

Human Anatomy Lab Manual

HUMAN ANATOMY LAB MANUAL

Julie Stamm, PhD, LAT, ATC and Patrick
Hills-Meyer, MA, LAT, ATC, CSCS

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Human anatomy is the study of the make-up of the human body. Therefore, as a human, this is one of the most relevant courses you will take in college. Our anatomy is made up of the structures under our skin (and the skin itself!) 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 own health.

PART I

UNIT 1: THORAX, ABDOMEN, AND PELVIS

1

LAB 1: COURSE INTRODUCTION | INTRODUCTION TO ANATOMY

Learning Objectives:

By the end of this lab, students will be able to:

- Explain how the course is setup 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 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

Terms of Motion

- Flexion / Extension
- Dorsiflexion / Plantar flexion
- Abduction / Adduction / Circumduction
- Pronation / Supination
- Rotation (Medial, Lateral)
- **Bone markings**
 - Sites of muscle attachment
 - Tuberosity
 - Crest
 - Trochanter
 - Line
 - Tubercle
 - Epicondyle
 - Spine
 - Process
 - Articular surfaces
 - Head
 - Facet
 - Condyle

Terms of Direction

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

Radiology Terms

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

- Depressions,
openings,
passageways
 - Foramen
 - Groove
 - Fissure
 - Notch
 - Fossa
 - Meatus
 - Sinus
-

Introduction

Welcome to Anatomy & Physiology 338! Today we will begin with an introduction to this human anatomy lab course. We will discuss some logistics of the course, and you can ask any questions you might have. We also ask that you review the course 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; 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 located. We will explore surface anatomy throughout the course.

The second most common way you will interact with anatomy in the clinic is through radiological imaging. For this activity you will listen to a presentation prepared by Dr. Lonie Salkowski, a radiologist at UW Hospital. She will describe the different types of radiological images that you may see in the clinic and show a few examples of cases using these types of imaging. There may be times in the presentation where she uses terminology that you aren't familiar with. That's ok. We will learn some of this terminology throughout the course. The key take-aways that you should get from the presentation are in the worksheet that you should complete at the end of this lab guide.

Lab Activities

Activity 1: Anatomical terminology, planes, motion, and axes.

Work in a small groups and complete the terminology, planes, and motion worksheet on the following pages. In this activity, you will spread out and actively complete several motions.

Plane	Axis	Descript
Sagittal	Transverse (Coronal / Frontal)	Bisects Extensi
Coronal / Frontal	Anterior-posterior (Sagittal)	Bisects Abduct
Transverse / Horizontal	Vertical / longitudinal	Divides usually

Check Your Understanding



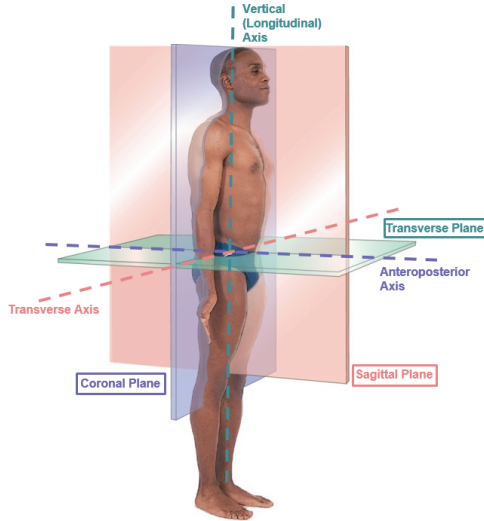
An interactive or media element has been excluded from this version of the text. You can view it online here:

<https://wisc.pb.unizin.org/humananatomylabmanual/?p=52>

- Why is it beneficial to use the directional terms outlined above? Discuss this with your partner and provide your answer.

Let's Move!

- With a partner actively complete the following motions and identify the associated plane



◦

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
- Trunk rotation
- Lateral bending of the trunk
- Internal and external rotation of the glenohumeral joint (shoulder)
- Cervical rotation to the right
- Flexion of the trunk
- Extension of the cervical spine
- Flexion and extension of the knee
- Hip extension

- Hip internal rotation (standing)
- List two common exercises that start in a prone position?
- List two common exercises that start in a supine position?
- If we used one of the planes of motion as a guide to slice my body into two pieces. Which plane would result in two pieces with the most bilateral symmetry? Why?
- Perform the following motions and explain the motion in the table below. What planes are associated with each motion? What axis is associated with each plane of movement?:
 - Squat
 - Push-up
 - Jumping Jack
 - Swinging a bat (right handed position)

Exercise	Joint	Movement	Plane	Axes
Squat (eccentric/ lowering)	Knee			
	Hip			
	Ankle			
Push-up (concentric/ lifting)	Wrist			
	Elbow			
	Shoulder			
Jumping Jack (end of movement)	Ankle			
	Hip			
	Shoulder			
Swing (moment of contact)	Trunk			
	L Elbow			
	R Shoulder			

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.

Activity 3: Bony Markings

- Look at the bones on display and take note of the areas marked with a star or an arrow.
 - 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? ****NOTE: You do not need to know the names of specific markings at this time.**** 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).

Humerus Markings

A.



B.



C.



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?

Scapula Markings



A.

B.



C.



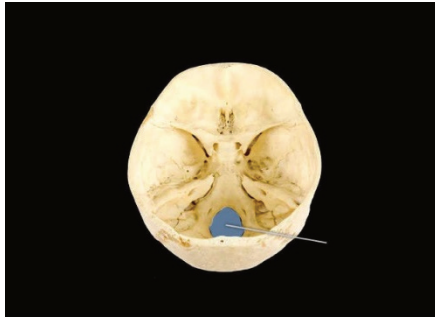
A. This is a fossa (supraspinous fossa). What is the purpose of this area?

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?

Skull Markings

A.



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

Femur Markings

A.



B.



C.



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?

Activity 4: The Navigator

In this activity, students will learn how to use the Anatomage Navigator. This tool includes a 3D printed model, a stylus, a digital rendering of the model, and cross-sectional images of the human cadaver that the

model was created from. You can move the stylus along the model and see the different levels in cross section. You can also see different structures labeled on the digital model as you move along the physical model. Layers and structures can be added or removed in the digital model so that you can examine specific structures.

- The TAs 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 to practice using the Navigator or 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 lab starting on Monday of next week. It is important that you use this lab activity to familiarize yourself with the tool so that you can get the most out of the tool in the upcoming labs.
-

Wrap-Up and Clinical Connections

After completing the stations during lab, you will come back together as a group to discuss the stations and go over clinical connections. These clinical connections are meant to give you an application to the information you are learning each day.

In this lab, you will discuss the purpose of studying bony markings and palpate some of the structures on yourself and/or a classmate. You will be doing palpation

activities throughout class. Please clean your hands before and after touching your classmates. You may not feel comfortable palpating your classmates at first but it will be something you will get used to. Remember as a future clinician, you will be examining the surface anatomy of your patients.

We will finish today by discussing the key take-aways from the cross-section activity and go through radiology cases examining a knee and finger.

Radiology Worksheet

- Explain why the x-ray below shows the bones very clearly but only shows a



slight outline of the

soft tissue of the hand?

- What is an advantage of fluoroscopy compared to traditional radiography or x-ray?
- CT scans can be reconstructed back into three-dimensional structures. What are the possible uses for these reconstructions?

- **T / F** A magnetic resonance image (MRI) is dependent upon the hydrogen atoms present in the water in the body; and the ability to align them using radiofrequencies.
- What are the advantages of using MRI over the other imaging techniques discussed today?
- What is an advantage of an interventional radiology technique (eg. angiogram)? Why would you want to use this technique?

2

LAB 2: SPINAL CORD | VERTEBRAL COLUMN | TRUNK WALL PART 1

Learning Objectives:

By the end of this lab, students will be able to:

- 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.
- In cross section, identify the location of the ascending and descending pathways in the spinal cord.
- Identify the anatomical features of the vertebrae.
- Describe the anatomical features of the sacrum.
- Identify and describe the function of the muscles of the back and abdominal wall.

Terms to Know

Spinal Cord Gross Anatomy

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

Spinal Cord Pathways

- Dorsal column medial lemniscus pathway
- Antrolateral system (spinothalamic tract)
- Corticospinal tract

Muscles of the Trunk Wall

- External Oblique
- Internal Oblique
- Transversus Abdominus
- Rectus Abdominus
- Erector Spinae
- Iliocostalis, Longissimus, Spinalis

Vertebral Column

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

longitudinal

Introduction

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

The vertebral column supports the weight of the body and helps to 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.

This is the first lab during which we will examine human cadaveric tissue. Today you will examine spinal cords. We will also be examining other organs throughout the rest of this unit. **Please be respectful and handle them with care!!! Be very gentle when moving the tissue to look for structures.**

Clinical Connections

Today's clinical connections will involve palpations. Please clean your hands before and after touching your classmates. You may not feel comfortable palpating your classmates at first but it will be something you will get used to. Remember as a future clinician, you will be examining the surface anatomy of your patients. We will also do an activity looking into a lumbar disc injury and an MRI of a disc injury, and then a few exercises to get you thinking about how the core works.

Lab Station Activities

Activity 1: Spinal Cord Anatomy

Wet Spinal Cord Specimens:

We have three wet human spinal cord examples in this lab. You should look at all three by the end of 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 these spinal cords have been sectioned along their path. 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!**

- 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 they will exit at. This group of spinal nerves is called the **cauda equina**. This term means “horse tail.”

- Observe the cervical region of the spinal cord. Notice that part of this region is larger (wider) than the rest. This is **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 is the **lumbar enlargement**.

Check your understanding: Why do we have a cervical and a lumbar enlargement? What do these regions of the spinal cord supply?

- The **meninges** are the layers of tissue that surround the brain and spinal cord. You can see them on the spinal cords in lab. The **dura mater** is the tough outer layer. The **arachnoid mater** is the thin, transparent layer, deep to the dura mater. 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

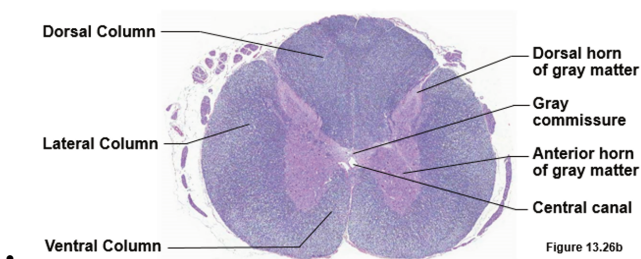
two places where you can observe the pia mater without magnification.

- The **filum terminale** is an extension of pia mater that anchors the spinal cord from the conus medullaris to the coccyx. This is difficult to see on the spinal cords that are cut, but it is visible in the other spinal cord example. 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**.
- On the same spinal cord, **gently** move the dura mater so that you can 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 the function to anchor the spinal cord laterally and 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.

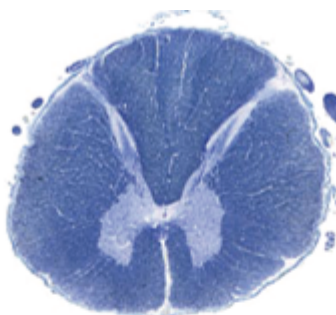
- Turn the spinal cord and gently move the dura to observe the **dorsal roots** (and **rootlets**). These carry sensory information, including fine touch, pain, and proprioception from the periphery to the spinal cord.
 - Follow the dorsal and ventral roots to the dura mater and, on the outer aspect of the dura mater, at a few levels you will see a small ball-like swelling. 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 mixes 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 be able to see the rami on the spinal cord tissue, you can observe these structures in images in the atlases in lab and on PAL 3.1.*

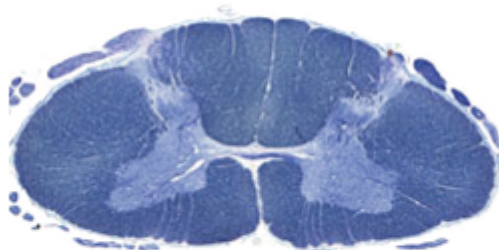


On the cut spinal cords, gently examine the cross sections. You can see the white matter and gray matter at the gross level without special staining. In this case the white matter looks darker and the gray matter looks lighter. This is because of the preservative used on them. Review the parts of the spinal cord in cross section and observe different levels along the spinal cord to see how the white and gray matter change in cross section from superior to inferior.

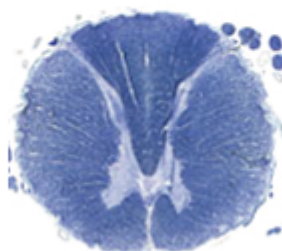
- Review the regions of the white matter and gray matter of the spinal cord in the cross-sectional image below to the right.



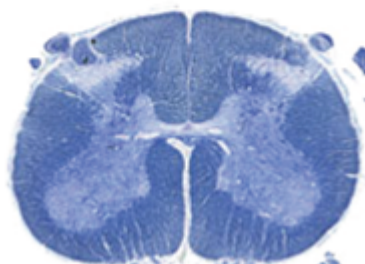
High Cervical



Cervical Enlargement



High Thoracic



High Lumbar

Plastinated Spinal Cord:

We have one plastinated human spinal cord for you to observe in this lab. This spinal cord is sitting within a spinal 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 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**.

Activity 2: Plastic Spinal Cord Model

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, 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 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)

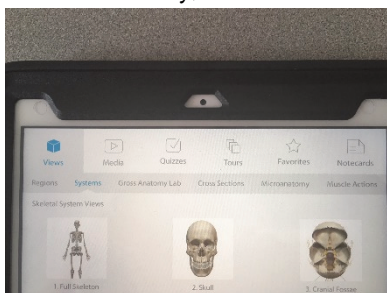
Activity 3: Trunk wall using the Visible Body Human Anatomy Atlas (iPad)

Today you will have the opportunity to learn how to use the iPad Human Anatomy Atlas program looking at the trunk wall. After you complete this station you should answer some of the questions provided at the end of this lab guide. Please follow the steps below for the iPad Atlas program and then answer any associated questions.

From the home screen, click on the Visible Body app . You will now be on the home page of the app (if it asks you to continue where you left off, select “No”).



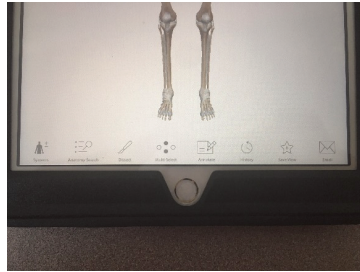
On the top bar, under the **Views** icon, you will see Regions, Systems (the preset), Gross Anatomy Lab, Cross Sections, Microanatomy, and Muscle Actions. Take a minute to



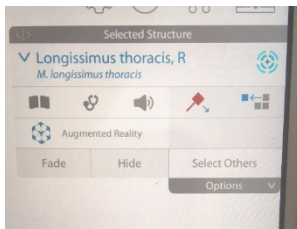
get a feel for the icons in the app and where they will take you. You will not need to use other icons aside from the views for the majority of this class.

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 where it says “Show More...”

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



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



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 with muscles this will provide you 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 smart phones; pinch to zoom out, separate your fingers to zoom in, rotate left to right and up or down.

- 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 Abdominus**
 - **Rectus Abdominus**
 - **Erector spinae: Iliocostalis, Longissimus, Spinalis** . Note that the iliocostalis runs from the iliac crest of the pelvis to the ribs (costals), the longissimus is the longest of the erector spinae muscles, and the spinalis is the most medial of the erector spinae muscles, closest to the spine.
 - **Anterior longitudinal ligament** of the spine. This ligament helps to prevent hyperextension of the vertebral column.
 - **Supraspinous ligament** of the spine
- 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 a variety of 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.

Activity 4: Spinal Column / Vertebrae:

- **Bony landmarks of the vertebrae:** For each

vertebrae 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 cord regions:** Identify the following structures/landmarks that are specific to vertebrae from different regions of the spinal cord.
 - **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**
 - Sacral Canal
 - Superior articular facet
 - Five fused bodies of vertebrae/transverse ridges
 - Median sacral crest
 - Anterior/posterior sacral foramina
- **Coccyx**
 - Three to five fused vertebrae
- Compare the superior and inferior articular processes and facets of a **thoracic** and **lumbar** vertebrae. 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.
- **Check your understanding:** How does this structure govern function? Does more rotation occur in the thoracic or lumbar spine? Does flexion and extension occur more in the thoracic or lumbar spine?

Activity 5: Build the Spinal Column

Each bone station will have a bag that contains bones from the regions of the vertebral column (sacral, lumbar, thoracic, and cervical). It seems that they were put away poorly and are not organized properly. *Your task* is to (carefully) arrange them on the worktop in proper anatomical order. It is essential to identify what makes each type of vertebra from these regions different. You should first try to 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.

Note: Do not worry about having each individual 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.

Check your understanding:

- How did you decide where each vertebra belonged?
- What characteristics are most unique for each type of vertebra?

3

LAB 3: TRUNK WALL PART II | HEART | RESPIRATORY SYSTEM

Learning Objectives:

By the end of this lab, students will be able to:

- List the bones of the thoracic cavity and their key landmarks.
- 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 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 the great vessels and outline the pattern of blood flow through the heart and lungs.

Terms to Know**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

Muscles of Respiration

- Intercostals (internal and external)
- Serratus posterior inferior
- Serratus posterior superior
- Diaphragm
 - Phrenic nerve

Respiratory System Structures**Heart Anatomy**

- Atria
 - Auricle
- Ventricles
- Right atrioventricular (tricuspid) valve
- Left atrioventricular (bicuspid) 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

Great Vessels

- Aorta
 - Superior vena cava
 - Inferior vena cava
 - Pulmonary Trunk
 - Pulmonary Vein
-

- Trachea
 - Carina
 - Bronchi
 - Lungs
 - Alveoli
 - Oblique and horizontal fissures
 - Superior, middle, and inferior lobes
 - Hilum
-

Introduction

In this lab you will be examining thoracic cavity, including the wall of this cavity, the lungs, and the heart. You will use the Visible Body app again to examine the musculature of the thoracic cavity and respiration. You will use the Anatomage Navigator to explore structures in this lab. You will also examine bones of the thoracic cage, including ribs, thoracic vertebrae, and the sternum.

You will also have the opportunity to examine preserved human heart and lung tissue. 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.

Clinical Correlations

For our clinical connections today, we will discuss interesting injuries to the bones of the thorax. We will also discuss heart conditions relating to the heart tissue we have in the lab.

Lab Activities

Activity 1: Muscles of Respiration: iPad & Bones Exercise – Ribs, Sternum, Thoracic Vertebrae

Visible Body App

You will utilize the iPad Atlas App to explore some of the muscles and bones from the list of terms for this lab. After you complete this station you should answer some of the questions provided at the end of this lab guide. Please follow the steps below and then work on your questions. This will allow more students access to the resource.

- Open the Atlas App and go to **Muscular System Views**.
 - Under the muscular system views click on **9. Inhalation and 10. Exhalation**.
 - Get an understanding for the muscles responsible for inhalation and exhalation.
- Identify the following muscles of respiration (work from superficial to deep):
 - **External intercostals**

- **Internal intercostals**
- **Serratus posterior superior**
- **Serratus posterior inferior**
- **Diaphragm**

Highlight each muscle, look at the box on the upper right side of the screen, and review the action of each muscle. You are only responsible for the actions of these muscles. Be sure to look at the muscle from a variety of angles and zoom levels to appreciate the architecture and orientation of the muscle. This is important when considering the action of the muscle.

Be sure to examine these muscles using an atlas or PAL. You will also be responsible for identifying these muscles on a cadaver image.

- 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).

Activity 2: Bones – Ribs / Sternum / Thoracic Vertebrae**Visible Body app**

Using the same views from above (9. Inhalation and 10. Exhalation), now you can look at some of the bones further.

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

Activity 3: Bones Exercise – Ribs / Sternum / Thoracic Vertebrae

In the last lab period you were asked to build the spinal column. *Your task* today is to (carefully) arrange the rib cage on the table aligning the thoracic vertebrae, ribs, and sternum. Each bone station will have a bag that contains either a full set of ribs or half set of ribs. Each station

will have thoracic vertebrae and a sternum. Do not worry about having the ribs in exactly the right order but make an attempt to get them in generally the right position based on the differences you notice in size and angle/curve of the ribs.

Using the atlas & ribcage you built, 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**
 - **Xyphoid process** (may not be present in the set of bones)
 - **Suprasternal notch**
 - **Clavicular notch**
 - **Sternal Angle**

Structures d-f 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.

Check your understanding: Does this rib articulate with the transverse process of the superior or inferior vertebrae? Would this rib share a number with the inferior or superior vertebrae?

Activity 4: Explore the heart and lungs using the Anatomage Navigator tool.

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

- In the toolbar at the top of the screen, make sure that the Highlight (furthest to the right) is selected. If this is selected, you will see structures outlined in green in the cross-sectional images as you move the stylus near them in the 3D printed model. There is a small bug in the system, so this button won't appear different whether the feature is on or off. You

can test it to see if it is on by moving the stylus and looking in the cross-sectional image for the outline of the organ.

- Also, click on the stylus icon in the toolbar and check the box under “Clipping” to enable this feature. Then click on OK. You can click this feature on or off throughout this activity.
- With these two features on, move the stylus around the area of the heart. Notice that, as the stylus moves, you can now observe cross-sections showing the internal anatomy of the heart and lungs. As you angle the stylus differently, the cuts on the digital torso model angle differently. Using this tool explore the internal anatomy of the heart and lungs. Compare what you are seeing on the 3D printed model, 3D digital model, and cross-sectional images to gain a better understanding of the anatomy of these structures.

If you want to freeze the image so you do not have to hold the stylus in one place while you examine a cut on the digital model, press the black button on the stylus once. When you are ready to continue click the black button again, and the image will be active. You can also freeze the image and rotate it moving the mouse to view the cuts from different angles.

- Remove the heart and a lung from the 3D printed model and examine them. The cut of the heart makes it somewhat more challenging to identify some internal structures. However, the valves and a few other features are visible.

Notice that the lung has a spongy texture. This is similar to that of a real lung. Observe the trachea and bronchi on the model.

- Between the digital model and the 3D model, you should be able to identify most of the structures listed on page one from the sections titled *respiratory system structures* (except for alveoli), *heart anatomy*, and *great vessels*.
- Also observe many of these structures in the cross-sectional images at the top of the screen. You will be able to see the chambers of the heart labeled as you move superiorly and inferiorly along the model. As you move the stylus, observe the position of the stylus on the model, the position of the crosshairs on the digital model, and the cross-section together to appreciate the level of the image and surrounding structures. You will be asked to identify structures in the cross-sectional images on the exams. A very helpful method for orienting yourself to the cross section is to identify structures surrounding a given structure. Understanding what other tissues look like around the target tissue can help you understand if you are more superior or inferior, medial or lateral, etc.

Spend some time exploring the structures in the digital model and in cross section. You can also observe muscles of breathing and the bones of the thoracic cavity on the Navigator if you have time.

Activity 5: Heart Tissue

Examine the wet and plastinated heart tissue. The wet organs were all 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.

Cases A and B were both males in their early 60s. Both have enlarged hearts (cardiomegaly) as a result of hypertensive and atherosclerotic cardiovascular disease. The heart in Case A is particularly enlarged. The typical male human heart weighs between 240-380g. The heart in Case A weighs 790g, and Case B weighs 600g.

Case A: This case had significant atherosclerosis in the left anterior descending (anterior interventricular) artery and circumflex artery, and they had stents placed in these arteries to maintain the lumen. The stents are difficult to see, but you may be able to see some metal protruding from the sectioned arteries. You can also feel the stents, but be sure to palpate gently. As mentioned, this heart is significantly enlarged with dilation of the ventricles and valves. These open spaces would not be this large in a healthy heart.

Case B: This case had severe atherosclerotic coronary arterial disease, and he also had stents placed in the left anterior descending (anterior interventricular) and circumflex coronary arteries. There is evidence of an acute myocardial infarction (MI, heart attack) in the interventricular septum near the left ventricle. It appears as a dark area running throughout the septum. (A blockage in which artery would have caused this MI?) As

mentioned above, this heart is enlarged (cardiomegaly), with right and left ventricular hypertrophy. The patient had a history of a reduced cardiac ejection fraction (the amount of blood pumped out of the left ventricle each with each contraction). He also had a previous history of having an Impella device (learn more here: <https://www.youtube.com/watch?v=HmH709RXmNE>)

Case C: The heart in case C is that of a woman in her late 30s. Her heart is considerably smaller than those of case A and B, though it is still mildly enlarged (450g). There is atherosclerotic cardiovascular disease, with a 40% blockage of the left anterior descending (anterior interventricular) artery.

The plastinated tissue is human tissue that has been preserved in a way that hardens it. While studying this tissue, you are able to touch it without gloves. However, please try to limit how much you are handling it (move it and set it back on the table to examine it or handle it with the plastic wrapping). 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 you examine these organs, use the laminated images and visible body app to help you identify structures. You can view these images again on through the PAL 3.0 program on Mastering A&P.

REMINDER: Never touch the iPads or the Plastinates with dirty gloves!!!

As you examine these hearts, you should be able to

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.

Check you understanding: Based on the laminated images, how might these hearts sit in anatomical position?

- 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**. Prior to birth, there is no need for blood to go to the lungs for oxygenation 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 is able to bypass pulmonary circulation and go straight from the right atrium to the left atrium and into systemic circulation. It closes shortly after birth, but the small oval indent, the fossa ovalis, remains.
- Observe the ventricles.

Check you understanding: How can you tell which ventricle is which (right vs left)? Which ventricle has a larger/thicker wall? Why?

- Observe the structures the internal features of the heart as listed on page 1.
 - 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, respectively.

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 backwards) 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. In the laminated images taken from a superior view, it may be difficult to

distinguish the aorta from the other vessels. The **superior and inferior vena cava** both 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.

- Note that the **left and right coronary arteries** branch off of 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.
- Use the heart tissue and laminated PAL images and tissue to identify the **coronary vessels** that supply the heart walls with blood. Most of these vessels can be seen on the wet heart tissue, but note that not all of these vessels are readily identifiable. On the wet tissue they have been sectioned as part of the pathological examination. Refer to the laminated images for a clear view of these vessels.
 - **Right coronary artery** – Branch off of the aorta
 - **Right marginal artery**
(difficult to see on the tissue)
 - **Posterior interventricular artery**
 - **Left coronary artery** – Branch off of the aorta

- **Anterior interventricular artery**
- **Circumflex artery**
- **Great cardiac vein** – runs with the anterior interventricular artery
- **Middle cardiac vein** – runs with the posterior interventricular artery (difficult to see on the tissue)
- **Small cardiac vein** – runs with the marginal artery
- **Coronary sinus** – collects blood from all of the cardiac veins (particularly clear on Case B)

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

Activity 6: Respiratory system tissue

Examine the wet lung tissue and tracheas and the plastinated respiratory system.

- The right lung has three **lobes**: **Inferior**, **superior**, and **middle**. These are separated by the **oblique** and **horizontal fissures**. The way that the lungs are cut makes it difficult to see the fissures and lobes, but they can be seen in Case C. They are also clearly visible on the laminated

images.

In Case C, you can see a darkened area at the inferior and posterior aspect of the lung. In this case, it is evidence of pneumonia.

In Case A, you may observe dark spots that are focal hemorrhages. This is a side effect of congestive heart failure. There are no significant pathological changes in Case B.

In all cases you may observe darkened spots may be observed occasionally throughout the lung. In some cases this can be evidence of smoke inhalation, though there would generally be more frequent spots in these cases. However, it can also occur with inhalation of polluted air.

- 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 the veins, and this will be evident in the hilum as well.

The orientation of these structures as the 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**”.

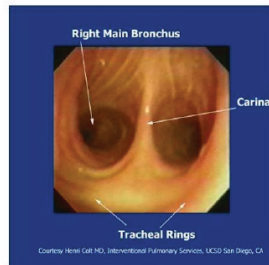
- In the **Right** lung the **pulmonary artery** will be **Anterior** to the main **bronchi**.
- In the **Left** lung the **pulmonary artery** is located **Superior** to the main **bronchi**.

Observe this in the wet lung tissue as well as on the plastinated tissue. It may be easiest to see this in the plastinated tissue first and then look at the wet specimen. We have both right and left lungs, so be sure to observe them all.

- 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**.

Trachea

- The trachea divides into two main bronchi : the left and the right bronchi, at the level of the sternal angle at the anatomical point known as the **carina**.



- Observe the **trachea** and primary (main) **bronchi** with the lung specimens. Feel this and

notice how hard they are. Cartilaginous rings help to maintain the lumen (open portion) of this tube 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.

The cause of death in Case C was adenovirus-associated acute respiratory distress syndrome. You can observe darkened regions of the lungs associated with pneumonia and alveolar damage. There is also a thick mucoid secretion still visible in the airways. (If you think it may make you uncomfortable to view these secretions, we encourage you not to look in the lumen of the airways. Also, the tissue has been embalmed with preservative, rendering the secretion harmless.)

- In the image in the lung packet of the thoracic cavity, observe the **diaphragm** and the **phrenic nerve**. 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.***
- Also observe the diaphragm in the plastinated tissue. Notice how thin this muscle is. Also notice its domed shape extending upward into the thoracic cavity.

Check for understanding: Was this diaphragm preserved in a position that it would be in at rest or while contracted?

4

LAB 4: THORACIC RADIOLOGY | DIGESTIVE SYSTEM

Learning Objectives:

By the end of this lab, students will be able to:

- Identify the structures of the thoracic cavity via multiple imaging modalities; X-Ray, CT, and Echo
- Identify the structures of the alimentary canal and the accessory structures of the digestive system.
- Identify the mesentery, and specifically the greater omentum and

understand its function.

- Identify the aorta, its parts, associated great vessels, and vasculature of the digestive tract.
- Identify the ducts carrying bile from the liver and gallbladder to the duodenum.
- Use the Navigator tool to examine specific structures of the digestive system using the advanced view.

Terms to Know

Vasculature

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

Digestive Tract

- Esophagus
- Stomach
 - Cardia
 - Fundus
 - Body
 - Pylorus
 - Pyloric sphincter
 - Rugae (gastric folds)
- Small Intestine
 - Duodenum
 - Ileum
 - *you are not responsible for specifically identifying the jejunum in the images or on a specimen
- Large Intestine
 - Cecum
 - Ascending

Accessory Digestive Organs

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

Abdominal Quadrants

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

- colon
 - Transverse
colon
 - Descending
colon
 - Sigmoid
colon
 - Rectum
 - Appendix
-

Introduction

Today you will review the structures of the thoracic region with radiological imaging and cross-sections as well as explore 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, as well as the accessory digestive organs. We have organs of the digestive tract that you can examine. 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.

As you are using 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 using the specimens and atlas images. However, if you do not see them, it may be because they are either difficult to identify or not present in certain views or on certain specimens. That is ok, and you should just try to identify these structures using another image or source (navigator, etc).

We are going to have two large stations today with smaller sub-stations. One large station will involve the cadaveric specimens. There are three sets of digestive organs, and you should observe structures on all three sets. Be sure to have an iPad with you when you go to these stations, as the app will be very helpful when you are viewing the organs. The other big station will involve activities without the cadaveric specimens. Here you will use the Navigator, observe structures on the iPads, organize the organs into their abdominal quadrants, and review thoracic structures through radiology.

Clinical Connection

For today's clinical connection, we will review the imaging of a liver laceration and cirrhosis of the liver.

Lab Activities

Activity 1: Thoracic Radiology

To start today's lab, you will view a multi-modal imaging presentation of the thoracic cavity. You will have the opportunity to see X-Ray imaging, Echo imaging and CT imaging of the thoracic cavity. As you are going through the images, we would like you to be able to identify the anatomical structures presented to you. In anatomy, we frequently use our knowledge of structures around a given structure to identify that structure. Practice

using that method here. You might find it helpful to take notes about your thought process as you do this to help you remember your cues for identifying certain structures.

X-Ray

- Lungs
- Heart
- Liver
- Ribs
- Vertebrae

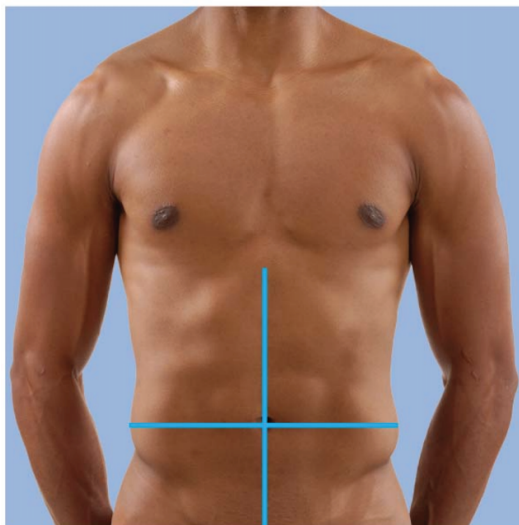
Echocardiogram (echo) – Heart

- 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

Activity 2: Abdominal Quadrants Exercise



How do you evaluate the location of internal organs when you can't see them? It is of critical importance for clinicians in a variety of 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.

Fortunately, the umbilicus (aka your belly button) sits right in the center and allows us to

create a grid or quadrant. 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). For the model below the umbilicus (belly button) represents where each line crosses.

- On a table in the lab, you will make a grid like the one shown above. Each of the organs, or part of an organ, (hint: some are in more than one quadrant) are listed on laminated cards. Your task is to properly label each quadrant and use the atlas to then distribute the organs to the correct locations. For example, the appendix card goes in the LRQ, etc.

Activity 3: Visible Body app

- Open the Atlas app and go to the **Digestive System Views** click on **10. Regional Vasculature**. From this view, you will be able to identify all of the vasculature 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 **6. Alimentary Canal**. From this view you will be able to identify the following digestive structures; **Esophagus, Stomach, Cardiac Sphincter, Pyloric Sphincter, Duodenum, Cecum, Appendix, Ascending Colon, Transverse Colon, Descending Colon, Sigmoid Colon, and the Rectum.**

(*NOTE you cannot see some of the features of the stomach 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 **9. 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, 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.

Activity 4: Explore the digestive system organs using the Anatomage Navigator tool.

- 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.
- You should see two cross-sectional windows at the top of the screen. One will be a transverse section, and the other will be perpendicular to the stylus that you will hold. If this setting is not already loaded, click on the layout icon and choose the layout with two squares above the main 3D image window. Then click done.
- Be sure to have the highlight feature on.
- Use the stylus to observe the relationship between the thoracic and abdominal organs in cross-section. You can turn on the clipping tool that you used last week to aid in this if you would like. You should be able to observe certain structures in a cross-sectional image based on the spatial relationships between structures. Note that, in the 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.
- Move the stylus to the level of the

heart. As you move the stylus, observe the **heart** and **lungs** with the highlighting tool. Note that the **lungs** are positioned lateral to the **heart**. Also note that the **heart** sits anterior to the **aorta**, **esophagus**, and **vertebral column**. The **esophagus** is directly anterior to the **vertebral column**. The **aorta** sits just anterior and slightly to the left of the **esophagus**.

- Move the stylus inferiorly and note the **liver** takes up a large portion of the superior abdominal cavity. Continue moving inferiorly and examining the cross-sectional images with respect to where in the 3D image and model you are pointing with the stylus, and explore the digestive structures you are able to 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, and 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 PAL, in the Atlas, or on the bones or specimens.

Activity 5: Digestive System Cadaveric Specimens.

We have digestive organs and spleens from Pathology that you will view in lab today. These are from the same cases that you viewed the heart and lungs from last week. 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. Also, your group should have an atlas or iPad with you as a reference when examining these organs.

- Observe the **spleen**. 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. Notice the difference between the spleens in the different cases.

Check your understanding: What might make a spleen enlarge?

- Observe the sections of the **liver**. 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 images to identify the lobes of the liver. There is usually a thin layer of tissue that separates the right and left lobes. On the inferior aspect, you can identify the caudate (posterior) and quadrate (anterior) lobes. The vasculature is located on the posterior and inferior aspect of the liver. The largest, thin-walled vessel is the **inferior vena cava**. This vessel ascends through the abdomen and carries blood from lower extremities and trunk back to the heart. It picks up blood that has been processed in the liver along its path. Normally on the inferior surface, you will see three vessels near each other that are cut near the surface of 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 will learn more about in the next lab. In the same region, you will see a larger, thinner-walled vessel. This is the **hepatic portal vein**. This vein carries blood from the digestive tract to the liver so that it can be processed and detoxified before entering general circulation. The final vessel you will see in this region is

the common hepatic duct, which carries bile from the liver to the duodenum.

Branches of these vessels and the hepatic ducts can be observed in the sections in case A.

- Using atlas image 10.6, observe the regions of the large intestines: the **cecum, ascending colon, transverse colon, descending colon, and sigmoid colon**.

This can also be observed on other images in PAL and in the Rohen's atlas.

The primary function of the large intestines is absorption of water. Cases A and B contain sections of the large intestines, including the cecum. Observe the small section of ilium attached to the cecum, and feel the ileocecal junction.

The ilium has more folds in the walls than the large intestine. Though orientation with this sample is challenging, we know that this sample includes the cecum because of a small tube-like structure that is hanging from it. This structure is the **appendix**. Though its function was misunderstood for a long time, we now know that the appendix has lymphatic and immune functions. There is a section of ileum and cecum in case C. However, this case has had an appendectomy, and there is evidence of the surgery on the cecum.

- Observe the organ group that includes the **esophagus, stomach, and**

proximal duodenum. 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 behind the trachea in the plastinated cadaver. The **esophagus** has to pass through the posterior aspect of the **diaphragm** in order to reach the **stomach**. Feel where the **esophagus** meets the **stomach**, and notice that there is 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 in two of the cases. Use atlas image 10.4 as a reference and try to identify the different regions of the **stomach**. 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**.

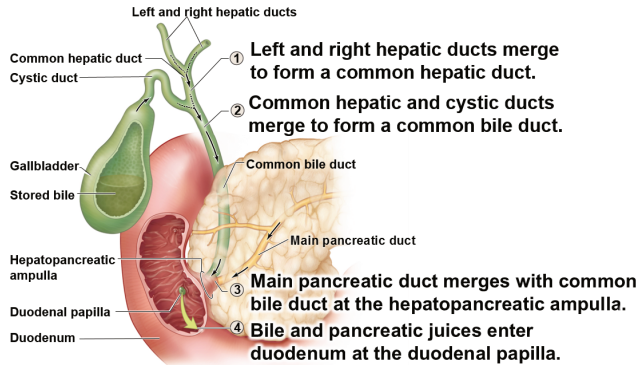
- Examine the structure of the proximal **duodenum**, the first part of the **small intestines**. Notice folds within the small intestines, which help to increase surface area for nutrient absorption. You may be asked to identify the duodenum on these specimens.
- In atlas figures 7.9 and 7.8, observe the artery that is twisting and winding near 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. The second branch of the celiac trunk is the **left gastric artery**, and it supplies the rest of the stomach and inferior esophagus. These can also be

observed with the digestive organs in case B. You can tell which artery is which based on where it is traveling to. We will observe the third branch in a moment.

- Observe the **gallbladder**. The gallbladder is typically green, but it is a lighter greyish color in case B. The **gallbladder** stores bile that has been produced by the liver. Bile plays an important role in fat digestion. 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.
- Observe the **common bile duct**, **common hepatic artery**, and **hepatic portal vein** traveling together towards the region where the liver would be (near the gallbladder). The **common hepatic artery** is the third branch of the celiac trunk, and it supplies the liver as well as parts of the stomach and duodenum. While this artery is supplying the liver with oxygenated blood, the **hepatic**

portal vein is supplying it with blood from the digestive system containing nutrients absorbed there.

- Observe the **pancreas**. It is light yellow in color and more granular than nearby adipose (fat) tissue. 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 just before both empty their contents into the duodenum. Follow the common bile duct to the duodenum. From there, you can follow the pancreatic duct a short ways to 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 observe the duodenal papilla, where these ducts empty their contents into the duodenum.



Also, look at image 10.6 and observe the greater omentum. In this image, it is folded up, but in other images, on PAL or in Rohen's atlas, you can see it lying over the top of 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.

5

LAB 5: RADIOLOGY OF THE ADOMEN & PELVIS, URINARY SYSTEM, REPRODUCTIVE SYSTEM

Learning Objectives:

By the end of this lab, students will be able to:

- Identify the structures of the abdomen and pelvis via multiple imaging modalities
- Identify and describe the anatomical features of the kidney.
- Describe the anatomy and function of the ureters, urinary bladder, and male and female urethras.
- Identify the blood vessels supplying the kidneys.
- Explain and identify the anatomy of the male reproductive systems.
- Explain and identify the anatomy of the female reproductive systems.
- Understand the structures within each quadrant of the abdominal cavity.

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 pampiniform plexus of veins
 - Ductus deferens
 - Testes
 - Epididymis
 - Ductus deferens
 - Ampulla
 - Prostate gland
 - Penis
 - Glans
 - External urethral orifice
 - Corpora cavernosa
 - Corpus spongiosum
-

Introduction

Today you will review the structures of the pelvic region with radiologic imaging as well as explore the organs of the urinary system, and the male and female reproductive system. We will use the Navigator tool, atlases, iPads, and cadaveric specimens. Some of the structure you will view are also visible in the 3D printed Navigator model. We will break up into two large stations today, again with one examining the cadaveric specimens and the other using technology in the lab to view these organs. You will also have an opportunity to review the bones of the thorax and vertebral column. 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.

Clinical Connection

For today's clinical connection we will discuss the clinical evaluation of the abdomen – utilizing palpation, auscultation, and percussion. Auscultation is performed by listening to the abdominal cavity with a stethoscope for altered bowel sounds (auscultation means listening to the sounds made by various body structures). Percussion is performed by tapping on the surface of the abdomen and listening to hear a dull or resonant sound. Palpation is the physical touching of the abdomen to evaluate for areas of rigidity, softness and pain/rebound tenderness.

Lab Activities

Activity 1: Pelvic Radiology

- You will now go through a multi-modal imaging presentation of the pelvis. 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 be able 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

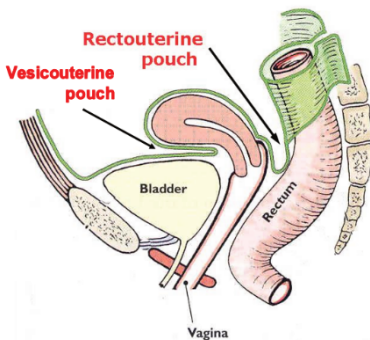
Activity 2: Navigator-Urinary and Reproductive Systems

- The navigator model is a female, so you will only be able to explore female reproductive anatomy in this section. You can review the male reproductive anatomy with the cadaveric tissue.
 - 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.
 - Be sure to have the highlight feature on.
 - You should see two cross-sectional windows at the top of the screen. One will be a transverse section, and the other will be perpendicular to the stylus that you will hold. If this setting is not already loaded, click on the layout icon and choose the layout with two squares above the

main 3D image window.
Then click done.

- Explore the **kidneys, ureters, and bladder** in the 3D printed model. 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. The ureters carry urine to the bladder, where the urine is stored until it is expelled through the urethra.
 - 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. For more information on peritoneal dialysis, visit the link in the Other Study Area box on the weekly lab Canvas page.



- Use the stylus to observe the **kidneys** in cross-section. Hold the stylus at the level of the kidneys and move it superiorly and inferiorly. Notice the kidneys in the cross-sectional image

on the left. These organs are located along the posterior abdominal wall.

- Zoom in on one of the kidneys in the 3D image (hold the black button on the stylus and move it close to the kidney in the model). Enable the clipping too by clicking the clipping icon on the toolbar or by clicking the stylus button on the toolbar and checking the box. Use the stylus to examine the internal aspect of the kidney in a transverse and coronal plane.
- Note that you can freeze the image by clicking the black button on the stylus, and you can unfreeze it by clicking the black button again.
- Now, as you did last lab, click on the eye (view) icon on the toolbar, and then click on Advanced. Here, you will isolate systems and structures in the 3D image on the screen.

Activity 3: iPad Digital Atlas

- Open the Atlas app and go to the **Urinary System Views** click on **9. 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 **17. Bladder Section (M)**. From this view you will be able to 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, in order 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 structures of the male reproductive system: **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

- Back to the systems view, open the **Reproductive System View** again and click on **18. Location of Organs**. From this view, you will be able to 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 provide you the opportunity 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.

Activity 4: Urinary system, reproductive system, and Aorta on the cadaveric specimens.

Obtain an atlas and 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 female organs and one set of male organs.

- Observe the **aorta** in cases A and B. (We do not have the aorta for case C.) Figure 7.11 can be used as a reference for this section. The aorta has been opened. You can see the arch and some branches coming off of the arch in one case. However, it will be easiest to observe these structures in Figure 7.11. Observe the portions of the aorta.
- Be sure to feel this artery, and observe the differences between cases A and B. There is evidence of significant atherosclerosis in case B, and this can be seen as the lighter-colored hardened areas of the aorta. However, this case is not nearly as severe as the calcification you will observe in case A. We encourage you to feel this aorta, but please do so gently and carefully.
 - **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 on 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 that is located in the thorax is called the thoracic aorta, while the portion located in the abdomen is called the abdominal aorta.
- In the superior abdominal region of the **descending aorta**, you will observe two midline openings pm the internal aspect of the aorta, one just superior to the other, where the **celiac trunk**(superior) and **superior mesenteric artery**(inferior opening) branched from the **aorta**. These are usually located just superior to where the renal arteries (going to the kidneys) branch. You may see one or both of the openings to the renal arteries just inferolateral to the superior mesenteric artery opening. 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, as well as the spleen and liver: the **common hepatic artery**, **splenic artery**, and **left gastric artery**. You observed these branches in the previous lab. The **superior mesenteric artery** supplies the second half of

the duodenum of the small intestines to the first 2/3 of the transverse colon. These arteries can also be observed on the external (anterior) aspect of the aorta. However, they have been cut shortly after they branched. The **superior mesenteric artery** angles slightly downward, while the **celiac trunk** branches roughly perpendicular to the aorta.

- Move inferiorly and observe the opening where the **inferior mesenteric artery** branched from the **aorta**. This is a smaller opening than the first two. On the external aspect of the inferior aorta, you can observe this artery branching at an angle downward (inferiorly). This artery supplies the digestive tract from the distal 1/3 of the transverse colon to the rectum.
- At the most inferior aspect of the aorta observe how it 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. You won't be able to tell which is the internal or external iliac artery with these organs because they are cut, but you can see the

branching point in most cases.

- Also, observe the **inferior vena cava** ascending next to the aorta. It is most evident in Case A. This vessel appears adhered to the right anterolateral aspect of the aorta, and its walls are much thinner than the aorta. This vessel carries blood from the legs and abdomen back to the heart.
- Examine the **kidneys** on the cadaveric specimens, and reference atlas images 11.1, 11.2, and 11.3. The kidneys in case A had cystic kidney disease, and they are significantly atrophied. The patient had end-stage renal disease and was on peritoneal dialysis. We have one kidney from Case C, and this kidney contains an infarct (a small localized area of dead tissue due to a loss of blood supply). This kidney also shows evidence of acute renal failure, as seen by the darkened areas and difficulty differentiating the cortex from the medulla. The kidneys in case B are relatively healthy and are the best for observing the internal anatomy. All

of these kidneys have been cut longitudinally. Look at the middle cut and observe the internal gross anatomy of these structures. 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**
- Observe the **ureters** leaving the kidney and traveling inferiorly. In case B observe how the ureters enter the inferior posterior aspect of the **bladder**. 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 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 is very painful. If the stone is too large, it cannot pass through these narrow structures and remains in the kidney.
 - In atlas images 11.6 and 11.7 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.

- Examine the **hilum** of the **kidney**. This is where the **renal arteries** enter the kidneys and the **renal veins** and ureters exit the kidneys. Also, observe the renal arteries branching from the abdominal aorta and the renal veins draining into the **inferior vena cava** (case A).
- In cases A and B, 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 then meets the **seminal vesicle**, which you can observe next to the ampulla, to form the short ejaculatory duct. Then the contents of the ejaculatory duct enter the **prostatic urethra**. This is particularly evident. The prostatic urethra is surrounded by the **prostate gland**.
 - These and the other structures of the male reproductive system can be

observed in figures 12.1-12.4 of the atlas. They can also be viewed on PAL 3.0.

- In case C, observe the female reproductive organs. We are lucky to have the opportunity to observe this particular set of organs, as they are still within child-bearing age. After menopause, the uterus and ovaries decrease in size, and the ovaries can become very difficult to see.
 - Observe the muscular uterus. It has been cut in the coronal plane (roughly) and opened. The uterus houses the embryo/fetus as it develops during the 9 months of pregnancy. You can also see the cervix in cross-section and follow it inferiorly to observe the opening to the **vagina**. There is a cyst in the cervix in this case.
 - Observe the **uterine (fallopian) tubes** and **ovaries**. The left uterine tube has a surgical clip on it. This may have been done as part of a tubal ligation, but it is not specified in the pathology report. The right uterine tube is discontinuous. Follow the uterine tubes and observe the fimbriae, near the ovary. These finger-like projections function to gently sweep the oocyte from the ovary into the uterine tube, as these two structures are not connected.
 - Now observe the ovaries. They have been sectioned, and you can observe cysts within the left ovary. There is also

a cyst in the area of the right ovary.

Please handle this gently.

- The structures of the female reproductive system that you did not observe in the Navigator model or tissue can be found in images 12.7 and 12.8 of the atlas.

PART II

UNIT 2: HEAD AND NECK

Welcome to Unit 2: Head & Neck!

6

LAB 6: THE CEREBRUM

Learning Objectives:

By the end of this lab, students will be able to:

- Explain the directional terms associated with 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 lobes of the brain and their components, using the whole-brain and midsagittally sectioned specimens.
- 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

Meninges

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

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

Ventricles

- Body of lateral ventricles
- Anterior horn of lateral ventricle
- Inferior horn of lateral ventricle
- Posterior horn of lateral ventricle
- Interventricular foramen (of Monro)
- Interthalamic adhesion
- Third ventricle
- Cerebral aqueduct
- Fourth ventricle
- Lateral aperture of fourth ventricle
- Median aperture of fourth ventricle
- Central canal

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
-

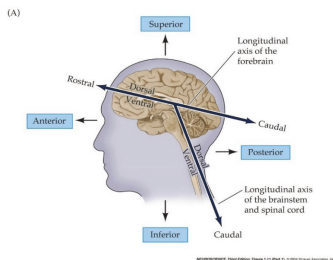
- Hippocampus
 - Amygdala
 - Occipital lobe
 - Calcarine sulcus
 - Lateral (Sylvian) Fissure
 - Parieto-occipital sulcus
 - Insula
 - Thalamus
 - Hypothalamus
 - Basal ganglia
 - Caudate nucleus
 - Putamen
 - Globus pallidus
 - Internal capsule
 - Anterior commissure
 - communicating artery
 - Posterior communicating artery
-

Introduction

In today's lab you will be learning about the brain. This mass of neurons and glial cells controls everything from our ability to breath, speak, and move our limbs, to our personalities, emotions, and higher-level thinking. You will use a variety of tools in lab today, including the navigator, ventricle models, and, most importantly, human brain specimens. ***The brain specimens must be handled with care and respect.*** Take extra care to ensure that these specimens do not dry out. Also, handle these specimens carefully to ensure you do not gouge or nick the specimen surfaces or pull with undue force at parts of the specimens. As a reminder, you are not allowed to take pictures of these specimens.

Before we begin with the lab activities, it is important to address two additional directional terms that are 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** is a term referring 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.

Lab Activities

Activity 1: Brain Specimens

We have several brain specimens available to you. Some are whole-brain sections, some are cut midsagittally and divided into hemispheres, while 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 you will explore the meninges. There are three connective tissue membranes that cover the brain: dura mater, arachnoid mater, and pia mater. The brain has a consistency like somewhat firm jelly during life, and the meninges function to 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 specimens, but it is present in one of the brain buckets. Observe how thick this meningeal layer is. The dura

mater follows the contours of the inner surface of the skull 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 using PAL and atlas images.

The **arachnoid mater** can be seen on the surface of some of the brain specimens. This 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; rather, it follows the form of the overlying dura. On several of these specimens 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 is covering the surface of the brain tissue, including within the sulci and gyri, of these specimens.

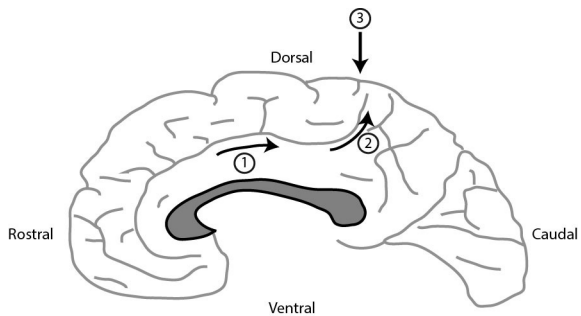
Cerebral Hemispheres: Gross Examination

The brain has four lobes: the **frontal lobe**, **temporal lobe**, **parietal lobe**, and **occipital lobe**. You will explore these lobes and their various components in this section.

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 in away from the visible surface of the

brain, while the gyri are the portion of the cortex that are exposed and visible. Sulci and gyri are important 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 specimens to identify the following structures of the cerebral hemispheres. Use an atlas to help you find the structures.



- 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 specimen.
- 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), there 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 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**.
- The temporal lobe contains three gyri running parallel to the lateral (Sylvian) fissure. The superior temporal gyrus runs inferior to the lateral (Sylvian) fissure and contains auditory association areas. The **middle temporal gyrus** is inferior to the superior temporal gyrus and is involved in object recognition. The **inferior temporal gyrus** is inferior to the middle temporal gyrus and is essential for visual object recognition.
- The **insula** is located deep within the Sylvian fissure. Its functions are not well understood, but it is thought to play a role in taste. It may be difficult to see on the whole-brain specimen, so be sure to look at it in cross section as well.

Observe a few additional features of the cerebral hemisphere the mid-sagittal view:

- The **thalamus** is located deep in the brain and cannot be seen in the whole-brain specimens. 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.

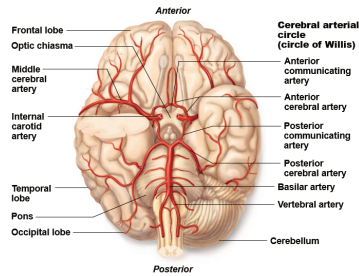
- The **anterior commissure** is located just anterior to the thalamus. It connects parts of the frontal and temporal lobes of the two hemispheres.

Though not part of the cerebrum, observe the **cerebellum** and the three parts of the brainstem: the **midbrain**, **pons**, and **medulla oblongata**. You will only be able to see the midbrain in the midsagittal section, as it is mostly hidden by other structures in the whole brain specimens. For now, just 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 sets of arterial trunks: the vertebral arteries and the internal carotid arteries. First look at these arteries on the inferior aspect of the whole-brain specimens. Then observe the anterior cerebral artery on the midsagittal section.

- The **vertebral arteries** fuse 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**.
- Locate the **internal carotid arteries**. They travel through the skull and have been cut here, so it looks as if their lumen is facing towards you.
- The **posterior communicating arteries** are thin arteries that connect the posterior cerebral and internal carotid arteries.
- The internal carotid arteries divide into two branches: the **anterior cerebral artery** and **middle cerebral artery**. The middle cerebral artery dives into the lateral fissure, while the anterior cerebral artery travels anteromedially to the median longitudinal fissure. Examine a

midsagittal section to follow the anterior cerebral artery.

- The two anterior cerebral arteries are connected just before they enter the median longitudinal fissure by the **anterior communicating artery**. This can be an artery connecting them, or the two anterior cerebral arteries can appear to just “touch” each other and then split again.

Together the three pairs of cerebral arteries and the three communicating arteries form the Circle of Willis, an arterial circle that provides means of 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: Models of ventricles of the Brain and the flow of Cerebrospinal Fluid

The brain contains several ventricles filled with cerebrospinal fluid. Utilize both the ventricle models and obtain a midsagittally sectioned brain specimen to see the ventricles. While observing the ventricle models, take time to familiarize yourself with the terms from the list above. The models have laminated images and a key with numbers corresponding to the list of terms above. Now, while looking at the midsagittally sectioned brain specimen, observe the open space in the middle of the hemisphere. This is the **lateral ventricle**. The **septum**

pellucidum is a thin membrane that separates the anterior part of the lateral ventricles from each other.

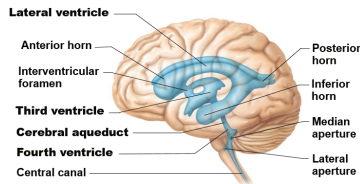
The **third ventricle** is a thin midline space that separates the left and right thalami. Notice that the third

The **fourth ventricle** lies between the pons and cerebellum. This ventricle narrows rostrally into the **cerebral aqueduct**, which connects it with the third ventricle. It also narrows caudally and then transitions into the central canal of the medulla and spinal cord.

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 specimens.

Flow of Cerebrospinal Fluid

CSF can be produced by the choroid plexus in all



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. Each lateral ventricle connects to the third ventricle by way of the **interventricular foramen (of Monro)**.

of the 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**, **medial aperture**, or central canal. These apertures can only be observed on the model.

Activity 3: Cross-sectional Anatomy of the Brain-Navigator, Atlases, and Brain Specimens

We have previously used the Navigator with the torso model. The Navigator also has a head model. Today we will use this model to observe the brain in cross-section. For this station, we will also have a coronally sectioned brain specimen at a nearby counter. You will have neuroanatomy atlases showing cross-sectional images to reference as well. We recommend that you use the atlases as a reference both when looking at the Navigator cross-section images and the coronal brain sections.

When you are using the navigator model, make sure that you have the clipping tool activated. To activate this, click on the stylus icon in the toolbar and check the “Clipping” box. Then click OK. Also make sure that the highlighter feature is active. If you do not see green highlighted structures as you move the stylus around the 3D printed model, click on this icon, furthest to the right on the toolbar.

****NOTE: BE PATIENT with the highlighter tool and the Navigator as a whole. You may need to hold the stylus to the model for a moment before it shows up. Don't just move the stylus around for a few seconds, decide it isn't working, and give up. This is a great tool to learn about structures of the brain in cross section, but you won't get anything out of it if you don't try.*

When observing the images in the atlas, note that the brain sections have been stained so that the white matter appears very dark compared to the gray matter.

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. Many of the structures span a large portion of the brain from anterior to posterior, while others are only visible in a few slices.

Observe the following structures in cross section the coronal cross section view:

- **Median longitudinal fissure:** Space between the two hemispheres superiorly.
- **Corpus callosum:** 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:** this is 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 and third ventricles:** These will be the empty spaces in the center of the brain in the images. Note that the inferior portion of the lateral ventricle can be seen in the temporal lobe as you move posteriorly at the same time that you see part of this structure in the frontal and parietal lobes.
- **Amygdala:** This structure is located in the anterior portion of the medial temporal lobe. It is involved in behavior and giving emotional meaning to sensory input and memory. This appears as a center of gray matter in this region.
- **Hippocampus:** This structure can be 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 portion of the lateral ventricle (which is thin here). The hippocampus is essential for storing new memories and is often atrophied in Alzheimer's disease. In fact, the coronally sectioned brain

specimen has significant atrophy of both the amygdala and hippocampus. (However, we do not know 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.

- **Basal ganglia:** This structure is involved in the control of voluntary motor function. Its structures are located in the deep portion of the cerebrum surrounding the ventricles, and they are separated by a white matter structure called the **internal capsule**. These structures are only visible in the anterior portion of the brain, as they sit anterior to the thalamus.
 - **Caudate:** Located medially next to the lateral ventricle. It is larger anteriorly and smaller posteriorly, and somewhat C-shaped in the sagittal plane.
 - **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 globus pallidus has two parts, which might be visible in some images.

- **Internal capsule:** Separates the caudate from the globus pallidus and putamen. Carries fibers to and from the cerebral cortex, including the fibers of the corticospinal tract.
- **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.

Activity 4: Visible Body App – iPad

- **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 cerebelli**. **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, but you will be able to see each the 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**. From this view you will be able to see the **lateral ventricle, third ventricle, cerebral aqueduct** and the **fourth ventricle**.
- **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 be able to see **vertebral arteries, internal carotid arteries, anterior cerebral arteries, middle cerebral arteries, posterior cerebral arteries, anterior communicating artery** and **posterior communicating artery**.

You should also spend some time studying images of the brain in the Nolte, Neuroanatomy Atlas, Atlas of Anatomy and Physiology, and the Rohen's, Color Atlas of Anatomy to explore some of the

structures not easily seen on the lab specimens. In particular, you should look at the dural reflections using these resources, as they are not seen in the specimens. This includes:

- **Falx cerebri:** Separates the right and left hemispheres
- **Tentorium cerebelli:** Separates the cerebrum from the cerebellum

7

LAB 7: BRAINSTEM, CRANIAL NERVES, & SKULL

Learning Objectives:

By the end of this lab, students will be able to:

- 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/Medulla oblongata
 - Pyramids
 - Pyramidal decussation
 - Olive
- Pons
- Midbrain
 - Cerebral peduncles
 - Interpeduncular fossa
 - Substantia nigra

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
- Occipital
 - Hypoglossal canal
 - Foramen magnum
 - Occipital condyles
- Sphenoid
 - Optic canal
 - Superior orbital fissure
- Parietal
- Temporal
 - Carotid canal
 - Internal acoustic meatus
 - Mastoid process
 - Styloid process
- Jugular foramen
- Foramen ovale
- Vomer
- Mandible
 - Mental protuberance
 - Temporomandibular joint
 - Condylar process
 - Coronoid process
- Maxillae
- Zygomatic
 - Zygomatic arch
- Lacrimal
- Nasal
- Palatine bone

Introduction

In today's lab we continue discussing the brain by examining the cerebellum, brainstem, and cranial nerves. We will also explore the bones, landmarks, fossa, and sutures of the skull. This lab is a bit shorter with regard to activities however it has a great deal of content; some of the content from this week will be repeated in our upcoming labs. This material lends itself well to methodical and regular studying.

Lab Activities

Activity 1: Brain Specimens- Brainstem, Cerebellum, and Cranial Nerves

Use the brain specimens to observe the brainstem, cerebellum, and cranial nerves. Also use the atlases and iPad app to help you find each structure on the specimens.

***Please remember to be GENTLE with the brain specimens. Do not dig around, spread apart lobes, or press down with more than a light touch on the specimens. Treat these with care, as we will be using these same specimens for several years. If you are having trouble identifying something, please ask a TA for help.*

Cerebellum:

The cerebellum smooths and coordinates voluntary movements and helps to maintain posture and equilibrium. It receives information from the primary

motor cortex of the frontal lobe about 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 specimens, 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 are the medulla oblongata, the pons, and the midbrain. The brainstem contains cranial nerve nuclei (collections of neurons); other important nuclei that communicate with the cerebrum, cerebellum, and spinal cord; and sensory and motor pathways connecting the cerebrum and the PNS.

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

- In a whole brain specimen, locate the **brainstem**.
- Locate the **pons** (bridge) on the ventral surface of the brainstem. The pons can be easily identified by its anterior bulge. The portion of the

pons that you can see contains nuclei that communicate with the cerebellum as well as fibers of the corticospinal tract. The other key features of the pons are visible on the dorsal aspect of the pons. We will observe these using the Navigator.

- Rostral to the pons, observe the **midbrain**. This structure is somewhat hidden on the whole-brain specimens, but it can be observed on the midsagittal section. We will observe the midbrain in more detail using the Navigator, but try to observe the following structures on the whole-brain specimen:
 - The midbrain surrounds the **cerebral aqueduct**, which is the pathway that CSF travels between the third and fourth ventricles.
 - 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, as well as descending fibers from other cortical regions.
 - Between the cerebral peduncles is a

space called the **interpeduncular fossa**.

- On the midsagittal specimen 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.
- Caudal to the pons, examine the **medulla**. The medulla 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. The pyramids are visible from their emergence at the pons to the **pyramidal decussation** at the junction between the medulla 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.

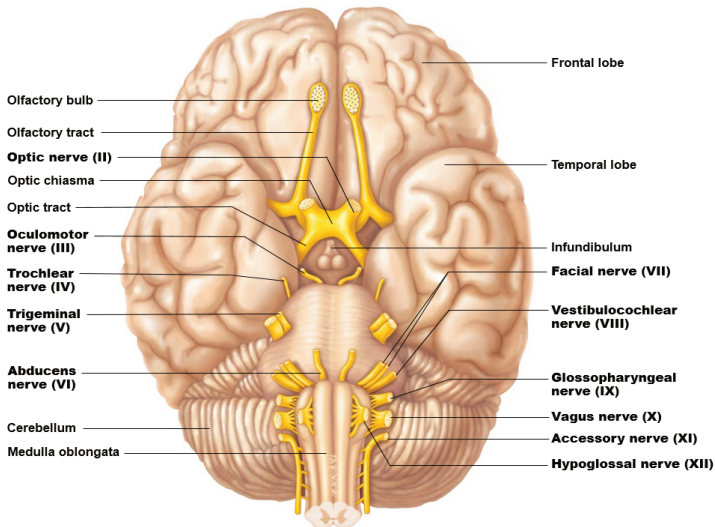
- On the ventral medulla, locate the **olive**, a bulge just lateral to the pyramids. This structure holds a nucleus that is important for motor coordination.

Cranial Nerves:

The cranial nerves are peripheral nerves that carry special sensory information (e.g. hearing, vision, taste, etc.), sensory information from the head, motor information to the head and neck, and visceromotor information to organs of the head, thorax, and abdomen. 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 muscles are described here, and 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 specimens. Some of the cranial nerves are not present on some of the specimens or on some sides (right or left) of the specimens. However, between all whole brain specimens, atlas images, and the navigator, 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**, which lies inferior to the frontal lobe of the cerebral hemisphere. The actual nerves have been lost during removal of the brain. Find 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 dorsal aspect of the brainstem. 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. 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 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 innervates 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. 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 as well as 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 between the **pyramid** and the **olive**.

***Tip:** The cranial nerves that have 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 dorsal aspect of the brainstem, but you can notice this with CN III, CN IV, and CN VI.*

A chart that describes the cranial nerves, their passageways through the skull, and their functions is posted in the Optional Study Tools section of the course canvas page. [ADD LINK](#)

Activity 2: Visible Body app and Navigator: Brainstem, Cerebellum, and Cranial Nerves

- Use the Navigator to observe the cerebellum and brainstem. Several presets have been created for you. To access these, click on the eye (view) icon on the toolbar. You can also click on Advanced to select/unselect structures and isolate the brainstem and spinal cord or isolate specific cranial nerves using this tool to observe where they emerge from the brainstem.
- The navigator can also be useful for observing the skull. You can turn on specific arteries and nerves and observe how they enter and exit the foramen of the skull, as described in activity 3 below.
- 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 be able to 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).

- 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**, **pons**, **midbrain** and all of the **cranial nerves**. **Note** you will not be able to see the associated structures for the cerebellum, medulla or midbrain in the app. You will need to hide layers of skull, zoom in/out and rotate the image to see all of the structures.

Activity 4: Skull-Bones and Foramen

In this activity you will use the human skulls to identify the bones of the skull, major features of the skull, and the passageways through the skull. **Obtain a skull and an atlas.** You will want to have an atlas with you to help you identify the bones and passageways listed below. Also, be sure you have pipe cleaners as well, 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. At the inferior portion of the **occipital bone,** which makes up the majority of the inferior portion of the cranium, observe the **occipital condyles.** These condyles articulate with the atlas of the vertebral column.
 - Observe the places where these bones meet. These are called **sutures.**
 - The **coronal suture** is where the frontal bone meets the two parietal bones.
 - The **sagittal suture** is

where the right and left parietal bones meet.

- The **lambdoid suture** is between the parietal bones and occipital bone.
- The **squamous suture** is 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 portion of the jaw and medial, portion of the cheek.
 - The **mandible** is the lower jaw bone. 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.

- 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 there are three bowl-like spaces formed by bony landmarks within the skull. 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. However, we will discuss these bones and features with other labs, such as the orbit, eye, and visual system lab, the oral cavity lab, and the nasal cavity lab.

- 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, for many of them, 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.

- ***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 specific foramina above.*

DRAG AND DROP?

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, CN XI (branch)
Jugular foramen	CN IX, X, and XI (branch); internal jugular vein
Hypoglossal canal	Hypoglossal nerve (CN XII)
Internal acoustic meatus	CN VII and CN VIII
Other Passageways of the Skull	

Stylomastoid foramen	Branch of CN VII that innervates the facial muscles
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8

LAB 8: ORAL CAVITY | NASAL CAVITY | PHARYNX | LARYNX

Learning Objectives:

By the end of this lab, students will be able to:

- 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

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
 - Superior pharyngeal constrictor
 - Middle pharyngeal constrictor
 - Inferior pharyngeal constrictor
- Piriform recess

- muscles
 - Epiglottis
 - Arytenoid cartilages
 - Vocal folds
 - Vestibular folds
 - Cricothyroid muscle
 - Oblique arytenoid muscles
 - Transverse arytenoid muscle
 - Recurrent laryngeal nerve
 - Thyrohyoid muscle
 - Hyoid bone
-

Introduction

Today in 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 provide 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. **CLINICAL CONNECTIONS?**

Lab Activities

Activity 1: Computer Images

Go through the images displayed on the computers and explore the structures on the list of terms. All of the regions you are examining today 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. Be sure to identify these structures in the new images.

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 in order 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 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 on the computer: 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 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.

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 medial aspect of the orbits, 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.

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:** 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 there is something caught in our throat.

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.
- There are several muscles that 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 transvers 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.

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.

Activity 3: Plastic Nose with Nasal Sinuses Model & Plastinated Tissue-Oral & Nasal Cavity, Pharynx, Larynx

You will be able to identify many of the structures in the list of terms above on the plastic model as well as the plastinated specimens. You can reference section 1 of this guide for a more thorough description of some of these structures.

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 frontal 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**.

Now look at the 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)

Activity 4: Visible Body Digital app-Oral Cavity and Nasal Cavity

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.

9

LAB 9: MUSCLES AND TRIANGLE OF THE NECK AND FACE | VASCULATURE OF THE HEAD AND NECK

Learning Objectives:

By the end of this lab, students will be able to:

- 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, middle, and posterior scalenes
- Suprahyoid muscles
 - Digastric (anterior and posterior bellies)
 - Geniohyoid
 - Stylohyoid
 - Mylohyoid
- Infrahyoid muscles
 - Omohyoid (superior & inferior bellies)
 - Sternohyoid
 - Thyrohyoid
 - Sternothyroid

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 (alaeque) nasi

Branches of the Facial Nerve CN VII

- Temporal branch
- Zygomatic branch
- Buccal branch
- Mandibular branch
- Cervical branch

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

- *Zygomaticus major*
- *Zygomaticus minor*
- *Orbicularis oris*
- *Risorius*
- *Mentalis*
- *Platysma*

Introduction

In today's lab, we 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 today's lab have a range of clinical implications; from the scalene muscles placing pressure on neurovascular structures to vascular compromise that can be fatal. We will also review the cross sectional anatomy of the brain using radiology.

Lab Activities

Activity 1: Visible Body App – Muscles and Vasculatures 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 system, nervous system, circulatory...ect) except for the skeletal and muscular from the side bar.
- First click on the *Platysma* muscle and hide it (you will learn about this muscle 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 own 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 either lateral flexion of the neck to the same side or rotation of the neck 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 indicates 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 the *sternohyoid*. They are the **sternothyroid** and **thyrohyoid**, which 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 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. That is also a digastric muscle, with two muscle bellies. However, this muscle's name is the **digastric muscle**. 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.

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.

Muscle		Description	Action	Emotion/
Occipito-frontalis	Frontal belly	Frontal belly covers forehead; occipital belly covers posterior skull;	Elevates eyebrows & wrinkles forehead horizontally	Surprise, Curio
	Occipital belly	Epicranial aponeurosis connects the bellies	Pulls the scalp posteriorly	
Corrugator supercilii		Small muscle in the medial eyebrow	Draw eyebrows inferomedially, creating vertical wrinkles above the nose	Concern, skepti
Orbicularis oculi		Thin, flat, sphincter of the eye, surrounds the orbit	Closes eyes	Winking, blinki
Levator palpebrae superioris***		Runs from the posterior orbit to the superior eyelid	Elevates superior eyelid to open the eye	Contributes to
Procerus		Between the eyebrows over the nasal bone	Depresses medial eyebrow, wrinkles skin over the nose	Dislike or distai

Nasalis	Over cartilage of the nose	Compresses bridge and depresses tip of nose, elevates corners of the nostrils	Flares nostrils,
Buccinator	Thin, horizontal muscle in the cheek, deep to the masseter.	Compresses cheek; holds food between cheek and teeth when chewing	Whistling, suck
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 alaeque 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.

Activity 2: Visible Body app-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.

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.

You should also use the navigator to examine the branches of the facial nerve that innervate the muscles of facial expression. The motor branch of the facial nerve exits the skull via the stylomastoid foramen, between the styloid process and mastoid process of the temporal bone. It divides into five branches that innervate these muscles. Those branches are, from superior to inferior:

- **Temporal branch:** runs towards the temporalis muscle and frontal belly of occipitofrontalis
- **Zygomatic branch:** runs over the zygomatic arch to the muscles superior to the eye
- **Buccal branch:** runs towards the buccinator, superior mouth, and lateral nose
- **Mandibular branch:** runs along the mandible to the lower mouth
- **Cervical branch:** runs inferiorly to innervate the platysma

Activity 4: Plastinated tissue.

We have a head and neck plastinated cadaveric specimen as well as a respiratory plastinated cadaveric specimen for you to observe the muscles of the face and neck and hyoid bone in this lab.

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 plastrate.
- Observe the muscles of facial expression on this specimen. 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.

Activity 5: Cross-sections of the Brain: Radiology review

On the main TVs in the lab, go through the radiology review PowerPoint. This will review the structures that you viewed in the lab last week using MRI images and reconstructions.

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LAB 10: EYE | EAR

Learning Objectives:

By the end of this lab, students will be able to:

- 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
 - Macula and fovea centralis
 - Optic disc (blind spot)
 - Lens
 - Vitreous humor/

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
-

- body
 - Orbit
 - Lacrimal sac
 - Optic nerve (CN II)
 - Optic chiasm
 - Optic tract
 - 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

In today's lab, we will explore the special sensory anatomy that makes up our vision, hearing, and vestibular systems. These sensory systems work in concert to contribute to our overall ability 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. Please review all the terms from the lab guide and pay special attention to the key terms that carry over from our previous lab sessions.

Lab Activities

Activity 1: Navigator-The Eye

You will use the navigator today to explore the anatomy of the orbit and the structures within it. When you begin using the Navigator. Click on the "View" icon, and then choose the preset that shows the bony orbit, eye, nerves, and extra-ocular muscles (ask your TA which preset it should be).

First explore the eye within the skull. The right side of the figure (on your left) has the skull intact, while part of the skull has been removed to provide a view from within the cranium on the left side of the figure.

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 either check the skeleton box or go back to

the main “View” window and choose the same preset.

DO NOT save any presents! All of the presets that you need have already been saved.

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.

Move the Navigator stylus along the Navigator model and 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. Ensure that the highlighter tool is on, as this can help you identify certain structures within the cross-sectional image. 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.

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)
 - To visualize how the extraocular muscles move the eye, use the pieces of Thera-band to simulate the muscles pulling on the eye (Ask your TAs for assistance).

Activity 3: Computers, Images from Pal, and Other Sources—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 changes the tension on the suspensory

ligaments, which in turn 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 the 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:** neural layer of the eye, which contains the photoreceptors for vision

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:** part of the vestibular system that senses rotational acceleration of the head.
 - **Cochlea:** snail-shaped chamber of the inner ear that houses the organ of hearing.

- 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 groove 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.

Activity 5: Skull review

You now have the opportunity to review the skull bones and foramen. In this activity, use both a ***skull and an atlas or the app*** to help you figure out the answers to the following questions.

TURN THIS INTO AN ACTIVITY!!

- Cranial and Facial bones (identify the bone)
 - Which ones are paired?
 - Which ones are unpaired?
- Sutures (identify the suture)
 - Which bones meet at the coronal suture?
 - Which bones meet at the sagittal suture?
 - Which bones meet at the lambdoid suture?
 - Which bones meet at the squamous suture?
- Cranial Fossa

- Which bones make up the majority of the middle cranial fossa?
- Which bones make up the majority of the posterior cranial fossa?
- Foramina/Passageways (identify and name contents)
 - Cribriform foramina in cribriform plate
 - Contents:
 - Optic canals
 - Contents:
 - Superior orbital fissure
 - Contents:
 - Foramen ovale
 - Contents:
 - Carotid Canal
 - Contents:
 - Foramen magnum
 - Contents :
 - Jugular foramen
 - Contents:
 - Hypoglossal canal
 - Contents:
 - Internal acoustic meatus
 - Contents:
 - Stylomastoid foramen
 - Contents:

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LAB 11: PHARYNX | LARYNX

Learning Objectives:

By the end of this lab, students will be able to:

- Identify the cartilage and muscles of the larynx and explain how the vocal cords function.
- Describe the parts of the pharynx.
- Review and describe the bones and foramen of the skull and the structures that pass through the foramen.

Terms to Know**Pharynx**

- Nasopharynx
 - Pharyngeal opening of auditory tubes
- Oropharynx
- Laryngopharynx
- Pharyngeal constrictors
 - Superior pharyngeal constrictor
 - Middle pharyngeal constrictor
 - Inferior pharyngeal constrictor
- Piriform recess

Larynx

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

*****Italicized structures have been viewed in previous labs***

Introduction

Today in lab you will explore the pharynx and larynx. 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 provide 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.

We will also spend time in this lab reviewing the bones and foramen of the skull.

Clinical Connection

In today's clinical connection we will explore the relationship between anatomical structures of the oral cavity and the nasal cavity and how common respiratory illness can influence these relationships.

Lab Activities

Activity 1: Computer Images

Go through the images displayed on the computers and explore the structures on the list of terms. All of the regions you are examining today 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. Be sure to identify these structures in the new images.

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*):

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:** 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 there is something caught in our throat.

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:** It sits inferior to the thyroid cartilage. It is thin anteriorly and much larger (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.
- There are several muscles that 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.

Activity 2: Plastinated Tissue-Pharynx and Larynx

You will be able to identify many of the structures in the list of terms above on the plastinated specimens. You can

reference section 1 of this guide for a more thorough description of some of these structures.

Begin with the respiratory dissection plastinated specimen:

- **Larynx:** Observe the **thyroid cartilage**, **laryngeal prominence**, and **cricoid cartilage**. You can also observe the **thyrohyoid** and **cricothyroid muscles**. Also observe the **epiglottis** at the opening to the oropharynx.
- **Pharynx:** Observe the **nasopharynx** and **oropharynx**. You can look down into the **laryngopharynx**, but this region has not been dissected in a midsagittal section.

Plastic Nose with Nasal Sinuses Model

You will be able to identify the **superior pharyngeal constrictor** on this model as well as the **nasopharynx** and **oropharynx**.

Activity 3: Visible Body app-Pharynx and Larynx

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.**

Activity 4: Skull review . THIS WAS IN THE LAST LAB

You now have the opportunity to review the skull bones and foramen. In this activity, use a both a *skull and an atlas* or *the app* to help you figure out the answers to the following questions.

Cranial and Facial bones (identify the bone)

Which ones are paired?

Which ones are unpaired?

Sutures (identify the suture)

Which bones meet at the coronal suture?

Which bones meet at the sagittal suture?

Which bones meet at the lambdoid suture?

Which bones meet at the squamous suture?

Cranial Fossa

Which bones make up the majority of the middle cranial fossa?

Which bones make up the majority of the posterior cranial fossa?

Foramina/Passageways (identify and name contents)

Cribriiform foramina in cribriform plate

Contents:

Optic canals

Contents:

Superior orbital fissure

Contents:

Foramen ovale

Contents:

Carotid Canal

Contents:

Foramen magnum

Contents:

Jugular foramen

Contents:

Hypoglossal canal

Contents:

Internal acoustic meatus

Contents:

Stylomastoid foramen

Contents:

PART III

UNIT 3: THE LOWER EXTREMITIES

12

LAB 12: BONES FO THE LOWER EXTREMITY

Learning Objectives:

By the end of this lab, students will be able to:

- 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.
- Explain structure governs function examples from the bones.

Terms to Know

Bones of the Lower Extremity

- Pelvic Girdle
 - Sacroiliac joint
 - Pubic symphysis
 - 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

Bone of the Lower Extermity (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)
-

- Inferior rami
 - Pubic crest
 - Pubic tubercle
 - Obturator foramen
 - Pectineal line
- Femur
 - Head
 - Fovea
 - Neck
 - Greater trochanter
 - Lesser trochanter
 - Gluteal tuberosity
 - Linea aspera
 - Medial supracondylar line
 - Lateral supracondylar line
 - Medial condyle
 - Lateral condyle
 - Medial epicondyle
 - Lateral epicondyle
 - Intercondylar fossa
 - Patellar surface
- Patella
 - Sesamoid bone
 - Medial articular facet
 - Lateral articular facet

Introduction

Today we 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, lower leg, ankle, and foot. Be sure to check the course canvas page, as we will be providing you with landmark and muscle charts to help clarify what material you will be responsible for and help you learn the material. Also, be sure to study PAL, as you will be asked to identify many bones, joints, muscles and neurovascular structures on cadavers and cadaver images throughout this unit.

Lab 1 for Unit 3 focuses on the bones of the pelvis and lower extremity. In this lab, you will use a variety of bone specimens, models, cadaver images, and radiology tools to explore the different bones and joints of the lower extremity. 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 examining bones of the pelvis and lower extremity, including the pelvis, femur, tibia, patella, fibula, tarsals, metatarsals, 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. more than one femur), as sometimes these features are more or less prominent due to anatomical variation. Finally, based on the landmarks, you should be able to identify if certain bones come from the right or left lower extremity. Students are encouraged to reference the muscle and bone landmark charts to better understand origin and insertion landmarks on the bones.

Lab Activities

Activity 1: Visible Body app and Atlas Images-Bony landmark of the Pelvis, Femur, and Patella Bones

- Each bone station is supplied with pelvis, femur, and patella specimens. Students should use an atlas and the iPads to identify the landmarks from the list above. A bony landmarks chart will be posted describing the function and/or structure that run near/attaches/articulates with each bony marking. You will be responsible for the information in that chart.
- 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 be able to determine 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.

iPads

- Using the iPads to help you identify the bones and specifically the bony markings for these stations will be very valuable. You can use either the atlas app or the skeleton app. You will want to highlight one of the selected bones, then use the isolate feature (looks like a femur with multiple colors). When you isolate the bones, you will be able to see all of the bony landmarks

and markings as listed in the charts and the terms to know.

Activity 3: Visible Body app and Atlas Images–Tibia, Fibula, Tarsals, and Phalange bones, joints and bony landmarks/markings

- Each bone station is supplied with tibia, fibula, tarsals and phalanges specimens. Students should use an atlas to identify the landmarks listed above. A bony landmarks chart will be posted describing the function and/or structure that run near/attaches/articulates with each bony marking. You will be responsible for the information in that chart.
- **iPads** using the iPads to help you identify the bones and specifically the bony markings for these stations will be very valuable. You can use either the atlas app or the skeleton app. You will want to highlight one of the selected bones, then use the isolate feature (looks like a femur with multiple colors). When you isolate the bones, you will be able to see all of the bony landmarks and markings as listed in the charts and the terms to know.
- **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 joints**, while the great to, like the thumb, only has an **interphalangeal joint**.

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. In this activity you will use radiology 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.

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 are seeing on the images. You can also use an atlas to compare the bones with the radiology.

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LAB 13: NERVES AND VESSELS OF THE LOWER EXTREMITY

Learning Objectives:

By the end of this lab, students will be able to:

- By the end of this lab, students will be able to:
- 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 use the Visible Body app, lower extremity dissections, plastinated specimens, and laminated images to explore the nerves, arteries, and veins of the gluteal region, thigh, leg, and foot. Keep in mind that all structures are not visible using all tools, and that is OK. By the end of the lab today you should have identified all of the structures on the list using multiple sources.

Lab Activities

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 wet lower extremity specimens 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 specimens and posterior structures on the other two specimens.

Posterior Neurovasculature of the Lower Extremity

- **Gluteal Region:** Use an atlas to see the inferior and superior gluteal nerves and inferior and superior gluteal arteries. Given that the pelvis is not present in the wet dissections, they will be difficult to see. However, if you look at the deep side of the gluteus maximus in one of the

specimens, you will be able to see the **inferior gluteal artery** and nerve traveling together. You can also observe a few of these vessels in the deep dissection plastinate.

- **Popliteal artery:** View the posterior aspect of the knee. Observe the diamond-shaped region bounded superiorly by the hamstring tendons on each side, and inferiorly be 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. You may notice that there are small branches off of this artery around the knee. These are called genicular arteries, and they create an anastomoses around the knee joint to supply this joint in multiple positions. 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** is composed of the **tibial and common fibular (peroneal) nerves** together within a fibrous sheath. The sciatic itself 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. In the plastinated specimen and atlas images, observe that the sciatic nerve runs deep to the piriformis and emerges at the inferior border of this muscle before descending in the posterior thigh. 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 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 between the superficial and deep posterior compartments, innervating the muscles in both compartments. It continues inferiorly between the deep and superficial posterior compartments of the leg, innervating both. After wrapping around the medial malleolus, it branches into the **lateral and medial plantar nerves**, which innervate the muscles of the plantar aspect of the foot. The **posterior tibial artery** also travels between the superficial and deep posterior compartments with the tibial nerve, 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

- **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 of the muscles in the medial aspect of the thigh.
- **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. These structures are more easily visible on the deep dissections.
 - **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 another 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 off 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. You may also be able to see the medial and lateral circumflex femoral arteries branching from the deep femoral artery and traveling towards the femur. However, if you do not see them here, you will be able to see these arteries on the iPads.
- **Femoral nerve:** This nerve branches into many small branches shortly after

entering the thigh. These branches innervate muscles of the anterior thigh as well as 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.
- **Neurovascular 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 innervated by one nerve and receives its blood supply from one artery.
 - **Anterior compartment:** 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, 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 joint, it becomes the **dorsal 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 with 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 off of the posterior tibial artery shortly after it branches from the popliteal artery in the popliteal fossa.

- **Great saphenous vein:** Observe the great saphenous vein traveling superficially along the medial aspect of the leg and thigh. This vein is commonly used in coronary artery bypass surgeries. It is draining blood from the superficial aspect of the medial foot, leg, and thigh.

Activity 2: Visible Body app-Neurovasculature of the Lower Extremity

We will use the iPads to explore the neurovasculature provided in the list of terms. While you are viewing the neurovasculature, use the muscle charts to make connections between the nerves and the muscles that they innervate. Also, use the information from activity 1 above to make connections between the vasculature and the muscles or regions they supply.

Arteries 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, muscular system, and the venous system. 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

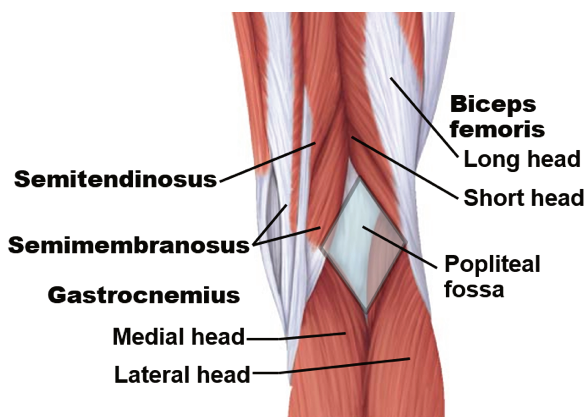
supply muscles of the lower extremity. Click on the **superior gluteal artery**, which is a superior branch that runs posteriorly to the gluteal region. With this artery highlighted, rotate the image to a posterior view and observe its path. From the posterior view, click on the internal iliac artery 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. You should know, however, 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 interosseus 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 of 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 the 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 travelling 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.

Activity 3: Laminated Images

Use the laminated images to study the arteries and nerves of the lower extremity. Note that not all arteries or nerves are visible in these images. As you are study the nerves consider all of the muscles that each nerve innervates. To help you with this, fill in the boxes below as you go. You can also make similar boxes for the arteries of the lower extremity.

<u>Inferior Gluteal Nerve</u>	<u>Superior Gluteal Nerve</u>				
<u>Obturator Nerve</u>	<u>Femoral Nerve</u>				
<u>Tibial Nerve</u>	<table border="1"><tr><td><u>Common Fibular Nerve</u></td><td><u>Deep Fibular Nerve</u></td></tr><tr><td><u>Superficial Fibular Nerve</u></td><td></td></tr></table>	<u>Common Fibular Nerve</u>	<u>Deep Fibular Nerve</u>	<u>Superficial Fibular Nerve</u>	
<u>Common Fibular Nerve</u>	<u>Deep Fibular Nerve</u>				
<u>Superficial Fibular Nerve</u>					
<u>Medial Plantar Nerve</u>	<u>Lateral Plantar Nerve</u>				

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LAB 14: POSTERIOR LOWER EXTREMITY

Learning Objectives:

By the end of this lab, students will be able to:

- 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 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)
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Introduction

Today in lab you will explore the muscles of the gluteal region, posterior thigh, posterior leg, and plantar layers of the foot. You will be able to examine the muscles using the iPad Atlas App, the human cadaveric wet specimens, and the plastinated specimens. The Navigator tool will be available to view muscles of the gluteal region, and some of the muscles are visible on the 3D printed model.

Lab Activities

Activity 1: Visible Body app–Sacroiliac Joint, Pubic Symphysis, Coxal Joint, Muscles of the posterior Lower Extremity

- **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.

- **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 muscles of the gluteal region and posterior thigh 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, often videos will pop up to demonstrate 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 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 you are looking at the muscles of the leg and foot, you can select the individual muscles, then click the red attachment icon. When you have clicked the attachment icon, often videos will pop up to demonstrate 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 motions of the leg and foot. 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.

Activity 2: Navigator-Hip, Gluteal Region and Posterior Thigh:

In this station you will 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 so that you can compare the deep and superficial muscles or to 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 muscles of the posterior thigh.

- With all muscles removed, examine the ligaments stabilizing the hip joint.
- Make sure that the highlighter feature is active and you can see two views at the top of the screen: one in the transverse plane and one perpendicular to the stylus. Hold the stylus in the sagittal plane and move it around the hip region of the 3D printed model. Observe the head of the femur, the gluteal muscles, and medial thigh muscles in the cross sections. As you move the stylus, you will see two intersecting lines on the cross-sectional image. As those intersecting lines move over certain structures, those structures will be highlighted. Remember, you can freeze the images at any point by pressing the black button on the stylus. Press the black button again to unfreeze the image.

Activity 3: Lower Extremity Cadaveric Tissue-Wet Specimens and Plastinates

We have four lower extremity wet specimens 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 in most cases, you can still observe most of the distal portion of the muscle.

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. The plastinated specimens also contain the os coxae, so you will be able to examine some of the muscles of the gluteal region on the plastinates that are difficult to see on the wet specimens. You should try to find all structures on both wet and plastinated specimens, though some will not be visible on each specimen. You can use the app and atlases to help you identify all structures.

****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. If you will be touching the plastinated specimens a lot, for example, if you are the designated person in your group in charge of turning the specimen, you should wear clean gloves. This is not to protect you, but to protect the specimens from repeated contact with our oily skin over time.

- **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. This can be best seen on the plastinated tissue with the gluteus maximus reflected. There are 5 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.

- **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 plantarflexor 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 muscle belly deep to the gastrocnemius and a long, thin tendon that extends 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.
- **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 flexes 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 **Tibialis posterior**, **flexor Digitorum longus**, and **flexor Hallucis longus** usually travel in a specific order around the medial malleolus. You can remember the order of these tendons using the mnemonic **Tom, Dick, an Harry**; “an” stands for posterior tibial **Artery** and tibial **Nerve**. **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.

- **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 a total of ten muscles or categories of 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. Like the hand, the **Dorsal** interossei **Abduct** the toes, while the **Plantar** interossei **Adduct** the toes (DAB and PAD). 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 other images.

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**LAB 15:
ANTERIOR,
MEDIAL, AND
LATERAL THIGH
| ANTERIOR
AND LATERAL
LEG | DORSAL
FOOT**

Learning Objectives:

By the end of this lab, students will be able to:

- Identify the muscles of the anterior, medial, and lateral thigh; anterior and lateral leg; & dorsal foot.
- Using the muscle charts as a guide, identify the action, origin, insertion, and innervation for the muscles of the anterior, medial, and lateral thigh; anterior and lateral leg; and dorsal foot.
- Identify the components of the knee joint.
- Identify the components of the ankle joint.
- Describe structure governs function examples based on muscle orientation and actions.
- **Examine muscles and ligaments of the**

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
 - Psoas major
 - Iliacus
 - (The above make up the Iliopsoas)
 - 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)

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

- longus
- Fibularis (peroneus) brevis
- cruciate ligament
- Posterior cruciate ligament
- Infrapatellar fat pad
- Talocrural (ankle) joint
 - Deltoid Ligament
 - Anterior tibiofibular ligament
 - Anterior talofibular ligament (ATF)
 - Calcaneofibular ligament

Introduction

Today in lab you will explore the muscles of the anterior, medial, and lateral thigh; anterior and lateral compartments of the leg; and the dorsal aspect foot. You will also explore the knee and ankle joints. You will be able to examine both the muscles and joints using the iPad App and the human cadaveric wet and plastinated specimens. Use the muscle charts and available resources 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 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. The 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 Activities

Activity 1: Visible Body app–Muscles of the Anterior, Medial, and Lateral Thigh, Anterior and Lateral Leg; Dorsal Aspect of the Foot; Knee and Ankle Joints

Animations and Muscle Movements:

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, often videos will pop up to demonstrate 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 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 charts.

- **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 against varus forces, which would result in the knee bending out laterally in the coronal plane and opening of 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 a commonly injured ligament. 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 result in damage to 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 of the bursae, or fluid filled sacs around the

knee, but you will not be tested on these.

- **Explore the muscles of the anterior and lateral leg:** Use the right leg to view the muscles of the anterior and lateral leg. 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 apart, 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 a **proximal** and **distal interphalangeal joints**, while the great to, like the thumb, only has an **interphalangeal joint**.

Activity 2: Lower Extremity Cadaveric Tissue-Wet Specimens and Plastinates

***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. If you will be touching the plastinated specimens a lot, for example, if you are the designated person in your group in charge of turning the specimen, you should wear clean gloves. This is not to protect you, but to protect the specimens from repeated contact with our oily skin over time.*

- **Medial thigh:** In the medial region of the thigh,

first observe the **gracilis**. This muscle is long and thin, and it inserts at the pes anserine insertion of the proximal medial tibia. For the other adductors, it may be particularly useful to use an atlas to help identify the muscles.

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. The **adductor longus** is thinner, longer, and anterior to the **adductor brevis**. You will need to gently move adductor longus to the side in order to observe adductor brevis, and **pectineus**, which are deeper muscles in the medial aspect of the thigh.

- **Anterior thigh:** Observe the **psoas major, iliacus, or iliopsoas** muscles on the plastinated tissue. While you will not be able to see the origin of the psoas major, you will be able to observe it merging 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.

- **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 both 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.
- 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 in to 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.

- **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 you are referring to this muscle. Deep to tibialis anterior is **extensor hallucis longus**. “Hallucis” means “great (1st) 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 it is blended in with extensor digitorum. You can see this muscle on 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.

Activity 3: Radiology using the Computers

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

16

LAB 16: INTRODCUTIONS TO JOINTS AND BONES OF THE UPPER EXTREMITY

Learning Objectives:

By the end of this lab, students will be able to:

- Describe the anatomy, classification, and movements of synovial joints.

- Identify the bony landmarks of the bones of the upper extremity.
- Identify bony landmarks of the bones of the upper extremity on radiological images.

Terms to Know

- Clavicle
 - Acromial end
 - Sternal end
 - Conoid tubercle
 - Shaft
- Scapula
 - Glenoid fossa
 - Coracoid process
 - Acromion process
 - Scapular spine
 - Medial border
 - Lateral border
 - Superior border
 - Inferior angle
 - Superior angle
 - Subscapular fossa
 - Supraspinous fossa
 - Infraspinous fossa
 - Infraglenoid tubercle
 - Suprascapular notch
- Humerus
 - Head
 - Greater tubercle
 - Lesser tubercle
 - Deltoid tuberosity
 - Intertubercular sulcus
 - Radial groove
 - Anatomical neck
 - Surgical neck
- 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

- Medial epicondyle
- Lateral epicondyle
- Lateral supracondylar ridge
- Medial supracondylar ridge
- Capitulum
- Trochlea
- Radial fossa
- Coronoid fossa
- Olecranon fossa
- Shaft

Lab Introduction

Today we will begin learning about 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 charts to help clarify what material you will be responsible for and help you learn the material. Also be sure to reference PAL, as you will be asked to identify many muscles and neurovascular structures on cadaver images.

In lab today you will be examining 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. Also, based on the landmarks, you should be able to identify if certain bones come from the right or left upper extremity. In another activity today you will be using the lab computers to review bony anatomy of the upper extremity on radiological images.

Lab Activities

Activity 1: Visible Body app and Atlas Images-Scapula, Clavicle, and Humerus bones and bony landmarks/markings

- At this station you will have a scapula, clavicle, and humerus. You should use an atlas and the iPads to identify the landmarks listed below. A chart will be posted describing the function and/or structure that runs near/attaches/articulates with each bony marking. You will be responsible for the information in that chart, and these markings will be reviewed again as we discuss the rest of the upper extremity.
- Also, you should be able to identify if 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 be able to determine 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 be able to determine if you are looking at a right or left humerus.

- **iPads** using the iPads to help you identify the bones and specifically the bony markings for these stations will be very valuable. You can use either the atlas app or the skeleton app. You will want to highlight one of the selected bones, then use the isolate feature (looks like a femur with multiple colors). When you isolate the bones, you will be able to see all of the bony landmarks and markings as listed in the charts and the terms to know.

Activity 2: Visible Body app and Atlas Images-Ulna, Radius, Carpals, and Phalanges bones and bony landmarks/markings

- At this station you will have an ulna, radius, carpals and phalanges specimens. Students should use an atlas to identify the landmarks listed below (same as from the list of terms).
- **iPads** using the iPads to help you identify the bones and specifically the bony markings for these stations will be very valuable. You can use either the atlas app or the skeleton app. You will want to highlight one of the selected bones, then use the isolate feature (looks

like a femur with multiple colors). When you isolate the bones, you will be able to see all of the bony landmarks and markings as listed in the charts and the terms to know.

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, it is important for you 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 are seeing on the images. You can also use an atlas to compare the bones with the radiology.

Clinical Correlations

We will end the lab by discussing clinical correlations with the bones of the upper extremity.

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LAB 17: NERVES AND VASCULATURE OF THE UPPER EXTREMITY

Learning Objectives:

By the end of this lab, students will be able to:

- Identify the brachial plexus, its branches, and what structures those branches innervate.
- Identify the vasculature 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

Today in lab you will discuss the brachial plexus, the arteries of the pectoral region and the neurovasculature of the elbow, wrist and hand. You will have various tools available to you in the lab to explore the structures listed above. Using the iPads, you will be able to examine and the neurovasculature of the upper extremity. Another activity is designed to help you learn the branches of the brachial plexus and the muscles that these branches innervate. Finally, you will use the cadaveric specimens to view the neurovasculature of the upper extremity.

Lab Activities

Activity 1: Neurovasculature of the upper extremity on the cadaveric tissue and images

You have already identified all of the muscles of the upper extremity. Now you will explore the vessels and nerves that supply and innervate the upper extremity. ***Remember to use landmarks to help you identify the neurovasculature!*** For example, if you know which muscles are innervated by a specific nerve, and you follow a nerve to that muscle, you can identify that nerve.

Nerves of the upper extremity:

- 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 that would be 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.

- Notice where the nerves are running to. If you know the muscles they innervate, and you can see them entering that muscle, you will be able to identify which nerve it is.
- 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. Be sure to observe this on the cadaveric tissue.

- **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 of 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:** This nerve can be seen branching off of 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 pastinated 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:** This nerve branches from the posterior cord and runs 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 send branches to the skin of the 5th digit and lateral aspect of the 4th digit. It also innervates the majority of muscles in the hand, except the thenar eminence muscles and lateral two lumbricals. On the plastinated specimen this a bit challenging to discern in the brachium (arm), but it is clear traveling 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, as well as the muscles of the thenar eminence and lateral two lumbricals. This nerve is also clearly visible on the

plastinated specimen.

- **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 coracobrachialis again and follows its normal path. While this branching pattern is abnormal, anomalies like this occur frequently 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.

Arteries:

- **Subclavian artery:** This is the primary artery providing the arm with blood. This is not visible on the cadaveric specimens, but it is visible 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 on 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 long thoracic nerve! This can be observed in images.
- **Thoracoacromial trunk:** This is a short trunk off of 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. Either way, 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.

Veins

The veins have been removed from the dissected cadaveric specimens. However, they are visible in images and on the plastinated specimens. There are two primary veins that originate in the forearm:

- the **cephalic and the basilic veins**. 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** join the basilica 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.

Activity 2: Anatomy TV-Upper Extremity Vasculature

Your lab TA will login to the AnatomyTV computer resource. We will use this resource to explore the neurovasculature of the upper extremity.

- Arteries of the Upper Extremity: Click on the tab marked Upper Body, you can also click on the upper limb tab and the views underneath it and be sure the red arteries circle is checked at the bottom of the window.
 - Explore the upper extremity arterial structure. To get the best view you will need to use the zoom and the mouse to slide the image into the best position. Look for the following:
 - Subclavian artery – visible
 - Thyrocervical trunk – visible
 - Suprascapular artery – not visible
 - Axillary artery – visible
 - Superior thoracic artery – not visible
 - Thoracoacromial artery – visible
 - Lateral thoracic artery – not visible
 - Anterior circumflex humeral artery – visible**
 - Posterior circumflex humeral artery – visible **

- ***note Anatomy TV calls these collectively the circumflex humeral artery, we want you to know both***
- Subscapular artery
 - visible
 - Thoracodorsal artery – not visible
 - Circumflex scapular artery – not visible
- Brachial Artery – visible
 - Deep Brachial Artery – visible
 - Radial Artery – visible
 - Ulnar Artery – visible

Students should refer to the atlas and the video available during lab to identify the arteries listed above that are not visible in Anatomy TV. See the notes below on tips for identifying the arteries of the axilla and arm.

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. Review as many of the visible vasculature structures as possible.

Work carefully through all the

layers. Be sure to rotate the structure to appreciate multiple points of view. Notice at layer 11 how the artery travels behind the pectoralis major and the proximity of the subclavian and axillary artery in relation to the first rib and clavicle. The arterial structures are best visualized in layers 1-5.

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, with the first part being medial to the muscle, the second part being deep to the muscle, and the third part being lateral to the muscle. The first part has one branch, the second part has two branches, and the third part has three branches.

Veins of the Upper Extremity:

Click on the tab marked Upper Body, you can also click on the upper limb tab and the views underneath it and be sure the blue and green circle is checked at the bottom of the window.

Explore the upper extremity arterial structure. To get the best view you will need to use the zoom and the mouse

to slide the image into the best position. Look for the following:

- Cephalic vein – visible
- Basilic vein – visible
- Median cubital vein – visible
- Brachial vein – visible
- Axillary vein – visible
- Subclavian vein – visible (under the head and neck tab)

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. Review as many of the visible vasculature structures as possible.

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

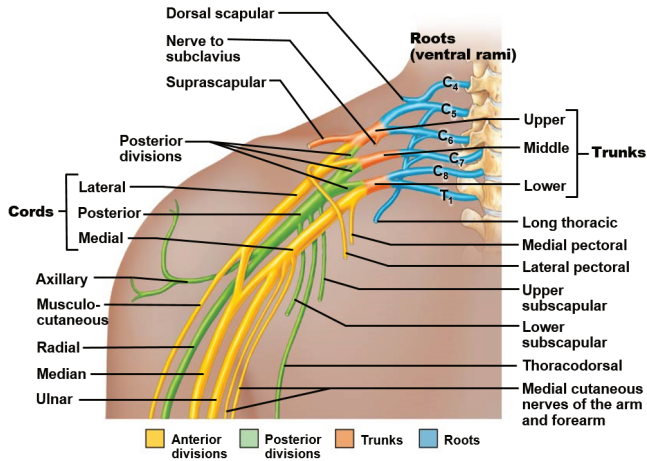
- Cephalic vein: This passes superficially on the lateral side of the forearm, ascending lateral to the bicep and medial to the deltoid.
- Median cubital vein: This is superficial ascending medially in the cubital fossa.
- Basilic vein: This is superficial on the dorsum of the hand, ascending the medial aspect of the forearm, continuing up the arm where it travels medial and deep to the biceps.
- Brachial vein: This ascends superficially on the medial side of the arm between the long head of the triceps and the biceps.
- Axillary vein: This ascends medially through the

axilla, it is a continuation of the brachial vein.

- Subclavian vein: This is a continuation of the axillary vein as it passes over the first rib.

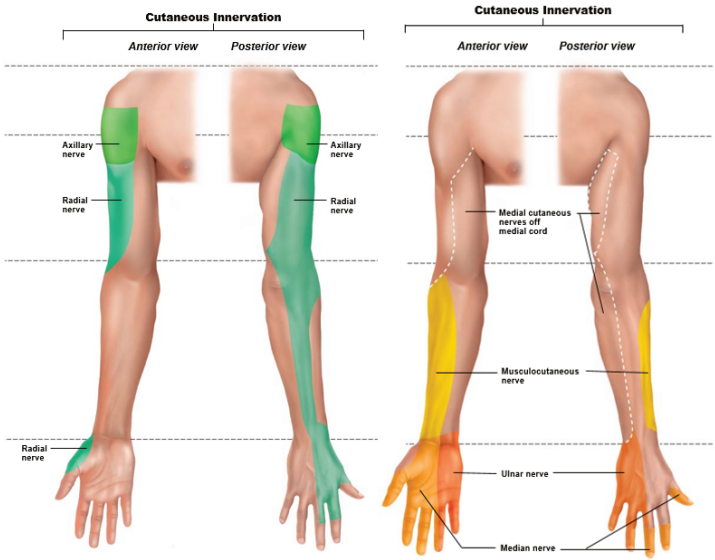
Activity 3: Brachial Plexus Exercise (Card Placement + atlas)

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 brachial 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.



(b) Roots (rami C₅-T₁), trunks, divisions, and cords

- 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 atlases and laminated images, first use the blue nerve labels to correctly label the branches of the brachial plexus. 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, as it can help you determine which nerve (or nerve root, as will be explained in lecture) may be damaged. The region of skin innervated by each terminal branch of the brachial plexus is shown in this figure:



18

LAB 18: THE PECTORAL GIRDLE

Learning Objectives:

By the end of this lab, students will be able to:

- 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 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
 - Brachialis
- Biceps brachii
 - Short head
 - Long head
- Triceps brachii
 - Long head
 - Lateral head
 - Medial head

Introduction

Today in lab you will explore the joints and muscles of the pectoral girdle. Using the iPads Atlas, you will examine the joints that make up the pectoral girdle and shoulder as well as the muscles acting on these joints. Make good use of the animations to help you understand movement of the scapulothoracic joint and the movements caused by each muscle listed. While exploring in the iPads you will also examine radiology

of the pectoral girdle and shoulder. You should compare what you are seeing on the iPads to what you see in the radiological images to help you understand what you are seeing using radiology. The Navigator tool will be available to view both the joints and muscles, and some of the muscles are visible on the 3D printed model. You should also explore the cross-sectional images using this tool.

You will also have the opportunity to explore these muscles on the human upper extremity tissue. Please treat this tissue with great care and respect. It is ok if you feel an emotional response when seeing this tissue for the first time. Some students may feel that the hands are more personal than the organs you have examined earlier this semester, and it is ok if you need to take a minute to feel comfortable examining this tissue. Know that these individuals donated their tissue because they want you to learn everything you can from them. Your TA can help you work through these emotions so that you can get the most out of this incredible opportunity.

Keep in mind that all structures are not visible using all tools, and that is OK. By the end of the lab today you should have identified all of the structures on the list using multiple sources. As a study tip, you may find it helpful to write a description of each muscle/structure as you identify them. When you write it in your own words, it may spark your memory as you look for that structure the next time you study.

Lab Activities

Activity 1: Visible Body app and Radiology-Joints and Muscles of the Pectoral Girdle and Shoulder

First, explore the muscles and joints of the pectoral girdle using the iPads.

- 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 the systems click on the arterial, venous, nervous and lymphatic systems twice to remove them, since we will not be looking at these systems today.

Explore the muscles of the pectoral girdle and arm listed below. 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) in order 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 you have highlighted the structure and click 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. If you would like to see the muscle(s) in action, there are two means to see this, the first is to click on the red pin when you have highlighted the muscle, this will drop down

motion videos. The second way to see muscle actions is to 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.

- **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**
- **Brachialis**
- **Biceps brachii**
- **Triceps brachii**
- Click on the *Systems* tab under the *Skeletal System Views*, select *14. Shoulder Girdle*. The “shoulder joint” is actually 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 to know them. The app will also show a few more ligaments than we have listed for you. You will only be responsible for knowing those 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. You may also find it interesting to look at the injury and clinical relevance (stethoscope icon). Sometimes it can be helpful to attach clinical meaning to these structures when trying to remember them.

- **Acromioclavicular Joint**
 - **Acromioclavicular ligament**
 - **Coracoclavicular ligament**
 - **shown as 2 ligaments; conoid portion and trapezoid portion
- **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 really highlight this joint, but you can see how the scapula articulates with the ribs)
- Click on the *Muscle Animations* 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 app)/retraction (called adduction in the app), and upward and

downward rotation of the scapula.

- While under the *Muscle Animations*, you can also 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.
- Now open the Shoulder radiology PowerPoint. This will be in an open documents window on the screen. Explore the muscles and joints listed above in the radiological images. Use the iPad renderings to help you understand what you are seeing in the radiological images.

Activity 2: Navigator and Plastinate

You will use the navigator to examine the anatomy of the pectoral girdle. Some of the 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. You can also examine the plastinated tissue in this station and compare the plastinated pectoral girdle to what you see in the Navigator computer model and cross sections.

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

- On the computer model, click on “View,” and use the presets to explore the muscles of the pectoral girdle in the list of terms on page 1. You can also click on “Advanced” in the View window to isolate specific muscles or structures. Uncheck 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.

- One preset shows the computer model with the muscles removed. Examine the ligaments stabilizing the joints of the pectoral girdle.
- Make sure that the highlighter feature is active. If you do not see green highlighted structures as you move the stylus around the shoulder of the 3D printed model, click on this icon, furthest to the right on the toolbar. Also, ensure that you can see two views at the top of the screen, one in the transverse plane and one that is perpendicular to the stylus. Hold the stylus in the sagittal plane and move it around the shoulder region of the 3D printed model. Observe the head of the humerus, scapula, and rotator cuff muscles in the cross sections. As you move the stylus, you will see two intersecting lines on the cross sectional image. As those intersecting lines move over certain structures, those structures will be highlighted. Move the stylus towards the posterior aspect of the model and observe the posterior muscles acting on the pectoral girdle: the trapezius and rhomboids (superiorly) and the latissimus dorsi (inferiorly). Remember, you can freeze the images at any point by pressing the black button on the stylus. Press the black button again to unfreeze the image.
- Spatial relationships are key! Understanding the

relationships between structures (e.g. posterior, anterior, medial, lateral, superior, inferior, superficial, deep) will help you understand what you are viewing at each level. For example, with the posterior muscles acting on the pectoral girdle, if you know that the trapezius is superficial (posterior) to the rhomboids, and you position the stylus at the superior thoracic level of the 3D printed model, you should be able to identify that the trapezius is the muscle closest to the skin in the middle back, while the rhomboid muscles would be just deep to the trapezius

- Examine the plastinated upper extremity tissue. Now that you have examined the muscles using the navigator, you can identify several of these muscles on the plastinated arm. Not all muscles are visible in this dissection. The vessels and nerves on this specimen are very fragile. Please **DO NOT** touch this tissue. You should ask the TAs to go through these muscles with you and move the tissue. You can compare what you see on the plastinated arm to what you viewed on the computer model and cross-section images on the Navigator.

Activity 3: Upper Extremity Tissue

There are four arms that have been dissected for you to examine in the lab. You are able to view all of the muscles on the list of terms either in part or on whole on this tissue. You should wear gloves while handling this tissue. We also have plastic aprons that you can wear while examining this tissue, as it will be wet and may

drip. You should look at all arms during each lab. Two arms have been dissected more superficially, while the others have been dissected so that you can identify some deeper structures. Each set of arms comes from the same person, there is anatomical variation between them, including an interesting anomaly that you will examine in this and another lab. You could be asked to identify most of these structures on either arm. It can be helpful for you to have the muscle charts with you while you are examining these structures. Looking at 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! Also, be gentle when moving the specimen and feeling the muscles. We need to keep these specimens for many semesters, so please do not pull too hard or damage any of the structures.

- Start by looking at the posterior aspect of the arm.
- Feel for the spine of the scapula. Extending superiorly from the scapular spine, examine part of the **trapezius**. This muscle has been cut, but you can see its fibers inserting on the scapular spine and, on the superficial dissection, wrapping around anteriorly and inserting on the lateral aspect of the clavicle.
- 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** (larger),

rhomboid minor, (thinner), and **levator scapulae** (also extending from the superior angle of the scapula).

- Move the trapezius back and observe the **supraspinatus** muscle sitting just deep to it. 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 there are nerves and vessels 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 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 the **latissimus dorsi** just 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 latissimus dorsi and teres major both run to insert on the anterior aspect of the humerus. This is important to appreciate so that you can understand how these muscles contribute to 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 to understand why the functions of the posterior, middle, and anterior fibers of the deltoid differ from each other.
- 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. Pectoralis 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 and scapulothoracic joints, 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 what you can see is the superior most portion of the **subclavius**.
- Now you will start examining the muscles of the arm that cross the glenohumeral joint. First observe the **coracobrachialis**. This muscle originates on the corocoid

process of the scapula and inserts on the humerus. This muscle is normally pierced by a nerve, the musculocutaneous nerve, in the middle portion of the muscle belly. However, notice how it differs on in the deep dissection. In this case, an earlier portion of the brachial plexus (which you will learn about next week) also pierces this muscle, giving it the appearance of having two muscle bellies. Anatomical variations are very common! This is just the first of several variations you will see in this course.

- 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**.

- 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. Lastly, observe the ring of tissue just surrounding the glenoid fossa. This is the **glenoid labrum**.

19

LAB 19: ELBOW AND WRIST JOINT | MUSCLES OF THE POSTERIOR ARM | NERVE AND VESSEL REVIEW

Learning Objectives:

By the end of this lab, students will be able to:

- 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

Introduction

Today you will review the elbow and wrist joints, as well

as the muscles of the posterior forearm using wet specimens, plastinates, and the Visible Body App. You will also have a chance to review the nerves of the upper extremity. Keep in mind that all structures are not visible using all tools, and that is OK. Also, take advantage of the opportunity to use other lab atlases and images to identify these structures. Before you start, here are a few things to keep in mind about structures you will be identifying today:

- **Posterior Forearm:** The muscles of the posterior compartment of the forearm generally contain muscles that extend the wrist. 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.
- **Hand:** The muscles of the hand can be divided into a few groups. The thenar muscles are those that act on the thumb, and the hypothenar muscles are those that act on the 5th digit. Both the thenar and hypothenar muscles are completely

located within the hand and contain an abductor, flexor, and opponens muscle. The opponens muscles act on the thumb or 5th digit to make these digits touch. The thumb also has a muscle that acts to adduct it, called adductor pollicis, but the fifth digit does not have a counterpart to this muscle. All muscles containing the word “pollicis” act on the thumb, and all muscles that contain the words “digiti minimi” act on the 5th digit.

Lab Activities

Activity 1: Cadaveric Specimens-The Elbow and Wrist Joints and Muscles of the Posterior Forearm

As you are exploring the muscles of the posterior forearm, especially those crossing the wrist and hand joints, you should gently pull on these tendons to watch how they move the wrist and digits.

- 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 difficult 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.

- 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.

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 of it.

- **Extensor digitorum** extends to the distal phalanx of digits 2-5 and extends the MCP, DIP, and PIP of these digits. Note that 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 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 laminated or atlas/PAL 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**. Another deep muscle of the posterior forearm is the **supinator**, which 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. Like the flexor retinaculum, this structure holds the extensor tendons in place and provides a mechanical advantage with extension.
- Observe the wrist. Though you may not be able to see the joints, you should be able to feel for the **distal radioulnar, radiocarpal, midcarpal, Intercarpal, and carpometacarpal joints**. Feel these joints as you move the wrist. These may be easier to feel on the deep

dissection.

Activity 2: Visible Body app

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

- Click on the *Regions* tab and scroll to *9. Cubital Fossa*. Under the systems tab 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 today. While under the systems tab, at the very top, 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 for 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. Some muscles are deep to others, thus you will have to remove the more superficial muscles in order to see the deep muscles. Some of the joints will not be specifically listed in the app, however you will be able to see the three ligaments of the elbow listed as well as the extensor retinaculum on the wrist.
- You will be asked to identify the origins, insertions, actions, and innervations of these muscles (this will be listed in the app after you have highlighted the structure and click the book). However, you may not need to know certain specifics for each muscle. Follow what is in the muscle charts for the specifics of what you need to know for each muscle. If you would

like to see the muscle(s) in action, there are two means to see this, the first is to click on the red pin when you have highlighted the muscle, this will drop down motion videos. The second way to see muscle actions is to 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.

- **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
- Click on the *Muscle Animations* tab (on the home page) and scroll to forearm and wrist motions to view the muscles that act on the forearm and wrist. Explore the animations of forearm pronation/supination, wrist extension/flexion, wrist abduction/adduction, finger extension/flexion, thumb extension/flexion and opposition.

Activity 3: Review of Nerves and Vessels of the Upper Extremity

Take the extra time in this lab to review the brachial plexus and vasculature of the upper extremity. Now that you know more of the muscles, try identifying a muscle and then find the nerve that innervates it. Then identify the nerves and point out the muscles that they innervate. Also review the vasculature of the upper extremity.

20

LAB 20: MUSCLES OF THE ANTERIOR FOREARM | THE HAND | BONY MARKINGS AND MUSCLE REVIEW

Learning Objectives:

By the end of this lab, students will be able to:

- 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

- Cubital Fossa
 - Flexor retinaculum
 - Carpal tunnel
 - Juncturae tendinae
-

Introduction

Today in lab you will review the joints of the hand, as well as the muscles of the anterior forearm and hand using wet specimens, plastinates, and the Visible Body App. You will also have a chance to review the blood vessels of the upper extremity. Before you start, here are a few things to keep in mind about structures you will be identifying today:

- **Anterior Forearm**

As you are looking at the muscles of the forearm, you should notice a few key things. First, the muscles of the anterior compartment, or anterior part of the forearm, are generally flexors of the wrist or fingers. The flexors originate from a flexor mass that has 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.

Lab Activities

Activity 1: Cadaveric Specimens-Muscles of the Anterior Forearm and Hand

As you are exploring the muscles of the anterior forearm, especially those crossing the wrist and hand joints, you should gently pull on these tendons to watch how they move the wrist and digits.

- On the anterior aspect of the elbow joint, observe the **cubital fossa**.
 - Which vein (from lab 2) crosses over the cubital fossa and is a common spot for blood draws?
- Observe the **brachioradialis**. This muscle originates in the brachium, or arm, and inserts onto the styloid process of the radius.
- Observe the muscles of the anterior forearm. The names of these muscles often tell a lot about their location and/or function. As mentioned earlier, all of these muscles flex or pronate the wrist and/or hand, and most have an origin at the medial epicondyle. 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:

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, including the person whose extremities were donated to our lab. Therefore, you will not identify this muscle on the cadaveric tissue, but you can see it in atlas or laminated images or on Anatomy TV.

Intermediate Layer:

Flexor digitorum superficialis (FDS) crosses the wrist, MCP and PIP joints of digits 2-5 in the hand. Notice how this muscle 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 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 amount of 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 this 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.

- Now observe the muscles of the hand. These are best observed on the deep dissection. As described above, 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 an 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-4th digits (if you turn your palm upwards). They flex the MCP joints while extending the PIP and DIP joints.
- Finally, on the dorsal aspect of the hand you can observe the **dorsal and palmar interossei**. Though their names specify directionality, you can actually see both from the dorsal aspect of the hand. You will need to observe fiber direction for these muscles. 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 (3rd) digit can only abduct, so it has only dorsal interossei on either side of it. 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 interosseus muscle on the lateral aspect of the digit with its fibers running distally towards the midline are dorsal interossei.

Activity 2: Visible Body App

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

- Click on the *Regions* tab and scroll to 9. *Cubital Fossa*. Under the systems tab 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 today. While under the systems tab, at the very top, 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 for 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 below. Some of these muscles will be deep to others, thus you will have to remove the more superficial muscles in order to see the deep muscles. Some of the joints will not be specifically listed in the app, however you will be able to see the three ligaments of the elbow listed as well as the extensor retinaculum on the wrist.
- You will be asked to identify the origins, insertions, actions, and innervations of these muscles (this will be listed in the app after you have highlighted the structure and click 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. If you would like to see the muscle(s) in action, there are two means to see this, the first is to click on the red pin when you have highlighted the muscle, this will drop down motion videos. The second way to see muscle actions is to 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.

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

- Click on the *Muscle Animations* tab (on the home page) and scroll to forearm and wrist motions to view the muscles that act on the forearm and wrist. Explore the animations of forearm pronation/supination, wrist extension/flexion, wrist abduction/adduction, finger extension/flexion, thumb extension/flexion and opposition.

Activity 3: Bony Markings, Muscles and actions

This lab station will allow students to make connections between the bony markings, muscles and actions of the muscles on the joints outlined in the *list of terms*.

*****Students should bring their muscle and bony marking charts with them to lab in order to help them with this station.***** If you complete all of these questions and there is still time left at the station, use the white board to practice grouping information from the muscle charts (examples – name all of the muscles that insert _____, name all of the muscles that flex the glenohumeral joint). Studying the muscle charts by grouping in this way can be extremely helpful for making connections between all the information learned in this unit.

Using Frank (Standing Skeleton)

- Name all of the muscles that insert along the length of this bony landmark.
- Name the muscle that originates here. What is the function of this muscle?
- Name this landmark and name the muscles that insert here.
- Name this landmark, name the three muscles

that have an attachment here, be specific

- Name all of the muscles that originate here.
- Name this landmark. What ligament holds this to the ulna?
- Name this landmark be specific. What muscle inserts here? What other bone has a landmark with the same name?
- What muscle inserts here?
- What motions are possible at the proximal joint that are not possible at the distal joint indicated here? What muscles are responsible for these motions at the proximal joint?

Using laminated images

- Name this muscle.
- What is the function of this muscle, name the joints it acts on.
- Name this muscle. Name the three most distal joints it acts on.
- Name this structure.
- What is the function of this muscle?
- Where do most of the muscles seen on this image of the posterior arm originate.
- What is the function of this muscle?
- Name this region and name all of the muscles that make up this region.
- Name this muscle. Name this region and name the other muscles that make up this region.
- Name these muscles. What action do they perform at the MCP? What action do they perform at the PIP?
- Name the function of these muscles.

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