from this donor, so the cause of these nodules is unknown.

Observe the large intestine and its subregions. The appendix is visible on both donors. Follow the large intestine throughout its path to the sigmoid colon and rectum. On the digestive donor tissue, be particularly gentle with this tissue. There are a few noticeable distended areas and areas of impacted fecal matter. In the cadaver donor, notice that the hepatic flexure is so superior it is almost to the axilla. That is abnormally high.

Observe the liver, including the right, left, and quadrate lobes. The caudate lobe may be difficult to see as it may be blocked by other tissue. Observe the gallbladder on the inferior aspect of the right lobe of the liver. On the digestive donor tissue, view the common bile duct, hepatic portal vein, and common hepatic artery traveling next to each other towards the liver. From a superior view you can see the inferior vena cava on the posterior aspect of the liver. Notice how superior into the thoracic cavity the liver is in the cadaver. Also notice how the diaphragm sits over it in anatomical position.

Observe the pancreas just inferior and somewhat deep to the stomach. The pancreas in the cadaver is has more fatty tissue within it, while that is not present in the digestive donor tissue. Also notice the sectioned portion of the pancreas in the digestive donor tissue and examine the internal structure of the organ. Observe how the splenic artery travels through it to reach the spleen. The spleen is substantially larger in the digestive donor tissue than in the cadaver. This is likely due to illness, though without a medical history, we can't be certain. The splenic vein is also present on both the digestive donor tissue and the cadaver.

LAB ACTIVITY 6: ABDOMINAL CAVITY RADIOLOGY

View the presentation on the computers in the lab on the radiology of the abdominal cavity, specifically the digestive organs and spleen. The slides will also be posted as a study tool. Observe the following structures in the radiology images.

- Stomach
- Pancreas
- Liver
- Small intestines
- Ascending colon
- Transverse colon
- Descending colon
- Hepatic flexure

- Splenic flexure
- Spleen
- Abdominal Aorta
- Inferior vena cava

An interactive H5P element has been excluded from this version of the text. You can view it online here:
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Lab 5: Radiology of the Abdomen & Pelvis, Urinary System, Reproductive System

LEARNING OBJECTIVES:

- Identify and describe the anatomical structures of the kidney.
- Identify the structures of the urinary system and its blood supply.
- Identify the anatomy of the female and male reproductive systems.
- Identify the structures of the pelvis using multiple imaging modalities.

TERMS TO KNOW

Vasculature

- Aorta
- Ascending aorta
- Aortic arch
- Descending aorta
- Inferior vena cava
- Celiac trunk
- Superior mesenteric artery
- Inferior mesenteric artery

Kidney

- Hilum
- Renal cortex
- Renal medulla
- Renal columns
- Renal (medullary) pyramids
- Minor calyx
- Major calyx
- Renal pelvis
- Renal arteries
- Renal veins

Urinary Tract

- Ureters
- Urinary bladder
- Urethra
- Prostatic urethra
- Membranous urethra
- Spongy urethra

Female Reproductive System

- Vesicouterine pouch
- Rectouterine pouch
- Ovaries
- Uterine tubes
- Uterus
- Vagina
- External genitalia
- Labia majora
- Labia minora
- Clitoris

Male Reproductive System

- Spermatic cord
- Testicular artery and vein
- Pampiniform plexus of veins
- Ductus deferens
- Testes
- Epididymis
- Ampulla
- Prostate gland
- Seminal Vesicle
- Penis
- Glans
- External urethral orifice
- Corpora cavernosa
- Corpus spongiosum

INTRODUCTION

In this lab, you will explore the organs of the urinary system and the male and female reproductive systems. You will also observe the abdominal aorta and the arteries that branch off of the aorta along its path through the abdominal cavity. As you are using the tools and specimens in the lab today, keep in mind that not all structures will be visible using all tools.

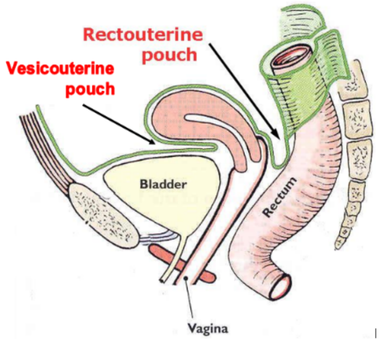
LAB ACTIVITY 1: URINARY AND REPRODUCTIVE SYSTEMS – ANATAMAGE NAVIGATOR

The navigator model has female anatomy, so you will only explore female reproductive anatomy in this section. You can review the male reproductive anatomy with the cadaveric tissue, atlas images, and digital atlas. First, ensure that the Navigator is on the correct settings. You should be able to see all of the internal pelvic organs present in the 3D model. If this is not the case, click on the eye (view) icon on the toolbar and choose another preset. Be sure to view the structures in all three planes.

- Explore the **kidneys, ureters, bladder, uterus, uterine tubes, and ovaries** in the 3D printed model.
    - Also, observe the **renal arteries** and veins that carry blood to each **kidney**. Notice that the

ureters and vasculature all enter/exit the kidney in the same area. As in the lung, this region is called the **hilum**.

- Posterior to the **bladder**, observe the **uterus**, **oviduct**, and **ovaries,** which are structures of the female reproductive system. Though not visible in this model, the **rectum** would sit just posterior to the **uterus**. Notice the spaces between these structures. The **vesicouterine pouch** is located between the **bladder** and the **uterus**, while the **rectouterine pouch** is located between the **uterus** and the **rectum**. These pouches represent the most inferior portions of the abdominal cavity. Fluids and infections within the abdominal cavity can accumulate in these pouches, especially in the **rectouterine pouch**. The **rectouterine pouch** is also the preferred place for peritoneal dialysis, a form of dialysis used in end-stage renal (kidney) failure patients.



- Observe the **kidneys** in cross-section. These organs are located along the posterior abdominal wall. You can see the renal medulla/renal pyramids and the renal cortex in cross-section.
- Observe the **bladder, uterus, and rectum** in cross section, and view the vesicouterine and rectouterine pouches, particularly in the sagittal plane. You can also see the ovaries and uterine tubes, though they can be more difficult to discern in these cross-sections.

An interactive H5P element has been excluded from this version of the text. You can view it online here:

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LAB ACTIVITY 2: URINARY AND REPRODUCTIVE SYSTEMS – DIGITAL ATLAS

- Open the Atlas app and go to the **Digestive System Views**. Click on **8. Stomach Vasculature**. Click twice on veins in the column at the left to remove the veins and give you a better view of the arteries.
    - Observe the **aorta**.
        - **Ascending aorta**: the portion of the aorta that carries blood superiorly as it leaves the heart. This is difficult to see on these aortas, but it can be seen in the hearts.
        - **Arch of the aorta**: the portion of the aorta the forms an arch between the ascending and descending aorta. Though the aorta has been cut open, you can generally still appreciate the arch of the aorta on this tissue.
        - **Descending aorta**: the portion of the aorta carrying blood inferiorly. The portion of the descending aorta located in the thorax is called the thoracic aorta, while the portion located in the abdomen is called the

abdominal aorta.

- Between the liver and stomach, click on the **celiac trunk** branching off of the descending aorta. It is a midline, unpaired artery.
    - Three branches of the **celiac trunk** supply the digestive tract from the inferior esophagus through the first half of the duodenum of the small intestines and the spleen and liver: the **common hepatic artery, splenic artery,** and **left gastric artery**. You observed these branches in the previous lab, and you can see them in this view in the digital atlas.
- Hide the stomach, body of the pancreas, transverse colon, ileum, and jejunum. Click on the **superior mesenteric artery,** which branches from the aorta just inferior to the celiac trunk. Notice its branches that supply the second half of the duodenum of the small intestines to the first 2/3 of the transverse colon.
- Click on the **inferior mesenteric artery,** which branches from the aorta more inferiorly. Notice its branches supply the digestive tract from the distal 1/3 of the transverse colon to the rectum.
- Click on Arteries in the column at the left to show the rest of the arteries. The most inferior aspect of the aorta branches into the **right and left common iliac arteries**. The common iliac arteries then branch into the **internal iliac artery**, which supplies pelvic and gluteal

structures, and the **external iliac artery**, which supplies the lower extremity.

    - Click on Veins in the column at the left to show the veins again. Observe the **inferior vena cava**ascending next to the aorta. This vessel carries blood from the legs and abdomen back to the heart.

- Go to the **Urinary System Views** click on **10 or 11. Renal Vasculature**. From this view, you will be able to identify the following structures to know for this lab; **Renal Pyramids**, **Renal Pelvis, Ureter, Renal Arteries, Renal Veins, Inferior Vena Cava, Descending Aorta**. You will not be able to see all of the structures from the list of structures under Kidney. You will have to rotate the figure around, zoom, zoom out, and tap on the structures to find exactly what you are looking for. As with all of the structures, feel free to click on the book icon to read a little further on the function of the structure.
- Back to the systems view, open the **Urinary System View** again, and click on **18 or 19. Bladder Section (M or F)**. From this view, you will identify the following Urinary Tract structures; **Ureters, Urinary Bladder, Urethra (Male only – Prostatic Urethra, Membranous Urethra, Spongy Urethra), Prostate Gland, Testes, Epididymis, (Vas) Ductus Deferens.** (***NOTE, to see the different parts of the male urethra, you will have to hide the muscles of the penis; **ischiocavernosus**, **corpus cavernosum**, and **bulbospongiosus**). You will have to rotate the figure around, zoom, zoom out, and tap on the structures to find exactly what you are looking for. As with

all of the structures, feel free to click on the book icon to read a little further on the function of the structure.

- Back to the systems view, open the **Reproductive System View** and click on **2. Pelvic Region (M)**. From this view, you can identify most of the male reproductive system structures: **Testes, Epididymis, (Vas) Ductus Deferens, Prostate Gland,** and **Penis**. (**To see the **Glans, Corpus Cavernosum, Corpus Spongiosum, Testicular Artery, and Pampiniform Plexus**, you will have to hide the fascial layers of the penis and testes twice, then these structures will be visible.) Again, you will have to rotate the figure around, zoom, zoom out and tap on the structures to find exactly what you are looking for. As with all of the structures, feel free to click on the book icon to read a little further on the function of the structure.

The Male Reproductive System
by **INTERVOKE**
on **Sketchfab**

- Back to the systems view, open the **Reproductive System View** again, and click on **18. Location of Organs (F)**. From this view, you will appreciate where the female reproductive organs are in relation to the pelvis. You will be able to see the following structures; **Ovaries, (Fallopian) Uterine Tubes, Uterus, Vagina, Labia Majora, and Minora,** as well as the **Clitoris.** Again, you will have to rotate the figure around, zoom, zoom out, and tap on the structures to find exactly what you are looking for. As with all of the structures, feel free to click on the book icon to read a little further on the function of the structure.
- Back to the systems view, open the **Reproductive System**

View again and click on **3. Internal Genitalia (M), 9. External Genitalia (M), 17. Internal Genitalia (F)** and **22. External Genitalia (F)**. These views will allow you to see the internal and external genitalia and allow you to remove surrounding structures and layers to see more anatomy of the region. As with all of the structures, feel free to click on the book icon to read a little further on the function of the structure.

Female Reproductive System
by **Ebers**
on **Sketchfab**

LAB ACTIVITY 3: AORTA, URINARY SYSTEM AND REPRODUCTIVE SYSTEM – CADAVERIC TISSUE FROM PATHOLOGY

Obtain an iPad to use as a reference when viewing these structures. Not all structures are visible on these organs. Be sure to examine all three of the organ sets. We have two sets of male organs and one partial set of female organs.

- In Case 3, observe the aorta. Feel how thick the walls are, and notice that portions of the aortic wall are calcified and hard. You can observe the opening for the celiac trunk and superior mesenteric artery near each other about halfway down the aorta. These arteries supply the majority of the digestive organs. They are single, midline arteries. Just inferior to the opening for the superior mesenteric artery, the renal arteries branch from the aorta to supply the kidneys. The inferior mesenteric artery is a single midline artery branching from the aorta just before it ends in the inferior abdomen. It supplies the last 1/3 of the transverse colon through the end of the alimentary canal.

Abdominal aorta aneurism
by **valchanov**
on **Sketchfab**

- Examine the **kidneys** on the cadaveric specimens. The kidneys in Case A have a cyst, which appears as a large space in the kidney. Most of these kidneys have been cut longitudinally. Look at the middle cut and observe the internal gross anatomy of these structures. The kidneys remove waste products from the blood and work to control fluid and electrolytes in the body. The latter function allows them to play a role in blood pressure regulation as well.
- Comparing these structures to an atlas image, observe the following features:
  - **Renal cortex**
  - **Renal pyramids**
  - **Renal medulla (Darker area made up of the renal pyramids)**
  - **Major calyx**

    - **Minor calyx**
    - **Renal pelvis**
    - **Renal column**

- Examine the **hilum** of the **kidney**. This is where the **renal arteries** enter the kidneys, and the **renal veins** and **ureters** exit the kidneys.
- Observe how the ureters enter the inferior posterior aspect of the **bladder**. The ureters carry urine to the bladder, where the urine is stored until it is expelled through the urethra. They enter the bladder at an angle. As the bladder fills with urine, the pressure on the ureters within the wall of the bladder increases and prevents the backflow of urine into the ureters.
    - Note the size of the ureters and imagine passing a kidney stone through these structures. The ureters are highly innervated, and passing kidney stones are excruciating. If the stone is too large, it cannot pass through these narrow structures and remains in the kidney.
    - In atlas images, observe the **urethra**. The male urethra has three parts: the **prostatic urethra, membranous urethra,** and **spongy urethra**. The female urethra is much shorter and is positioned anterior to the vagina.
- In cases, A and C, observe the male reproductive organs. Observe the gland just inferior to the bladder. This is the **prostate gland**. Observe the tube-like structures coming from the area of the prostate gland. These are the right and left **ductus deferens**. The ductus deferens carries sperm from the epididymis in the testes to the ejaculatory duct.

    - Follow the ductus deferens towards the bladder and notice that it is increasing in size as it reaches its end. This is called the **ampulla.** The ampulla meets the **seminal vesicle**, which you can observe next to the ampulla only in Case C, to form the short ejaculatory duct. Then the contents of the ejaculatory duct enter the **prostatic urethra. The prostate gland surrounds the prostatic urethra**.
    - These and the other male reproductive system structures can be observed in atlas images and the digital atlas.
- While Case B had female reproductive organs, the patient was many years post-hysterectomy. The left ovary is still visible but is smaller than it would be in a woman of child-bearing age. The right ovary and fallopian tube were removed during surgery to remove a pelvic mass.
    - The other female reproductive organs can be observed in atlas images or the digital atlas.

LAB ACTIVITY 4: FULL CADAVER TISSUE AND ADDITIONAL DONOR TISSUE

Observe the structures of the urinary system and reproductive system on the full cadaver. Begin by observing the **kidneys**. Both have evidence of renal cysts or fluid-filled sacs, with more on the left kidney. Observe the **renal artery** and **renal veins** supplying and draining blood from the kidneys, respectively. Also observe the **ureter** leaving each kidney and traveling inferiorly to the posterior wall of the **bladder**.

Posterior to the bladder, view the **ductus deferens**. This structure travels from the **testicle** through the **spermatic cord** and inguinal canal into the pelvic cavity. The inguinal canal has been surgically repaired on the right side, while the left side shows evidence of an inguinal hernia. The rest of its pathway is not visible in the cadaver. Now notice the artery traveling from the aorta into the spermatic cord. This is the **testicular artery** that supplies the testicle with blood. It is traveling through the abdominal cavity with the **testicular vein**. You can observe some of the **pampiniform plexus of veins** around the testicular artery in the spermatic cord, especially on the right where the cord is still bound by fascia.

Observe the testes and the epididymis. The left testicle has been cut in cross section. Observe the difference in the internal structure of the epididymis compared to the testicle.

Now observe the **penis**. It has also been sectioned to show the internal anatomy of the **corpora cavernosa** superiorly and the **corpus spongiosum** inferiorly. The **glans** and **external urethral orifice** are both visible distally.

LAB ACTIVITY 5: PELVIC RADIOLOGY

View the imaging presentation of the pelvis on the lab computers. You will have the opportunity to see X-Ray imaging, CT imaging, and a fluoroscopic study of the pelvis. As you are watching the images, we would like you to identify the anatomical structures presented to you. You may not be able to see all of the structures from each view. (An HSG is a fluoroscopic image where dye is injected into the uterus to evaluate for blockages of the uterine tubes.)

X-Ray

- Lumbar vertebrae
- Inter-vertebral Space (what fits here?)
- Ribs (which ones can you see and what vertebrae do they originate from?)
- Liver
- Colon
- Bladder
- HSG
- Uterus
- Fallopian Tubes

CT

- Lungs
- Liver
- Spleen
- Kidneys
- Renal Arteries
- Stomach
- Small intestine
- Large intestine
- Descending Aorta
- Common Iliac Artery

- Hepatic Portal Vein
- Bladder

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://wisc.pb.unizin.org/humananatomylabmanual/?p=91#h5p-25

PART II

UNIT 2: HEAD AND NECK

Welcome to Unit 2: Head & Neck!

Lab 6: The Cerebrum

LEARNING OBJECTIVES:

- Explain the directional terms associated with the orientation of the brain in the cranial cavity.
- Describe the layers of tissue that cover the brain and explain their function.
- Describe the structures of the cerebral hemispheres, including the lobs of the brain and their components, using the whole-brain and midsagittally sectioned tissue.
- Explain the various functions associated with identified regions of the brain.
- Describe the Circle of Willis.

TERMS TO KNOW

Directional Terms

- Rostral/Caudal
- Dorsal/Ventral

Cerebrum

- Cerebral hemispheres
- Sulci & Gyri
- Cerebral cortex
- Corpus callosum
- Median longitudinal fissure
- Central sulcus
- Frontal lobe
    - Precentral gyrus
- Parietal lobe
    - Postcentral gyrus
- Temporal lobe
    - Superior temporal gyrus
    - Middle temporal gyrus
    - Inferior temporal gyrus
    - Hippocampus
    - Amygdala
- Occipital lobe
    - Calcarine sulcus
- Lateral (Sylvian) Fissure
- Parieto-occipital sulcus
- Insula
- Thalamus
- Hypothalamus
- Basal ganglia
    - Caudate nucleus
    - Putamen
    - Globus pallidus
- Internal capsule
- Anterior commissure

Meninges

- Dura mater
- Dural reflections
    - Falx cerebri
    - Tentorium cerebelli
- Arachnoid mater
- Arachnoid granulations
    - Pia mater

Ventricles

- Lateral Ventricle
    - Anterior horn of lateral ventricle
    - Body of lateral ventricles
    - Inferior horn of lateral ventricle
    - Posterior horn of lateral ventricle
- Interventricular foramen (of Monro)
- Third ventricle
    - Interthalamic adhesion
- Cerebral aqueduct
- Fourth ventricle

Other Structures

- Cerebellum
- Brainstem
    - Midbrain
    - Pons
    - Medulla oblongata

Blood Supply to the Brain

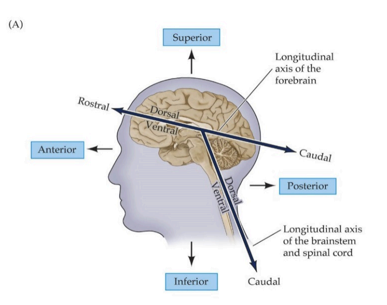
- Vertebral arteries
- Internal carotid arteries
- Anterior cerebral arteries
- Middle cerebral arteries
- Posterior cerebral arteries
- Anterior communicating artery
- Posterior communicating artery

INTRODUCTION

In today's lab, you will learn about the cerebrum of the brain and introduce the brainstem and cerebellum. This mass of neurons and glial cells controls everything from our ability to breathe, speak, and move our limbs, to our personalities, emotions, and higher-level thinking.

You will use various tools in this lab, including the Navigator, ventricle models, and, most importantly, human brain tissue. ***The brain tissue must be handled with care and respect.*** *Take extra care to ensure that these brains are covered with towels when they are not in use. Also, handle the tissue carefully to ensure you do not gouge or nick the brain surfaces or pull excessively at parts of the tissue.*

Before we begin with the lab activities, it is essential to address additional directional terms used with respect to the brain. A change in the long axis of the nervous system occurs between the cerebrum and the brainstem. The long axis of the cerebrum is relatively horizontal, while the long axis of the brainstem and spinal cord is relatively vertical.



As a result, some of the directional terms may have slightly different meanings depending on the structure to which they refer. **Rostral** refers to the most frontal portion of the brain (rostrum = nose), while **caudal** describes structures closer to the tip of the spinal cord (caudal = tail). When used in the context of the cerebrum, **rostral** refers to structures closer to the nose (as before), but **caudal** now refers to structures toward the back of the head (posterior). The terms **ventral** and **dorsal** can be used interchangeably with anterior and posterior with respect to the plan of the brainstem and spinal cord. However, in the plane of the cerebrum, these terms are interchangeable with inferior and superior.

The University of British Columbia has excellent resources that you may find helpful in studying the brain. These resources can be found at neuroanatomy.ca. The site contains videos, interactive modules, 3D models, cross-sectional images, radiology, and other tools.

LAB ACTIVITY 1: HUMAN BRAIN TISSUE

We have several brains available for you to learn from in the lab. Some are whole brains, some are cut midsagittally and divided into hemispheres, and others have been sectioned coronally. As you will observe, they all have the same structures, but there is some variation between each anatomically.

THE MENINGES

First, explore the meninges. Three connective tissue membranes cover the brain: dura mater, arachnoid mater, and pia mater. The brain has a consistency like somewhat firm jelly during life. The meninges protect this soft structure by anchoring it to the skull and preventing excessive movement within the skull.

The **dura mater** has been removed from the brain tissue, but it is present in one of the brain cases. Observe how thick this meningeal layer is. The dura mater follows the contours of the skull's inner surface and does not dive into the sulci of the brain. In a few places, the dura mater folds and dives into spaces between parts of the brain. These are called the **dural reflections**. You can explore the dural reflections in the images below.

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https://wisc.pb.unizin.org/humananatomylabmanual/?p=107#h5p-27

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https://wisc.pb.unizin.org/humananatomylabmanual/?p=107#h5p-28

The **arachnoid mater** can be seen on the surface of some of the brain tissue. It is the middle layer of the meninges, and it is a delicate, transparent membrane. The arachnoid mater does not follow the contours of the sulci and gyri; instead, it follows the form of the overlying dura. On several of these brains, you can notice aggregations of tiny white granules near the superior midline of the brain. These are **arachnoid granulations**. They function to return cerebrospinal fluid from the subarachnoid space (between this arachnoid mater layer and the pia mater layer of meninges) to the blood.

The **pia mater** is the innermost dural membrane. It cannot be seen with gross examination of the brain, but it covers the surface of the brain tissue, including within the sulci and gyri, of these brains.

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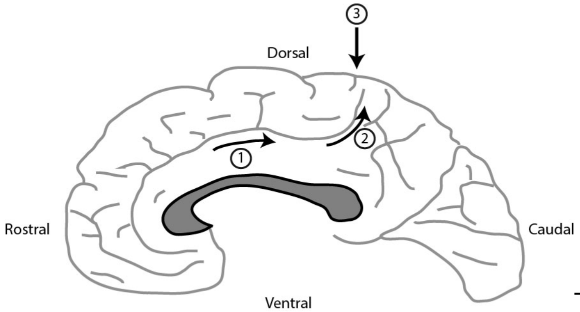
CEREBRAL HEMISPHERES: GROSS EXAMINATION

The **cerebral hemispheres** contain the brain regions involved in our higher cognitive functions, including language, learning, memory, and personality. The surface of the cerebral hemispheres is made up of the **cerebral cortex**, which is a layer of gray matter. This surface is thrown into many folds forming **sulci** and **gyri**. The sulci are the folds diving inward, while the gyri are ridges of the cortex that are visible on the surface of the brain. Sulci and gyri are essential because they increase the surface area of the cortex, giving us more room for neurons involved in higher cognitive functions.

Use the whole-brain and midsagittally sectioned brain tissue to identify the following structures of the cerebral hemispheres.

- The **median longitudinal fissure** separates the left and right hemispheres.
- The **corpus callosum** is the large white matter pathway connecting the right and

left hemispheres of the brain. Observe this structure in cross-section on a midsagittally sectioned tissue.



- The **central sulcus** marks the boundary between the **frontal** and **parietal lobes**. It can be tricky to identify, so to reliably identify it, start from the midsagittal section. Above the corpus callosum (gray in the image) is a curved gyrus called the cingulate gyrus. The sulcus dorsal to the gyrus is the cingulate sulcus. If you follow the cingulate sulcus (1) in the direction of the arrows, it bends dorsally (2) and comes to a stop very close to the dorsal aspect of the brain surface. Move rostrally one sulcus, and you've located the central sulcus (3). Now you can trace it over the lateral aspect of the brain.
- The **precentral gyrus** is in the frontal lobe, just anterior to the central sulcus. This is where the primary motor cortex is located, where all voluntary motor

signals begin.

- The **postcentral gyrus** is in the parietal lobe just posterior to the central sulcus. This is the primary somatosensory cortex, which processes general sensory information.
- The **parieto-occipital sulcus** separates the **parietal lobe** from the **occipital lobe**.
- The **calcarine sulcus** (fissure) is in the occipital lobe. It runs roughly perpendicular to the parieto-occipital sulcus and contains the primary visual cortex. These are visible on the midsagittal section.
- The **lateral (Sylvian) fissure** is the boundary between the **frontal** & **temporal lobes**.

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- The temporal lobe contains three gyri parallel to the lateral (Sylvian) fissure: the **superior temporal gyrus**,

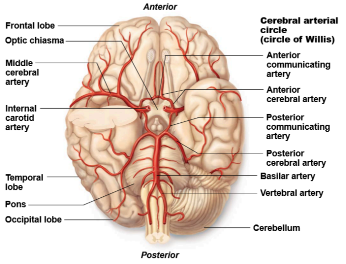
middle temporal gyrus, and **inferior temporal gyrus**. The primary auditory cortex is located in the superior temporal gyrus.

- The **insula** is located deep within the Sylvian fissure. Its functions are not well understood, but taste is one function that it is thought to play a role in. It may be difficult to see on the whole brain, so be sure to look at it in cross-section as well.
- The **thalamus** is located deep in the brain and cannot be seen in the whole-brain tissue. This is the relay center of the brain. Many pathways between the cerebrum, brainstem, cerebellum, and spinal cord have a synapse in the thalamus.
- The **hypothalamus** is located just anterior and inferior to the thalamus. This structure is responsible for many functions, including endocrine control, species-preserving behaviors (hunger, thirst), and circadian rhythm.
- The **anterior commissure** is located just anterior to the thalamus. It connects parts of the frontal and temporal lobes of the two hemispheres.

Though not part of the cerebrum, observe the **cerebellum** and the three parts of the brainstem: the **midbrain**, **pons**, and **medulla oblongata**. You can only see the midbrain in the midsagittal section, as it is mostly hidden by other structures in the whole brain tissue. For now, be familiar with the general location of these structures. We will discuss them more in-depth in the next lab.

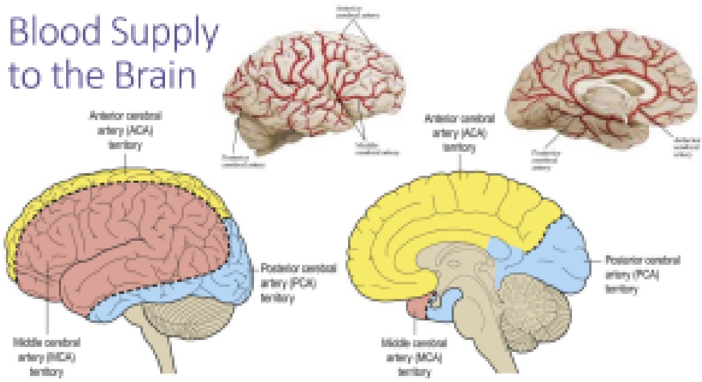
THE CIRCLE OF WILLIS: BLOOD SUPPLY TO THE BRAIN

The brain is supplied by two pairs of arteries: the **vertebral arteries** and the **internal carotid arteries**. They branch into arteries that eventually supply the whole brain. First, look at these arteries and their branches on the inferior aspect of the whole-brain tissue. Then observe the anterior cerebral artery on the midsagittal section.



- The **vertebral arteries** merge along the brainstem to form the single **basilar artery**.
- The **basilar artery** travels along the ventral surface of the pons (part of the brainstem). It gives off several branches to the cerebellum along its path.
- The basilar artery splits on the ventral surface of the pons to give off right and left **posterior cerebral arteries.** The posterior cerebral arteries supply the posterior aspect of the brain, including the occipital lobes, as well as the inferior portion of the temporal lobes.
- Locate the **internal carotid arteries**. They travel through the skull and have been

cut here, so it looks like their lumen is facing you.



- Each internal carotid artery divides into two branches: the **anterior cerebral artery** and the **middle cerebral artery**. The middle cerebral artery dives into the lateral fissure to travel to the lateral aspect of the brain, where it supplies the majority of the temporal lobe and a large portion of the frontal and parietal lobes (lateral aspects). The anterior cerebral artery travels anteromedially to the median longitudinal fissure where it supplies the superior and medial aspects of the frontal and parietal lobes. Examine a midsagittal section to follow the anterior cerebral artery as it runs along the anterior and superior border of the corpus callosum.
- The two anterior cerebral arteries are connected just

before they enter the median longitudinal fissure by the **anterior communicating artery**. This is usually a very short artery connecting them, or the two anterior cerebral arteries can appear to “touch” each other and then split again.

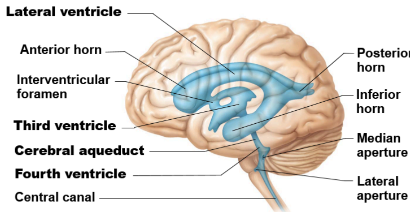
- The **posterior communicating arteries** are small arteries that connect the posterior cerebral and internal carotid arteries.

The three pairs of cerebral arteries and the three communicating arteries form the Circle of Willis, an arterial circle that provides collateral circulation. There is a great deal of variation in the sizes of the component arteries of the circle, including instances of left-right asymmetry. It is not unusual to have an incomplete circle of Willis, and you may notice some variations in the brain tissue in our lab.

ACTIVITY 2: VENTRICLE MODELS AND THE FLOW OF CEREBROSPINAL FLUID

The brain contains several open spaces, called ventricles, filled with cerebrospinal fluid. The ventricle models represent the shape of the open, fluid-filled spaces in the brain. Utilize both the ventricle models and obtain a midsagittally sectioned brain tissue to see the ventricles. The models have laminated images and a key.

Observe the open spaces in the middle of the hemisphere. These are the **lateral ventricles**. The **septum pellucidum** is a thin membrane that separates the anterior part of the lateral ventricles. The larger anterior portion is called the **anterior horn of the lateral ventricle.** The **body of the lateral ventricle** is the thinner portion, just posterior to the anterior horn. The portion in the temporal lobe is called the **inferior horn of the lateral ventricle.** The **posterior horn of the lateral ventricle** extends posteriorly.



The **third ventricle** is a thin midline space that separates the left and right thalami. Each lateral ventricle connects to the third ventricle by way of the **interventricular foramen (of Monro)**. Notice that the third ventricle in the image to the right appears to have a hole in the middle of it. This is created by a midline thalamic structure called the massa intermedia, or interthalamic adhesion, which connects the two thalami and passes through the third ventricle.

The third ventricle connects to the **fourth ventricle** via the **cerebral aqueduct**. The **fourth ventricle** lies between the pons and the cerebellum.

All of the ventricles contain choroid plexus, which produces cerebrospinal fluid (CSF) within the ventricles. This can be observed within some of the ventricles in the midsagittally sectioned tissue & the coronal sections. The choroid plexus can produce CSF in all cerebral ventricles, but the longest possible pathway of CSF flow begins in the lateral ventricle. Locate the midsagittally sectioned brain and the ventricle model to follow the flow of CSF from the production in the choroid plexus in the lateral ventricle through the CNS.

- **Lateral ventricle–>Interventricular foramen (of Monro)–>Third ventricle–>Cerebral aqueduct–>Fourth ventricle–>**From the fourth ventricle, CSF can escape via the **lateral apertures**, **median aperture**, or central canal. These apertures can only be observed on the model.

LAB ACTIVITY 3: VISIBLE BODY APP

Observe the following structures in the Visible Body app:

- **Meninges**: To see the meninges go to the search button and type in meninges. Here you can click on the outer layer of the meninges, the **dura mater**. If you hide the dura mater, you will be able to see the **falx cerebri** and the **tentorium cerbelli.** **You cannot see the arachnoid or pia mater in the app.
- **Cerebrum**: To see the cerebrum and associated structures, under the **Nervous System Views,** click on **2. Brain.** You will have to hide some of the skull bones. Still, you will be able to see each left **cerebral hemisphere, sulci and gyri, corpus callosum,** each **lobe**, **precentral gyrus, postcentral gyrus, central sulcus, lateral sulcus, parieto-occipital sulcus, basal ganglia, caudate**

nucleus, and **putamen** if you go back and click on **5. Thalamus,** you will be able to see the **thalamus** and **hypothalamus.**

- **Ventricles:** To see the ventricles, under the **Nervous System Views** click **4. Limbic System.** You will see the **lateral ventricle, third ventricle, cerebral aqueduct,** and **fourth ventricle from this view.**
- **Blood Supply to the Brain**: To see the arteries of the brain, under the **Circulatory System Views,** click on **4. Circle of Willis**. You will see **vertebral arteries, internal carotid arteries, anterior cerebral arteries, middle cerebral arteries, posterior cerebral arteries, anterior communicating artery,** and **posterior communicating artery.**

LAB ACTIVITY 4: CROSS-SECTIONAL ANATOMY OF THE BRAIN

THE NAVIGATOR

Observe cross-sectional images of the brain using the Navigator. Be sure to observe slices throughout the brain. Many structures span a large portion of the brain, while others are only visible in a few slices.

Observe the following structures in cross-section:

- **Median longitudinal fissure**: Space between the two hemispheres superiorly.
- **Corpus callosum**: This can be observed as the thick structure connecting the two hemispheres just inferior to the median longitudinal fissure.
- **Sylvian fissure:** Lateral space between the temporal lobe and the frontal or parietal lobes.
- **Insula**: Observed laterally but deep, buried within the depths of the Sylvian fissure.
- **Anterior commissure**: This commissural pathway (connecting the two hemispheres) is only visible for a few slices. It is observed connecting the hemispheres inferiorly.
- **Lateral ventricles:** The anterior horn, body, and posterior horn appear in the center of each hemisphere

anteriorly, in slices towards the middle, and posteriorly in the brain. The inferior horn can be seen next to the hippocampus in the temporal lobe, and it is typically relatively thin and flat in shape.

- **Third ventricle**: Located between the right and left thalami (thalami = plural of thalamus).
- **Amygdala**: Located in the anterior portion of the medial temporal lobe. This appears as a center of gray matter in this region. It is involved in behavior and giving emotional meaning to sensory input and memory.
- **Hippocampus**: Observed just posterior to the amygdala in the medial temporal lobe. While the amygdala is a region of gray matter, the hippocampus appears curled next to the inferior horn of the lateral ventricle. The hippocampus is essential for storing new memories and is often atrophied in Alzheimer’s disease.
- **Caudate nucleus**: Located deep in the brain next to the lateral ventricle. It is larger anteriorly and smaller posteriorly and somewhat C-shaped in the sagittal plane. The caudate is part of the basal ganglia, a collection of nuclei involved in the control of voluntary motor activity.
- **Internal capsule:** This white matter pathway is lateral to the caudate nucleus, between the caudate and the putamen (and globus pallidus). It carries primarily motor

fibers, including corticospinal tract fibers.

- **Globus pallidus and Putamen**: These are located just lateral to the internal capsule. The putamen is lateral and slightly superior to the smaller globus pallidus. The putamen is visible alone more anteriorly, and both structures are visible near the middle of the brain.
- **Thalamus**: Consists of a collection of nuclei that sit posterior to the basal ganglia structures. You do not need to know the different nuclei of the thalamus, but you will be able to observe some of the different nuclei in cross-section.
- **Hypothalamus**: Located just inferior to the thalamus.

CORONAL BRAIN CROSS SECTIONS

Observe the above structures in the coronally-sectioned brain tissue. When observing the medial temporal lobe, notice the significant atrophy of both the amygdala and hippocampus. This may be due to neurodegenerative disease, but we do not know the cause of death or medical history for this individual. If you observe the corresponding midsagittally sectioned hemisphere, you can see the atrophy of the intact medial temporal lobe.

Be sure to observe all coronal sections throughout the brain. Some structures are only visible in the anterior sections, while others are only visible posteriorly.

When observing the color-coded images included at this station, note that the brain sections are stained so that the white matter appears very dark compared to the gray matter.

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https://wisc.pb.unizin.org/humananatomylabmanual/?p=107#h5p-30

LAB ACTIVITY 5: RADIOLOGY OF THE BRAIN

Use the radiology paired with the University of British Columbia cross-sections page by clicking on “View MRI” or “View Labelled MRI” in the column at the right. Not all slices have associated radiology images, but this tool will allow you to view radiology images of the brain alongside cross-sectional images of the same slice.

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https://wisc.pb.unizin.org/humananatomylabmanual/?p=107#h5p-31

Lab 7: Brainstem, Cranial Nerves, and Skull

LEARNING OBJECTIVES:

- Describe the anatomical features of the cerebellum and brainstem.
- Identify cranial nerves I-XII.
- Describe the anatomy of the skull and identify the bones of the skull.
- Identify the selected foramen of the skull & explain the structures that run through these foramen.

TERMS TO KNOW

Cerebellum

- Folia

Brainstem

- Medulla oblongata
    - Pyramids
    - Pyramidal decussation
- Pons
- Midbrain
    - Cerebral peduncles
    - Interpeduncular fossa
    - Substantia nigra
    - Corpora quadrigemina (Tectum)
        - Superior colliculi
        - Inferior colliculi

Cranial Nerves

- CN I: Olfactory nerve
    - Olfactory bulb
    - Olfactory tract
- CN II: Optic nerve
    - Optic chiasm
    - Optic tract
- CN III: Oculomotor nerve
- CN IV: Trochlear nerve
- CN V: Trigeminal nerve
- CN VI: Abducens nerve
- CN VII: Facial nerve
- CN VIII: Vestibulocochlear nerve
- CN IX: Glossopharyngeal nerve
- CN X: Vagus nerve
- CN XI: Accessory nerve
- CN XII: Hypoglossal nerve

Skull

- Coronal suture
- Sagittal suture
- Lambdoid suture
- Squamous suture
- Anterior cranial fossa
- Middle cranial fossa
- Posterior cranial fossa
- Ethmoid
    - Cribriform plate and foramina
- Frontal bone
- Sphenoid
    - Optic canal
    - Superior orbital fissure
- Foramen ovale
- Parietal
- Temporal
    - Carotid canal
    - Internal acoustic meatus
    - Mastoid process
    - Styloid process
- Jugular foramen
- Occipital
    - Hypoglossal canal
    - Foramen magnum
    - Occipital condyles
- Vomer
- Mandible
    - Mental protuberance
    - Temporomandibular joint
    - Condylar process
    - Coronoid process
- Maxillae
- Zygomatic
    - Zygomatic arch
- Lacrimal
- Nasal
- Palatine bone

INTRODUCTION

We continue discussing the brain by examining the brainstem, cerebellum, and cranial nerves in this lab. We will also explore the bones, landmarks, fossa, and sutures of the skull. We combine the cranial nerves and skull into one lab because the cranial nerves will travel through the foramina of the skull that you will learn about. This material lends itself well to methodical and regular studying, and be sure to study the foramina and cranial nerves that travel through them together.

LAB ACTIVITY 1: BRAIN TISSUE – BRAINSTEM, CEREBELLUM, CRANIAL NERVES

Observe the brainstem, cerebellum, and cranial nerves on the brain tissue. Also, use the atlases and iPad app to help you find each structure on the tissue. If you are having trouble identifying something, please ask a TA for help.

***Please remember to be GENTLE with the brain tissue. Do not dig around, spread apart lobes, or press down with more than a light touch on the brains. Treat them with care, as we will be using these same brains for several years.*

CEREBELLUM

The cerebellum coordinates voluntary movements and helps to maintain posture and equilibrium. It receives information from the primary motor cortex of the frontal lobe about the intended movement, compares this intended movement with the actual positioning and movement of the body, and sends signals back to the frontal lobe to resolve any differences between the intended movement and current position. The cerebellum is also involved in coordinating higher cognitive functions and emotions.

On the whole brain tissue, locate the cerebellum and observe the two hemispheres. Also, observe the numerous fine grooves, or sulci, on the surface of the cerebellum running transversely. These are called the **folia**, and they are similar to the gyri of the cerebrum.

Observe the **folia** on the midsagittally sectioned brain. Also, observe how the fourth ventricle separates the cerebellum from the pons of the brainstem.

BRAINSTEM

The three major regions of the brainstem, from inferior to superior, are the medulla oblongata, the pons, and the midbrain. The brainstem contains cranial nerve nuclei (collections of neurons) that communicate with the cerebrum, cerebellum, and spinal cord, as well as nuclei that form the cranial nerves. It also contains sensory and motor pathways connecting the cerebrum and the spinal cord.

Locate the whole brain and midsagittally section brain tissue. Use these to identify the following major brainstem structures.

- Locate the **pons** (bridge) on the ventral surface of the brainstem. The pons can be easily identified by its anterior bulge.

- Rostral to the pons, observe the **midbrain**. It is located just inferior to the thalamus, which is best viewed in the midsagittal section. The temporal lobes somewhat hide this structure. Observe the following structures of the midbrain:
    - The midbrain surrounds the **cerebral aqueduct**, which is the pathway that CSF travels between the third and fourth ventricles. This is best seen in a midsagittal view.
    - The **cerebral peduncles** are located on the ventral side of the midbrain. These white matter pathways carry fibers of the corticospinal tract, originating in the primary motor cortex and descending fibers from other cortical regions. The space between the cerebral peduncles is called the **interpeduncular fossa**.
    - On the midsagittal tissue without the brainstem, look at the cut brainstem and observe a dark pigmented line in the midbrain. This is the **substantia nigra**. In Parkinson's disease, the neurons in this structure are destroyed, and the structure is light or no longer visible.
    - Observe the **corpora quadrigemina**, also known as the **tectum**. This is best seen on one of the

cross section cut brain specimens. It appears as four bumps on the posterior (dorsal) surface of the midbrain.

- The two superior bumps are called the **superior colliculi**. They are involved in visual reflexes, causing you to orient your head to focus your eyes on something seen in your periphery.
- The two inferior bumps are called the **inferior colliculi**. They are involved in auditory reflexes, causing you to orient your head to focus your eyes on something you hear.

- Caudal to the pons, examine the **medulla oblongata**. The medulla oblongata is continuous with the spinal cord. Identify the following on the medulla oblongata:
    - Locate the **pyramids**, the eminences of the corticospinal (pyramidal) tract that appear as tube-like bulges on the ventral aspect of the medulla oblongata. The pyramids are visible from their emergence at the pons to the **pyramidal decussation** at the junction between the medulla oblongata and spinal cord. Identify the **pyramidal decussation** where the sulcus between them disappears briefly. This is the decussation of the fibers of the corticospinal tract.

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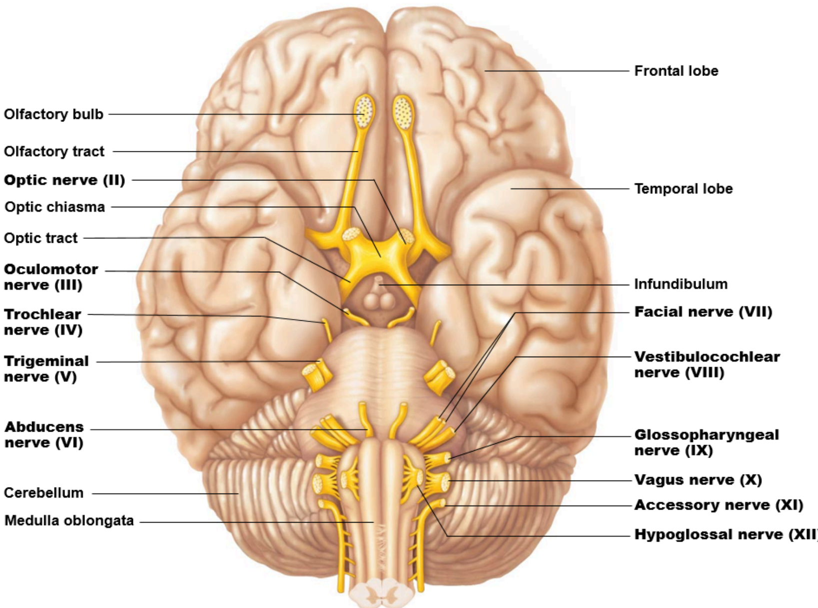
CRANIAL NERVES

The cranial nerves are peripheral nerves that carry various sensory and/or motor information from/to the head and neck. Ten of the twelve cranial nerves are associated with the brainstem, while cranial nerves I (olfactory) and II (optic) are associated with the cerebrum and thalamus, respectively. The functions of each of these nerves are described here. As part of these descriptions, we will mention structures that you haven't learned yet. However, we will discuss all of these structures by the end of this unit.

You can observe the cranial nerves on the whole-brain tissue. Some of the cranial nerves are not present on some of the brains or some sides (right or left) of the brains. However, between all whole brains, atlas images, and the Visible Body app, you should be able to observe all cranial nerves.



- **Olfactory Bulbs and Tracts – CN I**: The olfactory nerves arise in the olfactory epithelium of the nasal cavity and course dorsally to the **olfactory bulb** inferior to the frontal lobe of the cerebral hemisphere. The actual nerves were lost during the removal of the brain. Observe the **olfactory bulb,** where these nerves synapse, on the inferior aspect of the frontal lobe. The **olfactory tract** originates in the olfactory bulb and runs caudally on the ventral aspect of the frontal lobe.
- **Optic Nerves – CN II**: The optic nerves begin in the retina of each eye. These nerves course posteriorly and are united in the **optic chiasm**. The fibers split again immediately posterior to the optic chiasm and extend posteriorly as the **optic tracts**.

- **Oculomotor Nerves – CN III**: These motor nerves emerge in the **interpeduncular fossa** and innervate 4 of the 6 extraocular muscles: the medial rectus, superior rectus, inferior rectus, and inferior oblique.
- **Trochlear Nerves – CN IV:** These are the only nerves to emerge on the brainstem's dorsal aspect. They travel around the sides of the midbrain and pons to innervate the superior oblique. You can find these tiny nerves between the lateral rostral pons and the cerebrum.
- **Trigeminal Nerves – CN V**: These large nerves are the only cranial nerves to emerge from the lateral aspect of the pons. This nerve innervates the muscles of mastication (chewing) and conveys somatic sensation from the entire face.
- **Abducens Nerves – CN VI**: These nerves emerge near the midline at the border of the pons and the medulla oblongata. They innervate the lateral rectus muscle of the eye.
- **Facial Nerves – CN VII:** These mixed motor and sensory nerves emerge from the junction of the pons and medulla oblongata lateral to the emergence of the abducens nerves. They carry sensory

information from the taste buds of the anterior two-thirds of the tongue and innervate the muscles of facial expression, the lacrimal glands of the eye, and most salivary glands.

- **Vestibulocochlear Nerves – CN VIII**: These nerves, which carry both auditory and vestibular sensation, enter the brainstem lateral to (right next to) the facial nerves.
- **Glossopharyngeal Nerves – CN IX**: These nerves are composed of the most rostral of a series of rootlets that emerge posterior to the **olive** on the lateral aspect of the medulla oblongata. They receive sensory information from the tonsils, pharynx, middle ear, and posterior tongue and innervates the stylopharyngeus muscle and parotid gland.
- **Vagus Nerves – CN X**: These nerves emerge caudal to the glossopharyngeal nerves in the same series of rootlets. The vagus nerve has several functions, including providing parasympathetic innervation to organs of the thorax and part of the abdomen and the innervation of muscles of the larynx and pharynx.
- **Spinal Accessory Nerves – CN XI**: These

nerves, which innervate the trapezius and sternocleidomastoid muscles, emerge caudal to the vagus nerve.

- **Hypoglossal Nerves – CN XII**: These motor nerves innervate the musculature of the tongue. They emerge from the ventral aspect of the caudal medulla as a series of rootlets in the groove just lateral to the pyramids.

> *Tip: The cranial nerves with only motor functions (oculomotor, trochlear, abducens, and hypoglossal) emerge medially compared to the other cranial nerves. You cannot see this with the trochlear nerve because it emerges on the brainstem's dorsal aspect, but you can notice this with CN III, CN IV, CN VI, and XII.*

Review the summary of cranial nerves table. The chart describes the cranial nerves, their passageways through the skull, and their functions.

LAB ACTIVITY 2: VISIBLE BODY ATLAS-CEREBELLUM, BRAINSTEM, CRANIAL NERVES

Use the iPads to identify the structures of the **cerebellum, brainstem,** and **cranial nerves**. Under the **Nervous System Views,** click on **2. Brain, 5. Thalamus,** and **6. Cranial Nerves**. Within these views, you will be able to see the **cerebellum, medulla oblongata, pons, midbrain,** and all of the **cranial nerves**. **Note** you will not be able to see the associated structures for the cerebellum, medulla oblongata, or midbrain in the app. You will need to hide layers of the skull, zoom in/out and rotate the image to see all structures.

Use the iPads to identify the structures of the **skull**. Open the atlas app on the iPad, and under **Skeletal System Views,** click **2. Skull**. Here you will be able to see the **sutures** from the list above. However, they are not identified in the app. Return to the menu and click **3. Cranial Fossae.** Here you will be able to see the **fossa** listed above. However, they are not identified in the app. While in this view, you will be able to identify and see **CN I-XII**. You will have to zoom in/out and rotate the image to see all the cranial nerves. While manipulating the image, you should also identify and see the passageways for each cranial nerve (**see table at the end of the lab guide to help determine which passageways to look for). To click on the passageways, you will need to zoom in and specifically touch the passageway. You will identify every bone and listed anatomical feature from the terms above while in views **2. Skull, 3. Cranial Fossae, 4. Skull, Sagittal Section, 5. Skull Coronal Section** and **6.**

Disarticulated Skull (this view particularly will allow you to see every bone of the skull).

LAB ACTIVITY 3: NAVIGATOR – BRAINSTEM, CEREBELLUM, CRANIAL NERVES

Use the Navigator to observe the cerebellum, brainstem, and skull. You can click on Advanced to select/unselect structures and isolate the brainstem and spinal cord or isolate specific cranial nerves to observe where they emerge from the brainstem or travel through the skull.

You can also review the cross-sectional anatomy of the brain covered in the previous lab while you are at the Navigator in this lab.

LAB ACTIVITY 4: SKULL – BONES AND FORAMEN

Use the human skulls to identify the bones, major features, and passageways of the skull. Use a paper or digital atlas to help you identify the bones and passageways listed below. Also, be sure you have pipe cleaners, as you will use these to traverse several of the passageways of the skull.

- First, observe the bones that make up the majority of the external aspect of the cranium**:** the **parietal bones**, **occipital bone**, **temporal bones,** and **frontal bone**.
    - On the temporal bone, identify the **mastoid process** and **styloid process**. These are important sites of muscle attachment.
    - Look at the inferior aspect of the skull. Observe the occipital condyles at the inferior portion of the **occipital bone**, which makes up most of the inferior portion of the cranium. These condyles articulate with the atlas of the vertebral column.
    - Observe the places where these bones meet. These are called **sutures**.
        - **Coronal suture:** where the frontal bone meets the two parietal bones.
        - **Sagittal suture:** where the right and left parietal bones meet.
        - **Lambdoid suture:** between the parietal bones and occipital bone.
        - **Squamous suture:** between the parietal bone and temporal bone on each side.
- Then observe the bones that make up the face.
    - The **frontal bone** is the bone of the forehead.

- The **zygomatic bone** makes up the anterior cheek. The prominent part of the **zygomatic bone** meets part of the **temporal bone** laterally to form the **zygomatic arch**, which makes up our cheekbone.
- The **nasal bone** forms the superior portion of the nose.
- The **maxilla** forms the upper jaw and medial portion of the cheek.
- The **mandible** forms the lower jaw. This is the part of the jaw that moves when we chew or speak. The anterior tip of the mandible that forms the chin is called the **mental protuberance**. Also, observe the articulation between the mandible and the temporal bone. This is the **temporomandibular joint**. The posterior structure that articulates with the temporal bone is the **condylar process**. The flat portion protruding up just anterior to this is the **coronoid process** of the mandible.

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- Remove the top of the cranium from the skull. There are a few bones that are best viewed from the internal aspect of the cranium.
    - First, observe that bony landmarks within the skull form three bowl-like spaces. These spaces are called the **anterior cranial fossa**, **middle cranial fossa**, and **posterior cranial fossa**.
    - The **ethmoid bone** is a small anterior, medial bone located within the **anterior cranial fossa**. You can identify it by the several small holes in it.
    - Just posterior to the frontal and ethmoid bones, observe the **sphenoid bone**. This bone has a ridge that separates the anterior cranial fossa from the **middle cranial fossa**. The temporal lobes of the brain sit in the middle cranial fossa.
    - The rest of the **middle cranial fossa** is made up of the temporal bone.

The posterior aspect of the temporal bone has a ridge that separates the middle cranial fossa from the **posterior cranial fossa**. The posterior cranial fossa is made up of the occipital bone, and this space holds the cerebellum.

There are additional bones of the skull and additional features of these bones that we will discuss in this unit, such as the orbit, nasal cavity, and oral cavity. However, we will discuss these bones and features with other labs.

Many nerves and vessels enter and leave the skull. Therefore, there are many passageways within the skull. You will be asked to identify several of these passageways. Additionally, you will be asked to know which nerves or vessels travel through these passageways.

Using the atlas and a skull, identify the passageways listed in the chart below. Pass a pipe cleaner through the larger passageways to see where they exit the skull. Note that the stylomastoid foramen cannot be observed on the internal aspect of the skull. This foramen is visible between the mastoid process and styloid process of the temporal bone.

Foramina/Passageways	Contents (items that pass through)
Anterior Cranial Fossa	
Cribriform foramina in cribriform plate	Olfactory nerves (CN I)
Middle Cranial Fossa	
Optic canals	Optic nerves (CN II) and ophthalmic arteries
Superior orbital fissure	CN III, CNIV, & CN VI; (Ophthalmic) branch of CN V
Foramen ovale	(Mandibular) branch of CN V nerve
Carotid canal	Internal carotid artery
Posterior Cranial Fossa	
Foramen magnum	Medulla oblongata and meninges, vertebral arteries**
Jugular foramen	CN IX, X, and XI; internal jugular vein
Hypoglossal canal	Hypoglossal nerve (CN XII)
Internal acoustic meatus	CN VII and CN VIII

**Note: The trigeminal nerve gets its name because it divides into three branches (the name means "three twins"). The different branches pass through different foramina of the skull. You do not need to know or identify the branches of the nerve (in parentheses in the chart) in this lab. You will just be asked to know that a branch of the trigeminal travels through the specific foramina above.*

***A portion of the accessory nerve does travel through foramen magnum, but we will not test you on that in this course.*

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can view it online here:

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Lab 8: Muscles and Triangle of the Neck and Face | Vasculature of the Head and Neck

LEARNING OBJECTIVES:

- Identify the muscles of the neck and face, their actions, and their innervation.
- Describe the vasculature of the head and neck and identify the regions supplied or drained by each vessel, as described in the lab guide.
- Review the cross-sectional anatomy of the brain through radiology images.

TERMS TO KNOW

The Neck

- Hyoid bone
- Sternocleidomastoid
- Splenius capitis
- Anterior scalene
- Middle scalene
- Posterior scalene
- Suprahyoid muscles
    - Digastric
        - Anterior belly
        - Posterior belly
    - Geniohyoid
    - Stylohyoid
    - Mylohyoid
- Infrahyoid muscles
    - Omohyoid
        - Superior belly
        - Inferior belly
    - Sternohyoid
    - Thyrohyoid
    - Sternothyroid

Arteries of the Head and Neck

- Subclavian artery
- Vertebral artery
- Common carotid artery
- Internal carotid artery
- External carotid artery
    - Superior thyroid artery
    - Lingual artery
    - Facial artery
        - Angular artery
    - Occipital artery
    - Posterior auricular artery
    - Superficial temporal artery
    - Maxillary artery

Veins of the Head and Neck

- External jugular vein
- Internal jugular vein
- Subclavian vein
- Brachiocephalic vein

Muscles of Facial Expression

- Occipitofrontalis
    - Frontal belly
    - Occipital belly
    - Epicranial aponeurosis
- Corrugator supercilii
- Orbicularis oculi
- Levator palpebrae superioris
- Procerus
- Nasalis
- Buccinator
- Depressor anguli oris
- Depressor labii inferioris
- Levator anguli oris
- Levator labii superioris
- Levator labii superioris alaeque nasi
- Zygomaticus major
- Zygomaticus minor
- Orbicularis oris
- Risorius
- Mentalis
- Platysma

Nerves of the Head & Neck (Those visible in this lab)

- Facial nerve
- Vagus nerve
- Hypoglossal nerve
- Phrenic nerve

Other Structures

- Parotid gland (*described in further detail in Lab 9*)

INTRODUCTION

In this lab, you will explore the muscles and vasculature of the neck and face. These muscles allow us to express emotions from happiness to sadness, surprise to anger. The structures discussed in this lab have a range of clinical implications, from the scalene muscles placing pressure on neurovascular structures to vascular compromise that can be fatal.

LAB ACTIVITY 1: VISIBLE BODY – MUSCLES AND VASCULATURE OF THE NECK

Use the Visible Body app on the iPad to observe the muscles and vasculature of the neck.

MUSCLES OF THE NECK

- In the iPad Atlas App, go to the **Regions** tab and click on **1. Head and Neck**. Now, remove all of the systems (lymphatic, nervous, circulatory…etc.) except for the skeletal and muscular from the sidebar.
- First, click on the *Platysma* muscle and hide it (you will learn about it as a muscle of facial expression later in the lab). Just deep to the platysma, you can observe the **sternocleidomastoid** muscle. This muscle runs from the sternum and

clavicle to the *mastoid process* of the *temporal bone*. It is primarily innervated by CN XI, the *accessory nerve*. When only one side contracts, it causes rotation of the head to the *opposite side* of the muscle that is contracting. Try palpating your sternocleidomastoid muscles and rotate your head from side to side. The more you rotate your head to the opposite side, the more this muscle becomes prominent in the anterolateral portion of your neck. Bilateral contraction contributes to flexion of the neck.

- Rotate the images, so you are looking at a posterior view of the neck. Click on the *Trapezius,* hide it, & observe the **splenius capitis**. Bilateral contraction of this muscle causes extension of the neck. Unilateral contraction (contraction of this muscle on only one side) can cause lateral flexion of the neck to the same side or rotation to the same side.
- Rotate the image to an anterolateral view and observe the **anterior, middle, and posterior scalene muscles**. To get a better view of these muscles, you may want to hide the *sternocleidomastoid* muscle. The scalene muscles run from the cervical vertebrae to the first and second ribs. Their primary

action occurs with breathing. They act to elevate the ribs during forced inspiration. Unilateral contraction of these muscles also contributes to lateral flexion of the neck to the same side and rotation of the neck to the opposite side.

- Rotate the image to a lateral view and observe the **hyoid** bone. This bone is inferior to the mandible within the neck. The hyoid is suspended within the neck by muscles and provides an important site of attachment for them.
- Now rotate the image to a more anterior view and observe the **infrahyoid muscles**. As the name implies, these muscles are located inferior to the hyoid. The names of these muscles indicate the attachment points for these muscles. Together these muscles anchor the hyoid and depress both the hyoid and larynx during swallowing and speaking.
    - Observe the **omohyoid**. This muscle is digastric, meaning that it has two muscle bellies. Observe the short, intermediate tendon between the superior and inferior muscle bellies. This tendon is held to the clavicle by a fascial sling. The word part “omo” means scapula, and this muscle runs from the scapula to the hyoid bone.
    - View the **sternohyoid**. This muscle

runs from the sternum to the hyoid.

- Two additional muscles of this region are deep and visible when you hide the *platysma, sternocleidomastoid, omohyoid, and sternohyoid*. The **sternothyroid** and **thyrohyoid** run from the sternum to the thyroid cartilage and thyroid cartilage to the hyoid bone, respectively. We will discuss the thyroid cartilage with the larynx later in this unit, but you can highlight this cartilage superior to the trachea.

- Move the image so you can see under the chin (view from inferior to superior) and observe the **suprahyoid muscles**. These muscles are superior to the hyoid, and all have an attachment site on the hyoid. As a group, these muscles form much of the floor of the mouth and elevate the hyoid and larynx in swallowing and speaking.
  - Observe the **digastric muscle**. Note, don't confuse this with the omohyoid, despite their similar appearance. The **anterior belly of the digastric** runs from the mandible to the hyoid bone, and the **posterior belly of the digastric** runs from the hyoid bone to the temporal bone (near the

mastoid process).
  - Superior to the posterior belly of the digastric, observe the **stylohyoid**. This muscle travels from the styloid process of the temporal bone to the hyoid.
  - The **mylohyoid** can be seen just inferior and medial to the mandible. This muscle runs from the mandible to the hyoid and forms the anterior floor of the mouth.
  - In order to observe the **geniohyoid**, you will have to hide the *mylohyoid*. This muscle runs from the mandible to the hyoid bone as well, but it is smaller and sits deep to the *mylohyoid*. You may need to rotate the image slightly posteriorly to observe this muscle.

VASCULATURE OF THE NECK

From the home screen in the Visible Body Atlas, click on the **Systems** tab and then go to **Circulatory System** Views and click on **5. Carotid and Jugular** to show the arteries of the head and neck:

- In a right anterolateral view, observe how the brachiocephalic trunk divides into the **subclavian** and **common carotid arteries** (you may want to fade or hide brachiocephalic, internal jugular and subclavian veins). On the left side of the body, these two arteries branch directly off the aortic arch. Follow the subclavian artery laterally for a short span and observe the **vertebral artery**. This artery travels superiorly through the transverse foramen of the cervical vertebrae to supply the brain. You have already viewed this artery as it comes together to form the basilar artery when you studied the circle of Willis.

- Now observe the **common carotid artery**. This artery travels superiorly through the neck and branches into the **internal and external carotid arteries**. You will want to hide the *mandible* to see these arteries better. The internal carotid artery continues superiorly without branching in the neck, travels through the skull, and provides the majority of the blood supply to the brain.
- The **external carotid artery** supplies blood to the scalp, the face, and some structures of the neck. Six arteries branch from the external carotid artery before it terminates and divides into two arteries. To observe several of these arteries through their whole path, you will need to rotate the image back and forth. You may also want to zoom in on the branches. Observe the following arteries as they branch from the external carotid arteries, in order from inferior to superior:
    - *Ascending pharyngeal artery*: This is not visible in the app, and you will not be asked to identify it

on the exam. This artery ascends to supply the pharynx, middle ear, and cranial meninges.

- **Superior thyroid artery**: Runs inferiorly to supply the thyroid gland and larynx.
- **Lingual artery**: Observe how this artery runs medially to supply the tongue.
- **Facial artery**: This artery branches just superior to the lingual artery. In fact, sometimes the facial and lingual arteries branch from the external carotid artery as a common trunk before dividing. It travels along the inferior aspect of the mandible and then wraps around the middle portion of the mandible and ascends through the face. It supplies the submandibular gland, lips, and muscles of the face.
    - **Angular artery**: This terminal branch of the facial artery runs along the nose to the medial corner of the eye.
- **Occipital artery**: This artery arises from the posterior aspect of the external carotid artery and travels superiorly and posteriorly to supply the posterior scalp and

neck.

- **Posterior auricular artery**: This artery arises from the posterior aspect of the external carotid artery just superior to the occipital artery. It ascends just anterior to the mastoid process of the temporal bone and posterior to the ear, and it supplies muscles of this region, the parotid gland, and part of the scalp.
- **Superficial temporal artery**: The external carotid artery terminates as it divides into the superficial temporal artery and maxillary artery. The superficial temporal artery travels superiorly to supply part of the scalp and superolateral face.
- **Maxillary artery**: This is the primary artery supplying the deep structures of the face. It travels anteriorly and medially and gives branches that supply parts of the external ear, the cranial cavity, the scalp, the mouth (including the cheek, teeth, upper and lower jaw, palate, and gums), and the inferior portion of the orbit.

Go back to the home screen in the Visible Body Atlas and click on the **Systems** tab, then **Circulatory System** Views and click on **5. Carotid and Jugular** to show the veins of the head and neck:

- Now click on the **external jugular vein**, which empties into the subclavian vein. This vein drains part of the lateral aspect of the head.
- The **internal jugular vein** ultimately drains the majority of the blood from the head and neck. The **internal jugular vein** joins with the **subclavian vein** to form the **brachiocephalic vein**. Unlike the arteries of the same name, this happens on both the right and left side. This is because they both need to carry their blood toward the midline to reach the superior vena cava. However, for the arteries on the left side, the arch of the aorta already travels towards the left, positioning the subclavian and common carotid arteries in the appropriate place where they would normally branch.

LAB ACTIVITY 2: VISIBLE BODY – MUSCLES OF FACIAL EXPRESSION

Explore the muscles of facial expression using the iPad app. From the home screen click on the **Systems** tab and then click **1. Expression.** Begin in the most superficial layer to view these muscles. The muscles of facial expression generally originate on the bones and fascia of the skull and insert into the skin of the face, resulting in movement and wrinkling of the facial skin. All of these muscles, except for one (**levator palpebrae superioris**, **CN III**) are innervated by the *facial nerve, CN VII*. A chart is provided in this lab guide to provide you with more information about these muscles. *You are responsible for knowing actions and emotions or common motions conveyed by these muscles*. You are encouraged to study the description of the muscle actions while viewing the muscles.

While won't be asked about origins and insertions for these muscles, knowing where they insert can help you understand their action. For example, two muscles are located superior to the lip with nearby origins inferior to the eye. Though they both insert into the upper lip and elevate parts of the upper lip, they have different insertion points. As a result of these different insertions, contraction of these muscles conveys very different emotions. **Levator anguli oris** inserts into the corner of the mouth, while **levator labii superioris** inserts medial to that, in the upper lip. Therefore, when levator anguli oris contracts, it causes smiling, while contraction of levator labii superioris conveys sadness by elevating the upper lip. If you are taking the exam and you can't remember the action of one of these muscles, look at the insertion point, and this will help you reason through the action.

The one muscle that you will need to hide superficial layers to see is **corrugator supercilii.** In order to see this muscle you will have to hide the *depressor supercilii* and *occipitofrontalis*. Every other muscle of facial expression from the box below is visible using the app.

Muscle		Description	Action	Emotion/ Common Motion
Occipito-frontalis	**Frontal belly**	Frontal belly covers forehead; occipital belly covers posterior skull; Epicranial aponeurosis connects the bellies	Elevates eyebrows & wrinkles forehead horizontally	Surprise, Curiosity
	Occipital belly		Pulls the scalp posteriorly	
Corrugator supercilii		Small muscle in the medial eyebrow	Draw eyebrows inferomedially, creating vertical wrinkles above the nose	Concern, skepticism
Orbicularis oculi		Thin, flat, sphincter of the eye, surrounds the orbit	Closes eyes	Winking, blinking; squinting
Levator palpebrae superioris* **		Runs from the posterior orbit to the superior eyelid	Elevates superior eyelid to open the eye	Contributes to surprise, curiosity
Procerus		Between the eyebrows over the nasal bone	Depresses medial eyebrow, wrinkles skin over the nose	Dislike or distain
Nasalis		Over cartilage of the nose	Compresses bridge and depresses tip of nose, elevates corners of the nostrils	Flares nostrils, as with anger
Buccinator		Thin, horizontal muscle in the cheek, deep to the masseter.	Compresses cheek; holds food between cheek and teeth when chewing	Whistling, sucking
Depressor anguli oris		Runs from the angle of the mouth to the lateral chin	Draws the corner of the mouth inferiorly and laterally	Frown
Depressor labii inferioris		Runs from lateral chin to the lower lip	Depresses the lower lip	Frown

Levator anguli oris	Runs from the medial cheek to the angle of the lips	Widens the mouth, elevates the corners of the mouth	Smiling
Levator labii superioris	Runs from the inferior orbit to the lateral upper lip	Elevates and furrows the upper lip	Sadness;
Levator labii superioris alaequae nasi^	Runs alongside nose to medial upper lip, lateral to midline	Elevates the upper lip, dilates the nostrils	“Elvis” snarl
Zygomaticus major	Zygomatic arch to the corner of the mouth	Raises the corners of the mouth	Smile
Zygomaticus minor	Zygomatic arch to the lateral upper lip	Raises the corner of the mouth/lateral upper lip	Smile
Orbicularis oris	Thin muscle surrounding the entrance to the oral cavity	Closes the lips/mouth; purses and protrudes the lips	Kissing, whistling
Risorius	Runs horizontally and laterally from the angle of the mouth	Draws corner of lip laterally and down, tenses the lips	Frustration, sadness
Mentalis	Anterior chin to the lower lip	Elevates & wrinkles skin of the chin, protrudes the lower lip	Pouting

Platysma	Thin muscle within skin of the neck that runs from the clavicular region to the lower mandible and mouth	Tenses the skin of the inferior face and neck, depresses the jaw	

***Note: All of these muscles are innervated by the facial nerve (CN VII) except for levator palpebrae superioris, which is innervated by the oculomotor nerve (CN III).*

^This is the longest name of a muscle in the body.

An interactive H5P element has been excluded from this version of the text. You can view it online here:

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LAB ACTIVITY 3: NAVIGATOR-MUSCLES AND VASCULATURE OF THE FACE AND NECK

Use the Navigator to observe the structures described above and listed in the list of terms. Use the presets and observe the vasculature. Then use the advanced view window to add or remove muscles and vessels from the image. This tool can be very helpful for viewing the muscles and vasculature from different angles as well as for isolating the muscles and vasculature. **DO NOT save any pre-sets.**

If you are having difficulty seeing the vessels, you can change the background color of the Navigator screen. Click on *File* and then *Preferences*. Here you can choose a lighter background color.

LAB ACTIVITY 4: PLASTINATED TISSUE

Observe the muscles of the face and neck and hyoid bone on the head and neck and respiratory plastinated tissue.

ON THE HEAD AND NECK PLASTINATE:

- First observe the **hyoid bone**. It is difficult to see, but part of it can be seen/palpated just deep and inferior to the mandible. You can notice that several muscles are inserting into it from superior and inferior directions.
- Now observe the **sternocleidomastoid**. While its origin is not present in this model, the bulk of the muscle and its insertion at the mastoid process are visible.

- On the posterior aspect, observe the **splenius capitus**.
- Laterally, observe the **anterior, middle**, and **posterior scalenes**.
- Now look at the **suprahyoid muscles**. The **anterior** and **posterior bellies** of the **digastric** can be easily observed, with the common middle tendon being held to the hyoid bone. **Mylohyoid** sits just deep to the **anterior belly of the digastric**. **Stylohyoid** is very skinny and sits just deep to the **posterior belly of the digastric**. The **geniohyoid** is not visible here because it is deep to the **mylohyoid**.
- Now look at the **infrahyoid muscles**. Only the **superior belly of the omohyoid** is visible here. **Sternohyoid** is also visible, but it is cut before it reaches the sternum. However, you can tell it is the **sternohyoid** because it runs past and does not insert into the thyroid cartilage. **Thyrohyoid** and **sternothyroid** are visible, but they are better seen on the respiratory plastinate.
- Observe the muscles of facial expression on this plastinate. Not all muscles are visible. For example, the occipitofrontalis may have some visible fibers, but part has been cut, and the epicranial aponeurosis is not visible. However, you should be able to identify most of

them. Be sure to observe the direction of the muscle fibers and think about the actions that these muscles perform.

ON THE RESPIRATORY PLASTINATE:

- The **thyrohyoid** is more easily visible on this model. Several other muscles described above can be seen here as well.
- Observe the muscles of facial expression that are visible on this specimen. Again, not all of them will be visible, but you should be able to identify most of the muscles of facial expression between the two specimens.

LAB ACTIVITY 5: CADAVER TISSUE

Observe the muscles and neurovasculature of the face and neck on the cadaver. The right side of the face and neck has been dissected so that deeper structures are visible, while the left side has been dissected superficially.

Observe the following muscles of the neck on the cadaver:

- Sternocleidomastoid
- Anterior scalene
- Middle scalene
- Posterior scalene

Observe the position of the hyoid bone at the superior aspect of the neck. While the entire bone is not readily visible, you can see it as the common attachment location for the muscles acting on this bone. Identify the following muscles that act on the hyoid bone on the cadaver:

- Suprahyoid muscles
    - Anterior belly of the digastric (posterior belly is mostly hidden)
    - Mylohyoid
- Infrahyoid muscles
    - Omohyoid (superior and part of the inferior belly)
    - Sternohyoid
    - Thyrohyoid
    - Sternothyroid

Observe the neurovasculature of the head and neck. On the right side of the cadaver, observe the common carotid artery, and notice where it branches into the internal and external carotid artery. Next to the common carotid artery, notice the internal jugular vein. In this cadaver, the internal jugular vein appears to have very thin and somewhat translucent walls. Between the internal jugular vein and the common carotid artery, notice the vagus nerve descending through the neck. These three structures travel together in a common sheath through the neck.

Deep to the mandible on the left side, observe the lingual artery as well as the hypoglossal nerve looping anteriorly towards the tongue.

On the right side notice the facial artery ascending on the medial aspect of the face, lateral to the oral cavity. It becomes the angular artery on the lateral aspect of the nose. Also observe the superficial temporal artery on the lateral aspect of the cranium over the temporal bone. The facial nerve can be seen emerging from the parotid gland, the large gland near the ear. The facial nerve has five branches that innervate the muscles of the face. The cervical branch can be seen traveling to the platysma. The mandibular branch traveling towards the mandible and the buccal branch traveling to the buccinator have been cut, but a portion of the buccal branch is still visible. The zygomatic branch can be seen traveling deep to the zygomatic arch, while the temporal branch is visible traveling towards the temporal bone, though it has also been severed.

Observe the following muscles of facial expression on the cadaver. Some are only visible on one side or the other, and some will be visible bilaterally:

- Corrugator supercilii
- Orbicularis oculi
- Procerus
- Nasalis
- Buccinator
- Levator anguli oris
- Levator labii superioris
- Levator labii superioris alaeque nasi
- Zygomaticus major
- Zygomaticus minor
- Orbicularis oris
- Depressor anguli oris
- Depressor labii inferioris
- Risorius
- Mentalis
- Platysma

Lab 9: Oral Cavity | Nasal Cavity | Pharynx | Larynx

LEARNING OBJECTIVES:

- Identify the structures of the nasal cavity and the sinuses and describe their functions
- Identify the contents of the oral cavity, including the salivary glands.
- Describe and identify the muscles of mastication and muscles that act on the tongue.
- Identify the cartilage and muscles of the larynx and explain how the vocal cords function.
- Describe the parts of the pharynx.

TERMS TO KNOW

Nasal Cavity and Smell

- Nose
- Alar cartilage
- Nasal septum
- Superior nasal concha
    - Superior nasal meatus
- Middle nasal concha
    - Middle nasal meatus
- Inferior nasal concha
    - Inferior nasal meatus
- Paranasal sinuses
    - Frontal sinus
    - Ethmoid air cells (sinus)
    - Sphenoid sinus
    - Maxillary sinus
- Olfactory bulbs
- Olfactory tracts
- Olfactory nerves
- Nasal bones

Larynx

- Thyroid cartilage
    - Laryngeal prominence
- Cricoid cartilage
- Posterior cricoarytenoid muscles
- Epiglottis
- Arytenoid cartilages
- Vocal folds
- Vestibular folds
- Cricothyroid muscle
- Oblique arytenoid muscles
- Transverse arytenoid muscle
- Recurrent laryngeal nerve
- Thyrohyoid muscle
- Hyoid bone

Oral Cavity

- Oral vestibule
- Oral cavity proper
- Hard palate
- Soft palate
- Uvula
- Palatoglossal arch
- Palatopharyngeal arch
- Palatine tonsil
- Tongue
- Muscles of mastication
    - Temporalis
    - Masseter
    - Medial pterygoid
    - Lateral pterygoid
- Salivary Glands
    - Parotid gland
        - Parotid duct
    - Submandibular gland
        - Submandibular duct
    - Sublingual glands
- Temporomandibular joint
- Mandible
- Styloglossus
- Genioglossus
- Hyoglossus

Pharynx

- Nasopharynx
    - Pharyngeal opening of auditory tubes
- Oropharynx
- Laryngopharynx
- Pharyngeal constrictors
    - ***We won't ask you specifically about the superior, middle, or inferior constrictors, just the muscle group (pharyngeal constrictors)
- Piriform recess

INTRODUCTION

In this lab you will explore the nasal cavity, oral cavity, pharynx and larynx. The nasal cavity is the first part of the upper respiratory tract. It contains structures that swirl and condition the air before it moves on the next respiratory tract structures. The oral cavity is the first part of the digestive system. Its structures allow for mechanical digestion by chewing, chemical digestion by the products of salivary glands, and taste. The oral cavity is also part of the respiratory system, as, of course, we can take in air through the oral cavity. The larynx is part of the respiratory system, and it contains the vocal cords and other structures required for producing sound in speech. The pharynx sits posterior to the nasal cavity, oral cavity, and larynx. It contributes to the respiratory system by providing a passageway for air to travel from the nasal or oral cavities to the larynx. It also contributes the digestive system by connecting the oral cavity to the esophagus, and it contains muscles that function in swallowing.

LAB ACTIVITY 1: SLIDESHOW IMAGES

Go through the slideshow images displayed on the computers in lab and explore the structures on the Terms to Know. All of the regions you are examining in this lab are in close proximity. Therefore, you will see parts of the oral cavity, nasal cavity, larynx, and/or pharynx on the same image. There will also be structures labeled on some of the images that we have talked about in other labs. Within these images you will be able to identify all of the structures in the list of terms. The following section describes some of these structures in more detail (*and you are responsible for knowing this information*):

ORAL CAVITY

- The **oral cavity** can be divided into two parts. The **oral vestibule** is the portion of the oral cavity between the teeth and the lips. The **oral cavity proper** is the portion of the oral cavity between the teeth and the pharynx, where the tongue is located.
- **Palate**: The palate is the roof of the oral cavity. The most anterior portion is the **hard palate**. This is formed by part of the maxilla and the palatine bone. The **soft palate** is composed of skeletal muscle. At the posterior portion of the **soft palate** is the **uvula**, which closes off the entrance from the oropharynx to the nasopharynx during swallowing so that food does not enter the nasopharynx and nasal cavity.
- **Arches**: The oral cavity opens into the oropharynx through paired muscular folds: The **palatoglossal arch** and the **palatopharyngeal arch**. The palatoglossal arch is formed by the **palatoglossus muscle** and the membrane covering it, while the palatopharyngeal arch is formed by the **palatopharyngeus muscle** and the membrane covering it. Between these arches sits the **palatine tonsils**. These are aggregations of lymphatic tissue that trap foreign antigens entering the body via the mouth to mount an early immune

response. The palatine tonsils can sometimes become very inflamed with illness, which is called *tonsillitis*.

- **Tongue**: The tongue plays important roles in both the mechanical digestion of food and sound production (articulation). The tongue itself is composed of several different intrinsic muscles (muscles completely within the tongue), and it also has several extrinsic muscles that act on it. Three of these muscles can be observed in one of the images: The **styloglossus, genioglossus**, and **hyoglossus**. The names of these muscles help you to identify them based on their origins. The **styloglossus** originates from the styloid process of the temporal bone. The **genioglossus** originates under the chin (genio- means chin). The **hyoglossus** originates on the hyoid bone. All of these muscles insert into the tongue.
- **Muscles of Mastication**: The muscles of mastication act on the mandible and function in chewing our food. The **temporalis muscle** runs from the temporal bone to the coronoid process of the mandible. It elevates and retracts the mandible. The **masseter** originates on the zygomatic arch and inserts on the mandible. It is the prime mover of

elevation of the mandible (clenching the teeth), and it also protracts the mandible. The **lateral and medial pterygoids** originate on the sphenoid bone and insert onto the mandible. They protract the mandible and to move it side to side, as we do when we grind our food between our back teeth when chewing. All of these muscles are innervated by the **trigeminal nerve** (CN V).

- **Salivary glands**: The salivary glands produce saliva, which contains substances that help with the chemical digestion of food, moisten the oral cavity and ingested food, and dissolves food materials for taste. The **parotid gland** is the largest salivary gland, and it is located in the posterior cheek region, just anterior to the ear. The **parotid duct** pierces the buccinator muscle and enters the oral cavity. Production of saliva from the parotid gland is controlled by the **glossopharyngeal nerve (CN IX)**. The **submandibular glands** sit just inferior to the body of the mandible on each side, and they produce the majority (60-70%) of our saliva. The **submandibular ducts** carry the saliva from this gland to the floor of the mouth. The **sublingual glands** are smaller and sit just inferior to the tongue, anterior to the submandibular glands. They secrete their saliva into the floor of the oral cavity. Secretion from the submandibular and sublingual glands are controlled by the **facial nerve (CN VII)**.

- **Temporomandibular joint (TMJ)**: This joint is the articulation between the condyle of the mandible and the temporal bone. This hinge joint allows us to open and close our mouth.

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://wisc.pb.unizin.org/humananatomylabmanual/?p=114#h5p-36

NASAL CAVITY

- **Nasal bones:** The nose is formed by both cartilage and bone, with the **nasal bones** forming the bridge of the nose more superiorly and posteriorly.
- **Nasal septum**: Divides the nasal cavity into right and left halves. It is partially formed by bone and partially formed by cartilage

- **Nasal conchae**: The nasal conchae condition the air that enters through the nasal cavity. They cause the air to swirl, and the membranes that cover them help to warm and moisten the air before it travels further down the respiratory tract. The **superior and middle nasal conchae** are part of the **ethmoid bone**, while the **inferior nasal conchae** is its own bone. The space below each conchae is called a **meatus**, and it is named for the conchae above it.
- **Paranasal sinuses**: The sinuses are air-filled spaces in four bones of the skull. They function to lighten the skull, humidify and warm inhaled air (via their mucous lining), and provide resonant chambers for sound production. The **frontal sinuses** sit just superior to the orbits' medial aspect, while the large **maxillary sinuses** sit just lateral to the nose. The ethmoid bone contains many small sinuses sitting just superior to the nasal cavity, and these are called the **ethmoid air cells**. The **sphenoid sinus** sits just superior to the nasopharynx.
- **Olfactory structures**: An important function of the nose is olfaction, or smell. The mucous lining at the superior portion of the nasal cavity contains the

receptors of the olfactory nerves. The olfactory nerves run through the foramina of the cribriform plate of the ethmoid bone and synapse in the olfactory bulb. The axons of the neurons from the olfactory bulbs travel posteriorly through the olfactory tract to the primary olfactory region of the brain.

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PHARYNX

- **Nasopharynx**: Portion of the pharynx posterior to the nasal cavity.
- **Oropharynx**: Portion of the pharynx posterior to the oral cavity.
- **Laryngopharynx**: Portion of the pharynx posterior to the larynx.
- **Pharyngeal constrictors**: The **superior, middle, and inferior pharyngeal constrictors** contract sequentially during the swallowing process to move food

towards the esophagus. It can be difficult to define each visually, so we will refer to them together as the pharyngeal constrictors. These are skeletal muscles, and they are innervated by the **vagus nerve (CN X)**.

- **Piriform recess (Pyriform sinus)**: This region is located within the laryngopharynx on either side of the entrance into the pharynx. It is a common place for food to become trapped while swallowing. Though this is not really a significant problem, it can make us feel like something caught in our throat.

An interactive H5P element has been excluded from this version of the text. You can view it online here:

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LARYNX

- **Thyroid cartilage**: This is the largest laryngeal cartilage and is only located anteriorly and laterally. It does not form a complete ring around the larynx. The **laryngeal prominence** of the thyroid cartilage protrudes anteriorly, forming our Adams apple.

- **Cricoid cartilage**: Inferior to the thyroid cartilage. It is thin anteriorly and taller posteriorly.
- **Epiglottis**: This is the spoon-shaped flap of cartilage that folds over the opening to the larynx during swallowing to prevent food from entering the airway.
- **Arytenoid cartilages**: These are small, L-shaped cartilages involved in sound production. The vocal cords are attached to the thyroid cartilage anteriorly and the ends of the arytenoid cartilages posteriorly. As the arytenoids rotate within the larynx, the tension on the vocal cords changes, resulting in changes in sound production.
- **Vocal folds**: The **vocal folds** contain the vocal ligaments, or vocal cords. When viewing a midsagittal section of the larynx, you can observe two folds, one on top of the other, with a small space between them. The superior fold is the **vestibular fold**, also known as the false vocal fold. The true vocal folds are the inferior fold in this view. Sound production occurs as a result of movement of the vocal cords within the vocal fold.

- Several muscles act on the larynx during sound production, and most can be identified based on their names, which indicate their attachment points. The **cricothyroid muscle** runs from the cricoid to the thyroid cartilages. The **transverse arytenoid muscle** runs horizontally between the right and left arytenoids, while the **oblique arytenoid muscles** form an "X" shape on top of the transverse arytenoid muscle. The **posterior cricoarytenoid muscles** run from the cricoid to the arytenoid cartilages. Muscles acting on the arytenoid move these cartilages to change the tension on the vocal cords in sound production.
- **Recurrent laryngeal nerve**: This branch of the vagus nerve innervates most muscles of the larynx. If this nerve is damaged, the patient will have a hoarse voice or be unable to produce sound. This nerve is vulnerable because it travels down into the thorax near the heart (even wrapping around the arch of the aorta on the left) before it travels back up to the larynx.

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://wisc.pb.unizin.org/humananatomylabmanual/?p=114#h5p-39

LAB ACTIVITY 2: THE NAVIGATOR – MUSCLES OF MASTICATION, THE TONGUE AND SALIVARY GLANDS

Use the Navigator to observe the muscles of mastication, the tongue and the salivary glands. This tool can be very helpful for viewing the structures of these regions from different angles as well as for isolating the and identify the structures listed above. **DO NOT save any pre-sets. Preset 1 has already been created for you specifically for this lab.**

***Note: If you are having difficulty seeing the various structures, you can change the background color of the Navigator screen. Click on File and Preferences. Here you can choose a lighter background color.*

LAB ACTIVITY 3: PLASTIC NOSE WITH NASAL SINUSES MODEL

We have one plastic nose with nasal sinuses model for you to observe in this lab. *Please be gentle* when looking at the model, there are parts that come apart and can be damaged when trying to replace them or if they are dropped.

- Review the model as well as the laminated images and key to identify structures from the terms to know list above. (the terms on the key in light gray are numbered on the laminated images, but you are **NOT** responsible to know them for lab, although they might help you for the lecture course)

LAB ACTIVITY 4: PLASTINATED TISSUE – ORAL & NASAL CAVITY, PHARYNX, LARYNX

Begin with the respiratory dissection plastinated specimen:

- **Nasal Cavity:** The nasal septum has been removed, and you can observe the **superior, middle, and inferior nasal conchae** as well as the spaces below them: the **superior, middle, and inferior nasal meatus**. You can observe a small portion of the

frontal sinus in the fontal bone as well as the **sphenoid sinus** more posteriorly, deep in the skull. You can also see the location of the **ethmoid air cells**, just anterior to the sphenoid sinus, though there is bone in front of these air cells in this specimen.

- **Oral Cavity:** The **oral vestibule** and **oral cavity proper** can be challenging to discern here, as the teeth have been lost. However, you can somewhat see where the teeth would have been and understand generally where these two regions are located on this plastinate. You can easily observe the **hard palate, soft palate, uvula** and **tongue**. You can also see the **submandibular gland** inferior to the mandible. The other salivary glands have been removed. Finally, observe the **masseter** on this specimen.
- **Larynx:** Observe the **thyroid cartilage**, **laryngeal prominence**, **cricoid cartilage**, and **thyrohyoid** and **cricothyroid muscles**. Also observe the **epiglottis**.
- **Pharynx:** Observe the **nasopharynx and oropharynx.** You can look down into the **laryngopharynx,** but this region has not been dissected in a midsagittal section.

Now look at the head and neck plastinated specimen:

- **Muscles of mastication and temporomandibular joint:** On the specimen's left you can see the **temporalis** and **masseter** muscles. On the right, these muscles have been cut so that you can observe the **medial and lateral pterygoid muscles**. On both sides you can observe the **temporomandibular joint**.

LAB ACTIVITY 5: VISIBLE BODY DIGITAL ATLAS

ORAL CAVITY

- To see the oral cavity, click on the search box, now type in "Oral Cavity." If you hide the gingiva, you can see the **oral cavity proper.** In this view, you can rotate the image around and see: **hard palate, soft palate, uvula, sublingual glands, and submandibular glands.**
- Next, click on "Menu." To see the tongue, you can click on **1. Upper Digestive System** under the **Digestive System View**. If you hide the mandible, gingiva and the teeth, you can see the **tongue, styloglossus, genioglossus**, and **hyoglossus** when you rotate the image around.
- Now click on "Menu" to return to systems view, under **Muscular Systems View**, now click on **2. Mastication**. You will see the **temporalis and masseter** on a lateral view of this

image. To see the **lateral and medial pterygoids** you will need to hide the zygomatic, mandible and maxilla as well as the masseter, the pterygoid muscles sit deep to all of these structures.

NASAL CAVITY

- First, click **on Respiratory System Views**, then **1. Upper Respiratory**. Hide the skin of the face and head. Now you can see the nasal cavity and the sinuses. You will have to rotate the model around, but you can see the **ethmoidal air cells, the maxillary, frontal and sphenoid sinuses.**
- Click on "Menu" to return to systems view, now click on **2. Nasal Cavity**. In this view you can easily see the **nasal conchae (superior, middle, inferior)** and if you remove the cartilage on the nose, you can also see the **nasal septum** (septal cartilage).

PHARYNX AND LARYNX

- First click on "Systems," then under **Respiratory System Views**, click on **4. Pharynx and Larynx**. Explore the structures of the pharynx and larynx here, specifically you can see: the **pharyngeal constrictors (superior, middle, inferior)**.
- Click on "Menu" to return to the systems view, now click on **6. Laryngeal Muscles**. Identify the structures listed under the larynx here: **thyroid cartilage, cricoid cartilage**,

epiglottis, arytenoid cartilages, vocal folds and the muscles of the larynx; cricothyroid, transverse arytenoid and oblique arytenoid.

LAB ACTIVITY 6: CADAVER TISSUE

Identify the following structures on the cadaver tissue:

Larynx

- Thyroid cartilage
    - Laryngeal prominence
- Hyoid bone

Oral Cavity

- Muscles of mastication
    - Temporalis
    - Masseter
- Salivary Glands
    - Parotid gland
        - Parotid duct
    - Submandibular gland
- Mandible

Lab 10: Eye | Ear

LEARNING OBJECTIVES:

- Identify the bones of the orbit.
- Identify the structures that make up the eye.
- Identify the extraocular muscles of the eye and their actions.
- Identify the parts of the hearing and vestibular system.
- Review the bones and foramen of the skull and structures that pass through the foramen.

TERMS TO KNOW

Eye

- Extraocular Muscles
    - Lateral rectus
    - Medial rectus
    - Inferior rectus
    - Superior rectus
    - Inferior oblique
    - Superior oblique
- Fibrous layer of eye
    - Cornea
    - Sclera
- Vascular layer of eye
    - Choroid
    - Suspensory ligaments/ zonular fibers
    - Ciliary muscle
    - Ciliary body
    - Iris
    - Pupil
- Inner layer of eye
    - Retina
    - Optic disc (blind spot)
    - Lens
    - Vitreous humor/body
- Orbit
    - Lacrimal sac
    - Optic nerve (CN II)
    - Optic chiasm
    - Optic tract

Ear

- External ear
    - Auricle
    - External acoustic meatus
    - Tympanic membrane
- Middle ear
    - Tensor tympani muscle
    - Pharyngotympanic (auditory/Eustachian) tube
    - Auditory ossicles
        - Malleus
    - Incus
    - Stapes
- Internal ear
    - Vestibule
    - Oval window
    - Round window
    - Semicircular canals
        - Anterior, Lateral, Posterior
        - Ampulla
- Cochlea

Important Terms from Previous Labs

- Cranial nerves and brain structures
    - Abducens Nerve (CN VI)
    - Oculomotor nerve (CN III)
    - Trochlear nerve (CN IV)
    - Optic nerve (CN II)
    - Facial Nerve (CN VII)
    - Vestibulocochlear Nerve (CN VIII)
    - Occipital lobe
        - Primary visual cortex
        - Calcarine fissure
- Bones of the skull that make up the orbit
    - Frontal bone
    - Sphenoid bone
    - Maxilla
    - Ethmoid bone
    - Zygomatic bone

    - Lacrimal bone
- Internal acoustic meatus

INTRODUCTION

This lab will explore the special sensory anatomy that makes up our vision, hearing, and vestibular systems. These sensory systems work to contribute to our overall ability to see, hear, demonstrate balance, and navigate our surroundings with ease. When any of these structures are compromised, it has a profound impact on our daily function.

LAB ACTIVITY 1: NAVIGATOR – THE EYE

Use the Navigator to explore the anatomy of the orbit and the structures within it. First explore the eye within the skull. Next, you can remove the skull. Click on the "View" icon and choose "Advanced." In the left column, uncheck the skeleton box. Now you will have a clear view of the contents of the orbit. If you want to add the skull back in, you can check the skeleton box. **DO NOT save any presents!**

Examine the extraocular muscles. These muscles function to move the eye so that we can direct our visual attention. All but the inferior oblique muscle originate in a common tendinous ring at the posterior aspect of the orbit. Notice that the superior oblique muscle travels anteriorly to the medial corner of the orbit and then turns posteriorly and laterally to insert on the eye. There is a small pulley, or trochlea (hence, trochlear nerve), that the tendon of this muscle runs through. Therefore, when the superior oblique muscle contracts, it depresses the eye (causes the eye to look down). Also observe the nerves that innervate these muscles.

Extraocular Muscle	Action	Cranial Nerve Innervation
Lateral rectus	Moves eye laterally (abducts)	CN VI Abducens Nerve
Medial rectus	Moves eye medially (adducts)	CN III Oculomotor Nerve
Superior rectus	Elevates the eye (look up)	
Inferior rectus	Depresses the eye (look down)	
Inferior oblique	Elevates eye and turns it laterally	
Superior oblique	Depresses eye and turns it laterally	CN IV Trochlear Nerve

Next, follow the **optic nerve** posteriorly from the eye. The optic nerves come together at the **optic chiasm**. Here, some of the fibers within the optic nerves cross. After the optic chiasm, these axons continue on as the optic tract until the majority of them synapse in a nucleus of the thalamus.

Observe the eye in both **coronal and transverse cross sections**. It can be helpful to have all three cross sectional views visible at the top of the screen. Click on the "Layout" icon on the toolbar and choose the view with three boxes at the top of the screen. As you move through the transverse (axial) cross section, you can observe the eye, medial and lateral rectus muscles on the sides of the eye, and the optic nerve leaving the eye posteriorly. As you move through the coronal view, you can observe the four rectus muscles of the eye as well as the optic nerve. Also notice the adipose (fat) tissue surrounding the structures of the orbit. This tissue fills the space within the orbit and provides protection for these structures.

LAB ACTIVITY 2: PLASTIC EYE AND EAR MODELS

We have two plastic eye models as well as two plastic ear models for you to observe in this lab. ***Please be gentle*** when looking at the models, there are parts that come apart and can be damaged when trying to replace them or if they are dropped.

Review the models as well as the laminated images and key to identify structures from the terms to know list above. (the terms on the key in light gray are numbered on the laminated images, but you are **NOT** responsible to know them for lab, although they might help you for the lecture course)

LAB ACTIVITY 3: SLIDESHOW IMAGES – EYE AND EAR

Study the images on the lab computers that show the anatomy of the eye and the ear.

EYE

There are several images showing the internal and external anatomy of the eye. Some of these images show a superior or lateral view of the orbit, while others show cross sectional images of the eye. Some are cadaver images, and others show diagrams or models. In addition to the optic nerve, chiasm, and tract and extraocular muscles, identify the following structures of the eye:

- **Cornea**: transparent surface of the eye that bends (refracts) the light and focuses it on the back of the eye.
- **Sclera**: outer fibrous, white layer of the eyeball. The sclera and the cornea are continuous with each other but have different structure and function.
- **Lens**: changes shape to be able to focus light on the back of the eye regardless of the distance of the object
- **Suspensory ligaments** and **ciliary muscle:** Suspensory ligaments connect the **ciliary muscle** to the lens of the eye. Contraction and relaxation of this muscle change the tension on the suspensory ligaments, which changes the shape of the lens to focus our vision on objects near or far away.
- **Pupil**: opening in the center of the iris through which light enters the eye.
- **Iris**: surrounds he pupil and contains smooth muscle to dilate or constrict the pupil. It contains a pigmented layer that gives our eyes their color.
- **Vitreous humor**: jelly-like substance that fills the chamber of the eye posterior to the lens and gives the eye its shape. It transmits light to the retina.
- **Choroid**: highly vascular, darkly pigmented membrane that nourishes the

retina.

- **Retina**: the neural layer of the eye, which contains the photoreceptors for vision

Also examine the extraocular muscles here (described earlier).

EAR

There are several images showing the anatomy of the ear. Again, some are cadaver images, while others are drawings and images of models. Use these images to identify the following structures of the ear.

- **External ear**
    - **Auricle**: outer portion of the ear that is visible
    - **External acoustic meatus**: short tube running from the auricle to the eardrum
    - **Tympanic membrane**: eardrum
- **Middle ear**
    - **Auditory ossicles**: bones of the inner ear
        - **Malleus**: hammer
        - **Incus**: anvil
        - **Stapes**: stirrup
- **Inner ear**

- **Vestibule**: contains the utricle and saccule, which are part of the vestibular system. These structures help us to know the orientation of our head at any given time, and they sense linear acceleration of the head.
- **Semicircular canals**: sense rotational acceleration of the head, as in when we turn our head or our head rotates with our body. They are part of the vestibular system and function together with the utricle and saccule to give us a sense of balance, our position in space, and how our head is moving at a given time.
- **Cochlea**: snail-shaped chamber of the inner ear that houses the organ of hearing.

LAB ACTIVITY 4: VISIBLE BODY DIGITAL ATLAS: ORBIT, EYE, & EAR

Observe the orbit, eye, and ear using the Visible Body Digital Atlas.

- In the iPad atlas, open the **Systems** view and under the Skeletal Systems View click on **2. Skull.** Use both this atlas and the skull itself to examine the bones that make up the bony orbit, which protects the eye:
    - **Frontal bone**
    - **Sphenoid bone**
    - **Maxilla**
    - **Lacrimal bone**
    - **Ethmoid bone**
    - **Zygomatic bone**
    - **Palatine bone**
- Click on the **sphenoid bone** and isolate this bone (use icon that looks like a femur with multiple colors). The sphenoid bone can be a difficult bone to visualize given its deep position within the skull. For the sphenoid bone, this will take you to a different, color-coded view. Here you can examine some of the foramen that we discussed in previous labs.
- You have not yet looked closely at the **lacrimal** or **palatine bones** this unit. We will discuss the **palatine bone** more with the oral cavity, as it only forms a very small part of the medial wall of the orbit. The **lacrimal bone** forms a larger portion of the medial wall of the bony orbit. Each contains a fossa and grove that holds the lacrimal sac and nasolacrimal duct, which functions to gather tears and send them to the nasal cavity. Click on these bones

in the app and isolate them to see more of the surface features and also observe them on the skull.

- Examine the rest of the bones of the orbit in the app and on the skull. Also observe the **external acoustic meatus** of the temporal bone on the skull. This is the tube that connects the external opening of the ear to the tympanic membrane (ear drum).
- Go back to the main menu of the app and click on the **microanatomy** tab. Now click on **1. Eye** and explore the structures in the list on page 1 of this guide. You can return to the microanatomy tab and then click on **3. Lens and Zonular Fibers**. This will show the internal anatomy of the eye. "Zonular fibers" is another term for suspensory ligaments.
- Back to the microanatomy tab, click on **7. Ear**. From this view you will be able to see the **auricle, external acoustic (auditory) meatus,** and the **tympanic membrane.** If you did not zoom in to see the *tympanic membrane*, zoom in now to see the structures of the middle and inner ear. You will be able to see the **malleus, incus, stapes, cochlea, vestibule,** and the **semicircular canals.**
- Be sure to click on the **Facial nerve (CN VII)** and observe how it runs very close to the

middle ear before entering the stylomastoid foramen. This anatomy is why the facial nerve may be vulnerable during a middle ear infection, which can lead to Bell’s Palsy, as described in the previous lab.

PART III

UNIT 3: THE LOWER EXTREMITIES

Lab 11: Bones of the Lower Extremity

LEARNING OBJECTIVES:

- Name the bones of the lower extremity and describe their functions.
- Identify key landmarks on the bones of the lower extremity and explain their function or purpose.
- Identify and describe the joints of the foot, the bones that make up those joints.
- Explain structure governs function examples from the bones and articulations of the lower extremity (i.e., how is the degree of joint movement determined by the structure of the joint).

TERMS TO KNOW

Bones of the Lower Extremity

- Os coxae
    - Ilium
        - Arcuate line
        - Iliac fossa
        - Iliac crest
        - Anterior superior iliac spine
        - Anterior inferior iliac spine
        - Posterior superior iliac spine
        - Posterior inferior iliac spine
        - Greater sciatic notch
        - Ala
    - Ischium
        - Ischial spine
        - Ischial tuberosity
        - Ischial ramus
        - Lesser sciatic notch
        - Lunate surface
    - Pubis
        - Superior rami
        - Inferior rami
        - Pubic crest
        - Pubic tubercle
        - Obturator foramen
        - Pectineal line
- Femur
    - Head
    - Fovea
    - Neck
    - Greater trochanter
    - Lesser trochanter
    - Gluteal tuberosity
    - Linea aspera
    - Medial condyle
    - Lateral condyle
    - Medial epicondyle
    - Lateral epicondyle
    - Intercondylar fossa

Bone of the Lower Extremity (Cont.)

- Tibia
    - Medial condyle
    - Lateral condyle
    - Fibular articular facet
    - Tibial tuberosity
    - Gerdy's tubercle
    - Pes anserine insertion
    - Tibial border
    - Medial malleolus
- Fibula
    - Head
    - Articular facet
    - Neck
    - Lateral malleolus
- Interosseous membrane (between the tibia and fibula)
- Tarsals
    - Calcaneus
    - Talus
    - Navicular
    - Cuneiforms
        - Medial
        - Intermediate
        - Lateral
    - Cuboid
- Metatarsals
- Phalanges
    - Proximal
    - Middle
    - Distal
    - Hallux

Foot and Toe Joints

- Intertarsal joints
- Tarsometatarsal joints
- Metatarsophalangeal joints
- Interphalangeal joints (proximal & distal)

    - Patellar surface
- Patella
    - Sesamoid bone
    - Medial articular facet
    - Lateral articular facet

INTRODUCTION

In this lab, you will begin learning about the lower extremity. During this unit, we will discuss the bones, joints, muscles, nerves, and vasculature that make up our hip and gluteal region, thigh, knee, lower leg, ankle, and foot. On the course Canvas page, you will find a bony landmark table and muscle table to help clarify what material you will be responsible for and help you learn the material. The bone markings table describes the function and/or structure that run near/attaches/articulates with each bony marking. *You will be responsible for knowing the information in both the bony markings table and the muscle table.* Some of the information is overlapping between tables.

This lab focuses on the bones of the pelvis and lower extremity. In this lab, you will view various bone specimens, models, and radiology tools to explore the different bones and joints of the lower extremity, including the pelvis, femur, tibia, patella, fibula, tarsals, metatarsals, and phalanges. Keep in mind that the shapes and orientation of the bones and many of the ligaments are classic "structure governs function" examples. You will be asked to identify specific landmarks on these bones. You are encouraged to look at several different bones of the same type (i.e., more than one femur, from multiple sources). You are encouraged to reference the muscle and bone landmark charts to better understand origin and insertion landmarks on the bones. Sometimes, these features are more or less prominent due to anatomical variation. Finally, based on the landmarks, you should identify if individual bones come from the right or left lower extremity.

LAB ACTIVITY 1: BONY LANDMARKS OF THE PELVIS, FEMUR, AND PATELLA

Each bone station is supplied with pelvis, femur, and patella bones. Use the bones and the visible body app to identify the landmarks from the Terms to Know. Also, you should be able to identify whether or not each of these three bones come from the right or left side of the body. By knowing if a certain landmark is medial or lateral, anterior or posterior, you should easily determine the side of the body the bone came from. For example, the lateral position of the greater trochanter of the femur and the subsequent position of the head of the femur should help you orient bone as a right or left.

When using the Visible Body app, highlight one of the selected bones, then use the isolate feature (it looks like a femur with multiple colors). When you isolate the bones, you will see all of the bony landmarks and markings as listed in the charts and the terms to know.

- Observe the bones of the **os coxae**. The os coxae are the bones of the pelvis, and they are formed by three separate bones that fuse during development: the ilium, ischium, and pubis.
    - The **ilium** is the most superior of the bones of the os coxae. If you "put your hands on your hips," you are putting your hands on the iliac crest of your os coxae. Use the atlases to identify

the following landmarks of the ilium:

    - Arcuate line
    - Iliac fossa
    - Iliac crest
    - Anterior superior iliac spine
    - Anterior inferior iliac spine
    - Posterior superior iliac spine
    - Posterior inferior iliac spine
    - Greater sciatic notch
    - Ala

- The **ischium** is the posteroinferior bone of the os coxae. We bear weight on our **ischial tuberosity** every time we sit. Use the atlases to identify the following landmarks of the ischium:
    - Ischial spine
    - Ischial tuberosity
    - Ischial ramus
    - Lesser sciatic notch
    - Lunate surface
- The **pubis** is the anteroinferior bone of the os coxae. Use the atlases to identify the following landmarks of the pubis:
    - Superior rami
    - Inferior rami
    - Pubic crest
    - Pubic tubercle
    - Obturator foramen

- Pectineal line

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://wisc.pb.unizin.org/humananatomylabmanual/?p=132

Pelvic skeleton (Pelvis)
by Ebers
on Sketchfab

- The **femur** is the longest bone of our body. It is located between the hip and the knee. The **femoral head** articulates with the acetabulum of the os coxae to form the hip joint. The **fovea** is the attachment point for the ligament of the head of the femur or the ligamentum teres. The **greater trochanter** and **lesser trochanter** are large sites of muscle attachment on the proximal aspect of the bone. The **medial and lateral epicondyles** are attachment sites on the distal aspect of the femur. The **medial and lateral condyles** articulate with the tibia to form the knee joint. Use the atlases to identify the following landmarks of the femur:
  - Head
  - Fovea

- Neck
- Greater trochanter
- Lesser trochanter
- Gluteal tuberosity
- Linea aspera
- Medial condyle
- Lateral condyle
- Medial epicondyle
- Lateral epicondyle
- Intercondylar fossa
- Patellar surface

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Human Femur
by Eric Bauer
on Sketchfab

- The patella is a triangular-shaped **sesamoid bone** that sits within the tendon of the quadriceps muscle. A sesamoid bone is a bone that is located within a tendon.

That the patella only articulates with the femur. It does not have an articulation with the tibia. Observe the **medial and lateral articular facets,** which are the posterior surfaces that articulate with the femur.

LAB ACTIVITY 2: BONY MARKINGS OF THE TIBIA, FIBULA, TARSALS, AND PHALANGES

Each bone station is supplied with a tibia, fibula, and an articulated foot (the feet may be from an articulated model skeleton). Use the bones and the visible body app to identify the landmarks from the Terms to Know. When using the Visible Body app, highlight one of the selected bones, then use the isolate feature. When you isolate the bones, you will see all of the bony landmarks and markings as listed in the tables and the terms to know.

- The **tibia** and **fibula** are the bones of the lower leg. Most of our weight is carried on the tibia, while the fibula usually bears at most about 12% of our body weight. In some people, the fibula will bear little or no bodyweight. Superiorly, the **medial and lateral tibial condyles** articulate with the femur. Inferiorly the tibia and fibula articulate with the talus. The lateral protrusion at the ankle is the **lateral malleolus** of the fibula, while the **medial malleolus** of the tibia forms the medial protrusion at the ankle. The tibia and fibula are held together, in part, by the **interosseus membrane**, which is located between the two bones. Use the atlases to identify the following landmarks of the tibia and fibula:
    - Tibia
        - Medial condyle

        - Lateral condyle
        - Fibular articular facet
        - Tibial tuberosity
        - Gerdy's tubercle
        - Pes anserine insertion
        - Tibial border
        - Medial malleolus
    - Fibula
        - Head
        - Articular facet
        - Neck
        - Lateral malleolus
    - Interosseous membrane (between the tibia and fibula)

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://wisc.pb.unizin.org/humananatomylabmanual/?p=132

Human Tibia
by **Eric Bauer**
on **Sketchfab**

- The seven **tarsal bones** form the posterior aspect of the foot. Use the atlases to identify the following tarsals:
    - **Calcaneus**: We bear weight on this bone when we stand, as it forms our heel.
    - **Talus**: This bone articulates with the tibia and fibula to form the ankle joint.
    - **Navicular**: This is the proximal medial bone of the mid-foot. It sits just posterior to the cuneiforms.
    - **Cuneiforms**: These three bones sit anterior to the navicular on the medial aspect of the mid-foot.
        - **Medial**
        - **Intermediate**
        - **Lateral**
    - **Cuboid**: This is the large lateral bone of the midfoot.
- The **intertarsal joints** are located between the tarsal bones.
- The **tarsometatarsal joints** are located between the cuneiforms or cuboid and the metatarsal bones.
- The **metatarsals** are the long bones of the foot. They are numbered I-V based, with I being the great to or "big toe."
- The **metatarsophalangeal joints** are located between the metatarsals and the phalanges.
- The **phalanges** are the most distal bones that form the toes. Toes 2-5 have a proximal, **middle, and distal phalanx**. The first toe only has a **proximal and a distal phalanx**, and the first toe is referred to as the **hallux**.

- The **interphalangeal joints** are located between the individual phalanges. In toes 2-5, we have a **proximal and a distal interphalangeal joint**, and this occurs because these toes have three bones. With only two bones in the hallux, we only have an **interphalangeal joint** in our first toe.

- **Explore the joints of the foot (using the iPad Atlas):** Click on the *Systems* icon and then *Muscular System Views*. Go to **19. Ankle and** Foot. Move to the foot and observe the **intertarsal** (the app will define these, you do not need to know each one individually)**, tarsometatarsal, metatarsophalangeal** (the app will show the capsules of these joints), **and interphalangeal** joints. Note that interphalangeal joints are found in both the hand and foot. Like the hand, toes 2-5 have a **proximal and distal interphalangeal joint**, while the great toe, like the thumb, only has an **interphalangeal joint.**

One or more interactive elements has been excluded from this version of the text.

You can view them online here: https://wisc.pb.unizin.org/humananatomylabmanual/?p=132

Foot Seperated Bones With Label
by **Deepankar.Parmar**
on **Sketchfab**

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://wisc.pb.unizin.org/humananatomylabmanual/?p=132#h5p-41

LAB ACTIVITY 3: RADIOLOGY-BONES OF THE LOWER EXTREMITY

The most common way that you will see bones in the clinical setting is through radiology. Therefore, it is important for you to understand what normal bony anatomy looks like in radiological images. Use radiology images to identify landmarks on the bones of the lower extremity. You will primarily examine x-ray images, but there will be a few MR and CT images as well.

Compare the landmarks on the skeleton to the radiological images along the way. This will help you to make sense of what you are seeing on the images. You can also use an atlas to compare the bones with the radiology.

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://wisc.pb.unizin.org/humananatomylabmanual/?p=132#h5p-42

Lab 12: Nerves and Vessels of the Lower Extremity

LEARNING OBJECTIVES:

- Explain the anatomy of the nerves of the lower extremity.
- Identify the muscles and sensory regions innervated by each nerve of the lower extremity.
- Describe the arteries of the lower extremity and identify the regions supplied by each artery.
- Describe the veins of the lower extremity and identify the regions drained by each vein.

TERMS TO KNOW

Nerves of the Lower Extremity

- Superior gluteal nerve
- Inferior gluteal nerve
- Femoral nerve
- Obturator nerve
- Sciatic nerve
    - Common fibular nerve
        - Deep fibular (peroneal) nerve
        - Superficial fibular (peroneal) nerve
    - Tibial nerve
        - Medial plantar nerve
        - Lateral plantar nerve

Veins of the Lower Extremity

- Fibular vein
- Anterior tibial vein
- Posterior tibial vein
- Popliteal vein
- Femoral vein
- Deep femoral vein
- External iliac vein
- Great saphenous vein
- Small saphenous vein

Arteries of the Lower Extremity

- Internal iliac artery
    - Superior gluteal artery
    - Inferior gluteal artery
    - Obturator artery
        - Artery to the femoral head
- External iliac artery
    - Femoral artery
        - Deep femoral artery
            - Medial circumflex femoral artery
            - Lateral circumflex femoral artery
    - Popliteal artery
    - Anterior tibial artery
        - Dorsal pedis artery
    - Posterior tibial artery
        - Medial plantar artery
        - Lateral plantar artery
    - Fibular (peroneal) artery
    - Plantar arch
    - Digital arteries

Other Terms

- Popliteal fossa
- Femoral triangle

INTRODUCTION

Today you will learn about the neurovasculature of the lower extremity. You will explore the nerves, arteries, and veins of the gluteal region, thigh, leg, and foot. Keep in mind that all structures are not visible on all tissue or other tools, and that is okay. By the end of the lab today, you should have identified all of the structures on the list using multiple modalities. Over the next two labs, you will learn about the muscles, and you will make the connection between these nerves and vessels and the muscles they innervate or supply.

In this lab, we will mention the general area innervated and supplied by these nerves and vessels. In future labs, we will study this more in-depth. You should reference the muscle tables posted on Canvas to see the specific muscles innervated by each nerve.

LAB ACTIVITY 1: LOWER EXTREMITY CADAVERIC TISSUE-ARTERIES AND NERVES

Like the previous units, you should use nearby structures as a reference when identifying neurovascular structures of the lower extremity. By following a nerve or artery to a specific muscle, you can determine which artery or nerve it is.

The lower extremity tissue will be positioned with either the anterior side or posterior side up. **Please do not rotate them.** You will view the anterior structures on two of the extremities and posterior structures on the other two extremities.

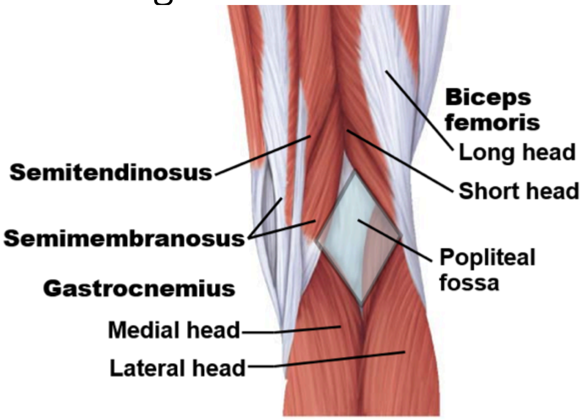
POSTERIOR NEUROVASCULATURE OF THE LOWER EXTREMITY

- **Gluteal Region:** Observe the **inferior and superior gluteal nerves and inferior and superior gluteal arteries**.

The inferior gluteal nerve and artery travel together, while the superior gluteal nerve and artery travel together. Together these nerves and vessels supply and innervate the muscles of the gluteal region and lateral thigh. The arteries are branches off of the internal iliac arteries.

  - The ligaments of the pelvis for the *greater sciatic foramen* in the region of the *greater sciatic notch* of the pelvis and the inferior and superior gluteal arteries and nerves both travel through this foramen. The **superior gluteal artery and nerve** leave the *greater sciatic foramen* superior to the *piriformis muscle. In comparison,* the **inferior gluteal artery and nerve** exit the *greater sciatic foramen* inferior to the *piriformis muscle*.

- **Popliteal artery**: Observe the diamond-shaped region at the posterior aspect of the knee, bounded superiorly by the hamstring tendons on



each

side and inferiorly by the lateral and medial heads of the gastrocnemius. This region is called the **popliteal fossa**. When the femoral artery travels through the opening in the adductor magnus and emerges into this space, it is now called the **popliteal artery**. The **popliteal vein** also travels with the artery in this space and is continuous with the femoral vein. The **popliteal artery** ends just inferior to the knee joint as it splits to form the **anterior tibial** and **posterior tibial arteries**. The **posterior tibial artery** may appear as a continuation of the popliteal artery with the **anterior tibial artery** branching off it.

- **Sciatic nerve**: The **sciatic nerve** comprises the **tibial and common fibular (peroneal) nerves** together within a fibrous sheath. (Note that fibular and peroneal are interchangeable. Peroneal is the older term, and it is slowly being replaced with fibular. Either would be acceptable on an exam.) In the gluteal region, the sciatic nerve runs deep to the piriformis and emerges at the inferior border of this muscle before descending in the posterior thigh. The sciatic does not innervate any muscles as it passes through the thigh, but its branches innervate hamstring muscles. The tibial division innervates the semimembranosus, semitendinosus, and long head of the biceps femoris, while the common fibular division innervates the short head of the biceps femoris. Notice that it splits into the **tibial nerve** and **common fibular (peroneal) nerve** in the popliteal fossa. Though this is the most common location of the split, this can occur anywhere along the sciatic nerve path, even as superior as the gluteal region.

- **Neurovasculature of the compartments of the leg and foot:** The muscles of the leg are divided into four compartments: anterior, lateral, deep posterior, and superficial posterior. Each compartment is typically innervated by one nerve and receives its blood supply from one artery.
    - **Superficial and deep posterior compartments:** The **tibial nerve** continues into the leg and travels inferiorly between the superficial and deep posterior compartments, innervating the muscles in both compartments. After wrapping around the medial malleolus, it branches into the **lateral and medial plantar nerves**, which innervate the muscles of the plantar aspect (bottom) of the foot. The **posterior tibial artery** also travels with the tibial nerve between the superficial and deep posterior compartments,

supplying both compartments. It then runs around the medial malleolus and divides into the **medial and lateral plantar arteries** that supply the medial and lateral aspects of the foot. The **lateral plantar artery** gives off the **plantar arch**, which gives off **digital arteries** to supply the foot and toes.

ANTERIOR, LATERAL, AND MEDIAL NEUROVASCULATURE OF THE LOWER EXTREMITY

- **Femoral Triangle**: The femoral triangle is a space created by the sartorius laterally, the adductor longus medially, and the inguinal ligament superiorly. The pectineus muscle forms the floor of this space. The **femoral nerve, femoral artery,** and **femoral vein** travel through this space wrapped together in a common sheath of tissue.
    - **Femoral artery:** This artery is an extension of the external iliac artery from the pelvis. It is named the femoral artery after it travels deep to the inguinal ligament to enter the leg. Similar to the arteries

of the upper extremity, this is a case of the same vessel ("tube") having a different name depending on its location. This artery supplies the anterior structures of the thigh. Follow this artery as it descends through the thigh, and notice that it travels through an opening in the adductor magnus muscle towards the posterior aspect of the knee.

- The largest branch of the femoral artery is the **deep femoral artery**. This artery runs posteriorly and supplies the muscles of the posterior and medial regions of the thigh. Also, observe the medial and lateral circumflex femoral arteries branching from the deep femoral artery and traveling towards the femur.

- **Femoral nerve:** This nerve branches into many small branches shortly after entering the thigh. These branches innervate muscles of the anterior thigh and some fibers of the pectineus, and you can follow the branches to these muscles.
- **Femoral vein:** This vein travels

with the femoral artery through the thigh. It carries blood from the lower extremity back to the pelvis. The artery has a thicker wall and maintains a round shape, while the vein tends to collapse against the artery.

- **Anterior compartment of the leg:** Observe the **common fibular (peroneal) nerve** wrapping around the head of the fibula. It then splits into the **superficial fibular (peroneal)** and **deep fibular (peroneal) nerves**. The **deep fibular nerve** travels through the anterior compartment of the leg and innervates the muscles of this compartment. From the popliteal artery and posterior tibial artery, follow the **anterior tibial artery** as it travels towards the anterior compartment. You can see this artery traveling with the **deep fibular nerve** deep to the tibialis anterior. As the **anterior tibial artery** crosses the talocrural (ankle) joint, it becomes the **dorsal pedis (dorsalis pedis) artery**, which supplies muscles and nerves on the dorsal aspect of the foot. If a clinician suspects blood flow to the foot may be blocked, which could occur with an injury such as a full knee dislocation or occlusion due to atherosclerosis, a clinician will check for a pulse at this artery.

- **Lateral compartment:** The **superficial fibular (peroneal) nerve** innervates the muscles of the lateral compartment of the leg. This compartment receives its blood supply from the **fibular artery**. This artery is a branch of the posterior tibial artery shortly after it branches from the popliteal artery in the popliteal fossa.
- **Obturator nerve**: Observe the nerve /nerve branches running to adductor longus, adductor brevis, and/or gracilis. These are branches of the **obturator nerve**, which innervates several muscles in the medial aspect of the thigh.
- **Obturator artery:** The **obturator artery**, which branches from the internal iliac artery inferior to the superior gluteal artery, runs anterolaterally along the ilium. It then runs through the *obturator foramen* of the pelvis along with the **obturator nerve**.
    - The obturator artery gives off the **artery to the femoral head**. This artery travels through the ligamentum teres and helps to supply the femoral head.

VEINS OF THE LOWER EXTREMITY

The veins may not be visible on all of the extremities. Use the Visible Body Atlas or another atlas to view these structures if you cannot identify them on the tissue.

- Observe the two main superficial veins of the leg, **the great saphenous vein,** and the **small saphenous vein**.

The **small saphenous vein** drains the lateral foot and leg and drains into the popliteal vein. The **great saphenous vein** drains the rest of the lower limb and drains into the femoral vein near the hip.

- The deep veins of the lower extremity travel with the artery of the same name. Notice how the **anterior tibial vein** travels with the **anterior tibial artery**, and the **posterior tibial vein** travels with the **posterior tibial artery**, for example. Furthermore, the **fibular vein** travels on the posterolateral aspect of the interosseous membrane with the **fibular artery**. The **fibular vein** drains the lateral leg and ankle and drains into the **posterior tibial vein**. The **anterior and posterior tibial veins** drain the anterior and posterior compartments of the leg, respectively, and unite to form the **popliteal vein**.
- Moving superiorly, observe the **popliteal vein** and notice that it ends just superior to the knee. At this point, it becomes the **femoral vein**. In addition to the great saphenous vein, the **deep femoral vein** also drains into the proximal portion of the **femoral vein**. Similar to the **femoral artery**, the **femoral vein** becomes the **external iliac vein** as it passes deep to the inguinal ligament.

LAB ACTIVITY 2: VISIBLE BODY DIGITAL ATLAS-NEUROVASCULATURE OF THE LOWER EXTREMITY

We will use the Visible Body Digital Atlas to explore the neurovasculature provided in the Terms to Know. While you are viewing the neurovasculature, use the muscle tables to make connections between the nerves and the muscles that they innervate.

ARTERIES OF THE LOWER EXTREMITY

Click on the *Regions* tab, and then choose **10. Hip**. In the side *Systems* toolbar, uncheck the lymphatic, nervous, muscular, and venous systems. You will be left with the bones and arteries of this region. Zoom in on the region of the hip and pelvis. From the anterior view, click on and observe the common iliac artery. This artery originates on each side as the aorta ends and splits in the lower abdominal region. Rotate the image, and observe that the common iliac artery divides into the internal and external iliac arteries.

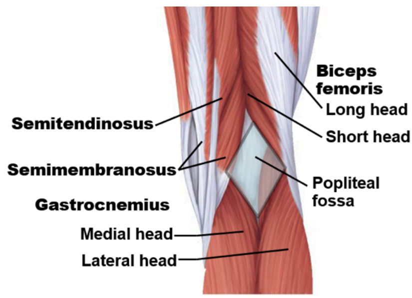
First, explore the **internal iliac artery** and its branches. While this artery also supplies the perineum and other pelvic structures, we will focus on the branches that supply muscles of the lower extremity. Click on the **superior gluteal artery**, a superior branch that runs posteriorly to the gluteal region. With this artery highlighted, rotate the image to a posterior view and observe its path. From the posterior view, click on the internal iliac artery again. Follow this artery inferiorly, and, as it divides, click on the more lateral artery, the **inferior gluteal artery**. While you still have the inferior gluteal artery highlighted, click on the radius blast (bullseye) *three* times. Observe how the ligaments of the pelvis form the *greater sciatic foramen* in the region of the *greater sciatic notch* of the pelvis, and notice how these arteries both travel through the *greater sciatic foramen*. The *piriformis muscle* has also been added to this image. You can now see that the **superior gluteal artery** leaves the *greater sciatic foramen* superior to the *piriformis muscle*, while the **inferior gluteal artery** leaves the *greater sciatic foramen* inferior to the *piriformis muscle*. The **superior gluteal artery** supplies the *gluteus maximus, gluteus medius, gluteus minimus*, and *tensor fasciae latae* muscles, while the **inferior gluteal artery** supplies the *gluteus maximus*, two lateral rotators, and the superior parts of the hamstring muscles.

Return to the anterior view, where you started this section, and remove the lymphatic, nervous, muscular, and venous systems. Now click on the **obturator artery**, which branches from the internal iliac artery just inferior to the superior gluteal artery and runs anterolaterally along the ilium. Observe how this artery runs through the obturator foramen of the pelvis. With this artery highlighted, rotate the image to view it from different angles. It supplies the thigh adductors, the proximal part of the hamstrings, and one lateral rotator muscle. The obturator artery gives off an anterior and a posterior branch, though you are not responsible for identifying these branches. However, you should know that the posterior branch of the obturator artery gives off the acetabular branch or the **artery to the femoral head**. Though it is not visible on the iPads, you should know that this artery travels through the ligamentum teres and helps to supply the femoral head.

Zoom out to view the full hip and thigh. Just distal to the common iliac artery, now click on the **external iliac artery**. Branches of this artery supply the rest of the lower extremity. Notice that the **external iliac artery** ends as it passes behind the inguinal ligament. Distal to the inguinal ligament, this vessel becomes the **femoral artery**. Zoom in to take a closer look at the branches of the femoral artery. Observe the **deep femoral artery** running posteriorly. The **deep femoral artery** gives off two branches that supply the hip joint: The **medial and lateral circumflex femoral**

arteries. They form an anastomosis to supply the hip region and the head and neck of the femur. Rotate the image to observe how this artery wraps around the proximal femur.

Observe the femoral artery from a medial view and notice that it moves posteriorly as it descends in the medial thigh. Also, notice that the femoral artery ends just superior to the knee joint. At this joint, the artery becomes known as the **popliteal artery**. This artery will be best viewed posteriorly.



The popliteal artery ends just inferior to the knee joint as it splits to form the **anterior tibial** and **posterior tibial arteries**.

Rotate the image to an anterior view, click on the **anterior tibial artery**, and observe that it passes through the interosseous membrane. It descends on its anterior aspect, supplying the anterior compartment of the leg. As it crosses the talocrural joint, it becomes the **dorsal pedis artery**.

The **posterior tibial artery** supplies both the deep and superficial posterior compartments. Soon after branching off the **popliteal artery**, it gives off the **fibular artery**, which travels just posterior to the interosseus membrane. The **fibular artery supplies** the lateral compartment of the leg.

Look at the plantar aspect of the foot. Observe the **posterior tibial artery** running around the medial malleolus and then dividing into the **medial and lateral plantar arteries** (you will need to hide the plantar fascia to see this). Also, observe the **plantar arch** and **digital arteries**.

VEINS OF THE LOWER EXTREMITY

Click on the *Regions* tab, and then choose **10. Hip**. In the side

Systems toolbar, uncheck the lymphatic system, nervous system, and muscular system. You will be left with the bones, arteries, and veins of this region. Zoom in on the region of the hip and pelvis. First, observe the two main superficial veins of the leg, **the great saphenous vein,** and the **small saphenous vein**. The **small saphenous vein** drains the lateral foot and leg and drains into the popliteal vein. The **great saphenous vein** drains the rest of the lower limb and drains into the femoral vein near the hip.

The deep veins of the lower extremity travel with the artery of the same name. Notice how the **anterior tibial vein** travels with the **anterior tibial artery**, and the **posterior tibial vein** travels with the **posterior tibial artery**. Furthermore, the **fibular vein** travels on the posterolateral aspect of the interosseous membrane with the **fibular artery**. The **fibular vein** drains the lateral leg and ankle and drains into the **posterior tibial vein**. The **anterior and posterior tibial veins** drain the anterior and posterior compartments of the leg, respectively, and unite to form the **popliteal vein**.

Moving superiorly, observe the **popliteal vein** and notice that it ends just superior to the knee. At this point, it becomes the **femoral vein**. In addition to the great saphenous vein, the **deep femoral vein** also drains into the proximal portion of the **femoral vein**. Similar to the **femoral artery**, the **femoral vein** becomes the **external iliac vein** as it passes deep to the inguinal ligament.

NERVES OF THE LOWER EXTREMITY

Click on the *Regions* tab, then **10. Hip**. In the side *Systems* toolbar, uncheck the lymphatic system, muscular system, and the vascular systems. You will be left with the bones and nerves of this region. Zoom in on the region of the hip and pelvis from a posterior view. Now use the Anatomy Search icon and type in *piriformis.* Add the *piriformis* as well as the *gluteus minimus*. Similar to the arteries of the same name, observe that the **superior gluteal nerve** leaves the *greater sciatic foramen* superior to the *piriformis*, while the **inferior gluteal nerve** leaves the *greater sciatic foramen* inferior to the *piriformis*. The **superior gluteal nerve** innervates the *gluteus medius, gluteus minimus*, and *tensor fasciae latae* muscles, while the **inferior gluteal nerve** innervates the *gluteus maximus* only.

Move to an anterior view. Click on the **femoral nerve**, and observe its branches traveling to the muscles of the anterior thigh. Now rotate to a posterior view. Observe a nerve running through the obturator foramen. This is the **obturator nerve**, and it innervates the muscles of the medial thigh (except the hamstring portion of the adductor magnus).

In this view, you can also observe the **sciatic nerve** exiting through the *greater sciatic foramen* inferior to the *piriformis*. As you move inferiorly, you will observe that the **tibial and common fibular nerves** comprising the **sciatic nerve** separate from each other in the superior **popliteal fossa**.

Observe the **tibial nerve** traveling through the posterior leg and branching into the **lateral and medial plantar nerves** (you will need to hide the plantar fascia to see this). Also, observe the **common fibular (peroneal) nerve** running rather superficially, wrapping around the head of the fibula. Then it splits into the **superficial and deep fibular (peroneal) nerves**. Notice that the **deep fibular (peroneal) nerve** travels just anterior to the interosseous membrane. This nerve innervates the muscles of the anterior compartment of the leg and the dorsal aspect of the foot. The **superficial fibular (peroneal) nerve** innervates the muscles of the lateral compartment of the leg.

An interactive H5P element has been excluded from this version of the text. You can view it online here:

https://wisc.pb.unizin.org/humananatomylabmanual/?p=140#h5p-43

Lab 13: Posterior Lower Extremity

LEARNING OBJECTIVES:

- Identify the muscles of the gluteal region, posterior thigh, superficial and deep posterior compartments of the leg, plantar layers of the foot, and name their actions.
- Using the muscle charts as a guide, identify the action, origin, insertion, and innervation for the muscles of the gluteal region, posterior thigh, superficial and deep posterior compartments of the leg, and plantar layers of the foot.
- Describe how structure governs function and provide examples based on muscle orientation and actions.
- Identify the sacroiliac joint, pubic symphysis, and hip joints, including ligaments and capsules.

TERMS TO KNOW

Muscles of the Lower Extremity

- Gluteal region
  - Gluteus maximus
  - Gluteus medius
  - Gluteus minimus
  - Piriformis
- Posterior thigh
  - Biceps Femoris
    - Long head
    - Short head
  - Semimembranosus
  - Semitendinosus
- Superficial posterior compartment of the leg
  - Gastrocnemius
  - Soleus
  - Plantaris
  - Calcaneal (Achilles) tendon
- Deep posterior compartment of the leg
  - Flexor digitorum longus
    - Flexor hallucis longus
    - Tibialis posterior
    - Popliteus

Intrinsic muscles of the foot

- Plantar fascia
- Plantar Layer 1
  - Flexor digitorum brevis
  - Abductor hallucis
  - Abductor digiti minimi
- Plantar Layer 2
  - Lumbricals
  - Quadratus plantae
- Plantar Layer 3
  - Adductor hallucis
  - Flexor hallucis brevis
  - Flexor digiti minimi
- Plantar Layer 4
  - Dorsal interossei
  - Plantar interossei

Joints of the Lower Extremity

- Sacroiliac joint
- Pubic symphysis
- Coxal (hip) joint
  - Acetabulum
  - Iliofemoral ligament
  - Ischiofemoral ligament
  - Pubofemoral ligament
  - (The above are within the capsule)
  - Ligament of the head of the femur (Ligamentum teres)

INTRODUCTION

In this lab, you will explore the muscles of the gluteal region, posterior thigh, posterior leg, and plantar layers of the foot. Here are a few important tips before learning about these muscles:

- You should know the origins, insertions, actions, and innervations presented in the muscle charts for these and all muscles of the lower extremity. The muscle table is color-coded, and the information about what we expect you to know from the muscle table is described in the chart document itself. Please read that information. We will ask you questions about the function, attachment site, and/or innervation of muscles on the exam.

- We recommend using landmarks to understand the attachment sites, action, and sometimes the innervation as you are studying. Follow the muscle to its attachment site if it is visible. Notice the joint the muscle crosses and the side of the joint it is on, and that will give you information about the muscle's action. In some cases, you can see the nerve go to or even through the muscle it innervates. These visual cues can help you remember the information from the muscle tables.

LAB ACTIVITY 1: VISIBLE BODY DIGITAL ATLAS–SACROILIAC JOINT, PUBIC SYMPHYSIS, COXAL JOINT

Explore the Sacroiliac joint and pubic symphysis: Click on the *Systems* icon, then under *Skeletal System Views*, click on **11. Pelvic Girdle**. Using finger gestures, zoom, rotate, highlight and isolate to explore the **sacroiliac joint** between the sacrum and ilium and the **pubic symphysis** between the right and left pubic bones.

Explore the Coxal (hip) joint: Still in the *Systems* icon, then under *Skeletal System Views*, click on **11. Pelvic Girdle**. First, observe the **iliofemoral, ischiofemoral, and pubofemoral** ligaments. Be sure to notice which bone of the pelvis they are attaching to, as this will tell you which ligament you are viewing. These ligaments all contribute to the capsule of the hip joint. They are difficult to see in images or on a cadaver, as the fibers all blend together. Therefore, you would only be asked to identify them on an image of the app. If you remove/hide the ligaments of the hip and the femur, you can now see the acetabulum, the articular surface of the os coxae. Also, observe the **ligamentum teres, or ligament to the head of the femur**. This ligament contains the artery to the head of the femur.

LAB ACTIVITY 2: VISIBLE BODY APP–MUSCLES OF THE POSTERIOR LOWER EXTREMITY

Explore muscles of the gluteal region and posterior thigh: Click on the *Systems* icon, then under *Muscular System Views*, click on **17. Hip**. Explore all of the gluteal region and posterior thigh muscles provided in the list of terms for this lab. As you navigate through, highlight the various muscles, and use your muscle charts to study the origins, insertions, and actions of these muscles with the images.

While you are looking at the muscles of the hip, you can select the individual muscles, then click the red attachment icon. When you have clicked the attachment icon, videos will often pop up to demonstrate the motion of the muscles you have selected. You can also go to the *Muscle Actions* icon from the home page and scroll down to see the motions of the gluteal and thigh region. Explore the various movements at the hip joint in relation to the muscle actions responsible for those movements. You should also review these muscle actions from your muscle charts.

Explore the muscles of the leg: Click on the *Systems* icon and then *Muscular System Views*. Go to **19. Ankle and** Foot. Use the right leg to view the muscles of the leg. Use finger gestures, rotation, zoom, and highlight tools to explore the muscles of the leg in the list of terms. Reference the muscle charts for origin, insertion, and innervation information. You will need to hide or remove the superficial muscles to see the deeper muscles of the leg.

Explore the muscles of the foot: Use the right leg to view the muscles of the foot. Use finger gestures, rotation, zoom, and highlight tools to explore the muscles in the list of terms. Some of these muscles are difficult to see on the dissected tissue, so be sure to observe all of the muscles of the foot using this resource. You will need to hide or remove the superficial muscles to see the deeper muscles of the foot.

Animations and Muscle Movements: While looking at the muscles of the leg and foot, you can select the individual muscles and then click the red attachment icon. When you have clicked the attachment icon, videos will often pop up to demonstrate the motion of the muscles you have selected. You can also go to the *Muscle Actions* icon from the home page and scroll down to see the leg and foot motions. Explore the various movements at the ankle and foot joints in relation to the muscle actions responsible for those movements. You should also review these muscle actions from your muscle charts.

LAB ACTIVITY 3: NAVIGATOR-HIP, GLUTEAL REGION AND POSTERIOR THIGH

Use the navigator to examine the hip, gluteal region, and posterior thigh.

- First, identify the **gluteus maximus** on the 3D printed model.
- On the computer model, click on "Advanced" in the View window. Highlight "Muscles" in the first column. In the next two columns, you can add and remove muscles. Remove the muscles of the trunk and add the muscles of the gluteal region and lower extremity. You may want to remove some layers just on one side to compare the deep and superficial muscles or examine the muscles and their attachment points. Note that some of the muscles of the thigh will be cut off in the images. However, this is still a good opportunity to view the origins of several posterior thigh muscles.
- With all muscles removed, examine the ligaments stabilizing the hip joint.

- Also, observe the head of the femur, the gluteal muscles, and medial thigh muscles in the cross-sections.

LAB ACTIVITY 4: LOWER EXTREMITY CADAVERIC TISSUE-WET SPECIMENS AND PLASTINATES

We have four wet tissue lower extremities for you to examine in this unit. Some are dissected so that you can view deep muscles, while others are dissected more superficially. Some of the muscles have been cut, but you can still observe most of the distal portion of the muscle in most cases. Some of the extremities contain a portion of the pelvis, while the others begin proximally at the femoral head.

We also have two plastinated specimens for you to examine in this unit. One contains more superficial muscles, while the other is a deep dissection also showing the neurovascular structures. You should try to find all structures on both wet and plastinated specimens, though some will not be visible on each specimen.

*****Reminder: Never touch the plastinated specimens with wet gloves!*** *Also, though you can turn the plastinated specimens to view different structures, you should try to* ***handle these as little as possible.***

- **Gluteal region**: In the gluteal region, first observe the **gluteus maximus**. This is the largest and most superficial of the gluteal muscles. Just deep to this is the **gluteus medius**. The **gluteus minimus** is the deepest of the gluteal muscles. The **piriformis** is an important lateral rotator of the hip. There are five other small lateral rotator muscles of the hip. While they are listed in the muscle chart, you will not be asked to identify these muscles in class.

- Explore the muscles of the **posterior thigh.** The posterior thigh muscles are collectively called the hamstring muscles. The hamstring muscles originate on the **ischial tuberosity**. Two muscles travel to the medial aspect of the knee. The semimembranosus has a thicker muscle belly and a shorter tendon. The **semitendinosus** has a thinner muscle belly and a longer tendon. It sits just superficial to the **semimembranosus**. The **biceps femoris** has two heads. The **long head of biceps femoris** originates on the ischial tuberosity, but the **short head of biceps femoris** originates on the femur. The two heads merge into a common tendon and insert onto the **fibular head**.

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https://wisc.pb.unizin.org/humananatomylabmanual/?p=143#h5p-44

- **Superficial posterior compartment of the leg:** The most superficial posterior leg muscle is the **gastrocnemius**. It has a medial and lateral head that cross the knee to insert on the femur. This muscle aids knee flexion and is the primary plantar flexor of the foot. The **soleus** sits deep to the gastrocnemius and originates on the tibia. The gastrocnemius and soleus tendons merge to form the **calcaneal (Achilles) tendon.** The **plantaris** is a small muscle with a tiny belly deep to the gastrocnemius and a long, thin tendon extending toward the calcaneus. This muscle is not present in all individuals. You may not see it in this tissue, but it is visible in images.

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://wisc.pb.unizin.org/humananatomylabmanual/?p=143

[**Leg Muscles (Posterior Superficial Muscle Group)**](#)
by [**Ebers**](#)
on [**Sketchfab**](#)

- **Deep posterior compartment of the leg:** There are four muscles of the deep posterior compartment of the leg. The **tibialis posterior** runs along the posterior aspect of the tibia and acts to plantarflex and invert the foot. **Flexor digitorum longus** tendons extend to digits 2-5 and flex these digits. **Flexor hallucis longus** originates on the posterior fibula, and its tendon wraps around the medial aspect of the ankle before it reaches the distal great toe. This long path gives the muscle a mechanical advantage and makes it a powerful flexor of the first digit. The muscles **T**ibialis posterior, flexor **D**igitorum longus, and flexor **H**allucis longus usually travel in a specific order around the medial malleolus. You can remember the order of these tendons using the mnemonic **T**om**, D**ick**, an H**arry; "an" stands for posterior tibial **A**rtery and tibial **N**erve. Tibialis posterior is most anterior/superior, and flexor hallucis is most posterior/inferior.

The last muscle of the posterior compartment of the leg is the **popliteus**. This muscle is difficult to see on the tissue, but you can see part of it on the deep dissections. It sits on the superior aspect of the tibia and crosses the knee joint. It functions to medially rotate the tibia and "unlock" the knee from full extension in the first few degrees of flexion.

One or more interactive elements has been excluded from this version of the text. You can view them online here: https://wisc.pb.unizin.org/humananatomylabmanual/?p=143

[Leg Posterior Deep Muscles](#)
by [Ebers](#)
on [Sketchfab](#)

- **Intrinsic muscles of the foot:** The intrinsic muscles of the foot are muscles that act on the foot and are entirely located within the foot. The muscles that we just examined in the leg would be considered extrinsic muscles of the foot. The plantar aspect can be divided into four layers containing ten muscles or categories of muscles. You will not be asked which muscles are in a given layer. However, organizing the muscles into four layers can be helpful when studying the muscles.
    - **Plantar fascia:** This thick layer of fascia is superficial to the muscles of the plantar aspect of the foot. It has been cut in both wet specimens, but you can observe how it would attach to the calcaneus in anatomical position. This fascia can become inflamed

with plantar fasciitis.

- **Plantar muscles layer 1:** The **flexor digitorum brevis** muscle is deep to the plantar fascia and flexes digits 2-4. The **abductor hallucis** is the large muscle on the medial aspect of the great toe. It abducts the great toe. Likewise, the **abductor digiti minimi** is located on the lateral aspect of the 5th digit and abducts that digit.
- **Plantar muscles layer 2:** The muscles of this layer attach to the tendon of flexor digitorum longus. **Quadratus plantae** runs from the calcaneus to the tendons of flexor digitorum longus to adjust the angle of pull of these tendons. Because the flexor digitorum longus runs around the medial malleolus, without the adjustment from quadratus plantae, this muscle would cause the toes to flex in a medial direction. The quadratus plantae aligns these tendons so that the toes flex within the sagittal plane. The lumbricals of the foot are similar to those of the hand. They insert on to the flexor digitorum longus tendons

distally and flex the MP and extend the PIP and DIP joints.

- **Plantar muscles Layer 3:** The **adductor hallucis** is similar to the adductor pollicis of the hand. It is "7" shaped, with transverse and oblique heads, and it adducts the great toe. The **flexor hallucis brevis** and **flexor digiti minimi** muscles flex the great toe and 5th digit, respectively. These muscles can be observed on the deep dissection.
- **Plantar muscles layer 4:** The deepest layer of muscles on the plantar aspect of the foot is composed of the **dorsal** and **plantar** interossei. The **D**orsal interossei **Ab**duct the toes, while the **P**lantar interossei **Ad**duct the toes (DAB and PAD). There are similar muscles with the same actions in the hand. However, be sure not to mix up the name of these muscles with those of the hand! In the foot, the interossei that adduct are called the *plantar* interossei, while in the hand, they are the palmar interossei. These muscles cannot be seen on the

dissected tissue, but they can be observed in atlas images.

Lab 14: Anterior, Medial, and Lateral Thigh | Anterior and Lateral Leg | Dorsal Foot

LEARNING OBJECTIVES:

- Identify the muscles of the anterior thigh, medial thigh, lateral thigh, anterior leg, lateral leg, and dorsal foot.
- Using the muscle charts as a guide, identify the action, origin, insertion, and innervation for the muscles of the anterior thigh, medial thigh, lateral thigh, anterior leg, lateral leg, and dorsal foot.
- Describe how structure governs function and provide examples based on muscle orientation and actions.
- Identify the anatomy of the knee joint.

- Identify the anatomy of the ankle joint.

TERMS TO KNOW

Muscles of the Lower Extremity

- Medial Thigh
  - Adductor longus
  - Adductor brevis
  - Gracilis
  - Pectineus
  - Adductor magnus
- Lateral thigh
  - Tensor fasciae latae
  - Iliotibial (IT) tract (band)
- Anterior thigh
  - Iliopsoas
    - Psoas major
    - Iliacus
  - Sartorius
  - Quadriceps
    - Rectus femoris
    - Vastus lateralis
    - Vastus medialis
    - Vastus intermedius
  - Patellar Tendon

Muscles of the Leg

- Anterior compartment
  - Extensor digitorum longus
  - Extensor hallucis longus
  - Fibularis (peroneus) tertius
  - Tibialis anterior
- Lateral compartment of the leg
  - Fibularis (peroneus) longus
  - Fibularis (peroneus) brevis

Muscles of the Leg (continued…)

- Superficial posterior compartment of the leg
  - Gastrocnemius
  - Soleus
  - Plantaris
  - Calcaneal (Achilles) tendon
- Deep posterior compartment of the leg
  - Flexor digitorum longus
  - Flexor hallucis longus
  - Tibialis posterior
  - Popliteus

Muscles on the Dorsal Aspect of the Foot

- Extensor hallucis brevis
- Extensor digitorum brevis

Joints of the Lower Extremity

- Knee joint
  - Medial meniscus
  - Lateral meniscus
  - Medial collateral ligament
  - Lateral collateral ligament
  - Anterior cruciate ligament
  - Posterior cruciate ligament
  - Infrapatellar fat pad
- Talocrural (ankle) joint
  - Deltoid Ligament
  - Anterior *tibio*fibular ligament
  - Anterior *talo*fibular ligament (ATF)
  - Posterior talofibular ligament
  - Calcaneofibular ligament

INTRODUCTION

In this lab, you will explore the muscles of the anterior thigh, medial thigh, lateral thigh; anterior compartment of the leg; lateral compartment of the leg; and the dorsal aspect foot. Use the muscle tables to guide your learning of the origin, insertion, action, and innervation.

Dynamic vs. Static stability of the Knee Joint

An interesting clinical point to consider is the dynamic vs. static stability of the knee joint. Static stability comes from all the non-contractile elements of a joint (e.g., bone shape, ligaments, cartilage, capsule) and gives us many structure governs function examples. Dynamic stability refers to joint stability provided by muscle actions. The knee provides two great examples: The action of the quad muscle directly support the PCL ligament (a ligament designed to protect posterior translation of the tibia on the femur), and the hamstrings directly support the ACL ligament (a ligament designed to protect anterior translation of the tibia on the femur).

LAB ACTIVITY 1: VISIBLE BODY DIGITAL ATLAS–MUSCLES OF THE ANTERIOR, MEDIAL, AND LATERAL THIGH AND THE KNEE JOINT

While you are looking at the muscles of the lower extremity, you can select the individual muscles, then click the red attachment icon. When you have clicked the attachment icon, videos will often pop up to demonstrate the motion of the muscles you have selected. You can also go to the *Muscle Actions* icon from the home page and scroll down to see the motions of the leg and foot. Explore the various movements at the knee and ankle joints in relation to the muscle actions responsible for those movements. You should also review these muscle actions from your muscle tables.

- **Explore muscles of the thigh:** Click on the *Systems* icon, then under *Muscular System Views*, click on **18. Knee**. Explore the muscles of the anterior, medial, and lateral thigh provided in the list of terms. As you navigate through, highlight the various muscles, and use your muscle charts to study the origins, insertions, and actions of these muscles with the images. Remember to explore the various movements at the knee joint and the muscles responsible for those movements. You should also review these muscle actions from your muscle charts.
- **Explore the Knee joint:** Click on the *Systems* icon, then under *Skeletal System Views*, click on **1. Full Skeleton.**
    - To see the **medial and lateral menisci**, zoom into the knee, then hide the femur. Now, rotate the image, so you are looking at it from a superior to inferior view. The menisci function as cushions and shock absorbers for the knee joint. The lateral meniscus is more “O” shaped, while the medial meniscus is more “C” shaped.
    - Reset the view to the full skeleton, zoom into the

knee, and observe the **medial collateral ligament**. This ligament protects against valgus forces at the knee, in which the knee bends inward in the coronal plane and opens the medial joint space. For example, a valgus force could occur when a football player hits the lateral aspect of another player's knee during a tackle. Now, look at the **lateral collateral ligament**. This ligament prevents varus forces, resulting in the knee bending out laterally in the coronal plane and opening the lateral joint space.

- To see the cruciate ligaments deep in the knee joint in the intercondylar space, you should first hide the patella and the patellar tendon. You may also need to hide the femur. Make sure to rotate around the image to appreciate these ligaments from an anterior and posterior view. The **posterior cruciate ligament**, or PCL, runs from the inner surface of the medial femoral condyle to the posterior intercondylar area of the tibia. It prevents the tibia from moving posteriorly on the femur. The **anterior cruciate ligament**, or ACL, is commonly injured. It runs from the inner surface of the lateral femoral condyle, wraps around the PCL, and inserts onto the anterior intercondylar area of the tibia. This ligament prevents anterior movement of the tibia on the femur, and it is crucial to the integrity and proper function of our knee. Many activities we do biomechanically involve forces that push our tibia anteriorly: walking, running, jumping, and more. If this ligament is damaged, it can feel as if our knee is "giving out." Forceful movements such as jumping without this ligament are difficult and can damage other structures in the knee.

- You will NOT be able to observe the **infrapatellar fat pad** just deep and inferior to the patella. This fat pad helps to cushion the joint. You can observe some bursae or fluid-filled sacs around the knee, but you will not be tested on these.

LAB ACTIVITY 2: VISIBLE BODY DIGITAL

ATLAS–MUSCLES OF THE ANTERIOR AND LATERAL LEG, DORSAL ASPECT OF THE FOOT, AND ANKLE JOINT

- **Explore the muscles of the anterior and lateral leg:** Use the right leg to view the anterior and lateral leg muscles. Use finger gestures, rotation, zoom, and highlight tools to explore the muscles in the list of terms. Reference the muscle charts for origin, insertion, and innervation information. You will need to hide or remove the superficial muscles to see the deeper muscles of the anterior and lateral leg.
- **Explore the muscles on the dorsal aspect of the foot:** Use the right leg to view the muscles on the dorsal aspect of the foot. There are only two muscles on the dorsal aspect.
- **Explore the Talocrural (ankle) joint and joints of the foot:** Click on the *Systems* icon and then *Muscular System Views*. Go to **19. Ankle and** Foot. Use the left foot to see the ligaments of the ankle, or **talocrural**, joint. The talocrural joint occurs between the tibia, fibula, and talus. Notice how the fibula projects more inferiorly than the tibia at this joint. This is why we have a greater range of motion with inversion of our ankle (pointing the bottom of the foot inwards) than with eversion (pointing the bottom

of our foot outwards). When our foot is at a 90-degree angle to our lower leg, as in standing in anatomical position, our talus is locked into a more stable position between the fibula and tibia. However, when we plantarflex our foot or point our toe, the talus moves out of this position, and we are more vulnerable to ankle sprains in this position. To better visualize the ligaments, hide the *extensor and flexor retinaculum*. Observe the **deltoid ligament** on the medial aspect of the ankle. The app shows different parts of this ligament. You do not need to know the different parts of the ligament, just that those medial ligaments together comprise the deltoid ligament. Anteriorly, observe the **anterior tibiofibular ligament** running from the distal tibia to the distal fibula. When a patient incurs a high ankle sprain, the tibia and fibula are forced apparat, and this ligament is injured. On the anterolateral aspect, observe the **anterior talofibular ligament (ATF)**. This ligament runs from the talus to the fibula, and it is commonly injured with eversion ankle sprains. Finally, view the **calcaneofibular ligament**, which runs from the fibula to the calcaneus.

Move to the foot and observe the **intertarsal** (the app will define these, you do not need to know each one individually)**, tarsometatarsal, metatarsophalangeal** (the app will show the capsules of these joints), **and interphalangeal** joints. Note that interphalangeal joints are found in both the hand and foot. Like the hand, toes 2-5 have **proximal** and **distal interphalangeal joints**, while the great toe, like the thumb, only has an **interphalangeal joint.**

LAB ACTIVITY 3: LOWER EXTREMITY CADAVERIC TISSUE-MUSCLES OF THE ANTERIOR, MEDIAL, AND LATERAL THIGH

Reminder: Never touch the plastinated specimens with wet gloves! *Also, though you can turn the plastinated specimens to view different structures, you should try to* ***handle these as little as possible.***

- **Anterior thigh**
    - Observe the **psoas major, iliacus, or iliopsoas** muscles. The psoas major originates on the lumbar vertebrae, and it merges with the

iliacus to form the iliopsoas. These muscles flex the hip.

- Observe the **sartorius**. This long, thin muscle runs across the anterior thigh from the ASIS to the pes anserine insertion on the tibia. This is the longest muscle in the body.
- Now observe the four muscles that make up the quadriceps muscle group. The **rectus femoris** is the superficial muscle located on the midline of the thigh. It crosses both the knee and hip joints. The **vastus lateralis** and **vastus medialis** are located just lateral and medial to the rectus femoris, respectively. The **vastus intermedius** is deep to the rectus femoris.

- **Medial thigh**
  - First, observe the **gracilis**. This muscle is long and thin, and it inserts at the pes anserine insertion of the proximal medial tibia.
  - Observe the **adductor magnus**. This large muscle has both hamstring and adductor parts. The adductor portion inserts just superior to the medial condyle of the femur at the adductor tubercle.
  - Observe **adductor longus, adductor brevis,** and **pectineus.** The **adductor longus** is thinner, longer, and anterior to the **adductor brevis**.

pectineus is also deep to adductor longus**.**

    - The medial thigh muscles appear somewhat fanned out along the medial thigh. All medial thigh muscles have an attachment to the pubis. They insert on the femur (except gracilis), in the following order from superior to inferior: Pectineus, adductor brevis, adductor longus, adductor magnus, and gracilis, which inserts onto the tibia at the pes anserine insertion.

- **Lateral thigh**
    - Near the hip, observe the **tensor fasciae latae (TFL)** on the lateral aspect of the thigh. The TFL anteriorly and gluteus maximus posteriorly attach to a long, flat, tendon-like, thick fascial layer called the iliotibial tract (IT band). The IT band inserts at Gerdy's tubercle on the lateral aspect of the proximal tibia.

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Thigh
by Digital Ecorche Massing Models
on Sketchfab

LAB ACTIVITY 4: LOWER EXTREMITY CADAVERIC TISSUE-THE KNEE

On the deep dissection, the knee has been opened. Lift the patella and quadriceps tendon and observe the deep aspect of the patella. There is evidence of osteoarthritis on the medial facet. It should be smooth and shiny. Also, observe the femoral condyles. There is significant osteoarthritis and bone spurs here, particularly on the medial condyle.

- Observe the tibial plateau and the **medial** and **lateral menisci**. Though you can't see the whole meniscus on either side, you can see the location and anatomy of these structures.

- The collateral ligaments are difficult to see because they blend into the capsule. The **medial collateral ligament (MCL)** has been isolated on the medial aspect of the knee. However, the **lateral collateral ligament (LCL)** has not been isolated.
- Deep in the knee, observe the **anterior cruciate ligament (ACL)** and **posterior cruciate ligament (PCL)**. Notice how the ACL inserts into the anterior aspect of the tibial plateau, while the PCL inserts onto the posterior aspect of the tibial plateau. Therefore, these ligaments cross each other. The ACL prevents anterior translation of the tibia on the femur. If an ACL tear is suspected, you can test this ligament by performing a Lachman's Test. You are encouraged to perform this test on the deep dissection, as the "end point" feels the same as it would with an intact ACL in a living person. To perform this test, place one hand around the proximal tibia with the palm on the posterior aspect of the tibia. Place the other hand around the distal femur, with the palm on the anterior aspect of the femur. Slightly bend the knee (about 10 degrees). Stabilize the femur while somewhat quickly pulling the tibia

anteriorly. You should feel a hard endpoint as the ACL prevents the tibia from moving anteriorly. Be sure to watch the ACL in action as you are performing this test.

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Knee Anatomy Model
by **University of Dundee, CAHID**
on **Sketchfab**

LAB ACTIVITY 5: LOWER EXTREMITY CADAVERIC TISSUE-ANTERIOR LEG, LATERAL LEG, AND DORSAL FOOT

Observe the following muscles of the leg and foot:

- **Anterior compartment of the leg:** Observe the muscle that appears to be tightly adhered to the lateral aspect of the anterior tibia. This is the **tibialis anterior**, and it is the primary dorsiflexor of the foot. Just lateral to it is the **extensor digitorum longus.** The tendons of this muscle extend to digits 2-5. Unlike the upper extremity, there are two "extensor digitorum" muscles, so it is critical to include "longus" in the name when referring to this muscle. Deep to tibialis anterior is **extensor hallucis longus**. "Hallucis" means "great (1^{st}) toe. You may not be able to see the entire muscle belly, but you will be able to see the tendon of this muscle extending to the great toe. Finally, observe the **peroneus (fibularis) tertius**. This muscle is very small, and it either is not present in our tissue or is blended in with the extensor digitorum. You can see this muscle in other images.
- **Lateral compartment of the leg:** There are two muscles of the lateral compartment of the leg. **Peroneus (fibularis) longus** is superficial to peroneus brevis and sends its long tendon under the arch of the foot to insert on the base of the first metatarsal. You can pull on the tendon near the base of the first metatarsal on the deep wet specimen and see the tendon move on

the lateral aspect of the foot. **Peroneus (fibularis) brevis** has a shorter tendon that inserts at the base of the 5th metatarsal on the lateral aspect of the foot. These muscles act to evert the foot.

- **Muscles on the dorsal aspect of the foot:** The **extensor digitorum brevis** muscle extends digits 2-*4*, while **extensor hallucis brevis** extends the great toe.

LAB ACTIVITY 6: RADIOLOGY OF THE LOWER EXTREMITY

Use the computers to view a tutorial on radiology of the gluteal region, thigh, and knee. The MRI images will have a few more structures listed than what you need to know for this lab. Focus on the list of terms to know from above.

PART IV

UNIT 4: THE UPPER EXTREMITIES

Lab 15: Introduction to Joints and Bones of the Upper Extremity

LEARNING OBJECTIVES:

- Name the bones of the upper extremity and describe their functions.
- Identify key landmarks on the bones of the upper extremity and explain their function or purpose.
- Identify and describe the joints of the upper extremity, the bones that make up those joints, the movements possible at those joints, and any key accessory structures that are part of the joint (e.g., bursae or ligaments).
- Explain structure governs function examples from the bones

and articulations of the upper extremity (i.e., how is the degree of joint movement determined by the structure of the joint).

TERMS TO KNOW

- Clavicle
    - Acromial end
    - Sternal end
    - Conoid tubercle
    - Shaft
- Scapula
    - Glenoid fossa
    - Infraglenoid tubercle
    - Supraglenoid tubercle
    - Coracoid process
    - Acromion process
    - Scapular spine
    - Medial border
    - Lateral border
    - Superior border
    - Inferior angle
    - Superior angle
    - Subscapular fossa
    - Supraspinous fossa
    - Infraspinous fossa
    - Suprascapular notch
- Humerus
    - Head
    - Greater tubercle
    - Lesser tubercle
    - Deltoid tuberosity
    - Intertubercular sulcus
    - Radial groove
    - Anatomical neck
    - Surgical neck
    - Medial epicondyle
    - Lateral epicondyle
    - Lateral supracondylar ridge
    - Medial supracondylar ridge
    - Capitulum
    - Trochlea
    - Radial fossa
    - Coronoid fossa
    - Olecranon fossa
    - Shaft
- Ulna
    - Trochlear notch
    - Olecranon process
    - Coronoid process
    - Radial notch
    - Head
    - Shaft
    - Styloid process
    - Interosseous border (crest)
- Radius
    - Head
    - Neck
    - Shaft
    - Radial tuberosity
    - Styloid process
    - Ulnar notch
    - Interosseous border (crest)
- Carpals
    - Scaphoid
    - Lunate
    - Triquetrum
    - Pisiform
    - Trapezium
    - Trapezoid
    - Capitate
    - Hamate
- Metacarpals
- Phalanges
    - Proximal
    - Middle
    - Distal
    - Pollex

INTRODUCTION

In this lab, you will learn about the bones of the upper extremity. During this unit, we will discuss the bones, joints, muscles, nerves, and vasculature that make up our shoulder region, arm, forearm, and hand. Be sure to check the course Canvas page, as we will be providing you with a bony landmark table and muscle charts posted on the lab canvas pages to help clarify what material you will be responsible for and help you learn the material.

This lab focuses on the bones of the upper extremities, including the scapula, humerus, clavicle, ulna, radius, carpals, metacarpals, and phalanges. You will be asked to identify specific landmarks on these bones. You are encouraged to look at several different bones of the same type (i.e., several different humeri), as sometimes these features are more or less prominent due to anatomical variation. Finally, you should identify if individual bones come from the right or left upper extremity based on the landmarks. Students are encouraged to reference the muscle and bone landmark charts to better understand the origin and insertion landmarks on the bones. You are responsible for knowing the bony landmark origins and insertions for many of the muscles of the upper extremity, as indicated on the muscle charts linked above.

LAB ACTIVITY 1: SCAPULA, CLAVICLE, AND HUMERUS

Observe the scapula, clavicle, and humerus. Use the bony markings table to learn the function and/or structure that runs near/attaches/articulates with each bony marking. You will be responsible for the information in that table, and these markings will be reviewed again as we discuss the rest of the upper extremity.

You should use the iPads to help you identify the landmarks listed in the Terms to Know. You will want to highlight one of the selected bones, then use the isolate feature (it looks like a femur with multiple colors). When you isolate the bones, you will see all of the bony landmarks and markings as listed in the charts and the terms to know.

You should identify if these three bones come from the right or left side of the body. By knowing if a particular landmark is medial or lateral, anterior or posterior, you should quickly determine the side of the body the bone came from. For example, the medial epicondyle is larger than the lateral epicondyle of the humerus, and the large olecranon fossa is posterior. By knowing this, you should determine if you are looking at a right or left humerus.

- Observe the following features of the **clavicle**:
    - Sternal end
    - Acromial end
    - Conoid tubercle
    - Shaft
- Observe the following features of the **scapula**:
    - Glenoid fossa
    - Infraglenoid tubercle
    - Supraglenoid tubercle

    - Coracoid process
    - Acromion process
    - Scapular spine
    - Medial border
    - Lateral border
    - Superior border
    - Inferior angle
    - Superior angle
    - Subscapular fossa
    - Supraspinous fossa
    - Infraspinous fossa
    - Suprascapular notch
- Observe the following features of the **humerus**:
    - Head
    - Greater tubercle
    - Lesser tubercle
    - Deltoid tuberosity
    - Intertubercular sulcus
    - Radial groove
    - Anatomical neck
    - Surgical neck
    - Medial epicondyle
    - Lateral epicondyle
    - Lateral supracondylar ridge
    - Medial supracondylar ridge

- Capitulum
- Trochlea
- Radial fossa
- Coronoid fossa
- Olecranon fossa
- Shaft

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Scapula – Right, Labeled
by **Bluelink Anatomy – University of Michigan**
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Humerus
by **Bluelink Anatomy – University of Michigan**
on **Sketchfab**

LAB ACTIVITY 2: ULNA, RADIUS, CARPALS, METACARPALS, AND PHALANGES

Observe the ulna, radius, carpals, and phalanges specimens. Use the Visible Body Atlas to help you identify the bones and bony markings. Use the bony markings table to learn the function and/or structure that runs near/attaches/articulates with each bony marking. You will be responsible for the information in that table, and these markings will be reviewed again as we discuss the rest of the upper extremity.

- Observe the following features of the **ulna**:
    - Trochlear notch
    - Olecranon process
    - Coronoid process
    - Radial notch
    - Head
    - Shaft
    - Styloid process

    - Interosseous border (crest)
- Observe the following features of the **radius**:
    - Head
    - Neck
    - Shaft
    - Radial tuberosity
    - Styloid process
    - Ulnar notch
    - Interosseous border (crest)
- Observe the bones of the wrist and hand:
    - Carpals
        - Scaphoid
        - Lunate
        - Triquetrum
        - Pisiform
        - Trapezium
        - Trapezoid
        - Capitate
        - Hamate
    - Metacarpals
    - Phalanges
        - Proximal
        - Middle
        - Distal
        - Pollex

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Ulna
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Radius
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Wrist Anatomy MDCT/Anatomía de la muñeca
by Chair_Digital_Anatomy
on Sketchfab

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LAB ACTIVITY 3: RADIOLOGY-BONES OF THE UPPER EXTREMITY

The most common way that you will see bones in the clinical setting is through radiology. Therefore, you need to understand what normal bony anatomy looks like in radiological images. In this activity, you will use radiology to identify landmarks on the bones of the upper extremity. You will primarily examine x-ray images, but there will be a few MR images as well.

There will be a skeleton near the computers. Compare the landmarks on the skeleton to the radiological images along the way. This will help you to make sense of what you see in the images. You can also use an atlas to compare the bones with the radiology.

Lab 16: Neves and Vasculature of the Upper Extremity

LEARNING OBJECTIVES:

- Describe the brachial plexus and its branches.
- Identify the components of the brachial plexus.
- Describe the vasculature of the upper extremity and identify the regions supplied or drained by each vessel.
- Identify the major arteries and veins of the upper extremity.

TERMS TO KNOW

Arteries of the Upper Extremity

- Subclavian artery
  - Suprascapular artery
- Axillary artery
  - Superior thoracic artery
  - Thoracoacromial artery
  - Lateral thoracic artery
  - Anterior circumflex humeral artery
  - Posterior circumflex humeral artery
  - Subscapular artery
    - Thoracodorsal artery
    - Circumflex scapular artery
- Brachial Artery
  - Deep Brachial Artery
- Radial artery
- Ulnar artery
- Superficial and Deep palmar arches
- Digital arteries

Veins of the Upper Extremity

- Cephalic vein
- Basilic vein
- Median cubital vein
- Brachial vein
- Axillary vein
- Subclavian vein

Brachial Plexus

- Dorsal scapular nerve
- Long thoracic nerve
- Suprascapular nerve
- Posterior cord
  - Lower subscapular nerve
  - Thoracodorsal nerve
  - Upper subscapular nerve
- Medial cord
  - Medial antebrachial cutaneous nerve
  - Medial brachial cutaneous nerve
  - Medial pectoral nerve
- Lateral cord
  - Lateral pectoral nerve
- Terminal branches
  - Axillary nerve
  - Median nerve
  - Musculocutaneous nerve
  - Radial nerve
  - Ulnar nerve

INTRODUCTION

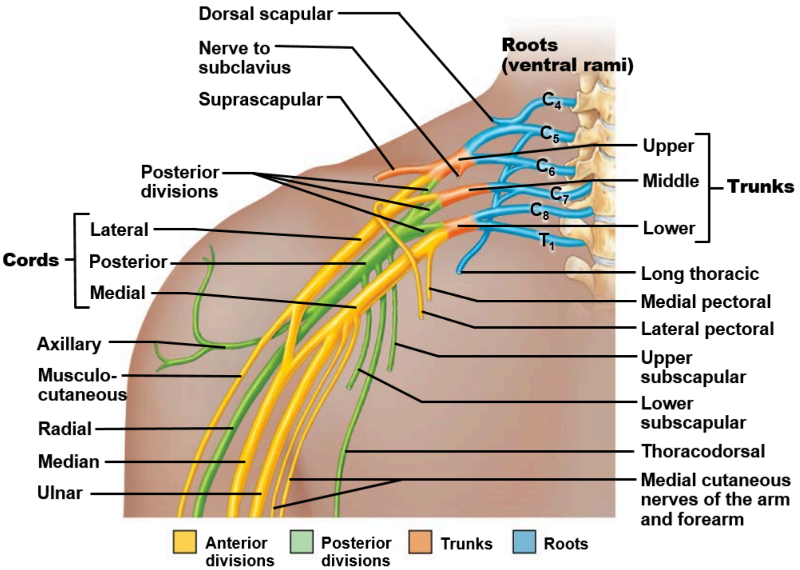
In this lab, you will learn about the neurovasculature of the upper extremity. You will learn about the brachial plexus, which eventually branches into all nerves that innervate the upper extremity. You will also learn about the subclavian, axillary, and brachial arteries and their branches that eventually provide the whole upper extremity with blood. You are responsible for the information in this lab guide on the muscles or structures innervated or supplied by these nerves and arteries.

LAB ACTIVITY 1: NEUROVASCULATURE OF THE UPPER EXTREMITY – CADAVERIC TISSUE

Observe the nerves and vessels of the upper extremity on the cadaveric tissue. ***Remember to use landmarks to help you identify the neurovasculature!*** For example, if you know which muscles are innervated by a specific nerve and follow a nerve to that muscle, you can identify that nerve.

NERVES OF THE UPPER EXTREMITY:

Explore the brachial plexus. In general, your first step should be looking for the “M” formed by the parts of the medial and lateral cords coming together to form the median nerve. This will help you get your orientation of what is medial and what is lateral. Once you know which is the medial or lateral cord, you can narrow down the branches coming from them. The “M” sits just anterior to the axillary artery. This also makes it easier to identify the posterior cord sitting posterior to the “M” and the axillary artery.



(b) Roots (rami C_5–T_1), trunks, divisions, and cords

- Here are a few tips for specific nerves in the axillary region:
  - **Dorsal scapular nerve**: This nerve is not present on the cadaveric tissue, but you will be able to identify it in images. This nerve will emerge very early from the brachial plexus, near the neck, and you will be able to see it running posteriorly to the rhomboids and levator scapulae.
  - **Suprascapular nerve**: This nerve will run posteriorly from the brachial plexus towards the scapula. It runs through the

suprascapular notch inferior to a ligament forming a bridge across the notch (called the transverse scapular ligament) to reach the supraspinatus and then through the spine of the scapula to reach the infraspinatus. In the deep dissection, this nerve has been dissected through its entire path to the infraspinatus.

- **Lateral pectoral nerve**: This nerve may not be present in the cadaveric tissue. On an image, you may see it run from the brachial plexus to the pectoralis major. You can also know that it is the lateral pectoral nerve rather than the medial because it will branch off the lateral cord.
- **Medial pectoral nerve**: This nerve also may not be present in the cadaveric tissue. This nerve is usually the first branch from the medial cord, and it runs through the pectoralis minor, innervating it on its path to the pectoralis major.
- **Medial brachial and medial antebrachial cutaneous nerves**: These nerves will branch distal to the medial pectoral nerve off of the

medial cord. They run to the skin of the medial arm and forearm. One of these is present in the cadaveric tissue, but we cannot tell which it is because it is cut, and we cannot follow it to its destination. These are visible on the plastinated tissue, superficial to the muscles.

- **Long thoracic nerve**: This nerve is easy to spot in images, as it runs tight to the thoracic wall, innervating the serratus anterior muscle. This is also visible running with the serratus anterior on the superficial dissection.
- **Thoracodorsal nerve**: Observe this nerve branching off the posterior cord and running to the latissimus dorsi muscle.
- **Upper subscapular and lower subscapular nerves**: These nerves branch from the posterior cord, with the upper branching proximal to the thoracodorsal nerve and the lower branching distal to the thoracodorsal nerve in most cases. They run posteriorly to the subscapularis and teres major (lower only) muscles. These are also clearly visible on the

plastinated specimen.

- **Axillary nerve**: This nerve branches from the posterior cord and runs posterolaterally. It travels with the posterior circumflex humeral artery through a space between the surgical neck of the humerus, the long head of the triceps, teres minor, and teres major to reach the deltoid.
- **Radial nerve**: Observe this nerve branching from the posterior cord and running to the posterior side of the arm. It is larger than the axillary nerve.
- **Ulnar nerve**: The ulnar is the most medial branch of the brachial plexus, branching from the medial cord. It continues along the medial side of the arm and passes around the medial epicondyle of the humerus on its path to the forearm. This nerve is responsible for our “funny bone.” You can also see it enter the hand, and it sends branches to the skin of the 5^{th} digit and the lateral aspect of the 4^{th} digit. It also innervates most muscles in the hand, except the thenar eminence muscles and

lateral two lumbricals. It is challenging to discern in the brachium (arm) on the plastinated specimen, but it travels around the medial epicondyle into the forearm and hand.

- **Median nerve**: In the axilla, the median nerve is evident as the middle nerve formed from the "M" of the brachial plexus, as it receives contributions from both the medial and lateral cords. It travels through the anterior arm and forearm to enter the hand and supply the skin of the lateral half of the 4th digit and digits 1-3 and the muscles of the thenar eminence and lateral two lumbricals. This nerve is also clearly visible on the plastinated tissue.
- **Musculocutaneous nerve**: The musculocutaneous nerve pierces (and supplies) the coracobrachialis muscle in the arm and then runs between the biceps brachii and brachialis muscles. It emerges on the lateral aspect of the arm as the lateral antebrachial cutaneous nerve. Be aware that the medial cord on the deep dissection

abnormally pierces the coracobrachialis muscle, then sends its contribution to the median nerve. The musculocutaneous nerve then pierces the coracobrachialis again and follows its normal path. While this branching pattern is abnormal, anomalies like this frequently occur with nerves and arteries. In the plastinated tissue, this nerve is not visible in the brachium. However, you can see it emerge in the forearm as the lateral antebrachial cutaneous nerve, where it innervates the skin of the lateral forearm.

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ARTERIES OF THE UPPER EXTREMITY:

Observe the arteries of the upper extremity.

- **Subclavian artery:** This is the primary artery providing the arm with blood. It is not visible on the cadaveric limbs, but a portion is visible on the full cadaver, and it can also be viewed in images.
- **Axillary artery:** This artery is continuous with the subclavian artery from the lateral border of the first rib to the inferior border of the teres major muscle. There are several branches you should be able to identify off of the axillary artery.
    - **Suprascapular artery:** The origin of this artery has been cut, but you can observe it in the deep dissection running over the transverse scapular ligament of the suprascapular notch and traveling to the supraspinatus. This artery runs posteriorly with the suprascapular nerve to supply the supraspinatus and infraspinatus.
    - **Superior thoracic artery:** This is the only branch off of the first part of the axillary artery. It will run inferiorly to the superior thoracic wall. It has been cut in the dissections, so you cannot follow it to its destination. It may be seen in atlas images.
    - **Lateral thoracic artery:** This

artery branches from the second part of the axillary artery and runs with the long thoracic nerve along the lateral thoracic wall to supply the lateral wall and the serratus anterior. Don't confuse the lateral thoracic artery and the long thoracic nerve! This can be observed in atlas images.

- **Thoracoacromial trunk:** This is a short trunk off the superior side of the second part of the axillary artery. It branches almost immediately into four parts that supply the acromion, deltoid, pectoral muscles, and clavicle. You can see its branches traveling to the pectoralis muscles. However, the other branches of this trunk have been cut in the cadaveric tissue.
- **Posterior and anterior circumflex humeral arteries:** These arteries branch from the third part of the axillary artery. They wrap around the surgical neck of the humerus and anastomose (join) with each other to provide circulation to this region via multiple routes. They

sometimes branch from a common trunk, or they can branch separately from the axillary artery. The posterior circumflex humeral artery runs posteriorly around the humerus with the axillary nerve, while the anterior circumflex humeral artery runs anteriorly around the humerus.

 - **Subscapular artery:** The subscapular artery is a short branch off of the third part of the axillary artery. As it runs inferiorly, it gives off two branches, both of which are visible on the cadaveric tissue. You can also observe these on the plastinated tissue.
     - **Circumflex scapular artery:** This runs posteriorly around the lateral scapula.
     - **Thoracodorsal artery:** This artery runs with the thoracodorsal nerve to the latissimus dorsi muscle.
- **Brachial artery:** This artery is continuous with the axillary artery at the inferior border of the teres major. It continues through the brachium to supply muscles of the anterior arm. This can be best observed on the deep dissection and plastinated tissue.
   - **Deep brachial artery:** This is the

only branch of the brachial artery you are responsible for in this unit. It branches from the brachial artery in the mid-arm region and runs posteriorly. This is difficult to see in the cadaveric specimens.

- **Ulnar and radial arteries:** The brachial artery divides into the radial and ulnar arteries in the cubital fossa. They run on the side of the antebrachium (forearm) of the bone with the same name. These are visible in the deep dissection, though the ulnar artery is cut in the forearm.
- **Superficial and deep palmar arches:** The superficial palmar arch is visible in the plastinated tissue, and both are visible in images. These are formed from the ulnar and radial arteries.
- **Digital arteries:** These branch from the superficial and deep palmar arches and travel to the sides of each digit.

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://wisc.pb.unizin.org/humananatomylabmanual/?p=156#h5p-51

VEINS OF THE UPPER EXTREMITY:

Most of the veins have been removed from the dissected cadaveric specimens. However, they are visible in atlas images and on the plastinated specimens. Two primary veins originate in the superficial forearm:

- The **cephalic vein** runs on the lateral aspect of the forearm and arm, while the **basilic vein** runs on the medial aspect of the forearm and arm.
- In the cubital fossa, the **median cubital vein** joins the basilic and cephalic veins. The median cubital vein is a common site for blood draws.
- The **brachial vein** drains the muscles of the arm and then joins the basilic vein to become the **axillary vein**. The cephalic vein drains into the axillary vein, and then the axillary vein becomes the **subclavian vein** at the border of the first rib.

LAB ACTIVITY 2: NEUROVASCULATURE OF THE UPPER EXTREMITY IN THE VISIBLE BODY DIGITAL ATLAS

Click on the tab marked *Systems***,** then under Circulatory System Views, click *1. Circulatory System*. On the left side of the screen, open the systems tab and click the venous system to DE-select it. Now you should only see the arterial system.

Explore the upper extremity arterial structure. You will need to use finger gestures to zoom and rotate the image into the best position to get the best view. Look for the following:

- Subclavian artery
    - Thyrocervical trunk
    - Suprascapular artery
- Axillary artery
    - Superior thoracic artery
    - Thoracoacromial (trunk) artery – **(hide clavicle to see)**
    - Lateral thoracic artery
    - Anterior circumflex humeral artery
    - Posterior circumflex humeral artery
    - Subscapular artery
        - o Thoracodorsal artery
        - o Circumflex scapular artery
    - Brachial Artery
        - Deep Brachial Artery – ****labeled as profunda brachii in the digital atlas**

- Radial Artery
- Ulnar Artery

Highlight each of the structures outlined above and look at the box on the upper right-hand side of the screen and review the information provided (click on the book for more information on the structure highlighted). Review as many of the visible vasculature structures as possible. Be sure to rotate the structure to appreciate multiple points of view.

Here are a few **tips for identifying arteries** of the axilla and arm:

- The subclavian becomes the axillary artery at the lateral border of the first rib.
- The axillary artery becomes the brachial artery at the inferior border of the teres major.
- The axillary artery is divided into three parts by the pectoralis minor muscle. The first part is medial to the muscle, the second part is deep to the muscle, and the third part is lateral to the muscle. The first part has one branch, the second part has two branches, and the third part has three branches.

Click on the tab marked *Systems*, then under Circulatory System Views, click *1. Circulatory System*. Open the systems tab on the left side of the screen, and click the arterial system to DE-select it. Now you should only see the venous system.

Explore the upper extremity venous structures. You will need to use finger gestures to zoom and rotate the image into the best position to get the best view. Look for the following:

- Cephalic vein

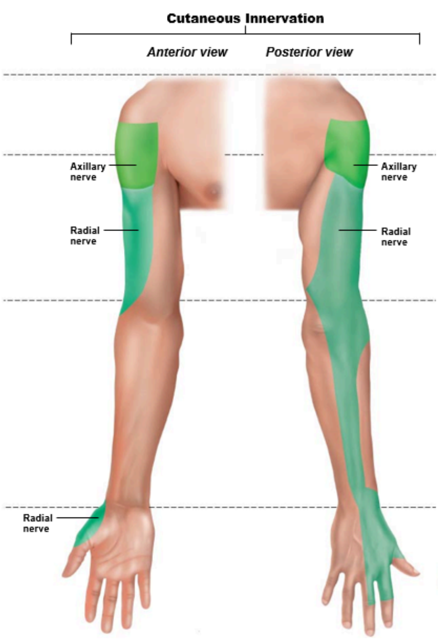
- Basilic vein
- Median cubital vein
- Brachial vein
- Axillary vein
- Subclavian vein

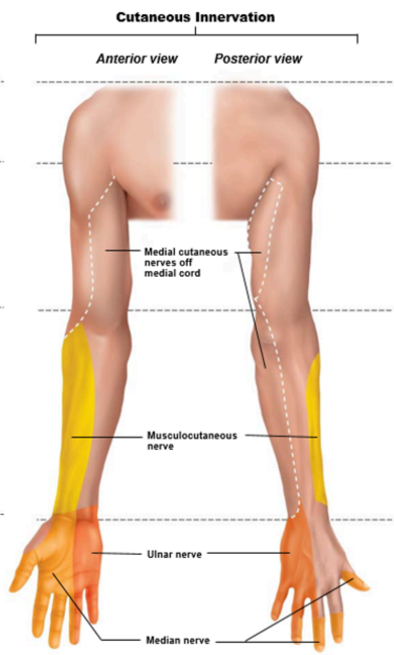
Click on the tab marked *Systems*, then under Nervous System Views, click *9. Brachial Plexus*. You will need to hide some muscles and bones to see all structures, including the pectoralis minor and biceps brachii short head.

LAB ACTIVITY 3: BRACHIAL PLEXUS EXERCISE (CARD PLACEMENT + ATLAS)

This exercise is designed to help you learn the branches of the brachial plexus and the muscles that those branches innervate. The brachial plexus provides innervation to all muscles and skin of the upper extremity. These nerves originate from the C5-T1 roots. Then they branch and merge, creating a web of nerves at the trunk, division, and cord levels. Several branches off of the trunk and cord levels innervate muscles acting on the pectoral girdle. Finally, the branchial plexus ends as five terminal branches. The posterior cord splits into the axillary and radial nerves. Branches of both the medial and lateral cords merge to form the median nerve. The rest of the medial cord becomes the ulnar nerve, while the rest of the lateral cord becomes the musculocutaneous nerve. These terminal branches innervate the rest of the muscles of the upper extremity.

- On the table, you will see a poster with an unlabeled brachial plexus. You will also see labels for nerves (blue) and muscles (red). Using the visible body atlas and laminated images, first use the blue nerve labels to correctly label the brachial plexus branches. Then, using muscle charts, place the muscles next to the nerve that innervates them.
- You should also be aware of the region of skin innervated by each terminal branch of the brachial plexus. Knowing both the muscles innervated by each branch and the region of skin innervated by the terminal branches has clinical relevance. It can help you determine which nerve (or nerve root, as explained in the lecture) may be damaged. The region of skin innervated by each terminal branch of the brachial plexus is shown in this figure:


Cutaneous Innervation
Anterior view
Posterior view
Axillary nerve
Radial nerve
Axillary nerve
Radial nerve
Radial nerve


Cutaneous Innervation
Anterior view
Posterior view
Medial cutaneous nerves off medial cord
Musculocutaneous nerve
Ulnar nerve
Median nerve

Lab 17: The Pectoral Girdle and Arm

LEARNING OBJECTIVES:

- Recognize the different categories of muscles with respect to movement.
- Describe the different types of muscle contractions
- Identify, describe, and palpate the joints of the pectoral girdle.
- Identify the rotator cuff muscles and describe their action, origin, insertion, and innervation.
- Identify and describe the posterior muscles acting on the shoulder girdle.
- Identify and describe the anterior muscles acting on the pectoral girdle.

TERMS TO KNOW

Joints of the Pectoral Girdle

- Sternoclavicular joint
- Sternoclavicular ligament
- Acromioclavicular Joint
- Acromioclavicular ligament
- Coracoclavicular ligament
- Coracoacromial ligament
- Glenohumeral Joint
- Glenoid labrum
- Articular capsule
- Scapulothoracic joint

Muscles Acting on the Elbow

- Brachialis
- Brachioradialis (discussed in the anterior forearm)
- Biceps brachii**
    - Short head
    - Long head
- Triceps brachii
    - Long head**
    - Lateral head
    - Medial head

**Acts on the glenohumeral joint and elbow

Muscles Acting on the Pectoral Girdle

- Trapezius
- Levator scapulae
- Rhomboid major
- Rhomboid minor
- Pectoralis minor
- Serratus anterior
- Subclavius
- Pectoralis major
- Latissimus dorsi
- Deltoid
- Coracobrachialis
- Teres major
- Rotator cuff muscles
    - Supraspinatus
    - Infraspinatus
    - Teres minor
    - Subscapularis
- Biceps brachii**
    - Short head
    - Long head
- Triceps brachii
    - Long head**

INTRODUCTION

In this lab, you will explore the joints and muscles of the pectoral girdle. Keep in mind that some structures are not visible using all modalities, and that is OK. By the end of the lab today, you should have identified all of the structures on the Terms to Know list using multiple sources. When using the digital atlas, use the animations to help you understand the movement of the scapulothoracic joint and the movements caused by each muscle listed.

As a study tip, you may find it helpful to write a description of each muscle/structure as you identify them. Writing it in your own words may spark your memory as you look for that structure the next time you study.

LAB ACTIVITY 1: JOINTS OF THE PECTORAL GIRDLE AND SHOULDER – VISIBLE BODY DIGITAL ATLAS

Use the Visible Body digital atlas to observe the three joints of the pectoral girdle and shoulder and the structures listed with them.

- Under the Systems tab, Skeletal System Views, click on *15. Shoulder Girdle*. The "shoulder joint" is made up of three joints and has many bursae. The bursae in the app will appear purple. You can select these structures and hide them as we will *not* hold you responsible for knowing them. The app will also show a few more ligaments than we have listed for you. You will only be responsible for knowing the ligaments listed below.
- Examine the three joints and the structures listed with them. Highlight the structures and observe the functions listed under the book icon. Sometimes it can be helpful to attach clinical meaning to these structures when trying to remember them. You may also find it interesting to look at the injury and clinical relevance (stethoscope icon).

- **Acromioclavicular Joint**
    - **Acromioclavicular ligament**
    - **Coracoclavicular ligament** (**shown as two ligaments; conoid portion and trapezoid portion. You will not need to know these two portions individually.)
- **Coracoacromial ligament**
- **Glenohumeral Joint**
    - **Articular capsule**
    - **Glenoid labrum:** This will be deep. Remove the capsule and other ligaments of the shoulder to see this structure.
- **Scapulothoracic joint** (you cannot highlight this joint, but you can see how the scapula articulates with the ribs. You will need to zoom out or move the view medially to view this joint.)

LAB ACTIVITY 2: MUSCLES OF THE PECTORAL GIRDLE AND SHOULDER – VISIBLE BODY

DIGITAL ATLAS

First, explore the muscles of the pectoral girdle using the visible body digital atlas.

- Click on the *Regions* tab and scroll to *8. Axilla.* Under the systems tab on the left side of the screen, click on the muscular system, so the whole arm is highlighted. Also, while under systems, click on the arterial, venous, nervous, and lymphatic systems twice to remove them since we will not be looking at these systems in this lab.
- Explore the muscles of the pectoral girdle and arm in the Terms to Know list. Some of these muscles will be deep to others. Thus you will have to remove the larger, more superficial muscles (pectoralis major, deltoid, trapezius, and platysma) to see the deep muscles.
- You will be asked to identify the origins, insertions, actions, and innervations of these muscles (this will be listed in the app after highlighting the structure and clicking the book). However, you may not need to know specific details for each muscle. **Follow what is on the posted muscle tables for the specifics of what you need to know for each muscle.**
- To see the muscles in action, click on the red pin when you have highlighted the muscle. This will drop down motion videos. You can also go back to the home screen of the app and select the Muscle Actions tab. From here, you will be able to see motions of the shoulder, and within those motion sequences, you can individually select muscles to see their action.
    - Click on the *Muscle Actions* tab (on the home page) and scroll to scapular motions to view the

muscles that act on the scapula. Explore the animations of elevation/depression, protraction(called abduction in the digital atlas)/retraction (called adduction in the app), and upward and downward rotation of the scapula.

- Click on shoulder motions and observe the animations of abduction/adduction, horizontal abduction/horizontal adduction, external(lateral)/internal(medial) rotation, and flexion/extension of the shoulder.

LAB ACTIVITY 3: NAVIGATOR

Use the Navigator to examine the anatomy of the pectoral girdle. Some muscles and joint structures are visible on the 3D printed model, while others can be seen on the computer model. You should also examine the anatomy of the shoulder complex in the cross-sections.

NOTE: DO NOT save any presets as you are examining these muscles.

- On the computer model, click on "View," then "Advanced" in the View window to isolate specific muscles or structures. Uncheck the pectoralis major so that you can view the pectoralis minor and the subclavius. You should be able to identify most of the muscles in the list of terms, although some are cut because the model only shows the superior portion of the arm.

- Remove the muscles to examine the ligaments stabilizing the joints of the pectoral girdle.
- Observe the head of the humerus, scapula, rotator cuff muscles, and other muscles acting on the pectoral girdle and glenohumeral joint in the cross-sections.
    - Spatial relationships are key! Understanding the relationships between structures (e.g., posterior, anterior, medial, lateral, superior, inferior, superficial, deep) will help you know what you are viewing at each level. For example, with the posterior muscles acting on the pectoral girdle, you know that the trapezius is superficial (posterior) to the rhomboids.

LAB ACTIVITY 4: UPPER EXTREMITY TISSUE

All muscles on the list of terms are visible either in part or on the whole on the upper extremity tissue. Be sure to view all extremity tissue available in the lab. Two arms have been dissected more superficially, while the others have been dissected so that you can identify some deeper structures.

It can be helpful for you to have the muscle tables with you while you are examining these structures. Noting the orientation of muscle fibers and the origin/insertions can help you understand the actions of these muscles.

*Handle this tissue with care and respect! B*e gentle when moving the specimen and feeling the muscles.

- Feel for the spine of the scapula. Extending superiorly from the scapular spine, examine part of the **trapezius**. This muscle has fibers running superiorly, horizontally, and inferiorly from the vertebral column to insert on the scapular spine, acromion, and clavicle. However, this muscle has been cut in some cases.
- Along the medial border of the scapula, you can identify three muscles that have been cut. From inferior to superior, these muscles are the **rhomboid major**, **rhomboid minor**, and **levator scapulae**. The rhomboid major is larger and inferior to the rhomboid minor. The rhomboid minor is thinner and located between the rhomboid major and the levator scapulae. The levator scapulae is the most superior of these muscles. These muscles run from the vertebral column to the medial border or superior angle of the scapula.
- Deep to the trapezius, observe the **supraspinatus** muscle. It has been partially retracted in the deep dissection, so you can also pull this muscle back to better appreciate how it sits in the supraspinous fossa. Be gentle when retracting the supraspinatus on the deep tissue, as there are nerves

and vessels attached to the deep side of this muscle.

- Inferior to the scapular spine, observe the **infraspinatus**. This muscle can also be retracted in the deep dissection to observe its position in the infraspinous fossa. Again, be careful when retracting this muscle, as nerves and vessels are attached to its deep aspect.
- Just inferior to the infraspinatus, observe the **teres minor**. This will be best viewed on the superficial dissection. The teres minor, infraspinatus, and supraspinatus are all part of the rotator cuff muscle group and are the three rotator cuff muscles located on the posterior aspect of the scapula.
- Inferior to teres minor, observe the larger **teres major**. Also, observe a portion of the **latissimus dorsi** inferior to teres major, which is cut in this dissection. Observe these muscles on the posterior aspect of this tissue, and then turn the tissue so you can observe it from an anterior view. Now notice how the latissumus dorsi and teres major both run to insert on the anterior aspect of the humerus. This is important to appreciate to understand how these muscles contribute to the internal rotation of the glenohumeral

joint.

- Observe the **deltoid** on the lateral aspect of the shoulder. This muscle wraps around the shoulder superiorly and comes together at a common insertion point on the humerus (the deltoid tuberosity). Notice how the orientation of the fibers changes as it wraps around the shoulder from anterior to posterior. This can help you understand why the functions of the posterior, middle, and anterior fibers of the deltoid differ.
- Observe the muscle on the anterior aspect of the scapula that has been cut but has an attachment point on the medial border of the scapula. This is **serratus anterior.** This muscle extends from the anterior aspect of the medial border of the scapula and wraps anteriorly around the thoracic cage to insert on the ribs. Think about how its structure contributes to its function of stabilizing the scapula.
- On the anterior aspect of the scapula, observe the **subscapularis** muscle. This is the fourth rotator cuff muscle, and it sits in the subscapular fossa.
- Observe **pectoralis major** and **pectoralis minor**. Both have been cut. Pectoralis major is larger and superficial to pectoralis minor. Pectorals major has an insertion on the humerus, while

pectoralis minor inserts onto the coracoid process of the scapula. As a result, pectoralis major acts on the glenohumeral joint, while pectoralis minor only acts on the scapulothoracic joint.

- Notice a small amount of muscle that is located on the inferior aspect of the clavicle. This muscle has been cut, but you can see the superior most portion of the **subclavius**.

Now you will examine muscles of the arm that cross the glenohumeral joint.

- Observe the **coracobrachialis**. This muscle originates on the coracoid process of the scapula and inserts on the humerus. This muscle is typically pierced by a nerve, the musculocutaneous nerve, in the middle of the muscle belly. However, notice how it differs in one of the deep dissections. In this case, an earlier portion of the brachial plexus also pierces this muscle, giving it the appearance of having two muscle bellies. Anatomical variation is very common!
- Now observe the **biceps brachii**. This muscle has two heads. The **long head** originates on the supraglenoid tubercle of the scapula. Follow it as high as you can on the deep dissection, towards the head of

the humerus. The **short head** originates on the coracoid process of the scapula.

- Just lateral to the biceps brachii, observe the **brachialis**. This muscle is the primary flexor of the elbow.
- On the posterior aspect of the arm, observe the **triceps brachii**. The **long head** is superficial and in the middle, and this is the only portion of the triceps brachii that crosses the glenohumeral joint. Also, observe the **medial and lateral heads**.

Examine the joints of the pectoral girdle:

- Observe the **acromioclavicular joint** on these dissections. You can palpate where the clavicle meets the acromion. On the superficial dissection, you may be able to see the **acromioclavicular** and **coracoclavicular ligaments**.
- On the deep dissection, you can also see the **coracoacromial ligament** running from the acromion process to the coracoid process of the scapula. Observe how the supraspinatus runs underneath this ligament as it moves towards the greater tubercle.
- Finally, look at the posterior aspect of the deep dissection. The infraspinatus has been cut, and the articular capsule has been opened so that you can observe the internal aspect of the **glenohumeral joint**. Notice

how smooth the articular cartilage on the head of the humerus is. Also, note how thick the **articular capsule** is. Observe the ring of tissue just surrounding the glenoid fossa. This is the **glenoid labrum**.

Be sure to examine the structures above on the plastinated tissue as well. Not all muscles are visible in this dissection. *(Note: The vessels and nerves on this specimen are very fragile. Please be gentle!)*

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://wisc.pb.unizin.org/humananatomylabmanual/?p=159#h5p-52

LAB ACTIVITY 5: RADIOLOGY OF THE PECTORAL GIRDLE AND ARM

On the lab computers, view the slideshow on the radiology of the pectoral girdle and arm. Explore the structures listed in the Terms to Know in the radiology images.

Lab 18: Elbow and Wrist Joints | Muscles of the Posterior Arm

LEARNING OBJECTIVES:

- Identify and describe the components of the elbow joint
- Identify and describe the joints of the forearm and wrist.
- Identify and describe the muscles of the posterior forearm.

TERMS TO KNOW

Elbow Joint

- Humeroulnar joint
- Ulnar collateral
- Humeroradial joint
- Annular
- Radial collateral
- Proximal radioulnar joint

Wrist and Hand Joints

- Distal radioulnar joint
- Radiocarpal joint
- Midcarpal joints
- Intercarpal joints
- Extensor Retinaculum

Muscles of the Posterior Forearm

- Superficial Layer
    - Extensor carpi radialis longus
    - Extensor carpi radialis brevis
    - Extensor digitorum
    - Extensor digiti minimi
    - Extensor carpi ulnaris
- Deep Layer
    - Abductor pollicis longus
    - Extensor pollicis brevis
    - Extensor pollicis longus
    - Extensor indicis
    - Supinator

Other Terms

- Juncturae tendinae
- Extensor retinaculum

INTRODUCTION

In this lab, you will review the elbow and wrist joints and the muscles of the posterior forearm. The muscles of the posterior compartment of the forearm generally contain muscles that extend the wrist. Most of these extensors originate from the area of the lateral epicondyle of the humerus. Palpate your lateral epicondyle and move your fingers to the mass of muscle just distal to it. Extend your wrist, and you should feel this extensor mass contract. The posterior compartment also contains a muscle that abducts the thumb, as well as the supinator muscle. The supinator muscle works with the biceps brachii to supinate the hand. Supination makes the palm face forward in anatomical position. You can remember the position of a supinated hand by thinking that, in the supinated position, you can hold a cup of soup.

LAB ACTIVITY 1: MUSCLES OF THE POSTERIOR FOREARM – CADAVERIC TISSUE

Observe the muscles of the posterior forearm. The names of these muscles tell a lot about their location and/or function. They tend to extend the wrist or digits, and most originate on the lateral epicondyle of the humerus. This compartment can be divided into superficial and deep layers, each with five muscles. We won't ask you which layer a muscle is located in. However, sometimes breaking the muscles into smaller groups can be helpful for learning. As you are exploring the muscles of the posterior forearm, especially those crossing the wrist and hand joints, you can *GENTLY* pull on these tendons to watch how they move the wrist and digits.

Be sure to observe these structures on each of the upper extremity tissues we have in the lab.

SUPERFICIAL LAYER:

- On the radial side of the forearm, observe the **extensor carpi radialis longus** and **extensor carpi radialis brevis** muscles. Don't confuse these with the brachioradialis, which sits partially superficial to these. The brachioradialis has an origin that is proximal to the lateral epicondyle, while these muscles originate on or near the lateral epicondyle. Both extensor carpi radialis longus and brevis cross the wrist and act to extend it. The difference between the longus and brevis muscles is in the tendon length and position. Extensor carpi radialis longus has a longer tendon and is just superficial to the extensor carpi radialis brevis. The **extensor carpi ulnaris** (only one on this side) extends the wrist and inserts on the ulnar side.

- **Extensor digitorum** extends to the distal phalanx of digits 2-5 and extends the MCP, DIP, and PIP of these digits. There is only one extensor digitorum muscle, so there is no other descriptor in the name (e.g., superficialis, profundus, brevis, or longus. Observe the small angled dense connective tissue connecting the tendons of the extensor digitorum in the hand. This is called the **juncturae tendinae**. It functions to coordinate and distribute force across the extensor tendons. Try extending your ring finger (4th digit) while keeping the other digits in a fist. You are not able to extend that finger without moving the others because of the juncturae tendinae. However, you can extend your 5th digit much farther while the others are flexed. That is because of the **extensor digiti minimi** muscle. This muscle acts to extend the fifth digit. In this tissue, it appears that this muscle has blended with the extensor digitorum muscle. Be sure to observe this muscle in atlas images.

DEEP LAYER:

- You may also notice that you can extend your 2nd digit (pointer finger) while flexing your other digits. That is because another muscle extends this digit: **extensor indices**.
- The **supinator** acts to supinate the forearm. This muscle is deep and more difficult to find, but it can be observed running from the lateral epicondyle to the shaft of the radius.
- The other muscles of the deep posterior forearm act on the thumb. **Abductor pollicis longus** acts to abduct the thumb, while **extensor pollicis brevis and longus** act to extend the joints of the thumb. The extensor pollicis brevis tendon sits between the abductor pollicis longus and extensor pollicis longus tendons.

Observe the dense connective tissue running over the extensor tendons. This is called the extensor retinaculum. This structure holds the extensor tendons in place and provides a mechanical advantage with extension.

LAB ACTIVITY 2: JOINTS OF THE UPPER EXTREMITY – VISIBLE BODY DIGITAL ATLAS

Explore the elbow and wrist joints using the Visible Body Digital

Atlas. Some of the joints and joint structures will not be specifically listed in the app.

- Begin by examining the elbow joint. The elbow is constructed of three separate joints: the **humeroulnar joint** between the humerus and ulna, the **humeroradial joint** between the humerus and radius, and the **proximal radioulnar joint** between the radius and ulna proximally. The ligaments of these joints are best seen on the iPads, but you may be able to appreciate them on one of the upper extremity dissections. Often these ligaments are blended into the surrounding capsule, so they can be challenging to define. However, you may be able to appreciate the **ulnar** or **radial collateral** ligaments on either side of the joint or the **annular ligament** surrounding the head of the radius.

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://wisc.pb.unizin.org/humananatomylabmanual/?p=162#h5p-53

LAB ACTIVITY 3: MUSCLES OF THE UPPER EXTREMITY – VISIBLE BODY DIGITAL ATLAS

Explore the muscles of the posterior forearm using the Visible Body Digital Atlas.

- Click on the *Regions* tab and scroll to *9. Cubital Fossa.* Click on Systems at the bottom left if the systems column is not already present on the left side of the screen. Click on the arterial, venous, nervous, and lymphatic systems twice to remove them since we will not be looking at these systems in this lab. At the very top of the systems column, you have the option to select a region. Scroll to the left and for shoulder/arm, click the muscle twice, so you only have the bones on the left side of the body and muscles on the right side of the body.
- Explore the muscles of the forearm and hand. Some muscles are deep to others. Thus you will have to remove the more superficial muscles to see the deep muscles.
- You will be asked to identify the origins, insertions, actions, and innervations of these muscles (this will be listed in the app after highlighting the structure and clicking the book). However, you may not need to know particular specifics for each muscle. Follow what is in the muscle tables for the specifics of what you need to know for each muscle.
- You can view the actions of these muscles by clicking on the Muscle Actions tab from the home screen and then selecting the movement you want to view.

Lab 19: Muscles of the Anterior Forearm | The Hand

LEARNING OBJECTIVES:

- Identify and describe the joints of the hand.
- Identify and describe the muscles of the anterior forearm.
- Identify and describe the muscles for the hand.

TERMS TO KNOW

Joints of the Hand

- Carpometacarpal joints
- Metacarpophalangeal joints (MCP)
- Proximal interphalangeal joints (PIP)
- Distal interphalangeal joints (DIP)
- Interphalangeal joint (thumb) (IP)

Muscles of the Anterior Forearm

- Brachioradialis
- Superficial Layer
    - Pronator teres
    - Flexor carpi radialis
    - Palmaris longus
    - Flexor carpi ulnaris
- Intermediate Layer
    - Flexor digitorum superficialis
- Deep Layer
    - Flexor pollicis longus
    - Flexor digitorum profundus
    - Pronator quadratus

Muscles of the Hand

- Thenar
    - Flexor pollicis brevis
    - Abductor pollicis brevis
    - Opponens pollicis
- Hypothenar
    - Flexor digiti minimi brevis
    - Abductor digiti minimi
    - Opponens digiti minimi
- Deep
    - Lumbricals
    - Dorsal Interossei
    - Palmar Interossei
    - Adductor pollicis

Other Terms

- Flexor retinaculum
- Carpal tunnel

INTRODUCTION

In this lab, you will view the muscles of the anterior forearm and hand and the joints of the hand.

LAB ACTIVITY 1: MUSCLES OF THE ANTERIOR FOREARM-CADAVERIC TISSUE

Muscles of the anterior compartment, or anterior aspect of the forearm, are generally flexors of the wrist or fingers. The flexors originate from a flexor mass with its proximal attachment point on the medial epicondyle of the humerus. Palpate your medial epicondyle and then move your fingers to the mass just distal to the medial epicondyle. Flex your wrist, and you should feel this flexor mass contract. The anterior compartment also contains pronators of the arm. From anatomical position, this motion would be turning your hand so that your thumb points medially and your hand faces backward. If you imagine holding a glass of water, pronation would also be the motion of turning your wrist and hand to pour the water out of the glass. The names of these muscles often tell a lot about their location and/or function.

The anterior compartment can be divided into three layers. We won’t ask you specifically which layer a muscle is located in. However, sometimes breaking up these muscles into smaller groups can be helpful for learning them.

SUPERFICIAL LAYER:

- Observe the **brachioradialis**. This muscle originates in the brachium, or arm, and inserts onto the styloid process of the radius.
- The **pronator teres** inserts onto the mid-shaft of the radius. It is the shortest muscle originating from the medial epicondyle.

- **Flexor carpi radialis** and **flexor carpi ulnaris** both cross only the wrist joints and act to flex the wrist (flexor = flex and carpi = wrist). They insert on the side of the wrist nearest the bone that is part of their name.
- The **palmaris longus** is a very small muscle and weak flexor of the wrist. It is not present in 10-20% of the population.

INTERMEDIATE LAYER:

- **Flexor digitorum superficialis** (FDS) crosses the wrist, MCP, and PIP joints of digits 2-5 in the hand. Notice how this tendon splits and inserts on the middle phalanx of these digits.

DEEP LAYER:

- First observe **flexor digitorum profundus** (FDP). Observe how it is deep (profundus) to the FDS. Both of these muscles act to flex the MCP and PIP joints of the digits. However, observe how FDP runs deep to the tendon of FDS through its split in the digits and continues distally to insert on the distal phalanx of digits 2-5. Therefore, only FDP will flex the DIP of the digits.
- The **flexor pollicis longus** muscle sends its tendon across the IP joint of the first digit to insert on the distal phalanx of digit 1, the thumb. Therefore, it flexes the MCP and IP joints of the thumb.
- Finally, very deep on the anterior aspect of the distal

forearm, observe **pronator quadratus**. This muscle sits just anterior to the **interosseus membrane**, which you can observe proximal to this muscle.

Observe how the tendons of these muscles run underneath a thick sheet of connective tissue. This is called the **flexor retinaculum**. This helps to hold these flexor tendons in place and create a mechanical advantage, increasing the force these muscles can produce. The median nerve, which you will observe in the next lab, also runs deep to the retinaculum. The space that these tendons and the median nerve runs through is commonly called the **carpal tunnel**. Irritation of the median nerve in this place and is called carpal tunnel syndrome. Note that the palmaris longus is the only muscle whose tendon does not travel through the carpal tunnel but, instead, travels superficial to the flexor retinaculum. If you forcibly squeeze your thumb and fingertips together, tensing your palm while flexing your wrist slightly, you can see this tendon clearly in the wrist area if you have this muscle.

An interactive H5P element has been excluded from this version of the text. You

can view it online here:

https://wisc.pb.unizin.org/humananatomylabmanual/?p=165#h5p-54

LAB ACTIVITY 2: MUSCLES OF THE HAND-CADAVERIC TISSUE

Observe the muscles of the hand. These are best viewed on the deep dissection.

- The **thenar** and **hypothenar** muscles act on the thumb and fifth digits, respectively. Each has a flexor, abductor, and opponens muscle. Notice that the **flexor pollicis brevis** and **abductor pollicis brevis** muscles have been cut so that you can observe the deeper **opponens pollicis muscle**. On the hypothenar side, the **flexor digit minimi** muscle has been cut so that you can see the **opponens digiti minimi** muscle. **Abductor digiti minimi** has been preserved.

- The **adductor pollicis** muscle is part of the deep muscles of the hand. You can move the tendons near the thumb to the side to observe this muscle on the palmar aspect of the hand. It may be helpful to observe this muscle in the digital atlas or laminated image first. Notice that there are two heads. One runs from the thumb horizontally across the hand, while the other runs from the same origin obliquely across the palm. These two heads create a “7” shape. This muscle acts to adduct the thumb.
- Observe the **lumbricals**, which attach to the flexor tendons within the hand. These thin muscles help you form an “L” with your 2nd-5th digits (if you turn your palm upwards). They flex the metacarpophalangeal joints while extending the proximal interphalangeal distal interphalangeal joints.
- On the dorsal aspect of the hand, you can observe the **dorsal** and **palmar interossei**. Though their names specify directionality, you can see both from the dorsal aspect of the hand. You will need to observe fiber direction for these muscles to determine which is which. You can remember their actions by remembering DAB and PAD:

Dorsal interossei ABduct the digits and Palmer interossei ADduct the digits. Therefore, by looking at the fiber directions, you can understand if that interossei would be pulling the fingers medially or laterally with respect to the midline of the hand. The middle (3^{rd}) digit can only abduct, so it has only dorsal interossei on either side. For the other digits, the interosseus muscle on the medial aspect of the digit with its fibers running proximally towards the midline are palmar interossei. The interosseous muscle on the lateral aspect of the digit with its fibers running distally towards the midline are dorsal interossei.

LAB ACTIVITY 3: ANTERIOR FOREARM AND HAND – VISIBLE BODY APP

First, explore the muscles and joints of the anterior forearm and wrist using the iPads.

- Click on the *Regions* tab and scroll to *9. Cubital Fossa.* Click on Systems at the bottom left if the systems column is not already present on the left side of the screen. Click on the arterial, venous, nervous, and lymphatic systems twice to remove them since we will not be looking at these systems in this lab. At the very top of the systems column, you have the option to select a region. Scroll to the left and for shoulder/arm, click the muscle twice, so you only have the bones on the left side of the body and muscles on the right side of the body.

- Explore the muscles and joints of the forearm and hand listed in the Terms to Know. Some of these muscles will be deep to others. Thus you will have to remove the more superficial muscles to see the deep muscles. Some of the joints may not be specifically listed in the app.
- You will be asked to identify the origins, insertions, actions, and innervations of these muscles (this will be listed in the app after highlighting the structure and clicking the book). However, you may not need to know certain specifics for each muscle. Follow what is on the posted muscle charts for the specifics of what you need to know for each muscle.
- Two view the actions of the muscles. You can click on the Muscle Actions tab on the home page, then click on the motion you would like to view.

Bonus Activity! Bony Landmarks Review

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This is where you can add appendices or other back matter.