

“Crowther’s 12th Marieb”

(a guide to your lab manual)

Laboratory exercises in Biology 241-242 are taken mostly from the *Human Anatomy & Physiology Laboratory Manual* by Elaine N. Marieb (“MARE-ibb”) and Lori A. Smith (cat version, 12th edition, 2016). This manual is nice in many respects, but includes far more details, activities, and questions than we can handle. For each assigned exercise, this “Crowther’s 12th Marieb” guide will tell you what to do and what not to do!

The Spring 2016 schedule below is color-coded by topic as follows:

- **Purple: introductory, integrative, or cross-cutting topics**
- **Orange: integumentary system (skin)**
- **Red: skeletal system (bones)**
- **Green: muscular system**
- **Blue: nervous system**

Day, Date	Exercise # or PhysioEx #
Tuesday, March 29	The first BBio 241 lecture will be given in lab during lab time!
Friday, April 1	Exercise 1 (The Language of Anatomy), Exercise 2 (Organ Systems Overview)
Tuesday, April 5	PhysioEx 1 (Cell Transport Mechanisms and Permeability)
Friday, April 8	Exercise 6 (Classification of Tissues)
Tuesday, April 12	Exercise 6 (Classification of Tissues), continued
Friday, April 15	Exercise 7 (The Integumentary System)
Tuesday, April 19	No lab
Friday, April 22	Exercise 8 (Overview of the Skeleton)
Tuesday, April 26	Exercise 9 (The Axial Skeleton)
Friday, April 29	Exercise 10 (The Appendicular Skeleton)
Tuesday, May 3	Exercise 11 (Articulations and Body Movements)
Friday, May 6	Exercise 13 (Gross Anatomy of the Muscular System)
Tuesday, May 10	Exercise 12 (Microscopic Anatomy and Organization of Skeletal Muscle)
Friday, May 13	PhysioEx 2 (Skeletal Muscle Physiology)
Tuesday, May 17	Exercise 14 (Skeletal Muscle Physiology: Frogs and Human Subjects)
Friday, May 20	PhysioEx 3 (Neurophysiology of Nerve Impulses)
Tuesday, May 24	Exercise 19 (The Spinal Cord and Spinal Nerves)
Friday, May 27	Exercise 17 (Gross Anatomy of the Brain and Cranial Nerves)
Tuesday, May 31	Exercise 21 (Human Reflex Physiology)
Friday, June 3	No lab
Tuesday, June 7	No lab (finals week)
Friday, June 10	No lab (finals week)

The Summer 2016 schedule below is color-coded as follows:

- **Purple: special senses**
- **Gray: endocrine system**
- **Red: cardiovascular system**
- **Orange: respiratory system**
- **Blue: digestive system**
- **Gold: urinary system**
- **Green: reproductive system**

Day, Date	Exercise # or PhysioEx #
Monday, June 20	No lab!
Wednesday, June 22	Exercise 24 (Special Senses: Visual Tests and Experiments)
Monday, June 27	Exercise 25 (Special Senses: Hearing and Equilibrium)
Wednesday, June 29	Cat Dissection Exercise 3 (Identification of Selected Endocrine Organs of the Cat) + PhysioEx 4 (Endocrine System Physiology)
Monday, July 4	No lab (UW holiday)
Wednesday, July 6	Exercise 29 (Blood)
Monday, July 11	Exercise 30 (Anatomy of the Heart)
Wednesday, July 13	Exercise 31 (Conduction System of the Heart and Electrocardiography)
Monday, July 18	Exercise 32 (Anatomy of Blood Vessels) + Cat Dissection Exercise 4 (Dissection of the Blood Vessels of the Cat)
Wednesday, July 20	Exercise 33 (Human Cardiovascular Physiology: Blood Pressure and Pulse Determinations)
Monday, July 25	Cat Dissection Exercise 6 (Dissection of the Respiratory System of the Cat) + PhysioEx 7 (Respiratory System Mechanics)
Wednesday, July 27	Exercise 37 (Respiratory System Physiology)
Monday, Aug. 1	Cat Dissection Exercise 7 (Dissection of the Digestive System of the Cat)
Wednesday, Aug. 3	Exercise 39 (Digestive System Processes: Chemical and Physical)
Monday, Aug. 8	Exercise 41 (Urinalysis)
Wednesday, Aug. 10	Reproduction dissections
Monday, Aug. 15	Review time (no new lab)
Wednesday, Aug. 17	Review time (no new lab)

Exercise 1 (The Language of Anatomy) & Exercise 2 (Organ Systems Overview)

Goals

- Learn basic terminology for body regions.
- Distinguish between the two main body cavities and the contents of each.
- Find major anatomical structures in a mammalian model.

Materials

- Preserved rats, one per pair of students
- Small dissection trays
- Dissection tools
- Human torso models
- Post-It notes, ~30 per pair of students

Exercise 1, Activity 1: Locating Body Regions

Learn the anatomical terms listed below, using Figure 1.1 as a reference. Find the landmarks listed in your book on yourself OR a lab partner OR a model (you don't have to do all three). Although they may seem like isolated, random bits of jargon, these words (or variations thereof) will show up again and again in BBio 241 and 242, as indicated in the examples below.

Surface anatomy term	Related terms
Abdominal	Abdominal cavity, rectus abdominis (muscle), transversus abdominis (muscle), abdominal aorta.
Acromial	Acromion (lateral part of the scapula bone), thoracoacromial artery.
Axillary	Axillary artery, axillary vein.
Brachial	Biceps brachii (muscle), brachialis (muscle), brachioradialis (muscle), triceps brachii (muscle), brachial nerve, brachial artery, brachiocephalic vein.
Buccal	Buccinator (muscle).
Calcaneal	Calcaneus (heel bone), calcaneal tendon of gastrocnemius and soleus muscles.
Carpal	Carpals (wrist bones), metacarpals (bones), flexor carpi radialis (muscle), flexor carpi ulnaris (muscle), carpal tunnel syndrome.
Cervical	Cervical vertebrae (in neck region), iliocostalis cervicis (muscle), semispinalis cervicis (muscle), splenius cervicis (muscle).
Coxal	Coxal bones (hip bones; also called ossa coxae).
Digital	Extensor digitorum (muscle), extensor digitorum brevis (muscle), extensor digitorum longus (muscle), flexor digitorum profundus (muscle), flexor digitorum superficialis (muscle), digital arteries, digital veins.

Dorsal	Latissimus dorsi (muscle).
Femoral	Femur (thigh bone), biceps femoris (muscle), rectus femoris (muscle), femoral artery, femoral vein.
Fibular	Fibula (leg bone), fibularis longus (muscle), fibular artery, fibular vein.
Frontal	Frontal bone of cranium, frontal lobe of brain, frontal belly of epicranium muscle.
Gluteal	Gluteus maximus (muscle), gluteus medius (muscle), superior and inferior gluteal arteries.
Hallux	Extensor hallucis brevis (muscle), extensor hallucis longus (muscle).
Lumbar	Lumbar vertebrae, lumbar arteries, lumbar veins.
Mammary	Mammary glands.
Mental	Mental foramen (hole in jaw bone), mentalis (muscle)
Nasal	Nasal bones, inferior nasal concha (bones).
Occipital	Occipital bone of cranium, occipital belly of epicranium muscle, occipital lobe of cerebral cortex of brain, occipital artery, occipital vein.
Olecranal	Olecranon (end of ulna), olecranon fossa (depression in humerus that accommodates olecranon).
Oral	Orbicularis oris (muscle surrounding mouth).
Orbital	Inferior and superior orbital fissures, infraorbital foramen, supraorbital foramen (holes in cranium).
Palmar	Palmar arches of blood vessels, palmaris longus (muscle).
Patellar	Patella (bone), patellar tendon of quadriceps muscles.
Plantar	Plantarflexion (toes move away from knee), plantar arteries, plantar veins, plantar fascia, plantar fasciitis.
Pollex	Extensor pollicis brevis (muscle), extensor pollicis longus (muscle), flexor pollicis longus (muscle).
Popliteal	Popliteus (muscle), popliteal artery, popliteal vein
Pubic	Pubic bone of pelvis, inferior and superior pubic rami, pubic crest, pubic symphysis, pubic tubercle.
Sacral	Sacral vertebrae, sacral promontory.
Scapular	Scapula (bone – includes subscapular fossa and suprascapular notch), subscapular artery.
Sternal	Sternum (bone), sternocleidomastoid (muscle), sternohyoid (muscle).
Sural	Triceps surae (muscles), sural nerve.
Tarsal	Tarsal bones in ankle, metatarsal bones.
Thoracic	Thoracic cavity, thoracic vertebrae, iliocostalis thoracis (muscle), longissimus thoracis (muscle), semispinalis thoracis (muscle), thoracic aorta, internal and lateral thoracic arteries, thoracoacromial artery, pneumothorax (collapsed lung).
Umbilical	Umbilical cord, umbilical arteries, umbilical vein.
Vertebral	Vertebrae (cervical, thoracic, lumbar, sacral).

Exercise 1, Activity 2: Practicing Using Correct Anatomical Terminology

Read about the body orientation/direction terms, then complete this activity in your worksheet (below).

Exercise 1, Group Challenge: The Language of Anatomy

Answer questions 1 through 4 on your worksheet (below).

Exercise 2, Activities 1-4

You and your lab partner will dissect a preserved rat, following the instructions in the lab manual. You do NOT need to locate and learn about every single structure listed in the lab manual, but do make your best effort to locate the structures listed in the worksheet below.

Exercise 2, Activity 5

Examine a human torso model and use it to label the torso model picture in the worksheet below.

Worksheet for Exercise 1 (The Language of Anatomy) & Exercise 2 (Organ Systems Overview)

Names:

Exercise 1, Activity 1

Surface anatomy terms that are NOT familiar to you:

Strategy or strategies you will use to learn these terms:

Exercise 1, Activity 2 questions

- 1.
- 2.
- 3.
- 4.
- 5.
- 6.
- 7.
- 8.

Exercise 1, Group Challenge questions

- 1.

2.

3.

4.

Exercise 2, Activities 1-4

Complete the following table.

Structure	Check if found	Body cavity*	Physiological system**
Bladder			
Diaphragm			
Fur			
Heart			
Intestines (small/large)			
Kidney			
Liver			
Lung			
Spleen			
Stomach			
Trachea			

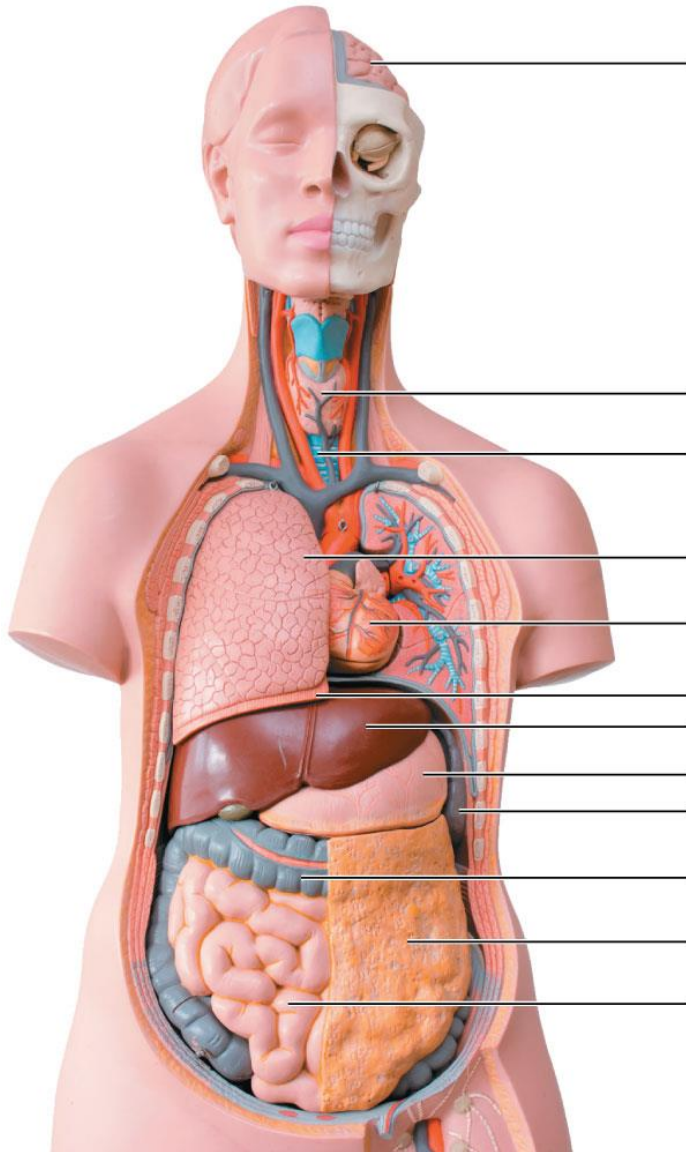
*choices: thoracic, abdominal, pelvic

**choices: cardiovascular, digestive, endocrine, integumentary, lymphatic, muscular, nervous, reproductive, respiratory, skeletal, urinary

Instructor's verification of structure identifications: _____

Exercise 2, Activity 5

Label the human torso model below (Figure 2.7).



PhysioEx 1: Cell Transport Mechanisms and Permeability

Goals

- To practice generating hypotheses and testing them experimentally.
- To review and deepen our understanding of diffusion, osmosis, and active transport.
- To contrast the forces that govern diffusion with the forces that govern filtration.
- To distinguish between simple diffusion, facilitated (carrier-mediated) diffusion, and active transport.

Materials

- Laptop computers, 1 per pair of students.

Instructions

Please complete Activities 1 through 5 of PhysioEx Exercise 1, found on pages PEx-3 through PEx-16 of your lab manual (toward the back).

- Activity 1: Simulating Dialysis (Simple Diffusion)
- Activity 2: Simulated Facilitated Diffusion
- Activity 3: Simulating Osmotic Pressure
- Activity 4: Simulating Filtration
- Activity 5: Simulating Active Transport

Log in to MasteringAandP.com, select "Study Area (myA&P)," select "PhysioEx 9.1," click on the blue text link ([PhysioEx 9.1](#)), and do the online simulations described in the manual.

You do NOT need to turn in answers to the questions shown in your lab manual or online. Instead, for each of the five activities, type or write a brief report with the following labeled components:

- EXPERIMENT
 - In about 2-4 sentences, describe the experiment that was done. (What was the basic setup? What variable was manipulated? What responses were measured?) If the experiment was similar to that in a previous activity, you can say, "This was similar to Activity X, except that...." Use correct units (millimeters, millivolts, seconds, etc.).
- HYPOTHESIS
 - Before you perform the experiment, predict how the key data will come out. You will not be graded on the correctness of your prediction, but generating predictions will help maximize your learning.
- RESULTS

- What key data (quantitative and/or qualitative) were generated from this experiment? Use correct units (millimeters, millivolts, seconds, etc.). You do not need to include every table or graph generated by the website, but do show me the most important bits (either summarized in the website's format, or presented in your own format) and briefly explain them to me. If you are using figures or tables generated automatically by the website, you may include screen captures, but please crop them for simplicity/clarity, as needed. Please do not take photographs of your computer screen with your phone, as the resolution will not be good.
- CONCLUSION
 - In about 2-3 sentences, state whether the data fit your prediction, and what conclusions you can draw. Conclusions relate directly to the data but go beyond reporting them. Try to explain (briefly) any key connections between the experiment and material we are covering in lecture. Why are the data important or interesting?

Your lab manual and the PhysioEx program should have all of the information that you need, but you are also welcome to consult outside sources. Please cite any outside sources that you do use, and please use quotation marks when appropriate.

Exercise 6: Classification of Tissues

Goals

- Learn the four basic types of tissues.
- View examples of each type.
- Connect specific structural features of these cells to their functions.

Materials

- Compound microscopes, 1 per pair of students
- Prepared microscope slides (see lists below), 1 set per pair of students, in folders.
- Color pictures of “mystery” epithelial and connective tissues, 2-3 sets per section

General background

Microscope slides are sometimes labeled with cryptic abbreviations. Here are some common ones to be aware of:

- h&e = hematoxylin & eosin stain (turns the nucleus blue and the cytoplasm pink, orange, or red)
- l.s. = longitudinal section
- sec = section
- s.m. = smear
- x.s. = cross-section

And here are some tips for drawing what you see on a slide:

- Do NOT draw an entire field of view unless an “overview” sketch is desired. If trying to record the appearance of individual cells, draw a small number of cells (1-2) in as much detail as possible. Sometimes it is best to do a two-part drawing, with an overview plus an inset.
- Don't draw details that you can't actually see (even if they are shown in other pictures).
- Label structures (e.g., “nucleus”).
- Indicate magnification and approximate distance scale.

Activity 0: Calibrating Your Microscope

When viewing tissue under the microscope, it is important to know how big things are. While some microscopes come with a ruler built into the eyepiece, you can determine the scale of your microscope's Field of View (FoV) using the time-honored “e-method” used by generations of A&P students (Figure 1). In brief, you measure the width of something (like a letter e), then estimate how much of the microscope's FoV is taken up by that something, then estimate the width of the FoV. For example, if the width of your letter e is 3 millimeters, and it takes up half of the FoV, then the total width of the FoV is 6 millimeters. Once you know the FoV width for one magnification, you can then calculate it for other magnifications. For example, if the magnification goes UP by a

factor of 3 (e.g., from 50X to 150X), then the FoV width goes DOWN by a factor of 3 (e.g., from 6 millimeters to 2 millimeters).

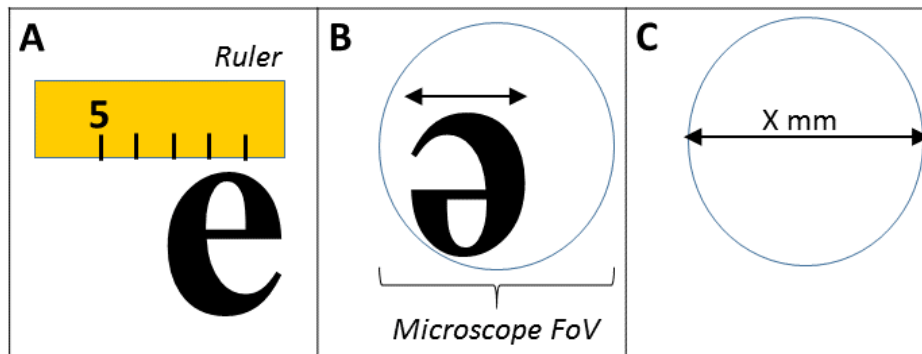


Figure 1: Calibrating a microscope's Field of View (FoV) with a lower-case letter e. Step A: Get a microscope slide that contains the letter e. Before putting the e-slide under the microscope, measure the width of the e with an ordinary ruler. Step B: Put the e-slide under the microscope. Use the lowest-power objective lens. Estimate how much of the FoV is taken up by the e. Step C: Estimate the width of the entire FoV according to how much of it is taken up by the e. Step D: Extrapolate to other magnifications.

Activity 1: Examining Epithelial Tissue Under the Microscope

Examine the slides listed on the worksheet. Compare them to the pictures in your manual.

Group Challenge 1: Identifying Epithelial Tissues

Complete the chart, putting your answers into your worksheet. Identify the mystery tissues.

Activity 2: Examining Connective Tissue Under the Microscope

Examine the slides listed on the worksheet. Compare them to the pictures in your manual.

Activity 3: Examining Nervous Tissue Under the Microscope

Examine the slide listed on the worksheet. Compare it to the picture in your manual.

Activity 4: Examining Muscle Tissue Under the Microscope

Examine the slides listed on the worksheet. Compare them to the pictures in your manual.

Group Challenge 2: Identifying Connective Tissue

Complete the chart, putting your answers into your worksheet. Identify the mystery tissues.

Activity X: Tissue Combos

Examine the slides listed on the worksheet.

Worksheet for Exercise 6 (Classification of Tissues)

Names:

Activity 0

Microscope calibration: use the letter-e slide to complete the table below for your microscope.

Total magnification*				
Width of Field of View				

*total magnification = magnification of eyepiece X magnification of objective lens

Activity 1: Examining Epithelial Tissue Under the Microscope

Tissue/feature	Check if found
Simple squamous epithelium (Bowman's capsule of kidney; Carolina 31-2360) <ul style="list-style-type: none"> • Notice how small the cells are! 	
Simple cuboidal epithelium (kidney tubule; Ward 96-3024)	
Simple columnar epithelium (intestine; Carolina 31-2426) <ul style="list-style-type: none"> • Nuclei • Goblet cells with mucus • Microvilli 	
Pseudostratified columnar ciliated epithelium (trachea; Ward 93-3034) <ul style="list-style-type: none"> • Cilia • Goblet cells with mucus 	
Stratified squamous epithelium (cheek cells; Carolina 31-2534) <ul style="list-style-type: none"> • Notice that these cells look like fried eggs when seen from this angle. 	
Stratified squamous epithelium, keratinized (squirrel foot pad; Flinn ML1290) <ul style="list-style-type: none"> • Layers of dead cells (no nuclei; stuffed with the protein keratin). 	

Name two different locations in the body where you have mucus-secreting goblet cells. What is the function of mucus in each of these locations?

Draw a piece of simple columnar epithelial tissue. Do not draw the entire field of view! Indicate the magnification, scale, and specific identity of the tissue. Label any structures you can identify. Also list any key structural features that are highlighted in the lab manual but that you cannot see under your own microscope.

Group Challenge 1: Identifying Epithelial Tissues

Complete the table below.

Magnified appearance	Tissue type	Locations in the body
<ul style="list-style-type: none"> • Apical surface has dome-shaped cells (flattened cells may also be mixed in) • Multiple layers of cells are present 		
<ul style="list-style-type: none"> • Cells are mostly columnar • Not all cells reach the apical surface • Nuclei are located at different levels • Cilia are located at the apical surface 		
<ul style="list-style-type: none"> • Apical surface has flattened cells with very little cytoplasm • Cells are not layered 		
<ul style="list-style-type: none"> • Apical surface has square cells with a round nucleus • Cells are not layered 		

Identities of “mystery tissues”:

Activity 2: Examining Connective Tissue Under the Microscope

Tissue/feature	Check if found
Adipose tissue (Carolina 31-2704) <ul style="list-style-type: none"> • Cell membrane • Nuclei • Fat droplets 	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
Areolar tissue (fasciae; Ward 93-3224) <ul style="list-style-type: none"> • Fibroblast cells • Collagen fibers • Elastic fibers 	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
Dense regular connective tissue (tendon; Carolina 31-2788) <ul style="list-style-type: none"> • Collagen fibers • Fibroblast cell nuclei 	<input type="checkbox"/> <input type="checkbox"/>
(Yellow) elastic tissue (ligamentum nuchae; Ward 93-3260) – note 2 orientations on 1 slide <ul style="list-style-type: none"> • Elastic fibers (how are they arranged?) 	<input type="checkbox"/> <input type="checkbox"/>
Hyaline cartilage (xiphoid process of sternum; Ward 93-3264) <ul style="list-style-type: none"> • Chondrocytes (cartilage cells) • Lacunae • Matrix 	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
Fibrocartilage (intervertebral disc or pubic symphysis; Carolina 31-2922) <ul style="list-style-type: none"> • Chondrocytes (cartilage cells) • Lacunae • Collagen fibers 	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
Bone (compact, ground; Carolina 31-2964) <ul style="list-style-type: none"> • Lacunae • Canaliculi • Osteocytes (bone cells) • Central canal • Lamellae 	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
Blood (Carolina 31-3158) <ul style="list-style-type: none"> • Red blood cells (RBCs/erythrocytes) • White blood cells (WBCs/leukocytes) • Platelets 	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>

In general, how does the amount of extracellular space in connective tissue compare to that of epithelial tissue? Which of the specific tissues you looked at is an exception to this rule?

Draw a piece of areolar tissue. Do not draw the entire field of view! Indicate the magnification and scale. Label any structures you can identify. Also list any key structural features that are highlighted in the lab manual but that you cannot see under your own microscope.

Group Challenge 2: Identifying Connective Tissue

Complete the table below.

Magnified appearance	Tissue type	Locations in the body
<ul style="list-style-type: none"> • Large, round cells are densely packed • Nucleus is pushed to one side 		
<ul style="list-style-type: none"> • Lacunae (small cavities within the tissue) are present • Lacunae are not arranged in the concentric circle • No visible fibers in the matrix 		
<ul style="list-style-type: none"> • Fibers and cells are loosely packed, with visible space between fibers • Fibers overlap but do not form a network 		
<ul style="list-style-type: none"> • Extracellular fibers run parallel to each other • Nuclei of fibroblasts are visible 		
<ul style="list-style-type: none"> • Lacunae are sparsely distributed • Lacunae are not distributed in a concentric circle • Fibers are visible and fairly organized 		

Identities of “mystery tissues”:

Activity 3: Examining Nervous Tissue Under the Microscope

Tissue/feature	Check if found
Neuron (giant multi-polar motor neurons from gray matter of spinal cord; Carolina 31-3570) <ul style="list-style-type: none"> • Cell body of motor neuron • Nucleus of motor neuron • Dendrites of motor neuron • Axon of motor neuron 	

Draw the nervous tissue provided. Do not draw the entire field of view! Indicate the magnification and scale. Label any structures you can identify. Also list any key structural features that are highlighted in the lab manual but that you cannot see under your own microscope.

Activity 4: Examining Muscle Tissue Under the Microscope

Tissue/feature	Check if found
Skeletal Muscle (Triarch HD2-22) <ul style="list-style-type: none"> • Striations (only visible at high magnification) • Nuclei • Cylindrical muscle cells (fibers) 	
Smooth Muscle (uterus; Carolina 31-3358) <ul style="list-style-type: none"> • Nuclei • Can you tell that the cells are spindle-shaped? 	

Cardiac Muscle (Carolina 31-3424) <ul style="list-style-type: none"> • Intercalated discs (only visible at high magnification) • Striations (only visible at high magnification) • Nuclei 	

Draw the cardiac muscle tissue provided. Do not draw the entire field of view! Indicate the magnification and scale. Label any structures you can identify. Also list any key structural features that are highlighted in the lab manual but that you cannot see under your own microscope.

Activity X: Tissue Combos

Tissue/feature	Check if found
Skin (Carolina 31-4558) <ul style="list-style-type: none"> • Can you find the border between the epithelial tissue and connective tissue? 	
Motor nerve ending with plates (Carolina 31-3864) <ul style="list-style-type: none"> • Can you distinguish the nerve cell from the muscle cells? 	
Muscle-tendon junction (Carolina 31-2806) <ul style="list-style-type: none"> • Can you distinguish the muscle tissue from the connective tissue? 	

Briefly summarize the general functions of epithelial, connective, nervous, and muscle tissues.

EPITHELIAL TISSUE:

CONNECTIVE TISSUE:

NERVOUS TISSUE:

MUSCLE TISSUE:

Review Sheet questions

1.

2.

- _____ 1.
- _____ 2.
- _____ 3.
- _____ 4.
- _____ 5.
- _____ 6.
- _____ 7.
- _____ 8.
- _____ 9.
- _____ 10.
- _____ 11.

22. (Identify tissues – no labels needed).

- (a) (b)
- (c) (d)
- (e) (f)
- (g) (h)
- (i) (j)
- (k) (l)

Exercise 7: The Integumentary System

Goals

- Explore the layers of the integumentary system.
- Define and distinguish between the top and bottom layers of the epidermis (stratum corneum and stratum basale).
- Learn how hair, melanin, sebaceous glands, and sweat glands contribute to the structure and function of the integumentary system.

Materials

- 3D skin models, 2-3 per section
- Compound microscopes, 1 per pair of students
- Prepared microscope slides, 1 set per pair of students, in folders:
 - Human scalp
 - Thin skin with hairs
- Sheet of 20# bond paper, ruled to mark off 1-cm² areas
- Scissors
- Betadine[®] swabs, or Lugol's iodine and cotton swabs
- Adhesive tape
- Color copies of Figure 2 from C.J. Smith & G. Havenith (*European Journal of Applied Physiology* **111**: 1391-1404, 2011), 3-4 per section

Activity 1: Locating Structures on a Skin Model

Do this activity as written.

Activity 2: Identifying Nail Structures

Isn't nail anatomy kind of boring? You can breeze through this section. Just notice the phalanx and cuticle of Figure 7.4.

Activity 3: Comparing Hairy and Relatively Hair-Free Skin Microscopically

Question 1 (multi-part) is hard, but do your best. Write your answers in your worksheet. You may skip question 2.

Activity 4: Differentiating Sebaceous and Sweat Glands Microscopically

Do as written. Answer the (again, somewhat challenging) question on the worksheet.

Activity 5: Plotting the Distribution of Sweat Glands

Do this activity as written.

Activity 6: Taking and Identifying Inked Fingerprints

Skip this activity.

Worksheet for Exercise 7 (The Integumentary System)

Names:

Activity 3: Comparing Hairy and Relatively Hair-Free Skin Microscopically

1.

Activity 4: Differentiating Sebaceous and Sweat Glands Microscopically

1.

Activity 5: Plotting the Distribution of Sweat Glands

Which skin area tested has the greater density of sweat glands?

How do these data compare to those reported by Caroline J. Smith & George Havenith in 2011 (*European Journal of Applied Physiology* 111: 1391-1404). Speculate as to the reasons for any discrepancies.

Review Sheet questions

1.

_____ 1.

_____ 2.

_____ 3.

_____ 4.

2.

a. _____

c. _____

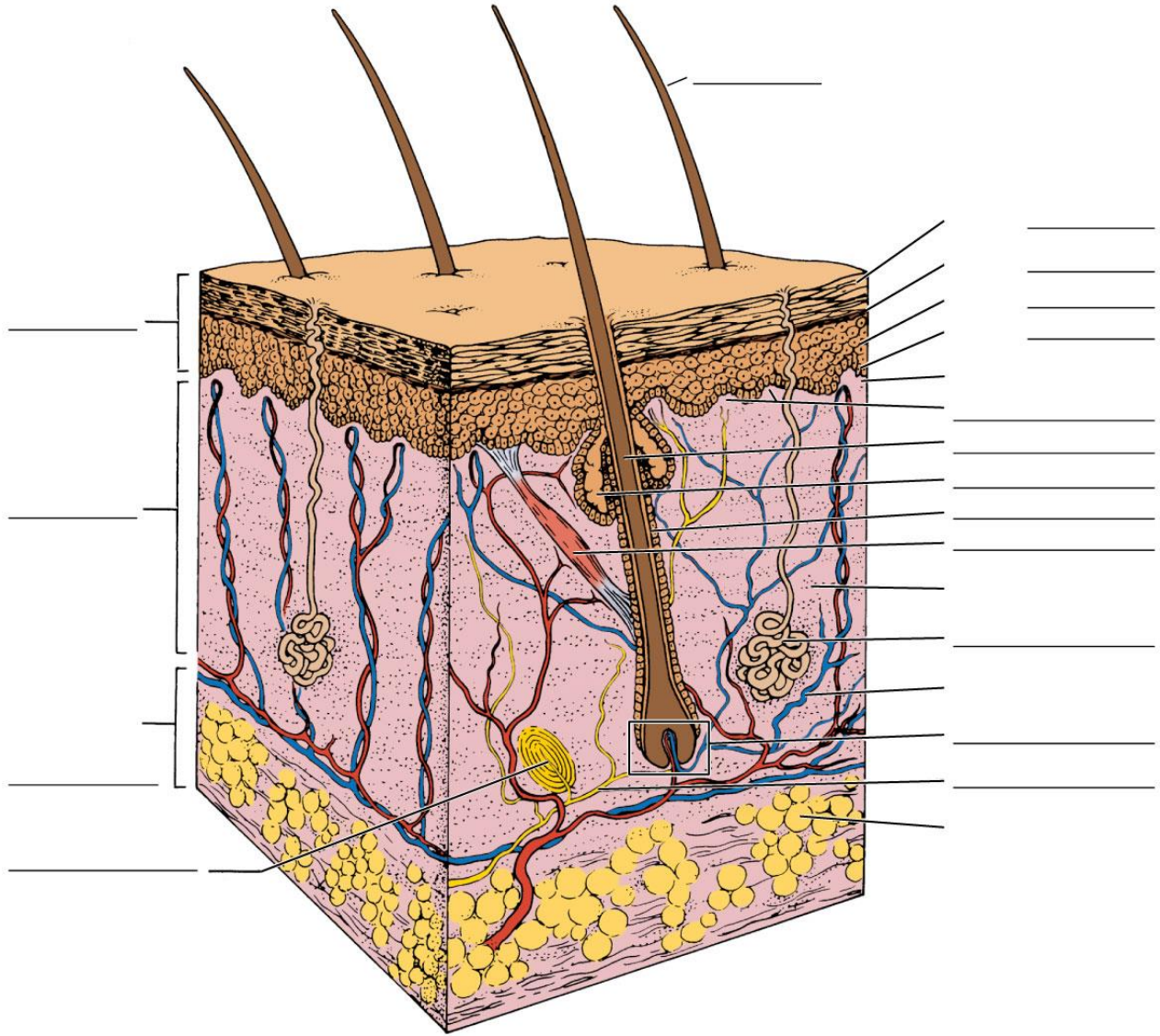
b. _____

d. _____

3.

- _____ 1.
- _____ 2.
- _____ 3.
- _____ 4.
- _____ 5.
- _____ 6.
- _____ 7.
- _____ 8.
- _____ 9.
- _____ 10.
- _____ 11.
- _____ 12.

4. (see next page)



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- a.
- b.
- c.
- d.
- e.
- f.
- g.

5.

6.

7. [2 parts]

8. [2 parts]

9.

_____ 1.

_____ 2.

_____ 3.

_____ 4.

_____ 5.

_____ 6.

_____ 7.

_____ 8.

_____ 9.

_____ 10.

10.

Exercise 8: Overview of the Skeleton

Goals

- Explore similarities and differences between bone and cartilage.
- Gain familiarity with different types of bone markings.
- Review the microscopic structure of bone tissue.
- Learn about endochondral ossification.

Materials

- Split calf femur, 1 per section
- Articulated skeleton, 1 per section
- Box of bones, 1 per section
- Compound microscopes, 1 per pair of students
- Prepared microscope slides, 1 set per pair of students, in folders
 - Ground bone
 - Developing long bone undergoing endochondral ossification

Activity 0

Find one example of each of the following bone markings on a skeleton or bone provided: condyle, crest, epicondyle, fissure, foramen, head, line, meatus, ramus, sinus, spine, trochanter, tubercle, tuberosity. Your lab manual (Exercises 9 and 10) and/or eskeletons.org can help you identify features. Record your examples in your worksheet.

Activity 1: Examining a Long Bone

Complete this activity as described.

Activity 2: Examining the Effects of Heat and Hydrochloric Acid on Bones

Skip this.

Activity 3: Examining the Microscopic Structure of Compact Bone

Revisit your drawing of the microscopic structure of compact bone. Do you notice any additional features this time around? Redo your drawing if appropriate.

Activity 4: Examining the Osteogenic Epiphyseal Plate

Our slide may not look quite like the picture in the lab manual, but draw what you see and label what you draw.

Worksheet for Exercise 8 (Overview of the Skeleton)

Names:

Activity 0

Type of bone marking	Brief description	Example
Condyle		
Crest		
Epicondyle		
Fissure		
Foramen		
Head		
Line		
Meatus		
Ramus		
Sinus		
Spine		
Trochanter		
Tubercle		
Tuberosity		

Activity 4: Examining the Osteogenic Epiphyseal Plate

Draw what you see on the slide. Include labels, scale, and magnification. Also note anything that you hoped to see based on figures in your manual, but couldn't.

Review Sheet

1.

_____ 1.

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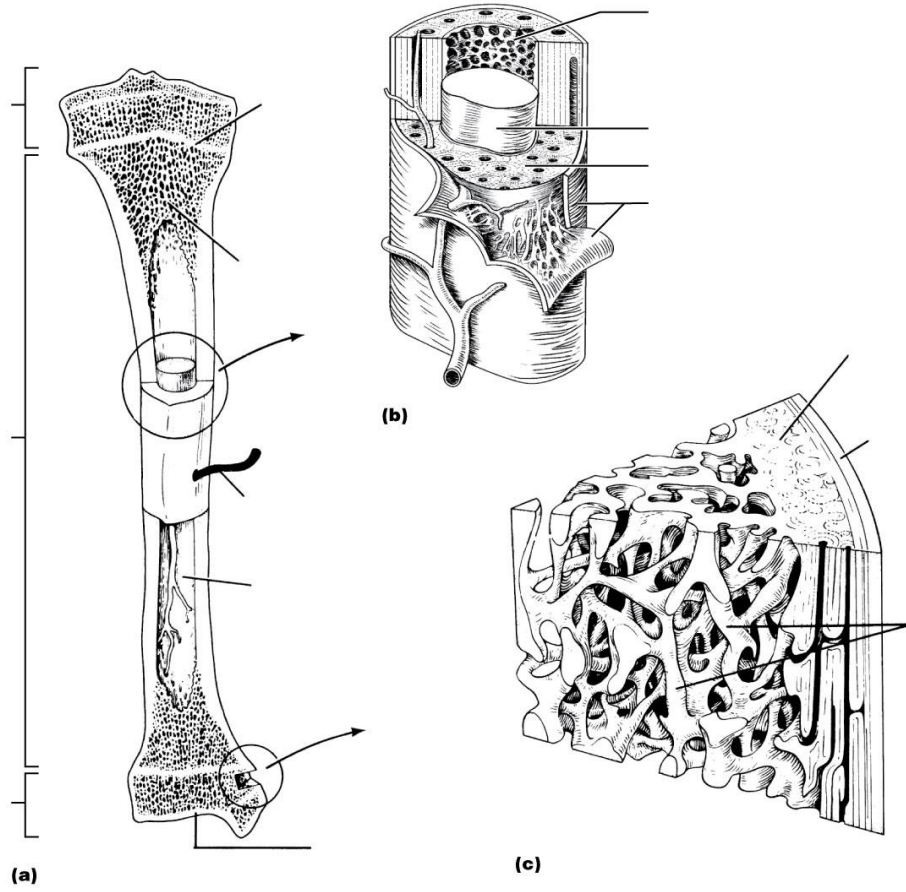
_____ 4.

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6. [see next page]

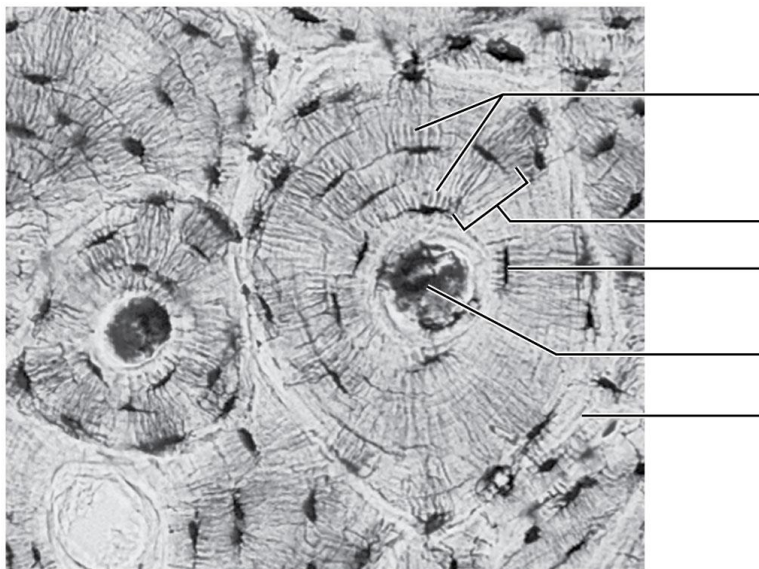


7.

8.

15.

- _____ 1.
- _____ 2.
- _____ 3.
- _____ 4.
- _____ 5.



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Exercise 9: The Axial Skeleton

Goals

- Learn the names and locations of (most of) the bones of the axial skeleton.
- Examine the structure of vertebrae individually and collectively.
- Compare and contrast fetal and adult skulls.

Materials

- Human adult skulls, 2 per section
- Human fetal skull, 1 per section
- Articulated vertebral column, 1 per section
- Articulated skeleton, 1 per section
- *Optional:* X-rays of scoliosis, kyphosis, lordosis, and normal spine

Activity 1: Identifying the Bones of the Skull

There are too many bones and features for you to digest in a single session. Focus on finding the following:

- *Cranial bones*
 - Frontal
 - Occipital
 - Parietal
 - Temporal
- *Facial bones*
 - Ethmoid
 - Mandible
 - Maxilla
 - Nasal
 - Palatine
 - Sphenoid
 - Zygomatic
- *Other bones*
 - Hyoid
- *Holes in bones*

Name of hole – figure	In which bone?	Cranial nerves passing through?
Cribriform foramina (olfactory foramina) – 9.3	Ethmoid	Cranial nerve I
Foramen lacerum – 9.3	[between occipital, sphenoid, and temporal]	[Internal carotid artery]
Foramen magnum – 9.2	Occipital	Cranial nerve XI [and medulla oblongata]
Foramen ovale – 9.3	Sphenoid	Cranial nerves V ₃ , IX

Foramen rotundum – 9.3	Sphenoid	Cranial nerve V ₂
Hypoglossal canal – 9.3a	Occipital	Cranial nerve XII
Inferior orbital fissure – 9.7	[between sphenoid and maxilla]	Cranial nerve V ₂
Infraorbital foramen – 9.7	Maxilla	Cranial nerve V ₂
Internal acoustic meatus – 9.3a	Temporal	Cranial nerves VII, VIII
Jugular foramen – 9.3	[between temporal and occipital]	Cranial nerves IX, X, XI
Mental foramen – 9.7	Mandible	Cranial nerve V ₃
Optic canal (optic foramen) – 9.7	Sphenoid	Cranial nerve II
Superior orbital fissure – 9.7	Sphenoid	Cranial nerves III, IV, V ₁ , VI
Supraorbital foramen – 9.7	Frontal	Cranial nerve V ₁

Group Challenge: Odd Bone Out

Do this activity; write your answers on your worksheet.

Activity 2: Palpating Skull Markings

Do as directed.

Activity 3: Examining Spinal Curvatures

Skip this activity.

Activities 4 (Examining Vertebral Structure), 5 (Examining the Relationship Between Ribs and Vertebrae), and 6 (Examining a Fetal Skull)

Do as directed.

Worksheet for Exercise 9 (The Axial Skeleton)

Names:

Group Challenge: Odd Bone Out

	Which is the "odd bone"?	Why is it the odd one out?
1.		
2.		
3.		

Review Sheet

- 1.
- _____ 1.
 - _____ 2.
 - _____ 3.
 - _____ 4.
 - _____ 5.
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 - _____ 11.
 - _____ 12.
 - _____ 13.
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- _____ 15.
- _____ 16.
- _____ 17.
- _____ 18.
- _____ 19.
- _____ 20.
- _____ 21.
- _____ 22.
- _____ 23.
- _____ 24.
- _____ 25.

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4.

6.

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_____	_____	_____	_____

10.

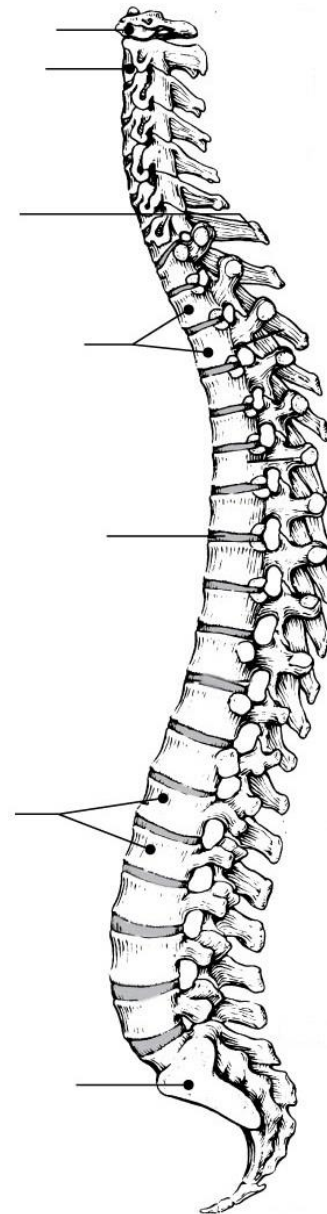
- _____ 1.
- _____ 2.
- _____ 3.
- _____ 4.
- _____ 5.
- _____ 6.
- _____ 7.

12.

14.

15. [2 parts]

17. [don't worry about the curvatures]



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18.

19. [2 parts]

22.

25. [3 parts]

Exercise 10: The Appendicular Skeleton

Goals

- Examine the structure of a developing long bone, focusing on the epiphyseal plate.
- Learn the names and locations of (most of) the bones of the pectoral and pelvic girdles and the limbs.
- View differences between the male pelvis and the female pelvis.

Materials

- Articulated skeleton, one per section
- Disarticulated skeletons, two per section
- Articulated pelvis, male and female

Activities

Do Activities 1 through 6. You will not need to remember the names of individual carpal or tarsal bones except for the calcaneus and talus, nor will you be responsible for most of the bone markings listed. But do try to notice the markings highlighted by the lab manual, focusing especially on the following:

- Acetabulum of the pelvis (formed by ilium, ischium, and pubis)
- Acromion of the scapula
- Anterior border of the tibia
- Glenoid cavity of the scapula
- Iliac crest of the pelvis
- Lateral malleolus (fibula)
- Medial malleolus (tibia)
- Olecranon of the ulna
- Pelvic inlet (pelvic brim) and pelvic outlet
- Pubic arch of the pelvis
- Pubic symphysis of the pelvis

Worksheet for Exercise 10 (The Appendicular Skeleton)

Names:

Review Sheet

1.

_____ 1.

_____ 2.

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_____ 14.

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_____ 16.

_____ 17.

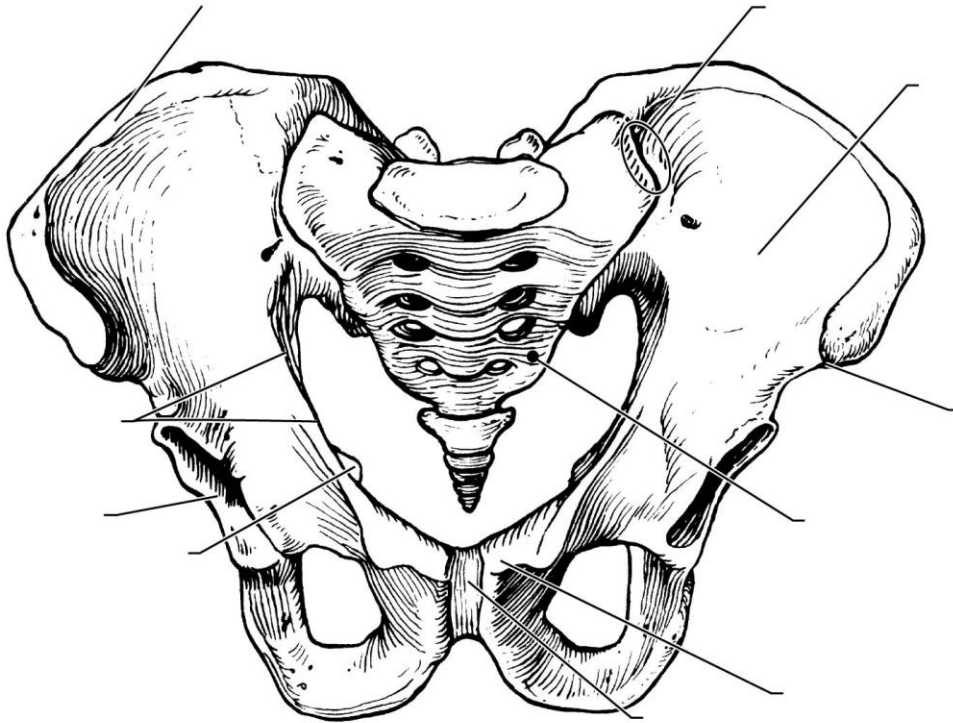
_____ 18.

_____ 19.

7. Pectoral: _____, _____, _____. Pelvic: _____, _____, _____,

8.

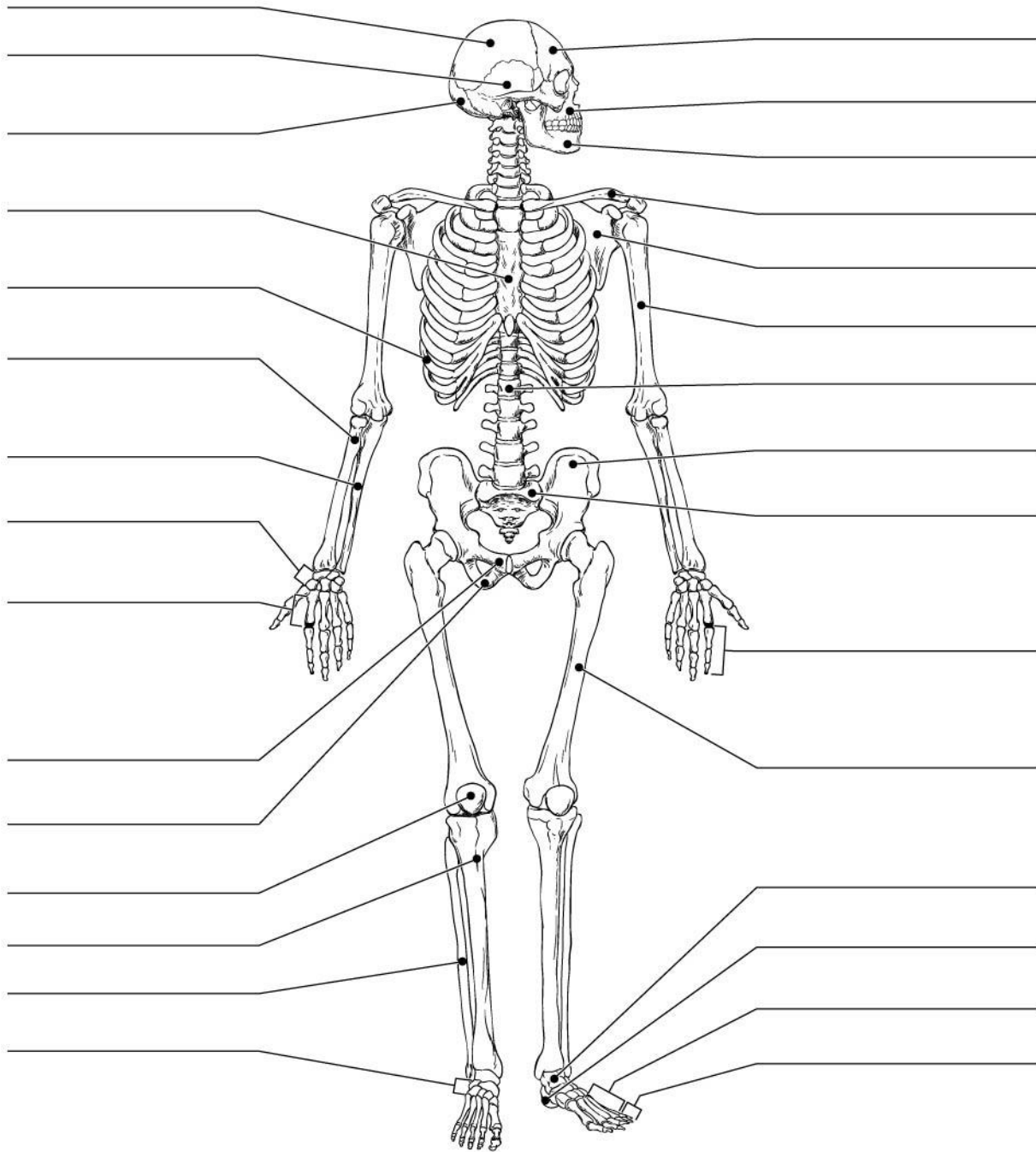
10.



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11.

17.



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Exercise 11: Articulations and Body Movements

Goals

- Distinguish between synarthrotic, amphiarthrotic, and diarthrotic joints.
- Examine the hip, knee, shoulder, and temporomandibular joints.
- Learn terms for describing different kinds of movements at synovial joints.
- Consider medical problems, age-related and otherwise, that can occur at joints.

Materials

- Skulls, 2 per section
- Articulated skeleton, 1 per section
- Functional models of hip, knee, and shoulder joints
- Water balloons and clamps
- X-ray images of normal and arthritic joints

Activities

Please complete Activities 1, 2, and 4 through 9. You may skip Activity 3 and the Group Challenge. Your instructor will provide you with pictures or slides of X-rays of normal and arthritic joints. Can you tell which is which?

Worksheet for Exercise 11 (Articulations and Body Movements)

Names:

Draw a picture of an arthritic joint as seen in an x-ray. Label any distinguishing features.

Activity 4: Demonstrating the Importance of Friction-Reducing Structures

4. [2 parts]

Review Sheet

1. _____ 1.
- _____ 2.
- _____ 3.
- _____ 4.
- _____ 5.
- _____ 6.
- _____ 7.
- _____ 8.
- _____ 9.

2.

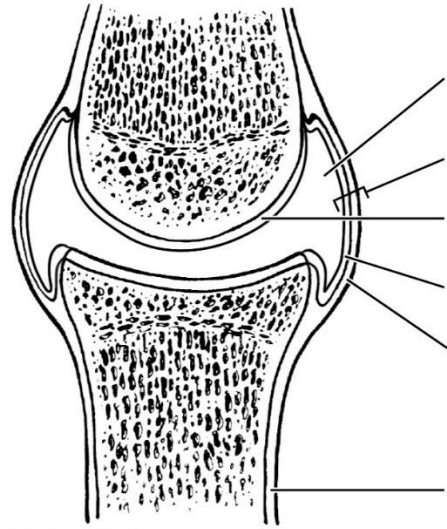
Ligament:

Tendon:

Articular cartilage:

Synovial membrane:

Bursa:



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3.

_____ 1.

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6. [3 parts]

8.

1. _____

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11.

(a) _____ (c) _____ (e) _____

(b) _____ (d) _____

(f) _____ (g) _____ (h) _____

12.

13. [2 parts]

14.

Exercise 13: Gross Anatomy of the Skeletal Muscular System

Goals

- Learn the names and locations of the most prominent, mostly superficial muscles.
- Relate these muscles' locations (origins and insertions) to their functions.

Materials

- Muscular mini-man models, 2 per section
- Muscular arm models, 2 per section
- Muscular leg models, 2 per section
- Articulated skeleton, 1 per section

Activities

Complete Activities 1 through 4, focusing mostly on the “top 32 muscles” listed below but performing all listed “Demonstrating Operations” exercises. Complete the Group Challenge (Name That Muscle). Skip Activities 5 and 6.

The Top 32 Muscles

Bolded information is most important and may be on quizzes or tests. If the name of the muscle is bolded, you may be asked to identify that muscle in a model or diagram.

Facial expression muscles (4)

Muscle	Origin	Insertion	Action	Innervation
Epicranius (frontalis/ occipitofrontalis)	Epicranial aponeurosis	Skin of eyebrows, bridge of nose	Raises eyebrows	Cranial nerve VII (facial nerve)
Orbicularis oculi	Medial margin of orbit	Skin around eyelids	Closes eyes	Cranial nerve VII (facial nerve)
Orbicularis oris	Maxilla and mandible	Lips	Closes lips	Cranial nerve VII (facial nerve)
Zygomaticus	Zygomatic bone	Corners of mouth	Smiling! ☺	Cranial nerve VII (facial nerve)

Chewing muscles (2)

Muscle	Origin	Insertion	Action	Innervation
Masseter	Zygomatic arch [temporal & zygomatic bones], maxilla	Lateral surface of ramus of mandible	Closes jaw (chewing)	Cranial nerve V (trigeminal nerve)

Temporalis	Fossa [shallow depression] of temporal bone	Coronoid process of mandible	Closes jaw (chewing)	Cranial nerve V (trigeminal nerve)
-------------------	---	------------------------------	-----------------------------	------------------------------------

Respiratory muscles (3)

Muscle	Origin	Insertion	Action	Innervation
Diaphragm	Ribs, sternum, lumbar vertebrae	Central tendon	Flattens, increasing thorax volume during inspiration	Spinal nerves C ₃ -C ₅
External intercostals (11 pairs)	Inferior border of rib above	Superior border of rib below	Elevate rib cage during inspiration	Spinal nerves T ₁ -T ₁₁
Internal intercostals (11 pairs)	Superior border of rib below	Inferior border of rib above	Lower rib cage during forced expiration	Spinal nerves T ₁ -T ₁₁

Muscles that cross the shoulder joint (6)

Muscle	Origin	Insertion	Action	Innervation
Biceps brachii	Coracoid process and glenoid cavity of scapula (2 heads)	Tuberosity of anterior proximal radius	Flexes elbow , supinates forearm [palm turns from posterior to anterior]	Spinal nerves C ₅ -C ₆
Deltoid	Lateral clavicle , acromion [lateral, superior] and spine [posterior] of scapula	Deltoid tuberosity of humerus [halfway down, lateral]	Abducts arm (if whole muscle is activated)	Spinal nerves C ₅ -C ₆
Latissimus dorsi	Spinous processes of lower thoracic and lumbar vertebrae, lower ribs, crest of ilium	Intertubercular groove/sulcus of anterior proximal humerus	Extends arm ; adducts and medially rotates arm	Spinal nerves C ₆ -C ₈
Pectoralis major	Inferior medial clavicle; sternum; cartilage of ribs 1-6	Intertubercular groove/sulcus of anterior proximal humerus	Flexes arm ; adducts, and medially rotates arm	Spinal nerves C ₅ -T ₁
Trapezius	Occipital bone; ligamentum nuchae [connects occipital bone & C ₇]; spinous processes of thoracic vertebrae	Acromion [lateral, superior] and spinous process [posterior] of scapula; lateral clavicle	Stabilizes scapula; exact action depends on state of other muscles	Cranial nerve XI (accessory nerve) and spinal nerves C ₃ -C ₄
Triceps brachii	Inferior margin of glenoid cavity of scapula, posterior humerus (3 heads)	Olecranon of posterior ulna	Extends forearm	Spinal nerves C ₆ -C ₈

Other upper-limb muscles (3)

Muscle	Origin	Insertion	Action	Innervation
Brachioradialis	Lateral ridge at distal end of humerus	Lateral styloid process of distal radius	Flexes elbow	Spinal nerves C ₅ -C ₆
Extensor digitorum	Lateral epicondyle of humerus	Distal phalanges	Extends fingers; extends hand; abducts fingers	Spinal nerves C ₇ -C ₈
Flexor carpi radialis	Medial epicondyle of humerus	Base of metacarpals II and III	Flexes wrist; abducts hand	Spinal nerves C ₆ - C ₇

Muscles that cross the hip joint (6)

Muscle	Origin	Insertion	Action	Innervation
Gluteus maximus	Dorsal ilium, sacrum, coccyx	Gluteal tuberosity of posterior proximal femur; iliotibial tract	Extends thigh; rotates and abducts thigh	Spinal nerves L ₅ -S ₂
Hamstrings: Biceps femoris	Tuberosity of inferior ischium ; linea aspera of femur (2 heads)	Head of fibula, lateral condyle of proximal tibia	Extends thigh, flexes knee	Spinal nerves L ₅ -S ₃
Hamstrings: Semimembranosus	Tuberosity of inferior ischium	Medial proximal tibia	Extends thigh, flexes knee	Spinal nerves L ₅ -S ₂
Hamstrings: Semitendinosus	Tuberosity of inferior ischium	Medial proximal tibia	Extends thigh, flexes knee	Spinal nerves L ₅ -S ₂
Quadriceps: Rectus femoris	Ilium: anterior inferior spine and superior rim of acetabulum	Tuberosity of proximal anterior tibia	Extends knee, flexes thigh	Spinal nerves L ₂ -L ₄
Sartorius	Anterior superior spine of ilium	Medial proximal tibia	Flexes, and laterally rotates thigh; flexes knee	Spinal nerves L ₂ -L ₃

Other lower-limb muscles (8)

Muscle	Origin	Insertion	Action	Innervation
Extensor digitorum longus	Lateral condyle of tibia, fibula, interosseous membrane	Middle and distal phalanges of toes 2-5	Extends toes; dorsiflexes foot	Spinal nerves L ₅ -S ₁
Quadriceps: Vastus intermedius	Anterior lateral femur , and linea aspera	Tuberosity of proximal anterior tibia	Extends knee	Spinal nerves L ₂ -L ₄
Quadriceps: Vastus lateralis	Anterior femur distal to greater trochanter, and linea aspera	Tuberosity of proximal anterior tibia	Extends knee	Spinal nerves L ₂ -L ₄

Quadriceps: Vastus medialis	Linea aspera of posterior femur	Tuberosity of proximal anterior tibia	Extends knee	Spinal nerves L ₂ -L ₄
Tibialis anterior	Lateral condyle and upper tibia	Inferior surface of first cuneiform and metatarsal I	Dorsiflexes foot; inverts foot	Spinal nerves L ₄ -S ₁
Tibialis posterior	Superior tibia and fibula, interosseous membrane	Several tarsals and metatarsals	Inverts foot	Spinal nerves L ₄ -L ₅
Triceps surae: Gastrocnemius	Condyles of distal femur	Calcaneus	Plantar-flexes foot; flexes knee	Spinal nerves S ₁ -S ₂
Triceps surae: Soleus	Proximal tibia and fibula, interosseous membrane	Calcaneus	Plantar-flexes foot	Spinal nerves S ₁ -S ₂

Worksheet for Exercise 13 (Gross Anatomy of the Skeletal Muscular System)

Names:

Pre-Lab Quiz

- 1.
- 2.
- 3.
- 4.
- 5.
- 6.
- 7.
- 8.
- 9.
- 10.

Group Challenge: Name That Muscle

Origin	Insertion	Muscle	Primary action
Zygomatic arch and maxilla	Angle and ramus of the mandible		
Anterior surface of ribs 3-5	Coracoid process of the scapula		
Inferior border of rib above	Superior border of rib below		
Distal portion of anterior humerus	Coronoid process of the ulna		
Anterior inferior iliac spine and superior margin of acetabulum	Tibial tuberosity and patella		
By two heads from medial and lateral condyles of femur	Calcaneus via calcaneal tendon		

Exercise 12: Microscopic Anatomy and Organization of Skeletal Muscle

Goal

- Revisit muscle cell anatomy to deepen our understanding of how structures (ew) and extend our knowledge of muscle structure at the gross and microscopic levels.

Materials

- Compound microscopes, 1 per pair of students
- 3D model of skeletal muscle showing neuromuscular junction, 1 per section
- Prepared microscope slides, 1 per pair of students, in folders
 - skeletal muscle (l.s. and x.s. views)
 - motor nerve ending with plates
 - muscle-tendon junction
- Pictures of electron micrographs of mammalian skeletal muscle, mammalian cardiac muscle, and rattlesnake tailshaker muscle, 3-4 sets per section

Directions

Examine the microscope slides, pictures of electron micrographs, and 3D model provided.

Worksheet for Exercise 12 (Microscopic Anatomy and Organization of Skeletal Muscle)

Names:

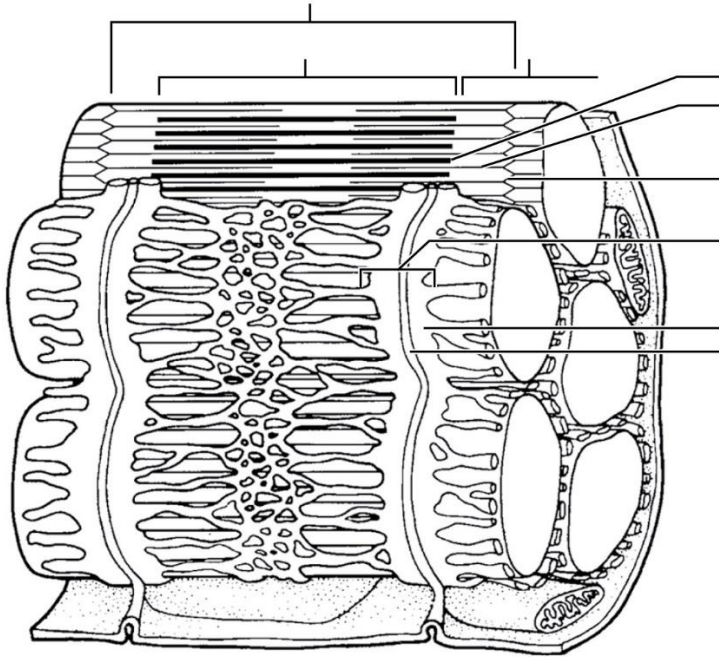
Draw a picture of skeletal muscle tissue, as seen under your microscope. Label a sarcomere and its bands, and say which proteins are found in which bands.

Compare/contrast the pictures of the mammalian skeletal muscle tissue, mammalian cardiac muscle tissue, and rattlesnake tailshaker muscle. How do the structural differences support the functional differences?

Review Sheet

3.

5. [on next page]

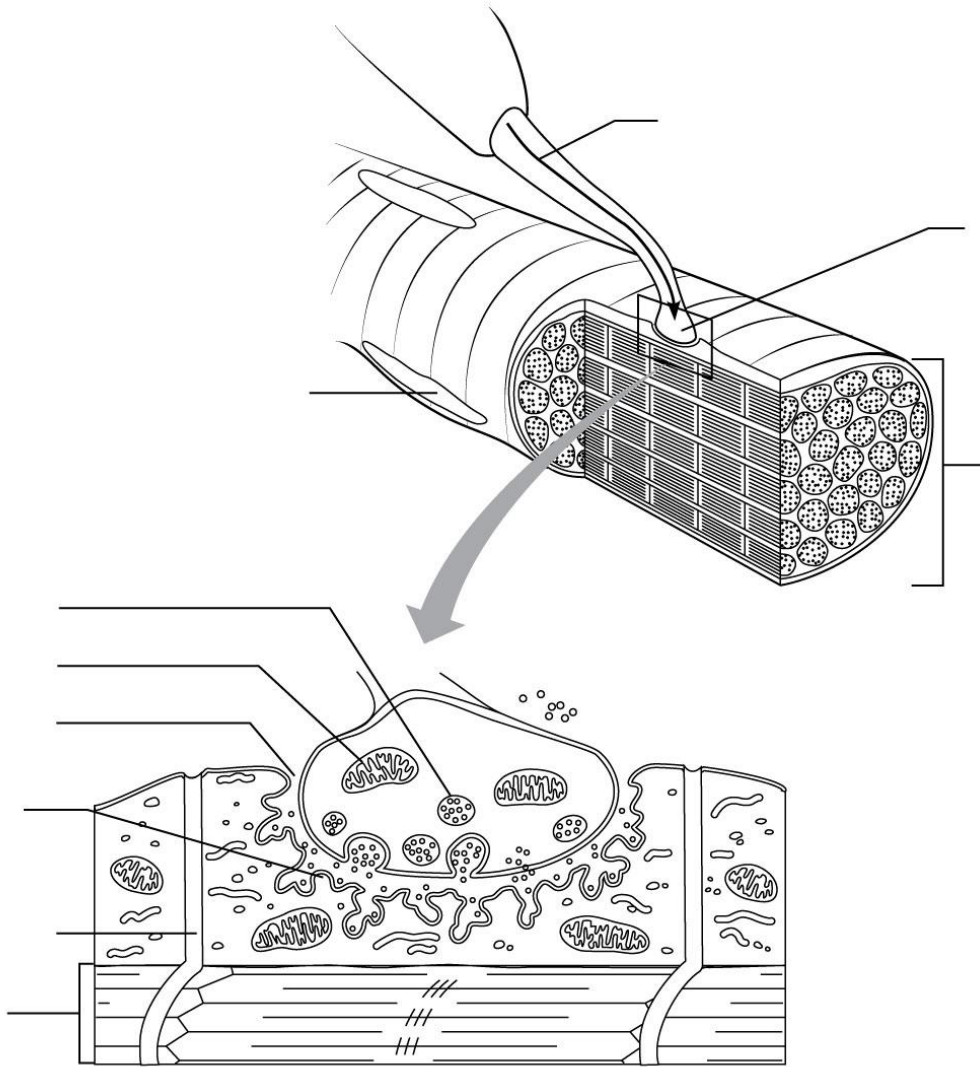


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7.

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3. _____
4. _____
5. _____
6. _____

8. [on next page]



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9.

10.

PhysioEx 2: Skeletal Muscle Physiology

Goals

- Learn what it's like to perform laboratory experiments on an intact isolated muscle (without actually sacrificing an animal).
- Observe excitation-contraction coupling at a macroscopic level.
- Study the relationship between the electrical input to a muscle and the force output.
- Collect and interpret data representing the length-tension and force-velocity curves.

Materials

- Laptop computers, 1 per pair of students.

Instructions

Please complete Activities 1 through 7 of PhysioEx Exercise 2, found on pages PEx-17 through PEx-34 of your lab manual (toward the back).

- Activity 1: The Muscle Twitch and the Latent Period
- Activity 2: The Effect of Stimulus Voltage on Skeletal Muscle Contraction
- Activity 3: The Effect of Stimulus Frequency on Skeletal Muscle Contraction
- Activity 4: Tetanus in Isolated Skeletal Muscle
- Activity 5: Fatigue in Isolated Skeletal Muscle
- Activity 6: The Skeletal Muscle Length-Tension Relationship
- Activity 7: Isotonic Contractions and the Load-Velocity Relationship

Follow the instructions given earlier for PhysioEx 1. Once again, you do not need to answer the questions shown in the lab manual or online; instead, you will submit a brief report for each activity that includes the following sections: Experiment, Hypothesis, Results, Conclusion.

Exercise 14: Skeletal Muscle Physiology: Frogs and Human Subjects

Based on a BBio 352 lab created by Jeff Jensen

("Mammalian hind limb anatomy, locomotion, and electromyography")

Goals

- Interpret the meaning of raw and integrated electromyographic (EMG) recordings.
- Interpret patterns of muscle activity (timing and intensity) in the context of human locomotion.

Materials

- Laptops with LabChart software, 1 per table
- PowerLab with USB cable, 1 per table
- 5 lead shielded Bio Amp cable, 1 per table
- Disposable electrodes, several per table
- Dry earth strap, 1 per table
- Pens/Sharpies, 1 per table

Introduction

When a motor neuron is excited, it passes its signal to skeletal muscle cells at motor end plate, causing action potentials in the muscle cells. These action potentials can be detected outside the cells as voltage fluctuations, just as action potentials in heart muscle cells can be detected as voltage fluctuations. In skeletal muscle, force is regulated by recruiting different numbers and different sizes of motor units, and large motor units generate larger fluctuations (greater amplitudes) than small motor units. Electromyographic (EMG) recordings can be made with electrodes inserted into the muscle using needles, or with surface electrodes attached to the skin. The latter approach is the one we will use in this lab!

Electromyography is used in a variety of research and clinical applications. Anatomy gives only limited information about how muscles are used to generate force and motion. For simple systems performing complex motions, or for complex systems, having information about which muscles are being used, when, and in what combinations, gives much more insight than could be derived from anatomy alone. Even in relatively simple systems, like mammal skulls, patterns of muscle use can be very complicated. In clinical settings, EMGs are used to (1) record nerve conduction velocity (a nerve is stimulated, and the time required for muscle response is recorded), (2) diagnose nerve/muscle deficits (e.g., abnormal recruitment of muscles during walking may indicate muscle or nerve damage), and (3) assess training and rehabilitation (muscle use by athletes can be analyzed and optimized, and patients with nerve damage can have their muscles stimulated to retrain them for waking). An emerging area of EMG work is to record muscle activity and send this information to prostheses, robots, and even video game controllers.

Today we will be doing an EMG experiment that is somewhat similar to Activity 4 (Electromyography in a Human Subject Using BIOPAC), but that uses ADInstruments equipment owned by UW-Bothell. Please follow the directions below rather than the directions in your lab manual, working in groups of 3 or 4.

This experiment will involve several muscles of the lower limb. To review the basic structure and function of these muscles, please complete the worksheet section titled "Basic Anatomy & Physiology of the Lower Limb."

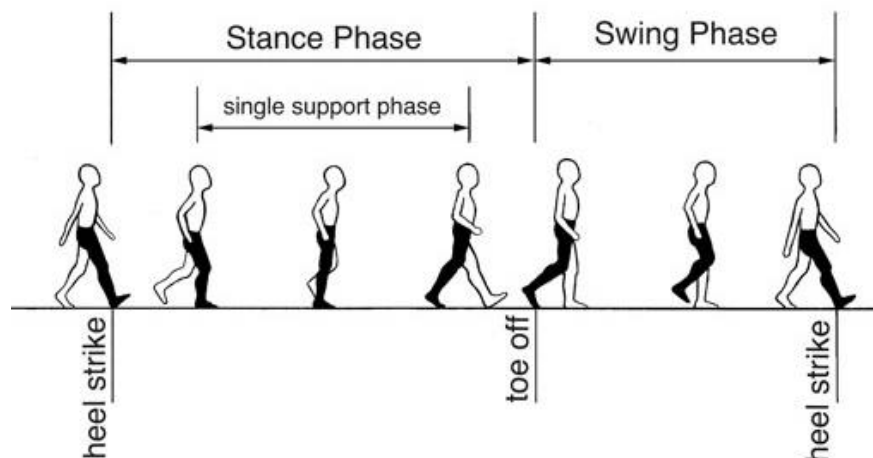
We will now use electromyography to investigate muscle recruitment during locomotion. Many muscles are involved in locomotion, but we will focus on those that are large enough and close enough to the surface for us to easily acquire recordings, and we will choose antagonistic muscles that we might expect to be active during different phases of the stride cycle. The muscles we will investigate are:

- **Upper leg:** Vastus medialis (VM), Biceps femoris (BF)
- **Lower leg:** Tibialis anterior (TA), Gastrocnemius (G)

Preliminary steps

1. Select one person to be the "subject." Since we will be recording through the skin and underlying tissue, a fairly lean subject may give clearer results (but don't make that the primary criterion for choosing a subject).

2. Examine the depiction of the human stride below (taken from "Symptoms in the opposite or uninjured leg" by Ian J. Harrington, 2005). In particular, notice that the stride for the right leg begins with "Heel Strike" when the heel hits the floor, followed by a "Stance Phase" during which some or all of the body weight is supported by the right leg. The stance phase ends when "Toe off" when the right leg loses contact with the ground and begins "Swing Phase" leading, eventually, back to "Heel Strike."



3. Spend some quality time with your subject. Can you identify the four muscles listed above? Based on your knowledge of A&P, when during the stride do you think each of

these muscles will be active? Depict your hypothesis in the “Initial Hypothesis” section of the worksheet.

Equipment setup and electrode attachment

4. Make sure the PowerLab is turned off and the USB cable is connected to the computer.
5. Connect the 5 Lead Shielded Bio Amp Cable to the Bio Amp Connector on the front panel of the PowerLab. The hardware needs to be connected before you open the settings file.
6. Attach the Shielded Lead Wires to the Bio Amp Cable. Channel 1 will lead to one muscle, Channel 2 will lead to the antagonistic muscle, and the Earth (Green) will be connected to the Dry Earth Strap. Attach the Disposable Electrodes to the end of the Channel 1 and Channel 2 wires and the Dry Earth Strap to the end of the Earth wire.
7. Begin with the lower leg. Identify the tibialis anterior and the lateral head of the gastrocnemius. On each of these muscles, use a ballpoint pen to mark two small crosses 2-3 cm apart on the skin above the muscle (see board for guidance). Remember, muscles shorten during contraction. Are you sure that the muscle will be under the two points you have selected during the entire motion?
8. Stick the Disposable Electrodes to the skin. Put the Dry Earth Strap around the volunteer's wrist, with the fuzzy side against the skin.
9. Check that all four electrodes and the Dry Earth Strap are properly connected to the volunteer and the Bio Amp Cable before proceeding. Turn on the PowerLab.

Data collection: tibialis anterior and gastrocnemius

You will be looking at recruitment of these two muscles during the stride cycle. Depending on electrical interference, the strength of your signal, and the mood of the EMG Gods, your signal may be very clear (flat, level baseline with very distinct EMGs during activity) or very noisy (wandering baseline and/or very thick baseline even when the muscle isn't firing, and indistinct signals when it is). Wandering baselines are usually caused by too much movement of the wires (“motion artifact”). We can solve that by holding the wires steady or only doing part of the activity at a time (e.g. record a heel strike, then record mid-stance, then record a toe-off, etc.). Fuzzy baselines are usually caused by poor connections (check all the connections!) and/or electrical interference. If all the connections seem fine and your baseline is still wide, consult your instructor – we may need to adjust electrical filter settings.

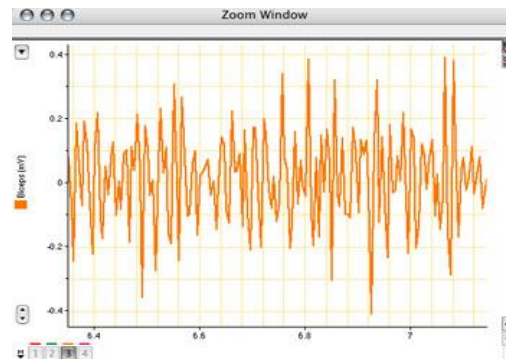
10. Launch LabChart and open the settings file “Voluntary Change Settings” from the **Experiments** tab in the **Welcome Center**. It will be located in the folder for this experiment (Human Electromyography).

Note: Channels 1 and 2 are the integrated activity of the two muscles – this means the area under all the spikes without regard to whether the spikes are above or below the baseline. Integrated activity is used commonly in the assessment of muscle function because it is easier to quantify. Use these two channels when completing your analysis.

11. Select **Bio Amp** from the Channel 3 Channel Function pop-up menu. Have the subject make a strong contraction of the tibialis anterior muscle (try to rotate the front of the foot upwards against resistance). Observe the signal and adjust the range in the dialog so that the maximal electrical response occupies about one half to two-thirds of the full scale.

12. Repeat step 3 for the lateral head of the gastrocnemius signal in Channel 4. In this case, forcefully contract the gastrocnemius by trying to rotate the front of the foot downward into the floor.

13. **Start** recording. Add a **comment** with the volunteer's name. Have the subject go through a stride, and mark heel strike and toe off on the trace. **Stop** recording. Try this a few times until you get the hang of entering comments; you will want to pre-enter a comment like "start," then hit enter right when the stride actually begins. For this experiment, it is vital to mark exactly when the subject starts and ends a cycle so that you can tell when during the cycle the muscles were more active and less active.



Raw EMG signal

Data analysis: tibialis anterior and gastrocnemius

14. Examine the raw EMG data in the Chart View. **Autoscale**, if necessary. Note the changes in activity in the tibialis anterior channel. When during the stride cycle did the tibialis anterior become active? When did it turn off?

15. Select a small part of the muscle activity and examine it in **Zoom Window**. The raw EMG signal is composed of many up-and-down spikes. What do these spikes represent?

16. Examine the data for the lateral head of the gastrocnemius (**Autoscale**, if necessary.) Note the changes in activity. When during the stride cycle did the gastrocnemius become active? When did it turn off? How does this relate to the onset and offset of the tibialis anterior?

17. Look at the integrated activity trace for the two muscles (Channels 1 and 2). Does the intensity of activity seem constant throughout the periods when the muscles are used, or are there periods of more and less intense firing?

18. Summarize the firing patterns of the tibialis anterior and gastrocnemius in the “Data Summary” section of the worksheet.

Data collection and analysis: vastus medialis and biceps femoris

19. Using the methods described above, collect data during the stride for the vastus medialis and biceps femoris.

20. Examine the data for the lateral head of the vastus medialis and the biceps femoris (**Autoscale**, if necessary.) Note the changes in activity. When during the stride cycle did these muscles become active? When did they turn off? How does this relate to the onset and offset of the antagonistic muscle?

21. Look at the integrated activity trace for the two muscles (Channels 1 and 2). Does the intensity of activity seem constant throughout the periods when the muscles are used, or are there periods of more and less intense firing?

22. Summarize the firing patterns of the vastus medialis and biceps femoris in the “Data Summary” section of the worksheet.

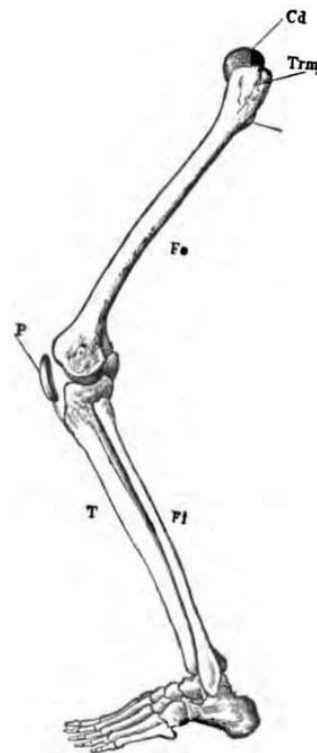
Worksheet for Exercise 14 (Skeletal Muscle Physiology: Frogs and Human Subjects)

Basic Anatomy & Physiology of the Lower Limb

Complete the chart below, then add these muscles to the drawing below the chart. (Get the origins and insertions about right, but complete anatomical realism is not required.)

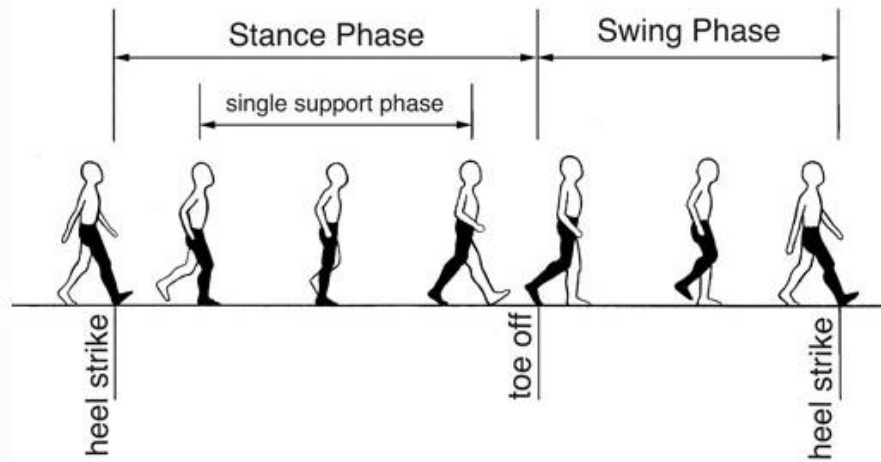
Muscle	Origin	Insertion	Action
Biceps femoris (BF)			
Gastrocnemius (G)			
Semimembranosus (SM)			
Semitendinosus (ST)			
Tibialis anterior (TA)			
Vastus lateralis (VL)			
Vastus medialis (VM)			

Image from *The Human Body: An Elementary Text-Book Of Anatomy, Physiology, And Hygiene* by H. Newell Martin



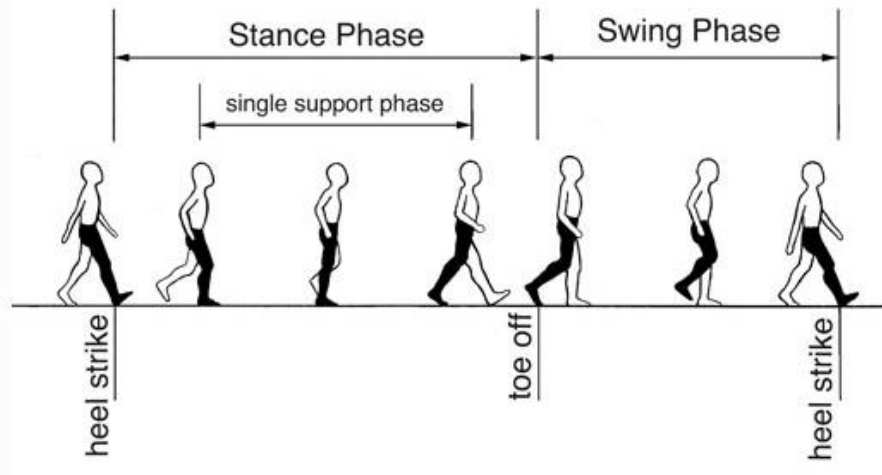
Initial hypothesis

On the diagram below (from Ian J. Harrington, 2005), predict when during the cycle each muscle will be most active.



- Vastus Medialis _____
- Biceps Femoris _____
- Tibialis Anterior _____
- Gastrocnemius _____

Data summary



Vastus Medialis	_____
Biceps Femoris	_____
Tibialis Anterior	_____
Gastrocnemius	_____

Discussion

How well did your hypotheses match your actual data? Describe the most notable discrepancies, if any.

Suggest a possible explanation for any discrepancies between your hypotheses and data.

PhysioEx 3: Neurophysiology of Nerve Impulses

Goals

- To collect and interpret experimental data illustrating to the following key concepts: voltage-gated ion channels, threshold, action potential, refractory period, conduction velocity.
- To understand how the chemicals lidocaine and tetrodotoxin (TTX) alter transmission of signals through the nervous system.
- To trace the spread of messages both within a neuron, via action potentials, and between neurons, via neurotransmitters.

Materials

- Laptop computers, 1 per pair of students.

Instructions

Please complete Activities 3 through 9 of PhysioEx Exercise 3, found on pages PEx-35 through PEx-58 of your lab manual (toward the back).

- Activity 3: The Action Potential: Threshold
- Activity 4: The Action Potential: Importance of Voltage-Gated Na⁺ Channels
- Activity 5: The Action Potential: Measuring Its Absolute and Relative Refractory Periods
- Activity 6: The Action Potential: Coding for Stimulus Intensity
- Activity 7: The Action Potential: Conduction Velocity
- Activity 8: Chemical Synaptic Transmission and Neurotransmitter Release
- Activity 9: The Action Potential: Putting It All Together

Follow the instructions given earlier for PhysioEx 1. Once again, you do not need to answer the questions shown in the lab manual or online; instead, you will submit a brief report for each activity that includes the following sections: Experiment, Hypothesis, Results, Conclusion.

Exercise 19: The Spinal Cord and Spinal Nerves

Goals

- Learn how sensory and motor information enter and exit the spinal cord.
- Become familiar with the plexuses formed by the fusion of ventral rami.
- Observe spinal cord organization in microscope slides and fresh tissue.

Materials

- Spinal cord model (cross section), 1 per section
- Spinal column model, 1 per section
- Torso models, 2 per section
- Laboratory chart of spinal cord and spinal nerves, 1 per section
- Fresh calf spinal column (split), 1 per section
- Prepared microscope slides of spinal cord (c.s.), 1 per pair of students
- Compound microscopes, 1 per pair of students
- Post-It notes, ~30 per table

Activities

Complete Activity 1 (Identifying Structures of the Spinal Cord), the Dissection (Spinal Cord), Activity 3 (Identifying the Major Nerve Plexuses and Peripheral Nerves), and the Group Challenge (Fix the Sequence). Skip Activity 2.

Worksheet for Exercise 19 (The Spinal Cord and Spinal Nerves)

Names:

Dissection: Spinal Cord

3. [2 parts]

Group Challenge: Fix the Sequence

- 1.
- 2.
- 3.
- 4.
- 5.
- 6.
- 7.

Perplexing Plexuses?

Back in Exercise 13, we encountered muscles such as those listed below. For each one, state whether its innervation comes from the cervical plexus, brachial plexus, lumbar plexus, sacral plexus, or none of these.

Muscle	Plexus?
Biceps brachii	
Deltoid	
Diaphragm	

Epicranius	
External and internal intercostals	
Flexor carpi radialis	
Gluteus maximus	
Hamstrings	
Masseter	
Pectoralis major	
Quadriceps	
Triceps surae	
Tibialis anterior	

Review Sheet

1.

_____ 1.

_____ 2.

_____ 3.

_____ 4.

2.

_____ 1. _____ 6. _____ 11.

_____ 2. _____ 7. _____ 12.

_____ 3. _____ 8. _____ 13.

_____ 4. _____ 9. _____ 14.

_____ 5. _____ 10. _____ 15.

3.

_____ 1.

_____ 4.

_____ 2.

_____ 5.

_____ 3.

_____ 6.

4. [2 parts]

5. [3 parts]

6.

10.

11.

12.

cervical nerves: _____

sacral nerves: _____

lumbar nerves: _____

thoracic nerves: _____

13. [4 parts]

14.

_____ 1.

_____ 3.

_____ 2.

Exercise 17: Gross Anatomy of the Brain and Cranial Nerves

Goals

- Locate various superficial and internal brain structures.
- Locate holes in the cranium through which cranial nerves pass.

Materials

- Preserved sheep brains, 1 per pair of students
- Human brain models, 2-3 per section
- Human skulls and pipe cleaners, 2 sets per section
- Wischnitzer & Wischnitzer dissection manuals, 1 per pair of students

Overview of the brain

The brain is super-fascinating but super-complicated! Below is a brief summary of SOME of the major functions of SOME of the major parts. Note that this outline is hierarchical, e.g., the cerebral cortex is part of the cerebrum, the frontal lobe is part of the cerebral cortex, and Broca's area is part of the frontal lobe. **Bold-faced structures are those you will should find in the human brain model and the sheep brain.**

- Brain stem
 - **Medulla oblongata**: controls basic functions like heart rate, blood pressure, and rate of breathing; relays sensory and motor information
 - **Pons**: relays sensory and motor information
 - Midbrain
 - **Corpora quadrigemina**
 - **Superior colliculus**: visual reflex center
 - **Inferior colliculus**: auditory reflex center
 - Substantia nigra: subconscious control of muscle
- **Cerebellum**: subconsciously adjusts posture and movement
- Diencephalon
 - **Thalamus**: relays and processes almost all modalities of sensory information, as well as motor information
 - **Hypothalamus**: regulates body temperature, heart rate, blood pressure, fluid loss, etc. (negative feedback central!)
 - Epithalamus
 - **Pineal gland**: secretes the hormone melatonin
- Cerebral hemispheres
 - Amygdala: influences emotions and their connections to memories
 - Hippocampus: a center for learning and memory
 - **Fornix**: connects the hippocampus with the thalamus via the mammillary body
 - **Cerebral cortex**
 - **Frontal lobe**: includes motor cortex (control of voluntary muscles) and prefrontal cortex (decision-making, problem-solving)

- **Precentral gyrus:** primary motor cortex
- Broca's area: affects speech production
- **Parietal lobe:** perceives touch/pressure, taste, pain, and temperature
 - **Postcentral gyrus:** primary somatosensory cortex (for touch)
- **Temporal lobe:** perceives smells and sounds
 - Wernicke's area: interprets language
- **Occipital lobe:** perceives visual information
- **Corpus callosum:** connects the two cerebral hemispheres
- **Olfactory bulbs:** process olfactory info (smell)

Overview of the cranial nerves

As with the brain, the cranial nerves have complexity well beyond what we have time to cover. Below is a summary that is adequate for our purposes.

#	Name	Sensory? Motor? Both?*	Function**	Passage through the cranium
I	Olfactory	S	Smell	Olfactory foramina in cribriform plate of ethmoid
II	Optic	S	Vision	Optic canal of sphenoid
III	Oculomotor	M	Eye muscles	Superior orbital fissure of sphenoid
IV	Trochlear	M	Eye muscles	Superior orbital fissure of sphenoid
V	Trigeminal	B	Facial senses, chewing	3 branches go through 3 separate holes in the sphenoid: <ul style="list-style-type: none"> • superior orbital fissure (V₁/ophthalmic) • foramen rotundum (V₂/maxillary) • foramen ovale (V₃/mandibular)
VI	Abducens	M	Eye muscles	Superior orbital fissure of sphenoid
VII	Facial	B	Facial expressions, taste	Internal acoustic meatus of temporal bone
VIII	Vestibulocochlear	S	Balance and hearing	Internal acoustic meatus of temporal bone
IX	Glossopharyngeal	B	Salivary glands and taste	Jugular foramen (between temporal and occipital bones)
X	Vagus	B	Parasympathetic innervation of visceral organs	Jugular foramen (between temporal and occipital bones)
XI	Accessory	M	Back and neck muscles	Jugular foramen (between temporal and occipital bones)
XII	Hypoglossal	M	Moving the tongue	Hypoglossal canal of occipital bone

*Different sources report this column differently, depending on their thresholds for calling a nerve "both" rather than purely sensory or purely motor.

**Functions are reported in the highly condensed format of Dr. C's "Cranial Nerve Functions" song (<http://faculty.washington.edu/crowther/Misc/Songs/cranial.shtml>).

Activities

Do Activities 1 (Identifying External Brain Structures) and 2 (Identifying Internal Brain Structures). Focus on finding the structures listed in bold type in the “Overview of the Brain” section above. Skip Activity 3.

Dissection: The Sheep Brain

Follow the directions in the manual. You can skip steps 1 and 2 of the *Dorsal Structures* section. Focus on finding the structures listed in bold type in the “Overview of the Brain” section above, as well as the following:

- **Optic nerve/optic chiasm/optic tract**
- **Oculomotor nerve**
- **Septum pellucidum** (structure #2 in Review Sheet question #5; separates the two lateral ventricles, which contain cerebrospinal fluid)

Once you have finished your dissection, your instructor will ask you to identify a few structures as a check on your work.

Bonus Activity: Cranial Nerve Openings

Get a model of a human skull. Find the cranial nerve openings listed in the table above, consulting Figures 9.3 and 9.7 as needed. These openings are how the cranial nerves get into and out of the brain! You can mark the openings with pipe cleaners. Once you have found the openings listed, your instructor will ask you to identify a few of them as a check on your work.

Worksheet for Exercise 17 (Gross Anatomy of the Brain and Cranial Nerves)

Names:

Dissection: The Sheep Brain

Ventral Structures

1. [2 parts]

Dorsal Structures

4.

Internal structures

2. [2 parts]

Instructor's initials, indicating successful completion of dissection exercise: _____

Instructor's initials, indicating successful completion of cranial nerve exercise: _____

Group Challenge: Odd (Cranial) Nerve Out

1. Which is the "odd" nerve? Optic nerve (II) Oculomotor nerve (III) Olfactory nerve (I) Vestibulocochlear nerve (VIII)	Why is it the odd one out?
2. Which is the "odd" nerve? Oculomotor nerve (III) Trochlear nerve (IV) Abducens nerve (VI) Hypoglossal nerve (XII)	Why is it the odd one out?
3. Which is the "odd" nerve?	Why is it the odd one out?

Facial nerve (VII) Hypoglossal nerve (XII) Trigeminal nerve (V) Glossopharyngeal nerve (IX)	
--	--

Review Sheet

1.

_____ 1.

_____ 2.

_____ 3.

_____ 4.

_____ 5.

_____ 6.

_____ 7.

_____ 10.

_____ 8.

_____ 11.

_____ 9.

_____ 12.

2.

10.

11.

12.

13. [2 parts]

16. [add diagram]

Exercise 21: Human Reflex Physiology

Goals

- Perform several simple tests of reflexes that are clinically informative.
- Trace the basic neuronal pathways underlying these reflexes.
- Consider the adaptive value of these reflexes.

Materials

- Reflex hammers, 2-3 per section
- Sharp pencils, 1 per table
- Absorbent cotton (sterile), 1 bag per section
- Tongue depressors
- Mini-flashlights, 1 per table
- 100-mL or 250-mL beakers, 1 per table
- 10-mL or 25-mL graduated cylinder, 1 per table
- Lemon juice in dropper bottle, 1 per table
- Wide-range pH paper, several pieces per table

General directions

Perform Activities 1 through 8 as described, except for the modifications noted below. Record your answers to the questions in the activities in the worksheet.

Activity 1: Initiating Stretch Reflexes

Skip step 4 (the effect of fatigue).

Activity 2: Initiating the Crossed-Extensor Reflex

Set up so that *either* hand of the subject might be pricked, so that they don't anticipate the prick!

Activities 3-5

Perform these as described in the manual.

Activity 6: Initiating Pupillary Reflexes

Don't worry about trying to measure pupil size in millimeters; just describe any changes that occur.

Activities 7-8

Perform these as described in the manual.

Worksheet for Exercise 21 (Human Reflex Physiology)

Names:

Activity 1: Initiating Stretch Reflexes

1. [3 parts]

2. [2 parts]

3.

5. [2 parts]

Activity 2: Initiating the Crossed-Extensor Reflex

[3 parts]

Activity 3: Initiating the Plantar Reflex

[2 parts]

Activity 4: Initiating the Corneal Reflex

[2 parts]

Activity 5: Initiating the Gag Reflex

Activity 6: Initiating Pupillary Reflexes

3.

4.

Activity 7: Initiating the Ciliospinal Reflex

[4 parts]

Activity 8: Initiating the Salivary Reflex

1. [2 parts]

2. [3 parts]

3. [3 parts]

Review Sheet

1.

2.

3.

6.

10.

12.

Exercise 24: Special Senses: Visual Tests and Experiments

June 22, 2016

Goals

- Perform relatively simple experiments such as those used in eye clinics (Activities 1-7).
- Relate the results of these experiments to lecture material on the fundamental anatomy and physiology of the visual system.

Instructions

Complete Activities 1 through 7 as described in your lab manual. Answer all interspersed questions on your lab worksheet.

- Activity 1: Demonstrating the Blind Spot
 - Switch the cross and the dot when you switch eyes!
- Activity 2: Determining Near Point of Accommodation
- Activity 3: Testing Visual Acuity
 - Do this activity as early in the lab period as you can, since we only have one or two Snellen eye charts. Don't look at the Snellen eye chart until you are ready to test one eye at a time.
- Activity 4: Testing for Astigmatism
- Activity 5: Testing for Color Blindness
 - Do this activity as early in the lab period as you can, since we only have one set of Ishihara's color plates.
- Activity 6: Testing for Depth Perception
- Activity 7: Demonstrating Reflex Activity of Intrinsic and Extrinsic Eye Muscles

Worksheet for Exercise 24 (Special Senses: Visual Tests and Experiments)

Names:

Activity 1: Demonstrating the Blind Spot

2. Right eye:

Left eye:

Activity 2: Determining Near Point of Accommodation

Near point for right eye:

Near point for left eye:

Activity 3: Testing Visual Acuity

4. Visual acuity, right eye without glasses:

Visual acuity, right eye with glasses:

Visual acuity, left eye without glasses:

Visual acuity, left eye with glasses:

Activity 4: Testing for Astigmatism

Is astigmatism present in your left eye?

Right eye?

Activity 5: Testing for Color Blindness

3. [2 parts]

Activity 6: Testing for Depth Perception

2.

Activity 7: Demonstrating Reflex Activity of Intrinsic and Extrinsic Eye Muscles

[6 parts]

Review Sheet

5. [5 parts]

8. [3 parts]

9.

10. [3 parts]

11. [3 parts]

12. [3 parts]

Exercise 25: Special Senses: Hearing and Equilibrium

June 27, 2016

Goals

- Learn anatomy of the auditory and vestibular systems, using a 3D model and diagrams (Activity 1).
- Perform simple clinical tests of hearing and balance (Activities 4, 5, and 7).
- Relate the results of these tests to lecture material on the fundamental anatomy and physiology of the auditory and vestibular systems.

Instructions

Complete Activities 1, 4, 5, and 7 as described in your lab manual. Answer all interspersed questions on your lab worksheet.

- Activity 1: Identifying Structures of the Ear
- Activity 4: Conducting Laboratory Tests of Hearing
 - Activity 4 includes the Weber and Rinne tests.
 - The Weber test determines whether hearing is equally good/bad on both sides, or whether one side is worse than the other. You can use the 256-Hertz tuning fork for this test.
 - The Rinne test determines whether conduction of sound through the air is better than conduction through bone, which should be the case unless there is conductive hearing loss. The 512-Hertz tuning fork is fine for this test
- Activity 5: Audiometry Testing
 - Do this activity as early as you can during the lab period; we only have one audiometer. You may want to retreat from the lab room to a quieter location such as the hallway.
 - Our audiometer only tests some of the frequencies and loudnesses shown on the chart on page 390.
- Activity 7: Conducting Laboratory Tests on Equilibrium

Worksheet for Exercise 25 (Special Senses: Hearing and Equilibrium)

Names:

Activity 1: Identifying Structures of the Ear

[nothing to fill in]

Activity 4: Conducting Laboratory Tests of Hearing

Acuity Test [3 parts]

Sound Localization [3 parts]

Frequency Range of Hearing [2 parts]

Weber Test to Determine Conduction and Sensorineural Deafness [1 part]

Rinne Test for Comparing Bone- and Air-Conduction Hearing [3 parts]

Activity 5: Audiometry Testing

		Frequency (Hertz)			
		500	1000	2000	4000
Loudness (decibels)	0				
	10				
	20				
	30				
	40				
	50				

Activity 7: Conducting Laboratory Tests on Equilibrium

Balance Tests

1. [3 parts]

2. [3 parts]

3.

Barany Test (Induction of Nystagmus and Vertigo) [1 part]

Romberg Test

2.

3.

4. [5 parts]

Role of Vision in Maintaining Equilibrium [2 parts]

Review Sheet

1.

_____, _____, _____ 1.

_____, _____, _____ 2.

_____, _____, _____ 3.

_____ 4.

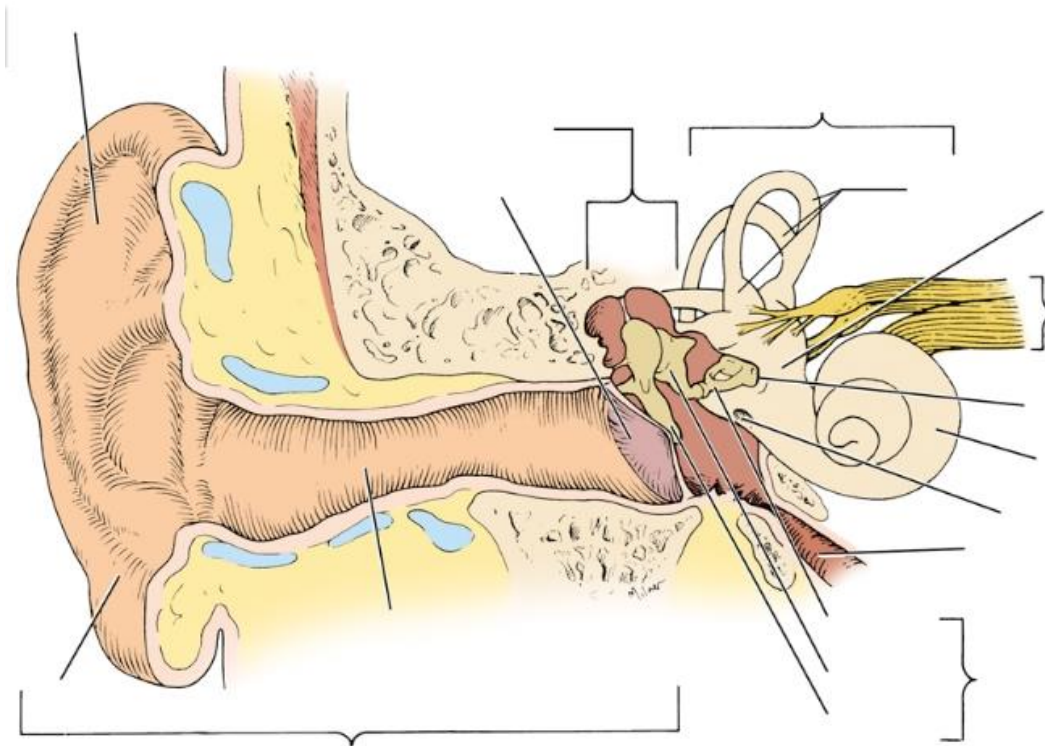
_____ 5.

_____, _____ 6.

_____ 7.

- _____ 8.
- _____ 9.
- _____ 10.
- _____ 11.

4.



6.

7.

8.

9.

12.

14.

- _____ 1.
- _____ 2.
- _____ 3.
- _____ 4.
- _____ 5.
- _____ 6.

15.

Dissection Exercise 3: Identification of Selected Endocrine Organs of the Cat June 29, 2016

Goals

- Prepare the cat for observation by opening the ventral body cavity (Activity 1).
- Identify and name the major endocrine organs on a dissected cat (Activity 2).

Safety

Come to lab dressed appropriately: long hair under control, long pants or long skirt, shoes that fully protect the feet.

Instructions

Complete Activity 1 (Opening the Ventral Body Cavity) and Activity 2 (Identifying Organs). After you have found the endocrine organs, your instructor will verify a couple of randomly chosen examples.

General dissection tips

- Use reference pictures from your lab manual, dissection manuals, and/or the Internet to help you find what you're looking for.
- Once you enter the body cavity, use the scalpel and scissors sparingly. When possible, push things around with the blunt probe rather than cutting.
- Use the spray bottles to keep the interior of the cat moist.
- Use your personal fume hoods to control odors.
- Take breaks inside and/or outside the lab as needed.
- Take turns with your lab partner, so that both of you get to "drive" with the dissection tools and "navigate" with the anatomical "maps."
- You are welcome to take pictures for study purposes, but please do not share on social media. Sketching is optional, but very helpful for some people.

Worksheet for Dissection Exercise 3 (Identification of Selected Endocrine Organs of the Cat)

Names:

Instructor's initials, indicating successful identification of endocrine organs: _____

Dissection Review

1.

2.

3.

4.

5.

PhysioEx Exercise 4: Endocrine System Physiology

Due July 5, 2016

Goals

- To understand the relationships between Thyrotropin Releasing Hormone (TRH), Thyroid Stimulating Hormone (TSH), and the thyroid hormones triiodothyronine (T₃) and thyroxine (T₄) (Activity 1).
- To understand how metabolic rate is measured (Activity 1).
- To determine the effects of pituitary or thyroid gland perturbations on metabolic rate (Activity 1).
- To estimate patients' plasma glucose levels based on a standard curve (Activity 2).
- To understand the relationships between insulin, glucose, and diabetes mellitus (Activity 2).
- To see how sex hormones like estrogen affect bone density, and how bone density can be measured and reported (Activity 3).

Instructions

Please do Activities 1 through 3 of PhysioEx Exercise 4 ("Endocrine System Physiology"), found on pages PEx-59 through PEx-74 in your lab manual:

- Activity 1: Metabolism and Thyroid Hormone
- Activity 2: Plasma Glucose, Insulin, and Diabetes Mellitus
- Activity 3: Hormone Replacement Therapy

Log in to MasteringAandP.com, select "Study Area (myA&P)," select "PhysioEx 9.1," click on the blue text link ([PhysioEx 9.1](#)), and do the online simulations described in the manual.

You do NOT need to turn in answers to the questions shown in your lab manual or online. Instead, for each activity, type or write a brief report with the following labeled components:

- **EXPERIMENT**
 - In about 2-4 sentences, describe the experiment that was done. (What was the basic setup? What variable was manipulated? What responses were measured?) If the experiment was similar to that in a previous activity, you can say, "This was similar to Activity X, except that...." Use correct units (millimeters, millivolts, seconds, etc.).
- **HYPOTHESIS**
 - Before you perform the experiment, predict how the key data will come out. You will not be graded on the correctness of your prediction, but generating predictions will help maximize your learning.

- RESULTS
 - What key data (quantitative and/or qualitative) were generated from this experiment? Use correct units (millimeters, millivolts, seconds, etc.). You do not need to include every table or graph generated by the website, but do show me the most important bits (either summarized in the website's format, or presented in your own format) and briefly explain them to me. If you are using figures or tables generated automatically by the website, you may include screen captures, but please crop them for simplicity/clarity, as needed. Please do not take photographs of your computer screen with your phone, as the resolution will not be good.

- CONCLUSION
 - In about 2-3 sentences, state whether the data fit your prediction, and what conclusions you can draw. Conclusions relate directly to the data but go beyond reporting them. Try to explain (briefly) any key connections between the experiment and material we are covering in lecture. Why are the data important or interesting?

Your lab manual and the PhysioEx program should have all of the information that you need, but you are also welcome to consult outside sources. Please cite any outside sources that you do use, and please use quotation marks when appropriate.

Exercise 29: Blood

July 6, 2016

Goals

- Observe general properties of plasma (Activity 1).
- Microscopically examine your own blood (Activities 2-3).
- Measure hematocrit and hemoglobin concentration (Activities 4-5).
- Measure the time it takes blood to clot (Activity 6).
- Perform ABO blood typing (Activity 7).

Safety

Come to lab dressed appropriately: long hair under control, long pants or long skirt, shoes that fully protect the feet.

Note the “ALERT: Special precautions when handling blood” section on page 424. You will be handling (small amounts of) your own blood, so these precautions apply to you! For UW-Bothell labs, any sharp objects contaminated with blood (used lancets, used microscope slides) should go in the red biohazard sharps container. Any non-sharp bloody material (cotton balls, paper, swabs, toothpicks) should go into regular biohazardous waste (an autoclave bag). We do not use bleach for the disposal of these items, despite what the lab manual says.

Instructions

Perform the following activities. Record all data and answer all questions within each activity, with the exceptions noted below.

- Activity 1: Determining the Physical Characteristics of Plasma
- Activity 2: Examining the Formed Elements of Blood Microscopically
- Activity 3: Conducting a Differential WBC Count
 - You do not need to do a formal count of the white blood cells. Just scan your slide and determine which WBC types are most common.
- Activity 4: Determining the Hematocrit
- Activity 5: Determining Hemoglobin Concentration
 - Use the Tallquist method, not a hemoglobinometer.
- Activity 6: Determining Coagulation Time
- Activity 7: Typing for ABO and Rh Blood Groups
 - Do ABO typing but not Rh typing.

Worksheet for Exercise 29 (Blood)

Names:

Activity 1: Determining the Physical Characteristics of Plasma

pH of Plasma [1 part]

Color and Clarity of Plasma [2 parts]

Consistency [1 part]

Activity 2: Examining the Formed Elements of Blood Microscopically

[nothing to fill in]

Activity 3: Conducting a Differential WBC Count

Which WBC type(s) appear(s) to be most common in your blood?

Activity 4: Determining the Hematocrit

Show your calculations and your results for % RBC, % WBC, and % plasma.

Activity 5: Determining Hemoglobin Concentration

_____ g/100 mL of blood

_____ % Hb

Activity 6: Determining Coagulation Time

[2 parts]

Activity 7: Typing for ABO and Rh Blood Groups

Clumping with anti-A antibody?

Clumping with anti-B antibody?

Blood type =

Review Sheet

1. [2 parts]

2.

6.

14.

15. [2 parts]

17. [5 parts]

18. [2 parts]

19. [2 parts]

Exercise 30: Anatomy of the Heart

July 11, 2016

Goals

- Identify and name the chambers, valves, and major blood vessels of the heart (Activity 1 and Dissection).
- Trace the flow of blood into, through, and out of the heart (Activity 2).
- Understand the major differences between the pulmonary and systemic circuits.

Safety

Come to lab dressed appropriately: long hair under control, long pants or long skirt, shoes that fully protect the feet.

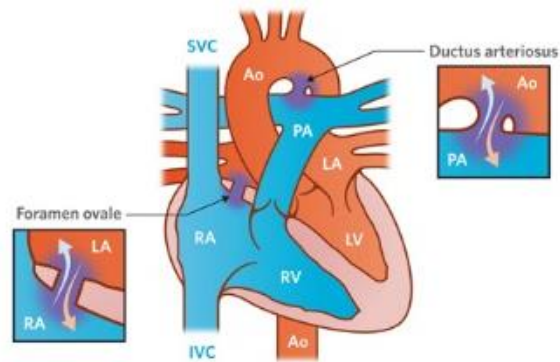
Instructions

Perform the following activities, answering all questions within each activity aside from the exceptions noted below.

- Activity 1: Using the Heart Model to Study Heart Anatomy
 - Use the model hearts embedded in the large human torso models. Focus on the following structures:
 - 4 chambers (what are their names?)
 - 4 valves (what are their names?)
 - chordae tendinae
 - superior and inferior venae cavae (plural of vena cava)
 - pulmonary trunk/arteries
 - pulmonary veins
 - aorta
- Activity 2: Tracing the Path of Blood Through the Heart
 - You may find this easier to do with a light-gray version of 11th Marieb Figure 30-2b, such as that shown below.
- Activity 3: Using a Heart Model to Study Circulation
 - We will not examine the cardiac circulation in detail. Find the left coronary artery, right coronary artery, and coronary sinus on the human torso model heart.
- Dissection: The Sheep Heart
 - We will use calf hearts rather than sheep hearts.
 - To orient yourself, note that (A) the vena cava is generally of a darker color than the other blood vessels and (B) the apex (the pointy bottom of the heart) is part of the left ventricle.
 - The aorta and pulmonary arteries can be hard to distinguish because they are sort of intertwined. You can cut the connective tissue in between them, then insert a blunt probe into them to determine the chambers to which they connect.
 - You do not need to answer the questions following steps 2, 3, and 10.
 - Focus especially on the structures listed above (Activity 1), plus...

- brachiocephalic trunk
- ductus arteriosus (prenatal) / ligamentum arteriosum (postnatal)
- foramen ovale (prenatal) / fossa ovalis (postnatal)
 - should be near opening of coronary sinus
- After you have finished, your instructor will verify a couple of randomly chosen examples of cardiac anatomy.

The heart of a newborn, showing the ductus arteriosus and foramen ovale. Ao = aorta; IVC = inferior vena cava; LA = left atrium; LV = left ventricle; PA = pulmonary artery; RA = right atrium; RV = right ventricle; SVC = superior vena cava. Figure from the Royal Children's Hospital, Melbourne, Australia.



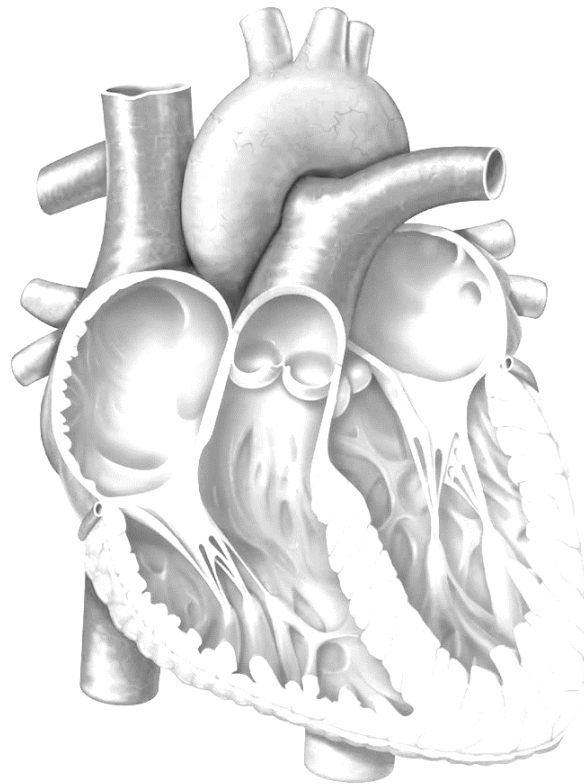
Worksheet for Exercise 30 (Anatomy of the Heart)

Names:

Activity 1: Using the Heart Model to Study Heart Anatomy

[nothing to fill in]

Activity 2: Tracing the Path of Blood Through the Heart



Activity 3: Using a Heart Model to Study Circulation

[nothing to fill in]

Dissection: The Sheep Heart

6. [2 parts]

8. [3 parts]

9.

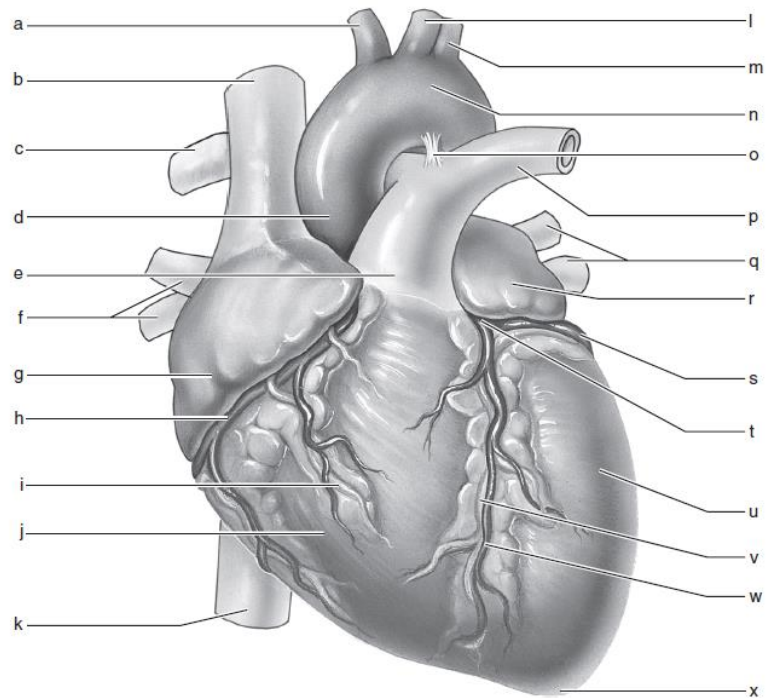
14. [6 parts]

Instructor's initials, indicating successful identification of cardiac structures: _____

Review sheet

1.

- _____ 1. right atrium
- _____ 2. right ventricle
- _____ 3. left atrium
- _____ 4. left ventricle
- _____ 5. superior vena cava
- _____ 6. inferior vena cava
- _____ 7. ascending aorta
- _____ 8. aortic arch
- _____ 9. brachiocephalic trunk
- _____ 10. left common carotid artery
- _____ 11. left subclavian artery
- _____ 12. pulmonary trunk
- _____ 13. right pulmonary artery
- _____ 14. left pulmonary artery
- _____ 15. ligamentum arteriosum
- _____ 16. right pulmonary veins
- _____ 17. left pulmonary veins
- _____ 18. right coronary artery
- _____ 19. anterior cardiac vein
- _____ 20. left coronary artery



- _____ 21. circumflex artery
- _____ 22. anterior interventricular artery
- _____ 23. apex of heart
- _____ 24. great cardiac vein

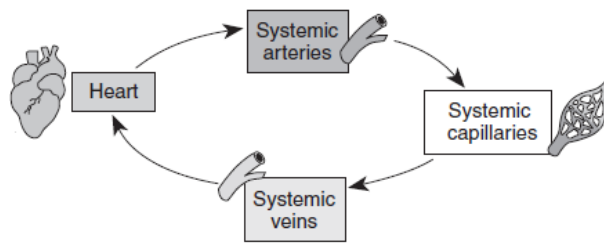
4.

5.

6.

A simple schematic of general circulation is shown below. Which circuit is missing from this diagram?

_____ Add to the diagram as best you can to make it depict the two circuits. Label the two circuits.



8.

Right atrium through the tricuspid valve to the _____, through the _____ valve to the pulmonary trunk, to the _____, to the capillary beds of the lungs, to the _____, to the _____ of the heart, through the _____ valve to the _____, through the _____ valve to the _____, to the systemic arteries, to the _____ of the tissues, to the systemic veins, to the _____, _____, and _____ entering the right atrium of the heart.

16.

Exercise 31: Conduction System of the Heart and Electrocardiography July 13, 2016

Goals

- Practice collecting an electrocardiogram (ECG or EKG) on a human volunteer (Activities 2-3).
- Use software to quantify the amplitude and duration of ECG components (Activities 4-5).
- Relate the electrical (muscle depolarization), mechanical (muscle contraction), and acoustical (heart sounds) events of the heart to each other (Activities 4-5).

Instructions

Rather than following the lab manual's instruction, we will use the alternate instructions provided below, which are specifically for our ADInstruments equipment.

Activity 1: Equipment Setup and Electrode Attachment

1. Make sure the PowerLab is turned off and the USB cable is connected to the computer.

2. Connect the 5 Lead Shielded Bio Amp Cable to the Bio Amp Connector on the front panel (Figure 1). The hardware needs to be connected before you open the settings file.

3. Attach the Shielded Lead Wires to the Bio Amp Cable. Channel 1 positive will lead to the left wrist, Channel 1 negative will lead to the right wrist, and the Earth will lead to the right leg. Attach the Disposable Electrodes to the end of the Channel 1 and Earth wires. Refer to Figure 1 for proper placement. Follow the color scheme on the Bio Amp Cable. Remove any jewelry from the volunteer's hands, arms, and right leg and stick the Disposable Electrodes to the skin (Figure 1).

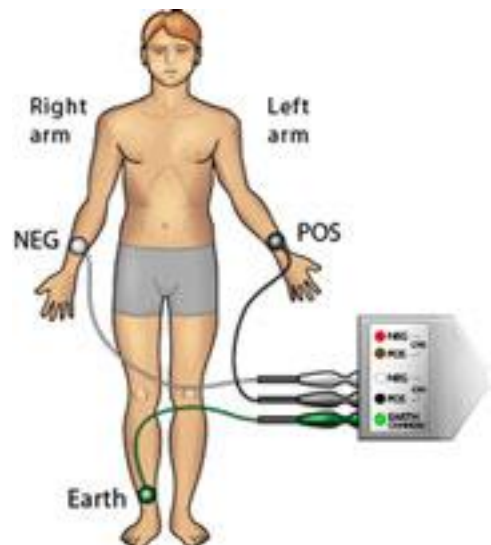


Figure 1: Electrode Placement
(figure by ADInstruments)

Note: Do not place the electrodes over the major muscles because muscle activity interferes with the signal recorded from the heart.

4. Check that all three electrodes are properly connected to the volunteer and the Bio Amp Cable before proceeding. Turn on the PowerLab, then launch the Lab Chart software and, from the Welcome screen, open the Heart Sounds Settings file (Experiments/HumanPhysiology/ECG_and_Heart_Sounds/Settings_files/Heart_Sounds_settings).

Activity 2: Resting ECG

1. Have the volunteer assume a relaxed position.
2. **Start** recording. Add a **comment** with "Resting ECG." Record the ECG for one minute.
3. Save your data when you are finished recording. Do not close the file.

Activity 3: ECG and Phonocardiography

In this exercise, you will use a Cardio Microphone placed over the chest wall to record the heart sounds, which allows the heart sounds to be displayed graphically in real time. (Note: We have stethoscopes if you want to listen directly as well.)

1. Connect the Cardio Microphone to Input 1 on the front panel of the PowerLab (Figure 2). The hardware needs to be connected before you open the settings file.
2. Open the settings file "Phonocardiography Settings" from the **Experiments** tab in the **Welcome Center**. It will be located in the folder for this experiment.

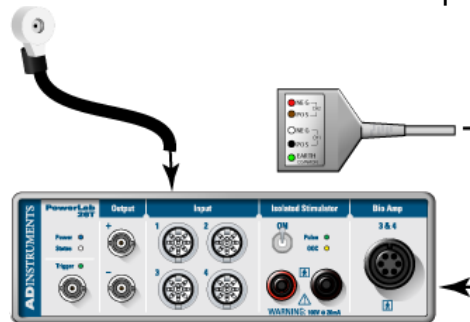


Figure 2: Equipment Setup for PowerLab 26T (figure by ADInstruments)

3. Have the volunteer place the Cardio Microphone on the left side of the chest against the skin.
 4. **Start** recording. Move the Cardio Microphone to get the best signal possible. When ready, **Stop** recording, and tape down the Cardio Microphone.
- Note:** It is important to tape down the Cardio Microphone instead of holding it as the hand introduces considerable noise into the recording.
5. Have the volunteer sit in a relaxed position, facing away from the monitor. Remind the volunteer not to move during the recording.
 6. When ready, **Start** recording. Record for 15 seconds, and **Stop**. Save your data.

Activity 4: Analysis of ECG in a Resting Volunteer

1. Examine the data in the Chart View. Use the **View Buttons** to set the horizontal compression to 5:1. Scroll through the data to observe the regularly occurring ECG cycles.
2. Use the **Marker** and **Waveform Cursor** to measure the amplitudes and durations of four P waves, QRS complexes, and T waves from the ECG trace.
 - To measure the amplitudes, place the **Marker** on the baseline immediately before the P wave. Then move the **Waveform Cursor** to the peak of the wave.
 - To measure the durations, place the **Marker** at the start of the wave or complex and position the **Waveform Cursor** at the end of the wave or complex.
3. Record these values in the table in your worksheet, and find the mean amplitude and duration for each phase of the cycle.
4. Use the **View Buttons** to set the horizontal compression to 10:1. Measure the time interval (in seconds) between three pairs of adjacent R waves using the **Marker** and **Waveform Cursor** (R-R time interval). For each interval, calculate the heart rate using the following equation:

$$\text{heart rate (beats per minute)} = \frac{60}{R - R \text{ time interval (sec)}}$$

5. Record these values in your worksheet.

Activity 5: Analysis of ECG and Phonocardiography

1. Examine the data in the Chart View, and **Autoscale**, if necessary. Note the relationship between the R wave and the first heart sound.
2. Place the **Marker** on the R wave, and place the **Waveform Cursor** on the beginning of the first heart sound. Note the time between these two events as shown at right.
3. Repeat steps 1 and 2 for the T wave and its relationship with the second heart sound.
4. Record these values in the worksheet table.

Worksheet for Exercise 31 (Conduction System of the Heart and Electrocardiography)

Names:

Activity 4: Analysis of ECG in a Resting Volunteer

1. Data table: ECG deflection waves

		Amplitude (mV)	Duration (s)
P Wave	1		
	2		
	3		
	4		
Mean			
QRS Complex	1		
	2		
	3		
	4		
Mean			

2. What does the P wave amplitude represent?

3. How much does P wave amplitude vary from beat to beat?

4. Is this similar to the variation one would expect in skeletal muscle EMG recordings? Why or why not?

5. Data table: heart rate

	R-R time interval (sec)	Heart rate (beats/min)
Pair 1		
Pair 2		
Pair 3		
Pair 4		
		Average heart rate:

Activity 5: Analysis of ECG and Phonocardiography

1. Data table: heart sounds

R wave to first sound (sec)	T wave to second sound (sec)

2. What do the sounds in the phonocardiograph represent?

3. How are they related to the electrical events of the heart? That is, how do the electrical events directly or indirectly lead to the heart sounds?

PhysioEx 6: Cardiovascular Physiology

Due July 18, 2016

Goals

- Compare and contrast the action potential of a cardiac muscle cell with that of a typical neuron (Activity 1).
- Compare and contrast the refractory period of a cardiac muscle cell with that of a typical neuron (Activity 1).
- Contrast the effects of the sympathetic nervous system and parasympathetic nervous system on the heart (Activities 2 and 4).

Instructions

Please complete Activities 1-2 and 4-5 of PhysioEx Exercise 6, found on pages PEx-93 through PEx-104 of your lab manual (toward the back).

- Activity 1: Investigating the Refractory Period of Cardiac Muscle
- Activity 2: Examining the Effect of Vagus Nerve Stimulation
- Activity 4: Examining the Effects of Chemical Modifiers on Heart Rate
- Activity 5: Examining the Effects of Various Ions on Heart Rate

Follow the instructions given for previous PhysioEx assignments. You do not need to answer the questions shown in the lab manual or online; instead, you will submit a brief report for each activity that includes the following sections: Experiment, Hypothesis, Results, Conclusion.

Exercise 32 (Anatomy of Blood Vessels) + Dissection Exercise 4 (Dissection of the Blood Vessels of the Cat) July 18, 2016

Goals

- Understand how the cross-sectional structures of arteries, capillaries, and veins reflect their functions (Exercise 32, Activity 1).
- Review and extend your knowledge of the mammalian heart and the vessels that connect directly to it (dissection).
- Find and name some of the large mammalian blood vessels (dissection).

Safety

Come to lab dressed appropriately: long hair under control, long pants or long skirt, shoes that fully protect the feet.

Instructions for Exercise 32

Do Activity 1, in which you will look at a microscope slide of a cross-section of arteries, capillaries, and veins.

Instructions for Dissection Exercise 4

Your lab manual splits the anatomy into separate sections for the heart, arteries, and veins. We will instead organize our search for structures according to regions of the body. Please make your best effort to locate each of the structures listed below. Once you have identified all the structures that you can, your instructor will ask you to point out a couple of them. You are not responsible for structures not listed below.

To identify unknown blood vessels, consider the “road map” approach, in which a road’s branchpoints (intersections/exits), orientation (e.g., north-south or east-west), size, and labeling (red = arteries, blue = veins) all provide clues.

Thorax: the heart

- Heart: atria and ventricles
- Pulmonary trunk
- Aorta
- Superior vena cava
- Inferior vena cava

Thorax: additional stuff

- Lungs
- Branches of the vena cava
 - Azygos vein
 - Internal thoracic vein
 - Vertebral veins
- Branches of the aortic arch
 - Brachiocephalic artery (1st branch)
 - Left subclavian artery (2nd branch)
- Intercostal arteries

Neck

- Brachiocephalic veins
- Branches of the brachiocephalic veins
 - Jugular veins
 - Subclavian veins
- Common carotid arteries

Abdomen

- Vena cava
- Renal vein
- Common iliac vein
- Abdominal aorta

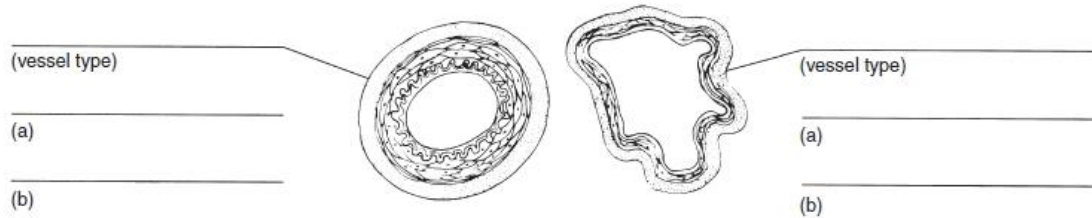
Worksheet for Exercise 32 (Anatomy of Blood Vessels) + Dissection Exercise 4 (Dissection of the Blood Vessels of the Cat)

Names: _____

Exercise 32 Review Sheet

1.

Cross-sectional views of an artery and of a vein are shown here. Identify each; on the lines to the sides, note the structural details that enabled you to make these identifications:



Now describe each tunic more fully by selecting its characteristics from the key below and placing the appropriate key letters on the answer lines.

Tunica intima _____ Tunica media _____ Tunica externa _____

Key:

- | | |
|---|---|
| <ul style="list-style-type: none"> a. innermost tunic b. most superficial tunic c. thin tunic of capillaries | <ul style="list-style-type: none"> d. regulates blood vessel diameter e. contains smooth muscle and elastin f. has a smooth surface to decrease resistance to blood flow |
|---|---|

Dissection Exercise 4 Review Sheet

4. [4 parts]

Instructor's initials, indicating successful identification of blood vessels: _____

Blood Vessel Nomenclature

Many blood vessels' names might seem mysterious, but are actually based on terms that you have already learned! To drive home that point, for the following vessels, please list a bone or surface anatomy term from BBio 241 that indicates where the vessels go! The first two are done for you as examples.

Blood vessel name	Related bone or surface anatomy term
Brachial artery/vein	brachial (surface anatomy term referring to the arm)
Femoral artery/vein	femur (thigh bone)
Iliac arteries/veins	
Median cubital vein	
Median sacral artery/vein	
Popliteal artery/vein	
Radial artery/vein	
Subclavian artery/vein	
Subscapular artery/vein	
Sural artery/vein	
Tibial arteries/veins	
Transverse scapular vein	
Ulnar artery/vein	

Exercise 33: Human Cardiovascular Physiology: Blood Pressure and Pulse Determinations

July 20, 2016

Goals

- Practice taking pulses by hand and listening to heart sounds (Activities 1-2).
- Practice taking blood pressure readings (Activity 5).
- Investigate post-exercise pulse rate as an indicator of physical fitness (Activity 7).

Instructions

Perform the following activities, answering all questions within each activity aside from any exceptions noted below.

- Activity 1: Auscultating Heart Sounds
- Activity 2: Palpating Superficial Pulse Points
- Activity 5: Using a Sphygmomanometer to Measure Arterial Blood Pressure Indirectly
- Activity 7: Observing the Effect of Various Factors on Blood Pressure and Heart Rate
 - Only do the *Exercise* portion of this activity (Harvard step test).
 - Only record pulse data, not blood pressure data.
 - The lab manual's formula for calculating the index of physical fitness is confusing. Use the one provided in the worksheet (below) instead.

Worksheet for Exercise 33 (Human Cardiovascular Physiology: Blood Pressure and Pulse Determinations)

Names:

Activity 1: Auscultating Heart Sounds

3. [2 parts]

4.

Activity 2: Palpating Superficial Pulse Points

[7 parts]

Activity 5: Using a Sphygmomanometer to Measure Arterial Blood Pressure Indirectly

4.

5.

6.

Activity 7: Observing the Effect of Various Factors on Blood Pressure and Heart Rate

Each member of your group should try the step test.

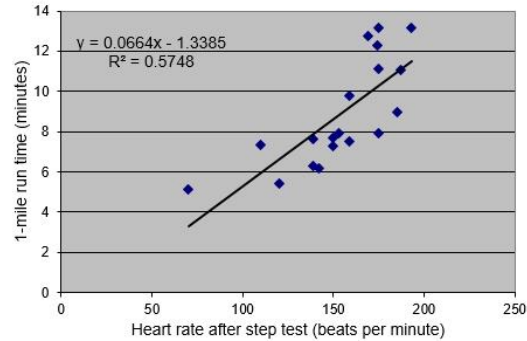
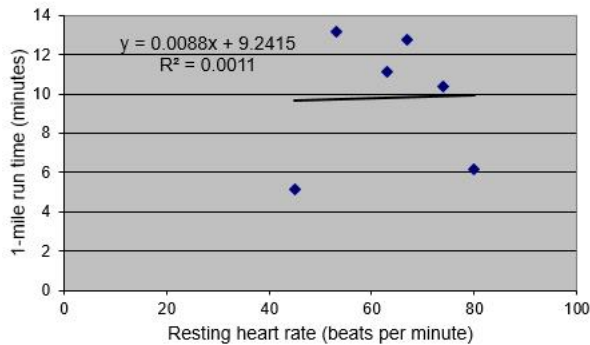
Name	Resting heart rate (beats per minute)	Exercise duration (up to 300 sec)	Heart-beats, 1:00-1:30 post-exercise	Heart-beats, 2:00-2:30 post-exercise	Heart-beats, 3:00-3:30 post-exercise	Index of physical fitness*	Interpretation of index (see p. 505)

$$* \text{ Index} = \frac{100 * (\text{exercise duration in seconds})}{2 * (\text{sum of post-exercise pulse counts})}$$

Supplement to Activity 7:Which is a better indicator of fitness, resting heart rate or post-exercise heart rate?

It should make sense that the lower your heart rate is after a standardized exercise, the fitter you probably are. However, fitter people also tend to have lower *resting* heart rates than unfit people. Can we just use resting heart rate as an indicator of fitness, and skip the step test altogether?

In a previous lab taught at UW-Seattle, students did a step test and then later a timed 1-mile run. Below are graphs showing correlations between resting heart rate and mile run performance, and between post-exercise heart rate and mile run performance.



Based on these data, which heart rate – at rest, or after the step test – is a better predictor of 1-mile run time? Explain.

Review Sheet

1. _____ 1.
- _____ 2.
- _____ 3.
- _____ 4.
- _____ 5.
- _____ 6.

- _____ 7.
- _____ 8.
- _____ 9.
- _____ 10.
- _____ 11.
- _____ 12.
- _____ 13.
- _____ 14.

2. [3 parts]

3. [10 parts]

5. [2 parts]

7.

1. _____

2. _____

3. _____

4. _____

5. _____

6. _____

7. _____

9. [3 parts]

20.

21. [3 parts]

22.

23. [2 parts]

PhysioEx 7: Respiratory System Mechanics

Due August 1, 2016

Goals

- Measure respiratory volumes such as tidal volume (TV or V_T), Residual Volume (RV), Forced Vital Capacity (FVC), and Forced Expiratory Volume in 1 second (FEV_1) (Activity 1).
- Determine how emphysema and asthma affect normal respiratory measurements (Activity 2).
- Explain how surfactant affects lung function (Activity 3).
- Explain how negative intrapleural pressure keeps the lungs inflated (Activity 3).

Instructions

Please complete Activities 1-3 of PhysioEx Exercise 7, found on pages PEx-105 through PEx-117 of your lab manual (toward the back).

- Activity 1: Measuring Respiratory Volumes and Calculating Capacities
- Activity 2: Comparative Spirometry
- Activity 3: Effect of Surfactant and Intrapleural Pressure on Respiration

Follow the instructions given for previous PhysioEx assignments. You do not need to answer the questions shown in the lab manual or online; instead, you will submit a brief report for each activity that includes the following sections: Experiment, Hypothesis, Results, Conclusion.

Exercise 37: Respiratory System Physiology (adapted from a BBio 352 lab by Jeff Jensen)

July 27, 2016

Goals

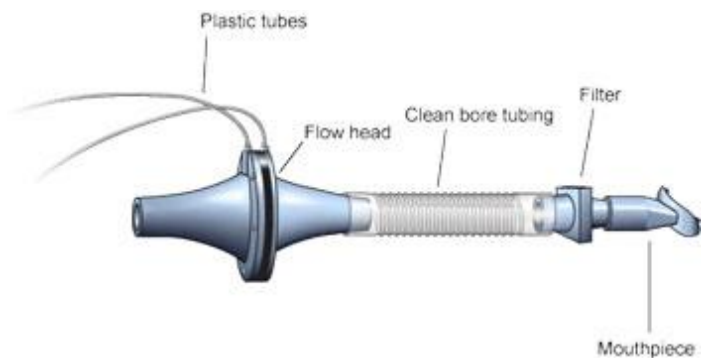
- Collect spirometric data (Activities 2 and 4).
- Measure respiratory parameters such as tidal volume (V_T or V_T), Residual Volume (RV), Forced Vital Capacity (FVC), and Forced Expiratory Volume in 1 second (FEV_1) (Activities 3 and 5).
- Explain how spirometry might be used to distinguish between obstructive lung disease and restrictive lung disease.

Background

Many important aspects of lung function can be determined by measuring airflow and the corresponding changes in lung volume. In the past, this was commonly done by breathing into a bell spirometer, in which the level of a floating bell tank gave a measure of changes in lung volume. Flow, F , was then calculated from the slope (rate of change) of the volume, V ($F = dV/dt$).

More conveniently, airflow can be measured directly with a pneumotachometer (from Greek roots meaning “breath speed measuring device”). The PowerLab pneumotachometer is shown in Figure 1.

Figure 1: The PowerLab Pneumotachometer. All figures for this lab are by ADInstruments.



Several types of flow measuring devices are available; the one you will use today is a “Lilly” type that measures the difference in pressure on either side of a mesh membrane with known resistance. This resistance gives rise to a small pressure difference proportional to flow rate. Two small plastic tubes transmit this pressure difference to the Spirometer Pod, where a transducer converts the pressure signal into a changing voltage that is recorded by the PowerLab and displayed in the Flow channel of LabChart (the top/red channel of Figure 8 below). The volume is then calculated from the flow. Specifically, volume is the area under the flow-time curve, i.e., the integral of flow over time ($V = \int F dt$).

A complication in the volume measurement is caused by differences between inhaled air (which starts off at the temperature of the environment) and exhaled air (which is at body temperature). Gas expands with warming; therefore, you will breathe out a larger *volume* of air even though you are not breathing out more *molecules* of air. The volume of air expired can also be increased by humidification (adding water vapor), which happens in the alveoli. Computer software corrections can correct the data to show what it would look like at constant temperature and humidity.

Spirometry allows many components of pulmonary function to be visualized, measured, and calculated (Figure 2). Respiration consists of repeated cycles of inspiration followed by expiration. During the respiratory cycle, a volume of air is drawn into and then expired from the lungs; this volume is the tidal volume (V_T or V_T). In normal ventilation, the breathing frequency (f) is approximately 15 respiratory cycles per minute. This value varies with the level of activity. The product of f and V_T is the expired minute volume (VE), the amount of air exhaled in one minute of breathing. This parameter also changes according to the level of activity. Even when a person exhales completely, there is still air left in the lungs. This leftover air is the residual volume (RV), which cannot be measured by spirometry.

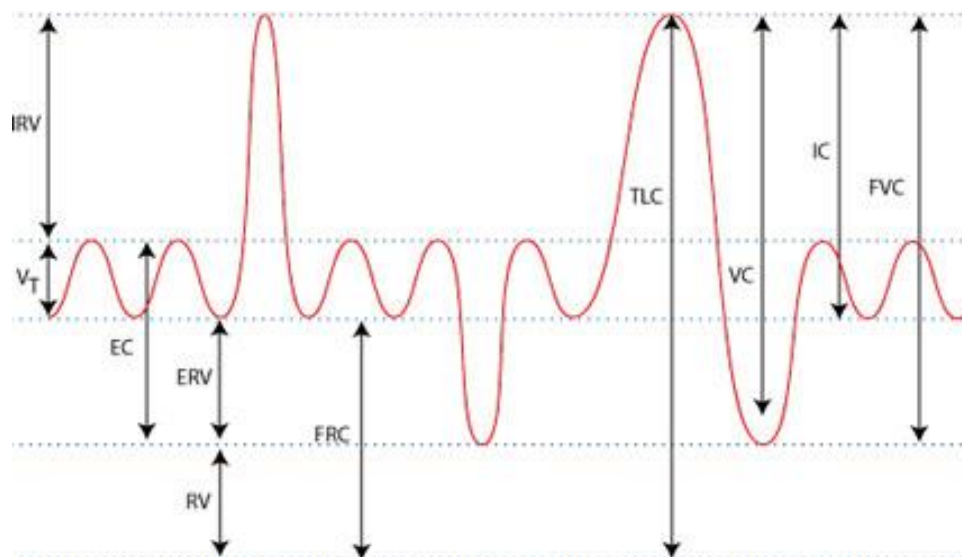


Figure 2. Lung Volumes and Capacities. EC = Expiratory Capacity; ERV = Expiratory Reserve Volume; FRC = Functional Residual Capacity; FVC = Functional Vital Capacity; IC = Inspiratory Capacity; IRV = Inspiratory Reserve Volume; RV = residual volume; TLC = total lung capacity; VC = vital capacity; V_T = tidal volume.

Instructions

For this lab we will follow the alternative instructions below, designed for our ADInstruments equipment. Please work in groups of 3 or 4.

If you are suffering from a respiratory infection, do not volunteer for this experiment.

Activity 1: Equipment Setup

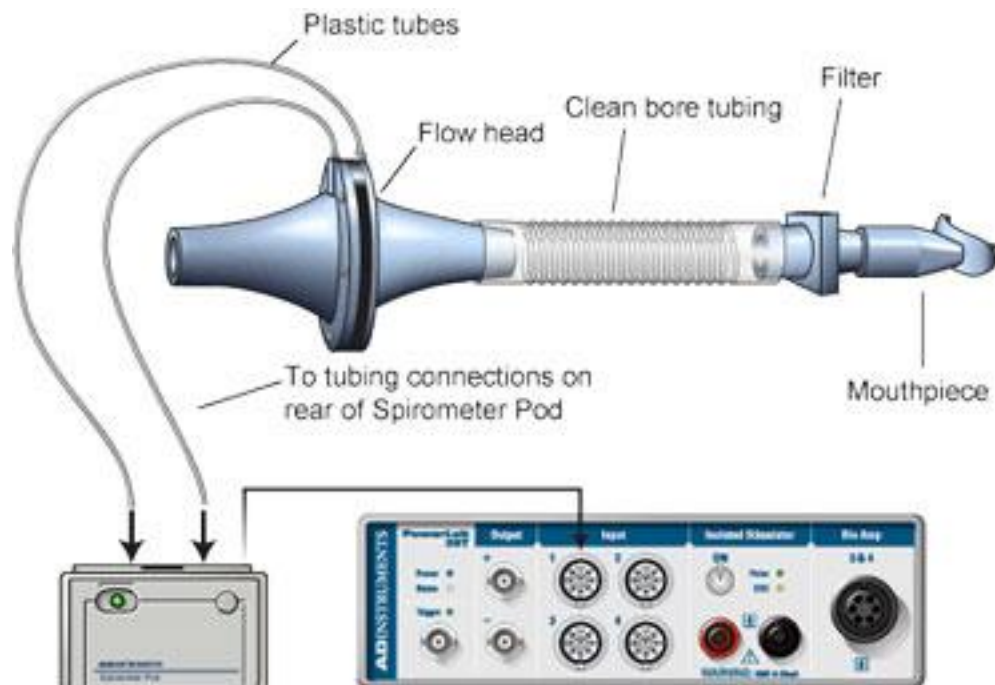
1. Make sure the PowerLab is turned off and the USB cable is connected to the computer.
2. Connect the Spirometer Pod to Input 1 on the front panel of the PowerLab (Figure 3). Turn on the PowerLab.

Note: Since the Spirometer Pod is sensitive to temperature and tends to drift during warm-up, it is recommended the PowerLab (and therefore the Spirometer Pod) is turned on for at least 10 minutes before use. To prevent temperature drift, place the Spirometer Pod in a shelf or beside the PowerLab, away from the PowerLab power supply to avoid heating.

3. Connect the two plastic tubes from the Respiratory Flow Head to the short pipes on the back of the Spirometer Pod. Attach Clean-bore Tubing, a Filter, and a Mouthpiece to the Flow Head (Figure 3).

Note: A clean Mouthpiece and Filter should be supplied for each volunteer. The Mouthpiece can be cleaned between uses with a suitable disinfectant.

*Figure 3:
Equipment
Setup for
PowerLab
26T.*



Activity 2: Familiarize Yourself with the Equipment

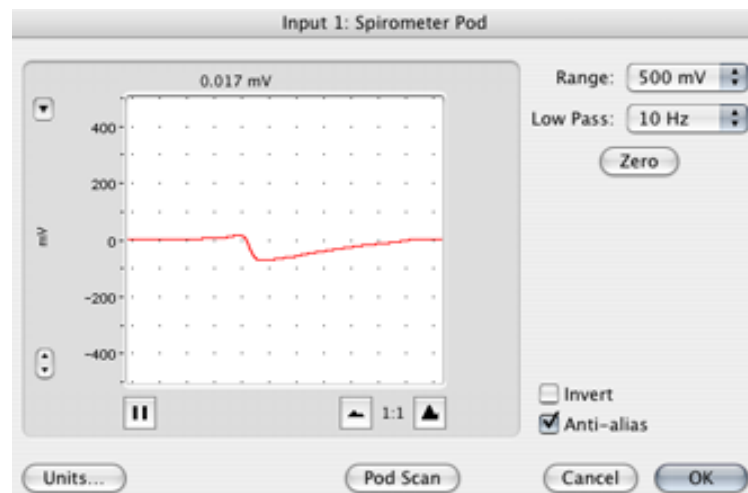
In this activity, you will learn the principles of spirometry and how integration of the flow signal gives a volume.

Calibrating the Spirometer Pod

The Spirometer Pod must be calibrated before starting this exercise. The Flow Head must be left undisturbed on the table during the zeroing process.

1. Launch LabChart and open the settings file "Airflow and Volume Settings" from the Experiments/HumanPhysiology/Respiratory Airflow & Volume/Settings folder.
2. Select Spirometer Pod from the Channel 1 Channel Function pop-up menu. Make sure the Range is 500 mV and the Low Pass is 10 Hz; then select Zero. When the value remains at 0.0 mV, have the volunteer breathe out gently through the Flow Head, and observe the signal (Figure 4). If the signal shows a downward deflection (it is negative), you can return to the Chart Window. If the signal deflects upward, you need to invert it. Click the Invert checkbox once. Click OK.

Figure 4: Spirometer Pod Dialogue Box with Downward Deflection.



Note: The signal can also be inverted by reversing the orientation of the Flow Head or by swapping the connections to the Spirometer Pod. The Invert checkbox is more convenient.

Using the Equipment

3. Have the volunteer put the Mouthpiece in their mouth and hold the Flow Head carefully with both hands. The two plastic tubes should be pointing upward.
4. Put the nose clip on the volunteer's nose. This ensures that all air breathed passes through the Mouthpiece, Filter, and Flow Head (Figure 5).
5. After the volunteer becomes accustomed to the apparatus and begins breathing normally, you are ready to begin.

Figure 5: Proper Positioning of the Flow Head.



6. **Start** recording. Have the volunteer perform a full expiration and then breathe normally. Record the volunteer's tidal breathing for one minute. At the end of one minute, have the volunteer perform another full expiration. Observe the data being recorded in the "Flow" (top) channel. Stop recording. The volunteer can stop breathing through the Flow Head and can remove the Nose Clip.

Setting Up the Spirometry Extension

The Spirometry Extension processes the raw voltage signal from the Spirometer Pod, applies a volume correction factor to improve accuracy, and displays calibrated Flow (L/s) and Volume (L) traces. The trace you recorded in the exercise above will provide reference points for the Spirometry Extension that allow it to correct the raw traces.

7. Drag across the Time axis at the bottom of the Chart Window to select the data you recorded. Select Spirometry Flow from the Channel 1 Channel Function pop-up menu. Make sure the settings are the same as those in Figure 6. Click OK.

8. Select **Spirometry Volume** from the Channel 2 Channel Function pop-up menu. Make sure Channel 1 is selected in the Spirometry Flow Data pop-up menu. Click the Apply Volume Correction checkbox to turn it on. Then select Apply to allow the extension to use the volume correction ratio that it has calculated from your data (Figure 7). The volume correction ratio should be between 1.02 and 1.12; if it isn't, check with your instructor. The Chart Window should now appear with calculated volume data in Channel 2 (lower channel).

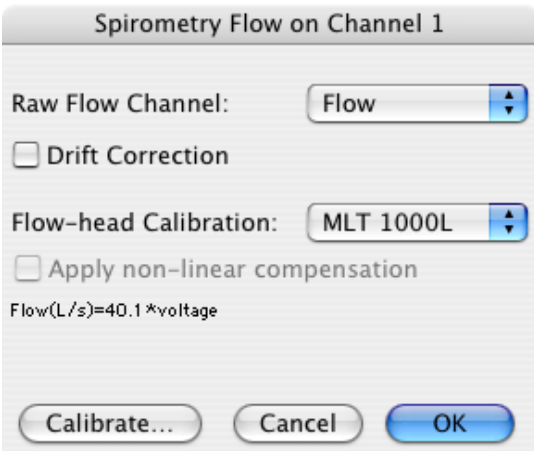


Figure 6: Spirometry Flow Dialogue Box. (Ours may look slightly different.)

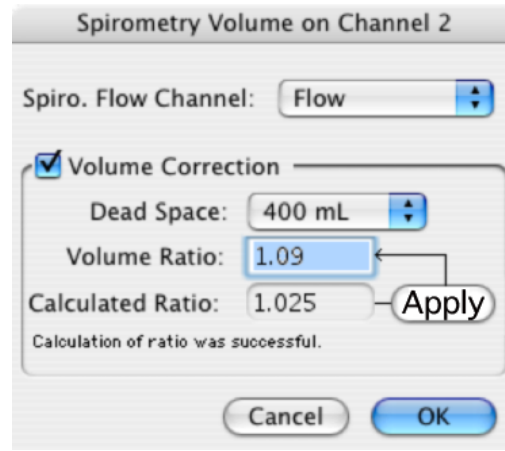


Figure 7: Spirometry Volume Dialogue Box. (Ours may look slightly different.)

9. Select Set Scale from the Scale pop-up menu in the Amplitude axis for the “Flow” channel (look for the triangle way in the upper left). Select “Set Scale,” then make the top value 15 L/s and the bottom value -15 L/s. Click OK.

Understanding the Importance of Volume Correction

10. Drag across the Time axis to select data from both channels, and open Zoom Window (at top, above “Window”). Note the relation between Flow and Volume. When the flow signal is positive (inspiration), “Volume” rises; when the flow is negative (expiration), the volume trace falls.

11. In Zoom Window, find part of the recording where the flow is zero. Note that at this time, “Volume” does not change (the line is horizontal) because if there is no flow in or out, the volume of air in the lungs is staying the same.

12. The volume trace is calculated by the extension in such a way that the displayed volumes at the end of the two full expirations are equal. In subsequent recordings, the volume correction is unlikely to be exact – you will notice a tendency for the volume to drift, typically 1-2 L over 1-2 minutes. To see the effect of having no correction, turn off the Volume Correction checkbox in the Spirometry Volume dialog box, and examine the data trace. Remember to turn it back on again afterward.

13. Save your data. Do not close the file.

Activity 2: Lung Volumes and Capacities

In this exercise, you will examine the respiratory cycle and measure changes in flow and volume.

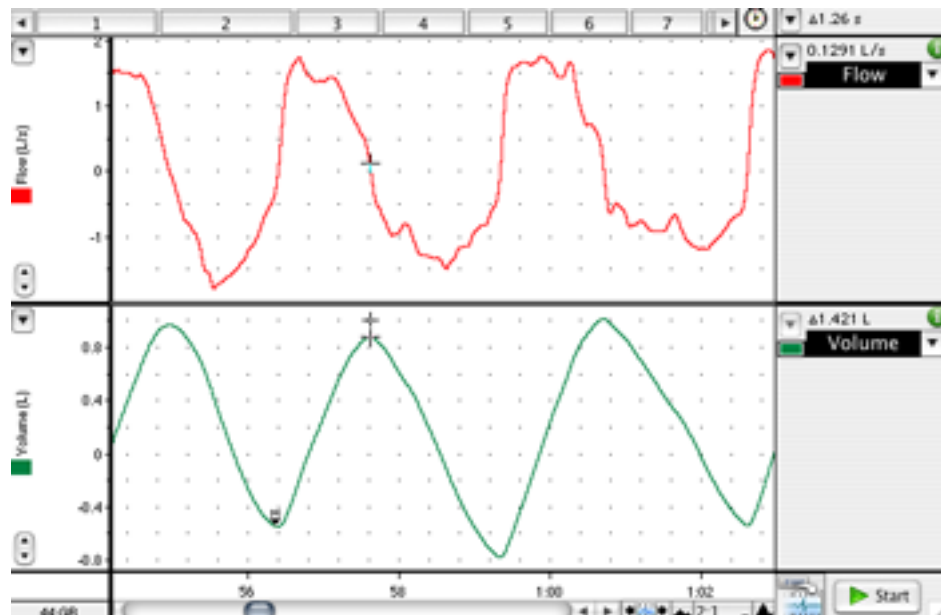
1. Have the volunteer face away from the monitor and read. This will prevent the volunteer from consciously controlling their breathing during the exercise.

2. When ready, Start recording. After two seconds, have the volunteer replace the Nose Clip and breathe normally into the Flow Head. Record normal tidal breathing for one minute. Add a comment with "normal tidal breathing" to the data trace.
3. After the tidal breathing period (at the end of a normal tidal expiration), ask the volunteer to inhale as deeply as possible and then exhale as deeply as possible. Afterwards, allow the volunteer to return to normal tidal breathing for at least three breaths. Stop recording when finished.
4. Position the cursor at the end of the deep breath. Right-click and select Add Comment. Add the comment "lung volume procedure" at the cursor position.
5. Save your data. Do not close the file.

Activity 3: Analysis of Lung Volumes and Capacities Data

1. Examine the normal tidal breathing data in the Chart Window, and Autoscale, if necessary. Calculate how many breaths there are in a one-minute period (BPM). Record RR/min in Table 1 of your worksheet.
2. Determine the volume of a single tidal inspiration by placing the Marker (M) and Waveform Cursor (+) to measure tidal volume. The value shown in the Range/Amplitude display for Channel 2 is the tidal volume (V_T or V_T) for that breath. Record this value in Table 1.

*Figure 8:
Positioning the
Marker (M) and
Waveform Cursor
(+) to measure
tidal volume.*



3. Use the values for tidal volume and the number of breaths observed over a one minute period to calculate the expired minute volume (V_E). Use the following equation:

$$V_E = RR \times V_T \quad (\text{L/min})$$

4. Find the “lung volume procedure” comment in your data trace. (You should be able to find it in a pull-down menu of comments.) Repeat steps 2-3 to determine the inspiratory reserve volume (IRV) (Figure 9) and expiratory reserve volume (ERV) (Figure 10; refer back to Figure 2 for definitions of volumes).

Note: The Marker (M) should be placed at the peak of a normal tidal inspiration for IRV, and it should be placed at the start (trough) of a normal tidal inspiration for ERV.

5. Calculate the inspiratory capacity (IC) using the following equation:

$$IC = V_T + IRV \quad (\text{L})$$

6. Calculate the expiratory capacity (EC) using the following equation:

$$EC = V_T + ERV \quad (\text{L})$$

Figure 9: Positioning the Marker (M) and Waveform Cursor (+) to Measure Inspiratory Reserve Volume (IRV).

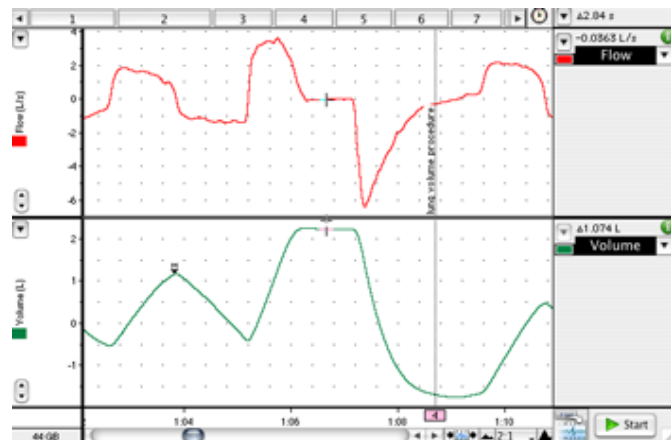
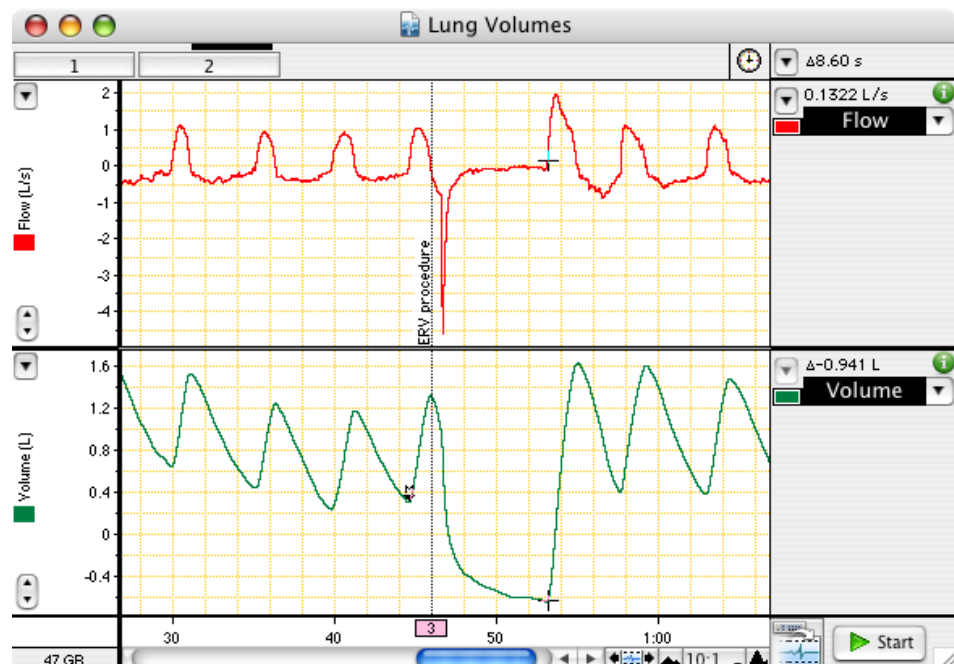


Figure 10: Positioning the Marker (M) and Waveform Cursor (+) to Measure Expiratory Reserve Volume (ERV).



7. Referring to the Appendix below, use the tables provided to determine the volunteer's predicted vital capacity (VC). The predicted value varies according to the volunteer's sex, height, and age.

8. Calculate the volunteer's measured VC using the experimentally derived values for IRV, ERV, and VT. Use the following equation:

$$VC = IRV + ERV + VT \quad (L)$$

9. Residual volume (RV) is the volume of gas remaining in the lungs after a maximal expiration. The RV cannot be determined by spirometric recording. Using the following equation, determine the predicted RV value for the volunteer:

$$RV = \text{predicted VC} \times 0.25 \quad (L)$$

10. The total lung capacity (TLC) is the sum of the vital capacity and residual volume. Calculate the predicted TLC for the volunteer using the following equation (use the measured VC rather than the predicted one):

$$TLC = VC + RV \quad (L)$$

11. Functional residual capacity (FRC) is the volume of gas remaining in the lungs at the end of a normal tidal expiration. Use the following equation:

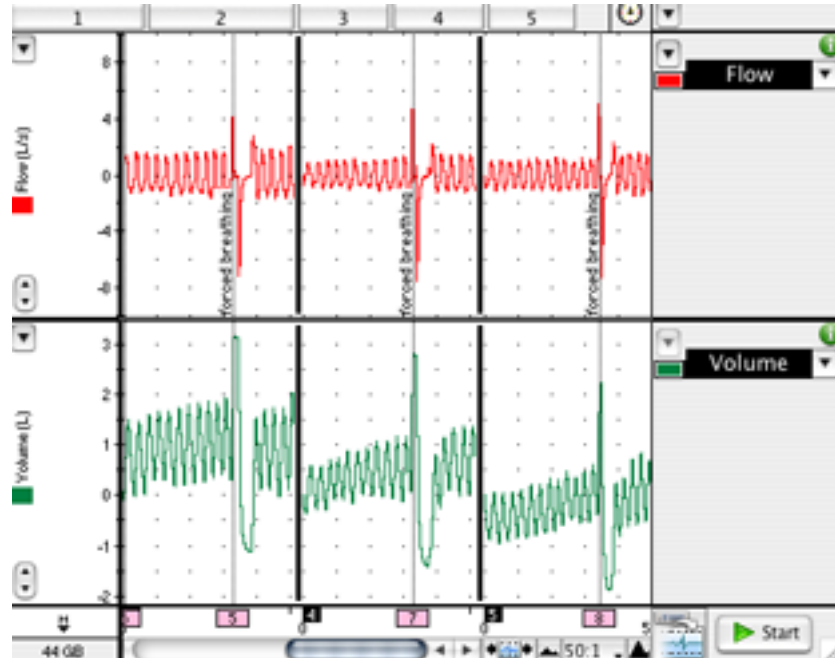
$$FRC = ERV + RV \quad (L)$$

Activity 4: Pulmonary Function Tests

In this exercise, you will measure parameters of forced expiration that are used in evaluating pulmonary function.

1. If necessary, zero the Spirometer Pod again, using the same procedure as before (Activity 2, step 2). Remember to leave the Flow Head undisturbed during the process.
2. Have the volunteer put on the Nose Clip and breathe normally into the Flow Head.
3. Start recording. Add a comment with the volunteer's name.
4. Prepare a comment with "forced breathing." Have the volunteer breathe normally for 30 seconds; then ask the volunteer to inhale maximally and then exhale as forcefully and fully as possible until no more air can be expired. Add the comment. After a few seconds, the volunteer should let their breathing return to normal. Stop recording. Do not close the file.
5. Repeat steps 3-4 twice more, so that you have three separate forced breath recordings (Figure 12). Save your data. Do not close the file.

Figure 12: Sample Data of Forced Breaths.



Activity 5: Analysis of Pulmonary Function Test Data

1. In the last data block of your LabChart recording for this exercise, move the Waveform Cursor to the maximal forced inspiration in "Flow." The absolute value displayed in the Range/Amplitude display is the peak inspiratory flow (PIF). Multiply the value by 60 to convert from L/s to L/min.
2. From the flow data trace, measure the peak expiratory flow (PEF) for the forced expiration. Multiply the value by 60 to convert from L/s to L/min. Disregard the negative sign.
3. To calculate the forced vital capacity (FVC), place the Marker on the peak inhalation of "Volume," and move the Waveform Cursor to the maximal expiration (Figure 15). Read off the result from the Range/Amplitude display, disregarding the delta symbol and negative sign.
4. Return the Marker to its box. To measure forced expired volume in one second (FEV₁), place the Marker on the peak of the volume data trace, move the Waveform Cursor to a time 1.0 s from the peak, and read off the volume value. If you find it hard to adjust the mouse position with enough precision, a time value anywhere from 0.96 s to 1.04 s gives enough accuracy. Disregard the delta symbol and negative sign.
5. Repeat this analysis until all three forced breaths have been analyzed.
6. Calculate the percentage ratio of FEV₁ to FVC for your experimental and Spirometry Extension results. Use the maximum values of FEV₁ and FVC, and use the following equation:

$$(\text{FEV}_1 / \text{FVC}) \times 100 \quad (\%)$$

7. Record your values in Table 2 of the worksheet.

Appendix: Predicted Vital Capacities for Males and Females

Age(years)	145	150	155	160	165	170	175	180	185	190	195	200
15	3.482	3.802	4.122	4.443	4.763	5.083	5.403	5.723	6.043	6.363	6.683	7.003
20	3.327	3.647	3.967	4.288	4.608	4.928	5.248	5.568	5.888	6.208	6.528	6.848
25	3.172	3.492	3.812	4.133	4.453	4.773	5.093	5.413	5.733	6.053	6.373	6.693
30	3.017	3.337	3.657	3.978	4.298	4.618	4.938	5.258	5.578	5.898	6.218	6.538
35	2.862	3.182	3.502	3.823	4.143	4.463	4.783	5.103	5.423	5.743	6.063	6.383
40	2.707	3.027	3.347	3.668	3.988	4.308	4.628	4.948	5.268	5.588	5.908	6.228
45	2.552	2.872	3.192	3.513	3.833	4.153	4.473	4.793	5.113	5.433	5.753	6.073
50	2.397	2.717	3.037	3.358	3.678	3.998	4.318	4.638	4.958	5.278	5.598	5.918
60	2.087	2.407	2.727	3.048	3.368	3.688	4.008	4.328	4.648	4.968	5.288	5.608
70	1.777	2.097	2.417	2.738	3.058	3.378	3.698	4.018	4.338	4.658	4.978	5.298
80	1.467	1.787	2.107	2.428	2.748	3.068	3.388	3.708	4.028	4.348	4.668	4.988

Table 1. Predicted Vital Capacities (in liters) for males, according to height (in centimeters) and age.

Age (years)	145	150	155	160	165	170	175	180	185	190	195	200
15	2.911	3.171	3.431	3.691	3.951	4.211	4.471	4.731	4.991	5.251	5.512	5.772
20	2.821	3.081	3.341	3.601	3.861	4.121	4.381	4.641	4.901	5.161	5.422	5.682
25	2.731	2.991	3.251	3.511	3.771	4.031	4.291	4.551	4.811	5.071	5.332	5.592
30	2.641	2.901	3.161	3.421	3.681	3.941	4.201	4.461	4.721	4.981	5.242	5.502
35	2.551	2.811	3.071	3.331	3.591	3.851	4.111	4.371	4.631	4.891	5.152	5.412
40	2.461	2.721	2.981	3.241	3.501	3.761	4.021	4.281	4.541	4.801	5.062	5.322
45	2.371	2.631	2.891	3.151	3.411	3.671	3.931	4.191	4.451	4.711	4.972	5.232
50	2.281	2.541	2.801	3.061	3.321	3.581	3.841	4.101	4.361	4.621	4.882	5.142
60	2.101	2.361	2.621	2.881	3.141	3.401	3.661	3.921	4.181	4.441	4.702	4.962
70	1.921	2.181	2.441	2.701	2.961	3.221	3.481	3.741	4.001	4.261	4.522	4.782
80	1.741	2.001	2.261	2.521	2.781	3.041	3.301	3.561	3.821	4.081	4.342	4.602

Table 2. Predicted Vital Capacities (in liters) for females, according to height (in centimeters) and age.

Source: *The Johns Hopkins Pulmonary Function Laboratory equations for pulmonary function* (<http://www.hopkinsmedicine.org>).

Worksheet for Exercise 37 (Respiratory System Physiology)

Names:

Table 1: Lung volumes and capacities

Respiratory Parameter	Value (include proper units)
Respiratory Rate (RR)	
Expired Minute Volume (VE)	
Tidal Volume (VT)	
Inspiratory Reserve Volume (IRV)	
Inspiratory Capacity (IC)	
Expiratory Reserve Volume (ERV)	
Expiratory Capacity (EC)	
Vital Capacity (VC)	Predicted (from table in appendix)
	Measured
Residual Volume (RV), estimated	
Total Lung Capacity (TLC)	
Functional Residual Capacity (FRC)	

Table 2: Pulmonary function tests

Respiratory Parameter	Value (include proper units)
Peak Inspiratory Flow (PIF)	1 st forced breath:
	2 nd forced breath:
	3 rd forced breath:
Peak Expiratory Flow (PEF)	1 st forced breath:
	2 nd forced breath:
	3 rd forced breath:
Forced Vital Capacity (FVC)	1 st forced breath:
	2 nd forced breath:
	3 rd forced breath:
Forced Expired Volume in One Second (FEV ₁)	1 st forced breath:
	2 nd forced breath:
	3 rd forced breath:
(FEV ₁ / FVC) x 100	

Study Questions

1. Explain why RV cannot be determined by ordinary spirometry.
2. How did the subject's measured VC compare to the VC predicted according to his/her age and height?
3. A typical FEV₁/FVC is ≥80%. Does your subject have a normal FEV₁/FVC?
4. Explain the basic difference between obstructive lung disease and restrictive lung disease.

5. Is a lower-than-normal VC most consistent with obstructive lung disease or restrictive lung disease?

6. Is a lower-than-normal FEV₁/FVC (<80%) most consistent with obstructive lung disease or restrictive lung disease?

Dissection Exercise 7: Dissection of the Digestive System of the Cat

August 1, 2016

Goal

- Identify and name key anatomical structures responsible for the digestion of food and excretion of waste.

Instructions

Perform the following activities:

- Activity 1: Identifying Alimentary Canal Organs
- Activity 2: Exposing and Viewing the Salivary Glands and Oral Cavity Structures

You do not need to find all of the structures mentioned in these activities; concentrate on the ones listed below. In finding those, you should use the following non-digestion/excretion structures as “landmarks” that you have seen in previous labs: diaphragm, kidneys, spleen.

- Anus
- Bile duct
- Cecum
- Colon (large intestine): ascending, transverse, descending
- Epiglottis
- Esophagus
- Gall bladder
- Liver
- Pancreas
- Rectum
- Salivary glands: parotid gland and submandibular gland
- Small intestine: duodenum, jejunum, ileum
- Stomach, with pyloric sphincter
- Teeth
- Ureter
- Urethra
- Urinary bladder

Worksheet for Dissection Exercise 7 (Dissection of the Digestive System of the Cat)

Names:

1. Instructor's initials, verifying identification of digestive system structures: _____
2. Complete the following table.

Structure	Function
Bile duct	
Cecum	
Colon (large intestine)	
Gall bladder	
Liver	
Pancreas	
Salivary glands	
Small intestine	
Stomach	

3. Do cats' teeth and ceca indicate that they are carnivores, herbivores, or omnivores (which eat both plants and animals)? How about humans' teeth and ceca? Explain.

Exercise 39: Digestive System Processes: Chemical and Physical

August 3, 2016

Goals

- Observe the activity of protein-digesting and lipid-digesting enzymes (Activities 2-3).
- Learn about mechanisms by which the digestive system propels and mixes food (Activity 5).

Instructions

In this lab you will work in groups of 3 or 4. Each table should form a group. Each group will perform the following parts of the lab:

- Activity 2: Protein Digestion
- Activity 3: Bile Action and Fat Digestion
 - Give a quick shake to the litmus cream before you use it.
- Group Challenge: Odd Enzyme Out
- Activity 5: Observing Digestion

The two main experiments are on protein digestion by trypsin (Activity 2) and fat digestion by lipase (Activity 3, *step 3*). Each experiment includes a 60-minute incubation step, so get these going before you do anything else. Then do the beginning of Activity 3 (emulsification of lipids by bile) and proceed to Activity 5.

This exercise includes the following tables for recording data: "Salivary Digestion of Starch"; "Trypsin Digestion of Protein"; "Pancreatic Lipase Digestion of Fats." Ignore the table on Salivary Digestion of Starch, as we will not be doing that experiment. During lab, fill in your predictions for each tube of the other two tables into the modified versions of these tables found in the lab worksheet.

Worksheet for Exercise 39 (Digestive System Processes: Chemical and Physical)

Names:

Activity 2: Protein Digestion by Trypsin

Tube no.	1T	2T	3T	4T	5T
Additives (3 drops each)	Trypsin, water	BAPNA, water	Trypsin (boil), then BAPNA	Trypsin, BAPNA	Trypsin, BAPNA
Incubation condition	37° C	37° C	37° C	37° C	0° C
Predicted color change?					
Actual color change?					

Explanation of protein digestion results (one paragraph or several bullet points):

Activity 3: Demonstrating the Emulsification Action of Bile and Assessing Fat Digestion by Lipase

2. In which tube has emulsification occurred?

Tube no.	1L	2L	3L	4L	5L	4B	5B
Additives (5 drops each)	Pancreatin, water	Litmus cream, water	Pancreatin (boil), then litmus cream	Pancreatin, litmus cream	Pancreatin, litmus cream	Pancreatin, litmus cream, bile salts	Pancreatin, litmus cream, bile salts
Incubation condition	37° C	37° C	37° C	37° C	0° C	37° C	0° C
Predicted color change?							
Actual color change?							

Explanation of lipid digestion results (one paragraph or several bullet points):

How are your test-tube digestion reactions similar to and different from what actually happens in your digestive tract?

SIMILAR:

DIFFERENT:

Group Challenge: Odd Enzyme Out

1. Which is the "odd enzyme"?	Why is it the odd one out?
2. Which is the "odd enzyme"?	Why is it the odd one out?
3. Which is the "odd enzyme"?	Why is it the odd one out?
4. Which is the "odd enzyme"?	Why is it the odd one out?

Activity 5: Observing Movements and Sounds of the Digestive System

2.

3. [2 parts]

4.

Review Sheet

1.

_____ 1.

_____ 2.

_____ 3.

_____ 4.

4.

Enzyme	Organ producing it	Site of action	Substrate(s)	Optimal pH
Salivary amylase				
Trypsin				
Lipase (pancreatic)				

5.

Proteins: _____ Carbohydrates: _____

Fats: _____ and _____

7. [2 parts]

12. [2 parts]

Exercise 41: Urinalysis

August 8, 2016

Goal

- Test for abnormalities in urine color, pH, [glucose], [protein], and specific gravity, which may be symptoms of underlying disease.

Materials

At each lab station:

- Urine specimen containers
- Disposable pipets
- Urine reagent strips
- pH strips
- absorbent paper towel

At the central materials station:

- Hydrometer and jar
- Distilled or deionized water
- pH chart
- 2 marking pens
- Simulated urine specimens
- 10-mL graduated cylinders

Instructions

For this lab exercise, we will NOT use the protocol in your lab manual; instead, we will follow the alternative directions below, provided by Carolina, the maker of the urinalysis kits.

Background

Normally, urine consists of approximately 95% water and 5% dissolved solids such as urea and sodium chloride. Almost all substances found in urine also are found in blood, but at different concentrations. Some substances, such as glucose, have a threshold that must be exceeded before the substance is excreted in the urine. The presence of such substances in the urine usually indicates disease.

Normal urine colors range from light yellow to amber, depending on the concentration of urochrome, the urinary pigment. Food, drugs, and disease can cause lighter or darker urine, as listed in Table 1. The pH of a solution is a measure of its free hydrogen ion (H^+) concentration, which indicates acidity or alkalinity. Typically, the pH of normal urine is about 6, which is slightly acidic. Some foods and diseases that can affect urine pH are listed in Table 2.

Table 1: Urine color and possible causes

Color	Diet	Drugs	Disease
Light yellow to amber	Normal	none	None
Clear to light yellow	Increased fluid intake	Alcohol, phosphate, carbonate	Uncontrolled diabetes mellitus
Yellow orange to dark green	Carrots	antibiotics	Bilirubin from obstructive jaundice
Red to red brown	Beets	Laxatives	Hemoglobin in in urine
Smoky red	Beets	Anticonvulsants	Unhemolyzed red blood cells from urinary tract
Dark wine	Beets	Anti-inflammatory drugs	Hemolytic jaundice
Brown black	Rhubarb	antidepressants	Melanin pigment from melanoma
Brown	Rhubarb	Barbiturates	Anemia or liver infections
Green	Green food dyes	diuretics	Bacterial infection

Specific gravity is the density of a solution relative to that of water, which is 1.000. The specific gravity of normal urine ranges from 1.010 to 1.025. Specific gravity varies according to fluid intake and can be affected by disease.

Glucose (sugar) should not be detected in normal urine; its presence usually indicates diabetes mellitus, a severe metabolic disorder caused by defective carbohydrate utilization. Glucose may also be present in the urine after a big meal or during times of emotional stress.

A very small amount of protein is normally present in the urine. Any change in the color of a protein test strip indicates an elevated level of protein in urine. Diet and disease can affect protein levels in urine. For example, patients with severe anemia usually excrete protein in their urine.

Table 2: Abnormal urinalysis results and possible causes

Test result	Possible causes	
	Diet	Disease
Low pH (<5)	High protein diet; cranberry juice	Uncontrolled diabetes mellitus
High pH (>8)	Diet rich in vegetables; dairy products	Severe anemia
Low specific gravity (<1.01)	Increased fluid intake	Severe renal damage
High specific gravity (>1.025)	Decreased fluid intake; loss of fluids	Uncontrolled diabetes mellitus; severe anemia
Glucose present (glucosuria)	Large meal	Uncontrolled diabetes mellitus
Protein present (proteinuria)	High-protein diet	Severe anemia

Procedure

In this activity, working in groups of two, you will perform five important tests routinely done in clinical urinalysis: color, pH, specific gravity, glucose, and protein. The Low, Normal, and High simulated urine samples are designed to produce results indicative of those characteristics.

1. Take three plastic urine specimen containers to the central materials station. Use a marking pen to label the containers *Low*, *Normal*, and *High*. Use the labeled graduated cylinders at the central materials station to transfer 10 milliliters of Low, Normal, and High Simulated Urine to the appropriate labeled containers.
2. Return to your lab station. Place the containers of simulated urine on the absorbent paper towel. Observe the samples, and record the color of each sample in your worksheet data table.
3. Use a pen or pencil to label one end of three of the pH test strips *L*, *N*, and *H*.
4. Holding the labeled end, dip the *L* strip into the Low sample. Shake off any excess liquid. Lay the pH strip in front of the Low sample on the absorbent paper towel. Repeat the process with the Normal (*N* strip) and High (*H* strip) samples.
5. Compare the color of the test strip to the pH color chart at the central materials station. In your data table, record the pH of each sample.
6. Label the plastic portion of three Urine Reagent strips *L*, *N*, and *H*, respectively.
7. Test each sample for glucose and protein using a Urine Reagent strip, as follows.
 - a. Observe the color of the test squares that are attached at one end of the urine reagent strip. The greenish square nearest the tip will be used for testing the glucose in the sample; the yellow square will detect protein in the sample.
 - b. Dip the end of the strip with the test squares into the urine sample, then withdraw it. Run the end of the strip against the rim of the urine container to remove excess urine.
 - c. Wait 30 seconds, then observe and record the color of the test squares.
 - *Green square*: A negative result produces no color change, indicating normal or low urine glucose. A darkening of the square indicates a higher than normal urine glucose level; the darker the color, the higher the glucose level.
 - *Yellow square*: A negative result produces no color change, indicating the absence of protein in the urine. A green or blue color indicates the presence of protein in the urine sample.
8. Calibrate the hydrometer, as follows.
 - a. Rinse the urine hydrometer and jar thoroughly.
 - b. Use a clean pipet to fill the jar slightly more than half-full with distilled or deionized water.

c. Insert the hydrometer as shown in Figure 1. The hydrometer should not touch the bottom of the jar. If it does touch, use a pipet to add water to the jar until the hydrometer floats.

d. Read the water level on the hydrometer scale, and record the value in your data table. Units on the hydrometer scale are 1.000, 1.020, 1.040, and 1.060. If the measured value is not 1.000, the standard specific gravity of water, you will need to adjust your urine measurements to compensate. The calibration factor is the value that must be added to or subtracted from the measurement to equal 1.000.

e. Record the calibration factor for the hydrometer in your data table.

f. Remove the hydrometer from the jar. Mark the level of the water remaining on the jar. You will use this line as the fill line when analyzing your samples.

g. Empty the jar.

9. Measure the specific gravity of Simulated Urine Low.

a. Rinse the urine hydrometer and jar thoroughly.

b. Use a clean pipet to fill the jar to the fill line with the sample.

c. Insert the hydrometer into the jar as shown in the figure.

d. Read the fluid level on the hydrometer scale, and record the value in your data table.

e. Add or subtract the calibration factor to or from your measurement. Record the adjusted value in your data table.

10. Repeat the specific gravity test for the Normal and High samples, and record the results in your data table.

11. Repeat the procedure for samples Unknown A and Unknown B. Analyze the color, pH, glucose, protein, and specific gravity of these samples, and record the results in your data table.

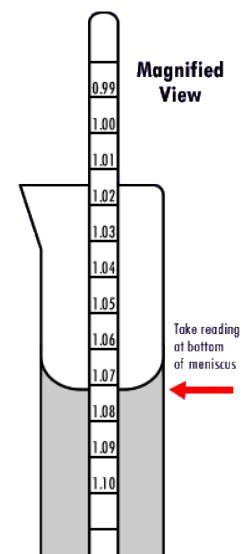


Figure 1: Calibrating a hydrometer. Image from grapestompers.com.

Worksheet for Exercise 41 (Urinalysis)

Names:

Data Table

Urine Test	Simulated Urine Samples				
	Low	Normal	High	Unknown A	Unknown B
Color					
pH					
Glucose					
Protein					
Specific Gravity					

Study Questions

1. Explain why it is important to ask patients about their diet and medications when analyzing their urine.
2. Using Table 1 and Table 2, determine which disease(s), if any, may be indicated by the urine test results for Unknown A and Unknown B. Explain your reasoning.
3. In a clinical setting, urine is often examined under a microscope. What information about a patient's health might be gained through this type of examination? Explain.

PhysioEx 9: Renal System Physiology

Due August 10, 2016

Goals

- To determine how afferent arteriole radius and efferent arteriole radius affect glomerular filtration rate (GFR), and thus how a relatively constant GFR can be maintained (despite changes in blood pressure) via alterations of these radii (Activity 1).
- To explain what leads to alterations of levels of aldosterone and antidiuretic hormone (ADH), and how these hormones affect the composition of urine (Activities 4 and 6).
- To explain why glucose is normally absent from the urine, but can appear in the urine during severe hyperglycemia (Activity 5).

Instructions

Please complete Activities 1-6 of PhysioEx Exercise 9, found on pages PEx-131 through PEx-148 of your lab manual (toward the back).

- Activity 1: The Effect of Arteriole Radius on Glomerular Filtration
- Activity 2: The Effect of Pressure on Glomerular Filtration
- Activity 3: Renal Response to Altered Blood Pressure
- Activity 4: Solute Gradients and Their Impact on Urine Concentration
- Activity 5: Reabsorption of Glucose via Carrier Proteins
- Activity 6: The Effect of Hormones on Urine Formation

Follow the instructions given for previous PhysioEx assignments. You do not need to answer the questions shown in the lab manual or online; instead, you will submit a brief report for each activity that includes the following sections: Experiment, Hypothesis, Results, Conclusion.

Reproduction Dissections

Adapted from a BBio 351 lab by Doug Wacker

August 10, 2016

Goals

- Find key reproductive structures in female and male cats.
- Find components of the reproductive pathway from a male sheep.

Safety

Come to lab dressed appropriately: long hair under control, long pants or long skirt, shoes that fully protect the feet.

Materials

- Sheep testes, 1 per pair of students
- Tongs for sheep testes
- Cats (previously used in other labs this quarter), 1 per pair of students
- Large dissecting pans, 1 per pair of students
- Dissecting tools, 1 set per pair of students
- 3D female and male reproductive models
- Laptops (available for student teams without their own)

Cat dissection

Using the cats that you began dissecting earlier in the quarter, you will find the structures listed below. Some are sex-specific, so groups should help each other out as necessary.

Find the following **male reproductive structures** on your cat or that of another team: epididymis, inguinal canal, penis, scrotum, spermatic cord, testes, and vas deferens (ductus deferens). As with the sheep, begin by cutting open the scrotal sac to reveal the testis. Attempt to identify the zig-zagging epididymis. Locate the spermatic cord exiting the testis. The spermatic cord contains the vas deferens, as well as arteries and nerves. Follow the spermatic cord as it actually enters the abdominal wall via the inguinal canal. When a bit of intestine slips into this hole, this is a variety of hernia. During development, the testes descend into the scrotum after emerging from the inguinal canals! Follow the spermatic cord further as it crosses over the ureter. The ejaculatory ducts form at the union of the vas deferens and the seminal vesicles (not visible). Finally, locate the penis. Aside from size, how is the cat penis different from the human penis?

Female reproductive structures to locate include the following: mammary glands, ovaries, placenta, umbilical cord, uterine horns, uterus (body).

The ovaries are usually easiest to find by starting from the uterus and following the uterine horns cranially until you reach the ovaries.

Pregnant females, if available, will include fetuses developing in the uterine horns. Examine the outer membranes that cover the fetuses. The chorion is the outermost membrane that surrounds the embryo, and the amnion is a thin transparent membrane that contains the amniotic fluid. Why is it important that the fetuses are suspended in liquid like this? Identify the placenta, a broad circular band of blood vessels around the chorion, about midway between the embryo's head and tail. Each fetus has its own placenta. Identify the umbilical cord.

Sheep testis dissection

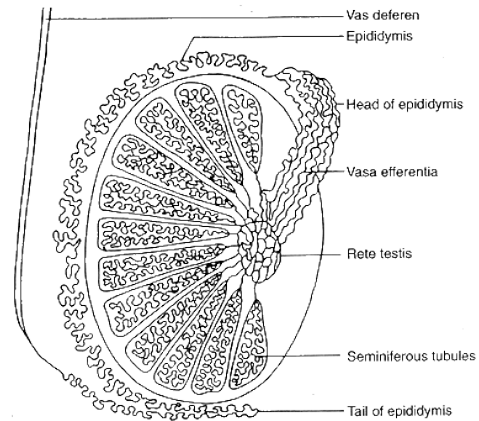
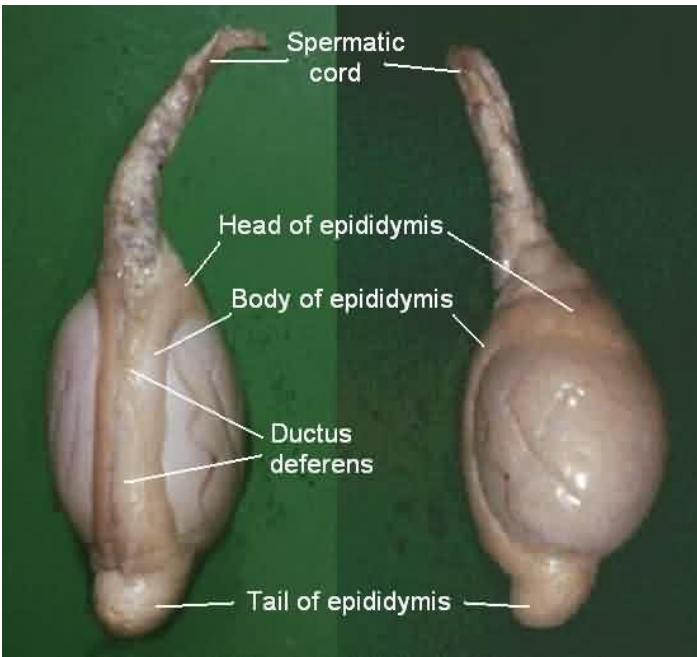


Figure 1: Testes.

Left: sheep testes (from fau.pearlashes.com/anatomy/dissections/reproductive/testis10.jpg).

Right: cross-section of mammalian testis (from nongae.gsnu.ac.kr/~cspark/teaching/images/fig_3_2.gif).

Obtain a sheep testis. Identify and cut away the scrotal sac. This sac is normally fluid-filled.

Locate and be able to identify the following structures on your specimen: head, body and tail of epididymis, ductus deferens, spermatic cord. Contained within the spermatic cord are a complex of veins, two arteries, nerves, the ductus deferens (also called the vas deferens), and the cremaster muscle. See if you can locate the cremaster muscle, which moves the testes toward or away from the body to keep them at an appropriate temperature.

The white covering that surrounds the testes is called the tunica albuginea. Using a scalpel or knife, make a longitudinal cross-section extending from the spermatic cord to the tail of the epididymis. Cut away the outer covering of the spermatic cord if you have not already done so.

The seminiferous tubules make up much of the yellowish or pinkish material within the testis. This is where the sperm initially develop. From these tubules they travel to the rete testis, which is a series of ducts leading to another set of ducts called the vasa efferentia (or efferent ductules), which feed into the epididymis, where the young sperm continue to mature. You can see the rete testis as slightly clearer areas within the center of the sectioned testis. The vas deferens (also known as the ductus deferens) begins where the tail of the epididymis ends. Locate this junction.

Worksheet for Reproduction Dissections

Names:

Male reproduction

1. From the seminiferous tubules, list all structures that sperm pass through on the way to fertilizing an oocyte. (You do NOT have to provide an anatomically realistic picture; text and arrows are OK.)

2. Does the urethra have any non-reproductive functions? If so, what?

3. List the structures that contribute to production of seminal fluid, but through which sperm themselves do not pass.

Female reproduction

4. List the structures through which an oocyte passes up to and including implantation. Where does fertilization occur, if it occurs?

5. What is an ectopic pregnancy, and where does it usually occur?

6. How is the location of the fetuses in a cat different from the location of human fetuses (even if there are more than one)?

Identification of structures

7. Instructor's initials to indicate successful identification of cat structures: _____

8. Instructor's initials to indicate successful identification of sheep structures: _____