

BIOSC 30: ANATOMY AND PHYSIOLOGY LABS



Staff
Los Medanos

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CHAPTER OVERVIEW

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1.1: Principles of Scientific Inquiry and the Scientific Method in the Anatomy and Physiology Lab

Learning Objectives.

Completion of this lab exercise ensures that you will be able to...

1. Describe the difference between a scientific observation and a non-scientific observation
2. Outline the steps necessary to perform an experiment via the scientific method
3. Write a hypothesis to explain an observation that you made about how the human body functions.

Pre-Lab Exercise:

1. True/False: A hypothesis is the same as a guess as to what will happen in an experiment.
2. All scientific experiment begins with either an or a about a phenomenon.
3. True/False: Being a scientist means following the scientific method of investigation to what is true and challenging your thoughts and assumptions about a topic through experimentation.
4. Hypothesis should never: .
5. One logical fallacy that you are aware of having made in the past is .

Materials:

- Video

Science and the Scientific Method

Science is a process of learning and acquiring knowledge, and any person that does science is a “scientist.” This means that at any point in time we can all be scientists. The only separation between students learning about human anatomy and physiology, and those in lab coats working to discover the cure for a disease is the approach to understanding a phenomenon. The person performing as a “scientist” will work through a problem in a methodical approach that follows the logical rules of science. The most important part of the rules of science is to not have a prejudiced view of what will happen. Yes, you will have an idea based on previous experience, but you must approach every problem as a new experience. When you approach each problem that you wish to solve as a new experience then you are beginning to use the scientific approach and thus are using science.

There is no set way on how to do science beyond following the general rules of science. The rules of science, and the scientific method, are intended to make the process as objective as possible, and thereby gain some level of understanding that is as close to a “true reality” as possible. One constant theme is that there is no certainty in science, only levels of probability and possibility for explaining the phenomenon being studied. Because of this, scientific understanding can always be challenged, or even changed, with new observations, or different interpretations of previous observations. New tools and techniques have resulted in new observations, sometimes forcing revision of what had been taken as fact in the past. With this ever-changing understanding and base of evidence there is only one certainty about science, which is, science does not “prove” it only allows for observations and explanations of those observations based on the assumptions that govern modern science.

Underlying the world of modern science are four major assumptions that must be held as being true for observations to be accurate, valid and reliable. First of these assumptions is that the world is real, and that the physical universe exists and is not just our imagination. This is regardless of whether, or not, it is something that can be sensed. Secondly, humans (or animals) can accurately perceive the real world, and that humans can express such understanding. Thirdly, processes that occur in nature can sufficiently explain the existence of the physical universe that we live in. Lastly, that the process being observed operates the same way, everywhere and at all times within the physical universe.

The way that we use these assumptions to study the human body and any other natural phenomenon is through the scientific method. This method of learning follows a set of rules that leads to a process of asking and answering questions to search for cause-and-effect relationships in a phenomenon, or action, that we are examining.

There are several rules of science that must be followed at all times. First, all explanations must be based on careful observations that come through testing a hypothesis to explain a phenomenon. Second, any hypothesis has a possibility and probability of being disproven (evidence from observation does not support the hypothesis). Third, conclusions cannot be based simply on one’s opinion or belief (popular or otherwise) about the phenomenon. Fourth, any observations and explanations must be based on the natural physical universe that can be sensed and perceived by everyone, in the same way at all times. Fifth, that the best hypothesis

is the choice for explaining the phenomenon that has the greatest amount of factual support, is based on logical analysis and makes the least number of assumptions to “best fit” all of the facts from the observations. Lastly, science is not democratically fair! It is based on empirical evidence (observations) that stem from the logical flow of critical thought and analysis following the rules of science.

It is very important to remember that the use of the scientific method is not developed to “prove” something “true”. Instead, it is intended to test how, what, when, where, and why something occurred. Because of this, we tend to think of the outcome of the use of the scientific method as leading to a contingent base of knowledge, rather than an absolute base of knowledge. That understanding a phenomenon is based on what evidence can support our understanding at any given point in time. This evidence changes over time and therefore our understanding of the phenomenon changes.

How do we do this investigation? The scientific method is a logical process that can be viewed as a sequential step-wise process that follows these key steps:

1. Observation
2. Question about Observation: What? When? Where? Why? How? for the observation
3. Hypothesis: explanation of the observation that answers the question based on deductive reasoning and understanding of the principles of science and previous knowledge
4. Experimentation and Recording of Results: Reproducible step-wise sequence of events based on the phenomenon and scientific principles that tests the validity of the hypothesis where observed responses are recorded objectively
5. Analysis of Results: logical statistical analysis of results used to accept or refute hypothesis
6. Interpretation and Inference of Analysis: logical process using inductive reasoning and inferential thinking to explain how analysis of results and observations made during the experimentation fits within understanding of the phenomenon and expands our overall knowledge of the principles and laws governing the phenomenon. Used to indicate the support for the hypothesis being tested
7. Conclusion: terminal argument of inductive reasoning based on the principles of logical thought referred to as Occam’s Razor (the most logical explanation with the fewest number of assumptions is the most likely to be true) that terminates one cycle of the scientific method and can serve as the next hypothesis in a reproduced experiment

How to Observe as a Scientist

In order to be a good scientist and follow the scientific method of experimentation, we must be good at making observations. The means of observing is based on how we develop and execute our experiment. This is done through defining and controlling for factors that might impact the phenomenon that is being studied. When designing an experiment, it is important that we are changing very little in the overall factors that can impact the phenomenon so that we can indicate that changes to one item causes something else to vary in a predictable way that allows us to draw a conclusion. The factors that are being observed and controlled are called variables.

There are two primary categories that all variables will fall into based on the amount of control that you have on the variable at any point of time of the experiment. Those that you are able to change, or manipulate, are termed **independent variables**. This variable can sometimes be referred to as the test condition. While those that you have no control over, unable to change, are termed **dependent variables**. The dependent variables are the variables that are being measured in any experiments. Along with these variables, there are other factors that have the ability to impact our observations. Those factors that we attempt to ensure don’t change or impact our experimental observations are referred to as **control variables**. In the studying of the human body, control variables typically fall under what is called “environmental conditions” that is where we set up the test environment to have the participants of the study seen under the same condition (temperature, time of day, humidity, food). There are also factors that we might try to control but have no control over yet will impact the dependent variable by acting as a different test condition. The variables that act as second independent variables are called **confounding variables**. When we do analysis and interpretation, we will take into consideration these confounding variables, as their influence will impact the assumptions that are made during the interpretation of the results.

Underlying scientific observations are four major assumptions that must be held as being true for observations to be accurate, valid and reliable. First of these assumptions is that the world is real, and that the physical universe exists and is not just our imagination. This is regardless of whether, or not, it is something that can be sensed. Secondly, humans (or animals) can accurately perceive the real world, and that humans can express such understanding. Thirdly, processes that occur in nature can sufficiently explain the

existence of the physical universe that we live in. Lastly, that the process being observed operates the same way, everywhere and at all times within the physical universe. The ability to ensure that your observations are valid and that the confounding variables are minimized makes for good experimental observations. The ability to do this is through the constant recording of observations and journaling methods used to make the observations. The more thorough the notes you take during experimentation, the more controlled the experiment, the more likely your results are to be correct, and the more reproducible your experiment.

How to write a hypothesis

A hypothesis is your explanation of a phenomenon based on your understanding of the laws and principles of physiology. The statement is formed via a process known as deductive reasoning. A process that forces you to use what information you already know to explain why the observation that you are making has occurred. It is not as many of you have learned previously a guess or a prediction. It is also not the explanation of observation based on the experimental outcome, that is the conclusion. The conclusion can be seen as a possible hypothesis, but only for subsequent studies and experiments within the reproduction of the experimentation that is at the heart of scientific inquiry. The hypothesis you have to view as your best explanation for why and how something occurs.

As such, it should be formulated and written in such a way so as to be supported or refuted by the evidence collected in the experiment. It is not a guess as to what might happen (that is a prediction) or an “if... then” statement (as this cannot be supported or refuted). It is the explanation that you are going to test within the experiment. Being a good scientist means that your explanation will constantly undergo refinement and rewriting as new evidence and experimental analysis provides us with a greater understanding.

What are the rules for writing the hypothesis? When you write a hypothesis, there are a few key steps that need to be remembered for writing. First, there is never a “good” or a “bad” hypothesis, just one that is not well written. Second, there is never a “right” or a “wrong” hypothesis, just one that gets supported (shown to be possibly true) or refuted (shown to possibly be false). Third, a hypothesis is always written to be tested by evidence that can be seen and measured.

Writing and Developing Hypothesis:

- In order to develop the hypothesis, you need to develop the summary report (What am I studying? Why am I studying it? What am I going to do (what are the key steps I need to remember) in the experiment? What are my test conditions and measurements?
- Be sure to focus on the purpose or the question that serves as the foundation for the experiment.
- The hypothesis needs to be written **as a testable claim** about the relationship between test condition (what you are doing) and measurements being collected (dependent variables).
- The hypothesis should never:
 - Use “if...then...” thinking
 - Form a tentative or conclusive claim
 - Be written to be too general (or specific) for the stated question that is being studied
 - Summarize the principle being studied
- Hypothesis never is written as the statement of the law or principle being studied, or a restatement of the purpose.
- Wording of the hypothesis must be open to interpretation that leads to it either being **supported** or **refuted** by the results of the experiment.

Poor Example: Individuals will breathe more when exercising. (Statement that summarizes the tri-phasic response)

Good Example: Females will have larger changes in tidal volumes than males of similar level of activity during and following a period of exercise.

References:

Clark, JE. 2010. Don't Worry, It's Only Science. TeachersPayTeachers. <http://www.teacherspayteachers.com>

ACTIVITY 1: Scientific Method and Hypothesis Testing

1. Watch the video that your instructor shows the class
2. Based on what you see, make a hypothesis that would explain what you just watched.

3. Share your hypothesis with your group and rewrite based on feedback provided

4. Have your instructor check your hypothesis and within your group agree on 1 hypothesis to use for testing through experimentation.

5. Develop the basic steps for your experiment.

ACTIVITY 2: Discussion and Interpretation and Analysis of Results

Discussion:

Discussions are written as well-organized paragraphs that allow you to discuss the meaning of your results from the experiment. This is not a summary of what you did, that is the methods. The discussion involves using inductive reasoning and inferential thinking to formulate explain both what happened and why it happened. This explanation involves using the principles to explain the observations and the observations to show how the principles hold to be true. In performing your interpretation, you are linking your observed experimental results with the principles of human physiology. This means you have to go back to what we already know about how the human body functions and then apply what do the results say about this understanding. You have to do this by limiting your assumptions and following a logical process of thinking. The logical process means that if you commit a fallacy in your thinking, then the entirety of your interpretation becomes nullified. To make sure that you do not make these fallacies, be aware of these very common mistakes:

- **Hasty Generalization:** This is a conclusion based on insufficient or biased evidence. In other words, you are rushing to a conclusion before you have all the relevant facts.
- **Post hoc ergo propter hoc/Because it happened last it must be the cause:** This is a conclusion that assumes that if 'A' occurred after 'B' then 'B' must have caused 'A.'
- **Begging the Claim:** The conclusion provided is proven as being validated within the claim of the conclusion.
- **Petitio principii/Circular Argument:** This restates the argument rather than actually proving it.
- **Either/or:** This is a conclusion that oversimplifies the argument by reducing it to only two sides or choices.
- **Ad populum/Bandwagon Appeal:** This is an appeal that presents what most people, or a group of people thinks, in order to persuade one to think the same way.
- **Ignoratio elenchi/Red Herring:** This diversionary tactic avoids the key issues, often by avoiding opposing arguments rather than addressing them.
- **Straw Man:** This move oversimplifies an opponent's viewpoint and then attacks that hollow argument.
- **Argumentum ad ignorantiam/Appeal to ignorance:** A conclusion that offers no proof of anything except that you don't know something
- **False dilemma/False dichotomy:** Conclusion that limits all options down to two supposed counter points and offers opinion that manipulates the argument into an either or statement
- **Slippery slope:** Conclusion offers argument that outcome will likely lead to further outcomes that do not logically flow due to lack of evidence
- **Tu Quoque:** conclusion does not provide argument but distracts from the argument due to a position that the opposite occurs from a hypocrisy in the opposing viewpoint
- **Ambiguity/Equivocation:** Conclusion that confuses and misleads by stipulating that one thing is equal to something else
- **Non sequitur:** a conclusion does **not** follow logically from what preceded it.
- **Argumentum ad verecundiam/Appeal to Authority:** Conclusion that is justified because of citation of an experiment that agrees with the conclusion
- **Non causa pro causa/Causal Fallacy:** any logical breakdown when identifying a cause based on argument revolving around unproven causal relationship

When writing your discussion, think about the following (do not answer them as individual questions, instead use them to guide your thinking about the data and the analysis): What does the results of the statistical analysis tell you about the relationship between observations? What does the correlations tell you about the relationship between the observations? (Think about: What is the importance of understanding the correlative values between measures (think about: What does the correlations tell me? Does having a correlation between values mean anything about the change in one causing a change in the

other?)? **How does the relationship determined by your analysis align with the hypothesis (is it supported or refuted)? What are limitations that could interfere with your ability to infer or induce a conclusion?** (Think about: Where are the differences in the measures? What does differences in measurements indicate? What does the similarity between measures indicate? What errors might have occurred? How might errors in the experiment or analysis impact my results? How might accuracy impact the experimental conclusions that can be drawn?)

1. Use the following set of data from an experiment that tested the hypothesis: Males will be larger and thus stronger than females.

Group	Number of Participants	Average Days of Resistance Training/Weightlifting per week	Average Height (cm)	Average Body Mass (kg)	Average BMI (kg/m ²)	Average Maximal Leg Press Load (kg)	Ratio of Maximal Leg Press-to-Body Mass
Whole Class	80	3.35	167.1	64.05	23.1	235.9	3.68:1
Males Only	26	5	184.2	80.01	24	295	3.68:1
Females Only	54	2.5	157.3	55.33	22.3	204.2	3.68:1

2. Working as a group and based on what you are given, develop a discussion (based on your understanding of human anatomy and physiology) to explain the findings.

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1.2: Anatomical Terminology and Identification

Objectives:

At the end of this lab, you will be able to...

1. Use correct anatomical language when describing areas and regions of the body
2. Determine anatomical sides and cuts of the body, based on the concept of anatomical mirroring

Pre-Lab Exercise:

After reading through the lab activities prior to lab, complete the following before you start your lab

1. The anatomical planes include the sagittal plane that divides the body into a .
2. True/False. The purpose of using anatomical references is to ensure that everyone knows what you are discussing or identifying.
3. When looking at someone in anatomical position, the palms of their hands should be oriented .
4. Color the images for use as a reference for identifying.

Materials:

- Clay
- Knife/Scalpel
- Torso Models
- Stickers
- Felt Pens

The study of human anatomy and physiology is filled with terminology that has at its root in classical words, word fragments and meanings. These terms extend into the closely related disciplines within the medical fields. As such, it is expected that students of anatomy and physiology will be excessively exposed to these words and word fragments in their classical language forms (Greek and Latin). In particular, as they are extensively used to name structures and concepts so as to ensure these structures and concepts can be internationally understood during studying anatomy. Therefore, we need to take time to review the meanings behind the technical terms used in the study of anatomy and used by professionals across medical, science and health professions.

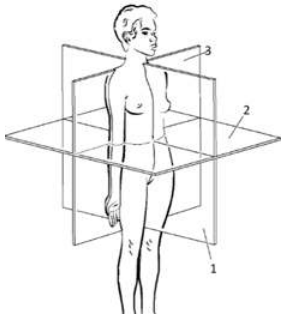
Activity 1: Planes and Organization of the Body

When discussing anatomical terms, the references that we use will depend on where you are attempting to reference. the development of three reference planes that generally used to divide the body, or regions of the body, about the imaginary geometric axis. These planes are the **CORONAL (FRONTAL) PLANE**, that divides along the X-axis of the body, the **TRANSVERSE (CROSS-SECTIONAL, TRANSAXIAL) PLANE** that divides along the Z-axis of the body, and the **SAGITTAL PLANE**, that divides along the Y-axis. There is a special case within the sagittal plane (**MID-SAGITTAL**) that divides evenly into two halves. Finally, there is a plane that will cut an angle to the geometric axis of the body, the **OBLIQUE PLAN**.

Methods:

1. Obtain clay, knife/scalpel from your instructor
2. Turn your clay into a column or cube

3. Using the image, indicate the three principal anatomical planes of the body



Anatomical Planes:

1= Sagittal Plane

2= Transverse Plane

3= Frontal (Coronal) Plane

Use your colored pencils to color each plane in a different color

4. Using your pencil trace the cuts of the anatomical planes into the clay

5. After tracing the Sagittal Plane, cut the clay along the Sagittal plane.

a. Question: How will this divide your clay?

6. Following the Sagittal Plane cut, cut one half of the clay along the Transverse Plane.

a. Question: How will this divide your clay?

7. Following the Transverse Plane cut, use the other half of the clay from the Sagittal Plane cut and cut the clay along the Coronal (Frontal) Plane.

a. Question: How will this divide your clay?

8. Compare cuts with your lab group.

9. Discuss with your lab group: Why is it important to understand the planes of the body? **Share your thoughts with your instructor**

10. Make the clay whole again and clean-up your area.

Activity 2: Orientational and Localization Terminology

There are also references as to the position of a structure relative to other parts of the body, or body segments. This type of reference is dependent upon the point of reference that is being taken in explaining the location of the structure of interest. With that in mind, we must discuss the anatomical terminology based on reference to the body as a whole or based on a regional area of the body or body segment.

Terms and Definitions:

VENTRAL: Toward the Stomach side of the body (front of the body)

DORSAL: Toward the Vertebral side of the body (back of the body)

CRANIAL: Toward the head

CAUDAL: Toward the tail/feet

IPSILATERAL: On the same side of the body

CONTRALATERAL: On the opposite side of the body

ANTERIOR: Toward the front side of the region, organ, or limb

POSTERIOR: Toward the back side of the region, organ, or limb

PROXIMAL: Closer to the torso

DISTAL: Further from the torso

LATERAL: Away from the midline of the long axis of the body or region of the body

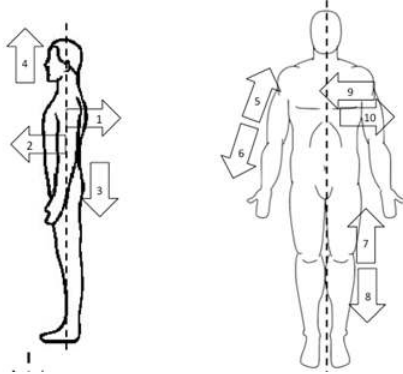
MEDIAL: Closer to the midline of the long axis of the body or region of the body

SUPERIOR: Region is above along the long axis of the body or region of the body

INFERIOR: Region is below along the long axis of the body or region of the body

SUPERFICIAL: Closest to the outer surface

DEEP: Furthest from the outer surface



References:

1= Dorsal

2= Ventral

3= Caudal

4= Cranial

5= Proximal

6= Distal

7= Superior

8= Inferior

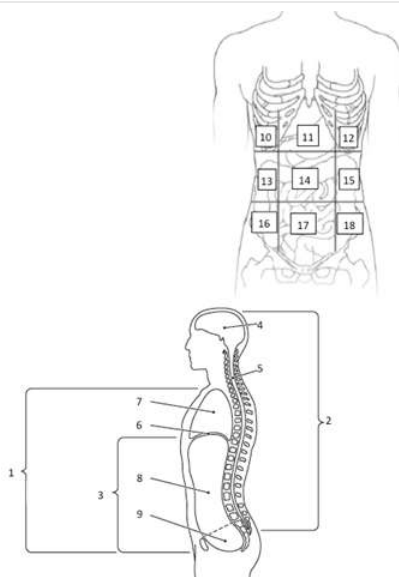
9= Medial

10= Lateral

11= Anterior

12= Posterior

Use your colored pencils to color each term in a different color to assist with identification



Cavities of the body and Regions of the Abdominopelvic Cavity:

1= Ventral Cavities

- 2= Dorsal Cavities
- 3=Abdominopelvic Cavity
- 4= Cranial Cavity
- 5= Vertebral (Spinal) Cavity
- 6= Diaphragm
- 7= Thoracic Cavity
- 8= Abdominal Cavity
- 9= Pelvic Cavity
- 10= Right Hypochondriac
- 11= Epigastric
- 12=Left Hypochondriac
- 13= Right Lumbar
- 14= Umbilical
- 15= Left Lumbar
- 16= Right Iliac
- 17= Hypogastric
- 18= Left Iliac

Use you colored pencils to color each cavity and region in a different color to assist with identification.

1. Obtain torso models, stickers and felt pen from instructor
2. Using the reference images, indicate the correct terms for orientation and localization of body parts
3. Using the models as a reference. Write the orientational reference terms in the blanks to label the anatomical models to correctly indicate the relationship between:
 - a. The elbow is to the shoulder.
 - b. The nose is to the ears.
 - c. The shoulder is to the hips.
 - d. The sternum is to the neck.
 - e. The right knee is to the left foot.
 - f. The scalp is to the skull.
4. Write the abdominopelvic region terms on the stickers
5. Using the anatomical model correctly label the regions and indicate an organ that might be found in that region
6. After labeling the models have your instructor check your work.
7. Clean-up your area

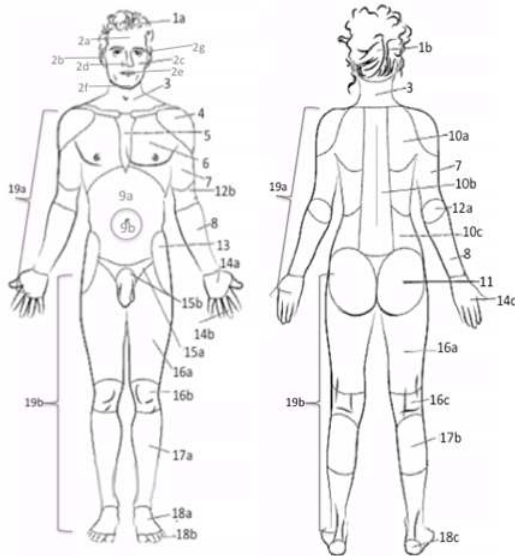
Activity 3: Anatomical Identifications and Translation

There are also references that allows for us to name and identify the various parts of the body, or body segments. This type of reference is independent of the point of reference or the plane of the body that is being used. That is unless we were to be referencing a specific side (right or left) on the person. Especially when we are doing locations when facing the person. Whenever you face the person, there is a phenomenon called **anatomical mirroring** that comes into play with identification. The mirroring indicates that what would be in our right side is actually the person's left and what is in our left side is actually the person's right.

With that in mind, we must discuss the anatomical terminology based on structures of the body as a whole or based on a regional area of the body or body segment.

<i>Common Phrase</i>	<i>Anatomical Term</i>	<i>ID on Image</i>	<i>Common Phrase</i>	<i>Anatomical Term</i>	<i>ID on Image</i>
Nose	Nasal	2d	Shoulder	Deltoid	4
Mouth	Oral	2e	Collar Bone	Clavicle (Clavicular)	
Neck	Cervical	3	Top of Shoulder	Acromial	
Head	Cephalic	1a	Armpit	Axillary	
Inside of Head	Cranial		Arm	Brachial	7
Head (Brain)	(Cranium)		Forearm	Antebrachial	8
Forehead	Frontal	2a	Front of Elbow	Antecubital	12b
Eye	Orbital (Ocular)	2g	Back of Elbow	Olecranon	12a
Cheek	Buccal	2c	Wrist	Carpal	
Mental	Chin	2f	Hand	Manus	
Ear	Auricle (Otic)	2b	Palm of Hand	Palmar	14a
Side of Head	Temporal		Back of Hand	Dorsum	14c
Back of Head	Occipital	1b	Fingers	Digits	14b
Rib	Costal		Thumb	Pollex (Polis)	
Sternum	Sternal	5	Hip	Coxal	13
Breast	Mammary		Buttock	Gluteal	11
Chest	Pectoral	6	Thigh	Femoral	16a
Spinal Column	Vertebrae	10b	Kneecap	Patellar	16b
Low Back	Lumbar	10c	Back of Knee	Popliteal	16c
Tail Bone	Sacral/Coccygeal		Calf	Sural	17b
Belly Button (Navel)	Umbilicus	9b	Leg (shin)	Crural	17a
Abdomen (Stomach)	Abdominal	9a	Ankle	Tarsal	
Abdomen (Gut or lower Abdomen)	Pelvic (Bowl)		Heel	Calcaneal	18c
Genitals	Pubic	15b	Foot	Pes	
Outside of Shin	Fibular		Top of foot	Dorsum	18a
Area around Anus	Perineal		Sole of foot	Plantar	
Crotch/Groin	Inguinal	15b	Toes	Digits	18b
Arm	Upper Extremity	19a	Big Toe	Hallux	
Leg	Lower Extremity	19b			

Using colored pencils, shade the various regions and structures in the image:



1. Obtain torso models, stickers and felt pen from instructor
2. Write the anatomical terms on stickers
3. Taking turns within your group, correctly label the anatomical model
4. Have your instructor check your work.
5. After checking your work, remove the stickers (but don't throw them away).
 - a. Select one member of your group to be the "leader" the group and one member to "model" for your group
 - b. The leader will use the term sheet and ask other members to correct label the model one person at a time. If the identification is correct, the next person will label. However, if the leader must correct the label that person will go again until they correctly label the model.
 - c. After three rotations through your group, switch roles with the leader and the model now labeling and the labelers being the leader and the model.
 - d. Continue switching roles until you have no more structures to label.
6. Discuss in your group. Question: Why is important to know the anatomical terms and the concept of anatomical mirroring? **Share your response with your instructor**
7. One of the things that we will have to do routinely in our careers is change our speech based the audience that we are talking with. This becomes even more problematic when are constantly going between medical charts and our patients. To make sure that you are able to do this transition, translate the following kid's sing-along into correct anatomical terminology:

Head and shoulders knees and toes
 Knees and toes
 Head and shoulders knees and toes
 Knees and toes
 And eyes and ears
 And mouth and nose
 Head and shoulders knees and toes
 Knees and toes
 Feet and tummies arms and chins
 Arms and chins
 Feet and tummies arms and chins

Arms and chins
And eyes and ears
And mouth and shins
Feet and tummies arms and chins
Arms and chins
Hands and fingers legs and lips
Legs and lips
Hands and fingers legs and lips
Legs and lips
And eyes and ears
And mouth and hips
Hands and fingers legs and lips
Legs and lips
Head and shoulders knees and toes
Knees and toes
Head and shoulders knees and toes
Knees and toes
And eyes and ears
And mouth and nose
Head and shoulders knees and toes
Knees and toes

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1.3: ORGANIZATION of the BODY CELLS and TISSUES

Learning Objectives

Students will be able to...

1. Differentiate between the various organs and tissues of the body
2. Correctly troubleshoot issues with microscope
3. Be able to focus and change magnifications of view on the microscope
4. Differentiate between the cytology of the various types of tissues
5. Identify and explain the functions of the various organelles of the cells of the body

Pre-Lab Exercise:

After reading through the lab activities prior to lab, complete the following before you start your lab.

1. There are types of tissues.
2. True/False: Tissues are the building blocks of the human body. .
3. When using a microscope, you only use coarse adjustment at a magnification of .
4. Color the images for use as a reference for identifying the models and dissected specimens

Materials:

- Stickers
- Felt Tip Pen
- Cell Model
- Microscopes
- Slides: Lung and Bronchiole, Kidney, Skin, Urinary Bladder, Ileum, Fibrocartilage, Elastic Cartilage, Bone, Ligament, Areolar Connective Tissue, Reticular Connective Tissue, Skeletal Muscle Cardiac Muscle, Nerve Smear

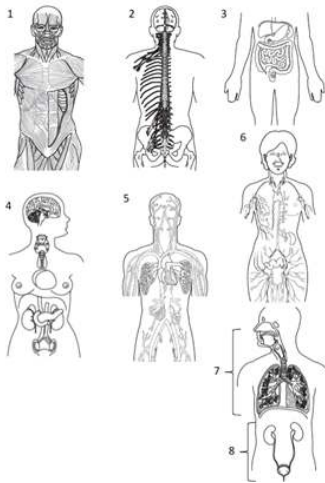
Organization of the Body

We must think of the body as being built in layers of ascending complexity beginning with the atom and ending with entire organism. Each level of complexity is developed through an increase in the various components that are interacting within that level. This begins with the atom and the subatomic components (electrons, neutrons, protons) followed by the interaction of atoms with other atoms forming molecules that will interact with other molecules forming the macromolecules. We tend to think about in these macromolecules as being carbohydrates, lipids, and proteins, but also include molecules like adenosine triphosphate (ATP) and nucleic acids. From these macromolecules we have interactions that eventually form the organelles and cells that will interact with each other leading to the formation of the tissues. Tissues are conglomerations of cells that share a similar function for the body that will work and interact with each other. Developing into regulated (or control) organs, a conglomeration of tissues with a shared function within the homeostasis of the body. These organs eventually coordinate their independent functions into the systems that comprise the body that we typically think about when discussing human anatomy and physiology.

There are four distinct types of tissues. The first type of tissue that we should be aware of is the epithelial tissue. The epithelial cells are found throughout the body and are typically found as a tissue that lines the body. In their function as a barrier tissue, these cells will be attached to these tissues by a layer of connective tissue layer described as the basal membrane. The next type of tissue is the connective tissue. Connective tissue is comprised of cells that produce different types of protein fibers that are exuded from cells that develop a matrix of protein and fluids that connect different tissues of the body into a network of tissues that provides functional units of the organ systems of the body. There is a vast array of connective tissue structures and functions throughout the body. Each type of connective tissue has different cells that provide the materials for the matrix and the matrix of the connective tissue will differ to match the desired function of the connective tissue type. The third type of tissue is muscle tissue. Muscle tissue is a special type of cell that unlike the cell types already described are deemed to be an “excitable” tissue. Meaning that they function by generating electrical currents within the tissue to perform the function of the tissue. In this way, all muscle tissue, regardless of the distinct type will exhibit the following qualities: irritability, extensibility, elasticity, and contractility. Each one of these qualities provides the foundation for the difference in physiology of the muscle tissue. The final type of tissue is nervous tissue. Nerve tissue is made of specialized excitable cells termed neurons and support cells termed glia. Neurons are specialized columnar epithelial cells that function to transmit electrical signals between cells and tissues. While glial cells are host of various types of cells that support the function and “health” of the neurons.

When we examine the body, it is generally done based on a systems approach. These systems include the musculoskeletal (skeletal

muscle and skeletal) systems, the nervous system, the cardiorespiratory (cardiovascular and respiratory) systems, the immune system, the excretory system, the digestive system, the neuroendocrine system, the reproductive system and the integument system. While each system will have an independent function, they function in a coordinate manner so as to ensure that the body is able to remain in a stable state and respond effectively to any stimulus that might disrupt this stability.



Systems of the Body

1= Musculoskeletal

2= Nervous

3= Digestive

4= Neuroendocrine

5= Cardiovascular

6= Lymphatic/Immune

7=Respiratory

8= Urinary

Use you colored pencils to color each plane in a different color

Organ System	Function	Organ System	Function
Integument	Functions to serve as barrier between the body and the external environment. Provides as a means for sensory information as to the conditions of the external environment and a means to thermoregulate to maintain a homeostatic core body temperature	Respiratory	Functions to exchange volatile chemicals (gasses) between the body and the external environment. Provides a means to regulate the chemistry of the plasma via gas exchange at the alveoli.
Musculoskeletal	Functions to serve as the mechanical lever systems for movements of the body and rigid structures to provide stable morphology of the body. Involved with metabolic and immune regulation, ion balance, and thermogenesis to maintain a homeostatic internal environment	Immune	Functions to serve as a means to protect the body from foreign or toxic materials. Provides responses to eliminate infectious agents, inflame areas following injury to “splint” and ensure limited damage following the injury and the repair of the tissues
Nervous:	Functions to serve as a means to transmit information from various tissues of the body to other parts of the body via specific cells (neurons). Provides the ability to instantaneously regulate	Gastrointestinal	Functions as an open tube through the body to ingest and digest materials necessary to tissue repair and energetic balance. Provides a sequestered area to mechanically and chemically digest and then absorb

	homoeostasis via reflex loops and through specific central structures establish memories to provide anticipation for reflex loops and coordinate functions between tissues.		nutrients without over expression of immune response to foreign materials
Neuroendocrine	Functions to produce and release chemical signals to regulate the metabolic functions of tissues. Provides a means to signal tissues of the metabolic stress being encountered by different regions of the body and then regulate, and control, the metabolism of cells and tissues to ensure that homeostasis is maintained.	Excretory	Functions to eliminate metabolic waste products and toxins from the body. Provides a means to regulate the chemistry of the body to ensure homeostatic balance of ions, water, and chemicals within the blood and tissues of the body.
Cardiovascular	Functions to serve as transportation medium of chemicals and specific cells throughout the body. Heart functions as hydraulic pump moving blood through the body via tubule structures (vessels). Provides as a means for conveying chemical information as to the conditions of the internal environment, transportation of metabolites, and a means to thermoregulate to maintain a homeostatic core body temperature through heat exchanges.	Reproductive	Functions to form gametes and regulate maturation of the body to allow for sexual reproduction and for females the system is involved with pregnancy and care of the infant. Highly integrated within the neuroendocrine system. Provides a means to allow for offspring to be formed and cared for during infancy and early childhood.

Activity 1: Identifying Cellular Organelles

Cell and Organelles

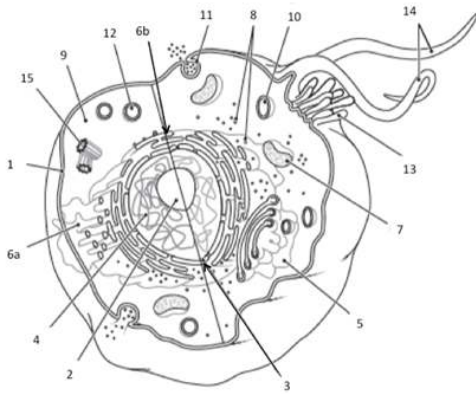
Cells are the building blocks of the body. Each cell itself is made of various components that perform functions that all for the cell to maintain its own homeostasis.

Organelle	Associated Function
Cell Membrane	Phospholipid bilayer that surrounds outer surface of the cell forming “protective” envelope
Integral Membrane Proteins	Proteins embedded into cell membrane that either attach internally to membrane anchored vesicle/vacuole, or externally to function as “marker” of cell or adhesion point to join with other cells
Transmembrane Protein	Proteins that span the membrane that allow for materials to move between the external and internal cellular environments
Nucleus	Organelle that is responsible for “housing” genetic materials (DNA, mRNA, tRNA, rRNA) of the cell
Nucleolus	Subregion within the nucleus that contains ribosome proteins prior to movement to cytosol or endoplasmic reticulum
Endoplasmic Reticulum	Phospholipid membrane that anchors to the outer membrane of the nucleus and runs throughout the cell, identified as being “smooth” or “rough” depending on presence of ribosomes. Responsible for production of lipids and proteins (from embedded ribosomes).
Ribosome	Responsible for translation and protein synthesis, comprised of 2 components (protein component and nucleic acid component, rRNA)
Lysosomes	Vesicle responsible for sequestering digestive enzymes for use by the cell on materials following pino-, or phago-cytosis
Peroxisomes	Vesicle housing peroxides and digestive enzymes responsible for cellular digestion of materials following pinocytosis, or phagocytosis. Involved with fatty-acid oxidation
Vacuoles	Vesicle responsible for “storage” of cellular materials and compounds
Mitochondria	Organelle responsible for aerobic phosphorylation of ADP to ATP
Golgi Apparatus	Stacked membrane organelle connected with endoplasmic reticulum that “coats” materials for secretion, or release, from the cell
Cilia	Membrane extensions comprised of cytoskeletal protein core and cell membrane “envelope” responsible for motility, and locomotion, of the cell (or in colony movement of materials)
Microvilli	Membrane extensions comprised of rigid cytoskeleton that increases the total surface of the cell membrane
Flagella	Elongated membrane extension comprised of cytoskeletal protein core and cell membrane “envelope” responsible for locomotion of the cell
Cytoskeleton-Proteins	Functional proteins responsible for maintenance of cell shape in response to external/internal environmental cues
Centrioles	Protein based organelle only functional during mitosis that is responsible for segregation of chromosomes between daughter cells
Cytosol	Internal environment of cell comprised of electrolytes, proteins and non-organelle materials

Organelles and Structures of the Cell

- 1= Cell Membrane
- 2= Nucleolus
- 3= Nuclear Envelope/Nuclear Membrane
- 4= Nucleus
- 5= Golgi Apparatus/Golgi Bodies
- 6a= Smooth Endoplasmic Reticulum
- 6b= Rough Endoplasmic Reticulum
- 7= Mitochondria
- 8= Ribosomes
- 9= Cytoplasm
- 10=Lysosome
- 11= Clathrin Pit/Endocytosis or Exocytosis
- 12= Peroxisome
- 13= Cilia
- 14= Flagella
- 15= Centriole

Use you colored pencils to color each part of the cell in a different color for reference when identifying.



1. Obtain cell model, stickers and felt pens from your instructor
2. Write the organelle names on the stickers
3. Taking turns within your lab group,
 - a. Each member will label one organelle of the cell on the model.
 - b. Check that they have labeled the organelle correctly and if correct move the next member. If it is not correct, a member in your group should correct the label.
 - c. Proceed to the next member in the group and continue until all labels have been used.
 - d. Once you have labeled the entire model, have your instructor check your work
4. Clean-up your labels from the cell model

Activity 2: Tissues and Histology (study of the tissues by using a microscope)

Using the Microscope

The microscope is a key tool for examining the cells and tissues of the body. In order to successfully examine tissues, you must be able to use the microscope correctly. Before we start off with studying tissues and cells it is important to be able to use the microscope correctly is having the knowledge of magnification of the tissue through the microscope and what to do if something goes wrong.

Principles of Magnification

Microscopes have 3 magnifications: Scanning, Low and High. Each objective will have written the magnification. In addition to this, the ocular lens (eyepiece) has a magnification. The total magnification is the ocular x objective

Total Magnification

Objective Lens	Ocular Lens	Total Magnification
4x	10x	40x
10x	10x	100x
40x	10x	400x

Focusing Specimens

1. **Always start with the scanning objective.** Odds are, you will be able to see something on this setting. Use the Coarse Knob to focus, image may be small at this magnification, but you won't be able to find it on the higher powers without this first step. Do not use stage clips, try moving the slide around until you find something.

2. **Once you've focused on Scanning, switch to Low Power.** Use the Coarse Knob to refocus. Again, if you haven't focused on this level, you will not be able to move to the next level.

3. **Now switch to High Power.** (If you have a thick slide, or a slide without a cover, do NOT use the high- power objective). At this point, ONLY use the Fine Adjustment Knob to focus specimens.

4. If the specimen is too light or too dark, try adjusting the diaphragm.

5. If you see a line in your viewing field, try twisting the eyepiece, the line should move, that is the pointer, and is useful for pointing out things to your lab partner or teacher. **Drawing Specimens**

1. Use pencil - you can erase and shade areas

2. All drawings should include clear and proper labels (and be large enough to view details). Drawings should be labeled with the specimen name and magnification.

3. Labels should be written on the outside of the circle. The circle indicates the viewing field as seen through the eyepiece, specimens should be drawn to scale (if your specimen takes up the whole viewing field, make sure your drawing reflects that).

Troubleshooting

Occasionally you may have trouble with working your microscope. Here are some common problems and solutions.

1. If the Image is too dark!

Make sure your light is on

Adjust the diaphragm

2. There's a spot in my viewing field, even when I move the slide the spot stay in the same place!

Your lens is dirty. Use lens paper, and only lens paper to carefully clean the objective and ocular lens. The ocular lens can be removed to clean the inside.

3. I can't see anything under high power!

Remember the steps, if you can't focus under scanning and then low power, you won't be able to focus anything under high power.

4. Only half of my viewing field is lit, it looks like there's a half-moon in there!

You probably don't have your objective fully clicked into place.

Part A: Epithelial Tissue

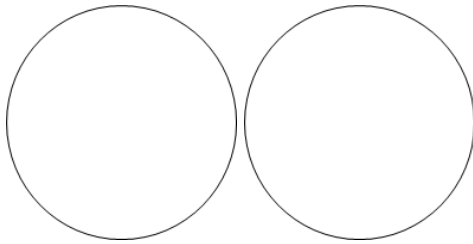
The description of epithelium is based on the shape of the cell or based on the number of layers of cells contained in the tissue. The identification that is based on layers of epithelium is given by the number of layers of cells between the basal membrane of the tissue and the outer most cells. It is generally divided into either being a single layer of cells or appearing to have more than a single layer of cells. In which we discuss epithelial cells as: simple (only 1 cell layer of epithelium), stratified (more than 1 cell layer of epithelium), or pseudostratified (appears to have multiple layers of cells, but all cells make contact with the basal membrane). The layer identification is then combined with the general shape of the epithelial cell to give the complete identification. The shapes are described as: squamous (flat elongated cells associated with lining of tissues and organs, primary cell of the epidermis), cuboidal (cube shaped cells that are associated with absorbing materials but may also be involved with secretory functions of glands), or columnar (column shaped cells that are associated with secreting and absorbing materials from the extracellular spaces).

Additionally, epithelial cells can be discussed based on cellular structures. Ciliated epithelium is typically columnar (or cuboidal) that use the cilia and microvilli to establish a "brush boarder" within the tissue. These brush boarders are used to either increase total

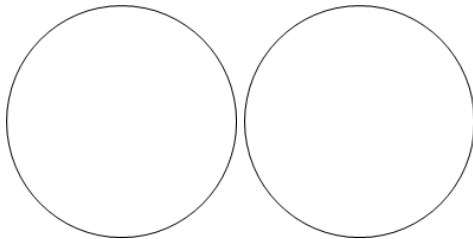
surface area for interaction between substances with the epithelial cells or assist with the movement of materials along surface of tissue. There are also some specialized columnar cells. One such cell are the secretory cells that are identified as “goblet” and the prototypical cell used for most tissues involved with secretions within lumens of the body. Within the types of epithelium are specialized secretory cells (cells that secrete materials into the extracellular fluids. These are “glandular tissues” are described using 3 general classifications. There are merocrine glands, which release only secretions from the cell into ducts or onto tissues. There are apocrine glands that release small parts of the cell that are “squeezed off” from the cell into the ducts for secretion. Lastly there are holocrine glands that release entire cells into the ducts for secretion. The other type of secretory glandular epithelial is the serosa epithelial. These epithelial cells secrete a mucous coating that allows for a decrease the friction between two interacting surfaces of tissues within the body.

Procedures:

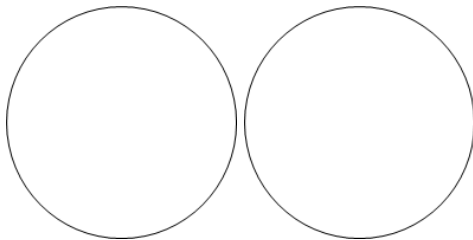
1. Examine the slides of epithelial tissues under scanning and high magnification.
2. For each power, one person in your group will draw what is seen in the ocular of the microscope and the other person will draw the image at the other magnification.
3. Simple Squamous (Lung and Bronchiole Slide)



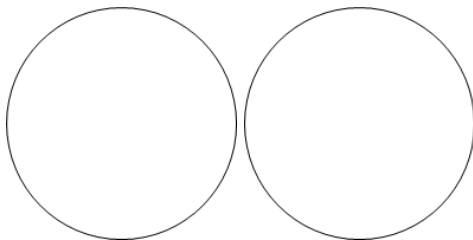
4. Simple Columnar (Ileum Slide)



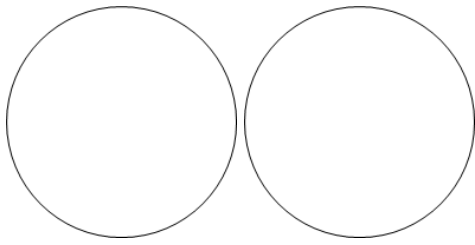
5. Simple Cuboid (Kidney Slide)



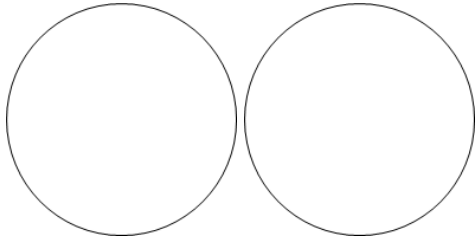
6. Pseudostratified Ciliated Columnar (Trachea Slide)



7. Transitional Epithelial (Urinary Bladder Slide)



8. Stratified Squamous Epithelial (Keratinized) (Skin)



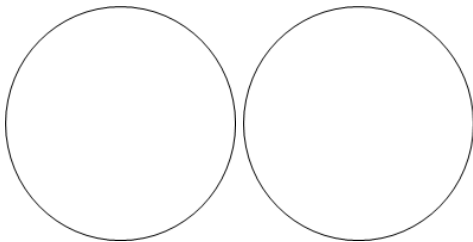
9. Compare your slides and diagrams within your group.

Part B: Connective Tissue

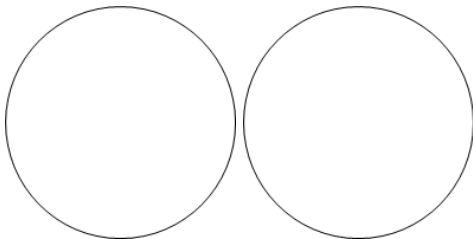
We generally use three distinct classes of tissues to describe the array of cells and tissues that comprise the connective tissues. There is true connective tissue, which form a protein matrix that connects tissues to each other that are classified as being either dense or loose. There is supportive: forms solid matrixes that form the rigid or semi-rigid structures of the body. Then there is the liquid: protein matrix is dissolved within an aqueous solution, used for transportation connection between tissues and includes tissues such as blood and lymph.

Procedures:

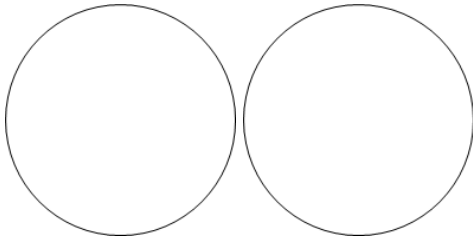
1. Examine the slides of connective tissues under scanning and high magnification.
2. For each power, one person in your group will draw what is seen in the ocular of the microscope and the other person will draw the image at the other magnification.
3. Dense Regular Connective Tissue (Ligament Slide)



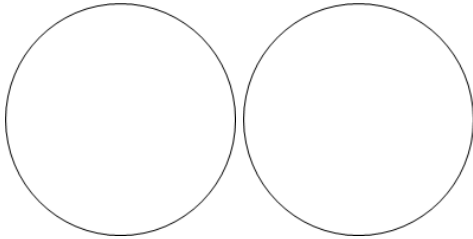
4. Dense Irregular Connective Tissue (Skin Slide)



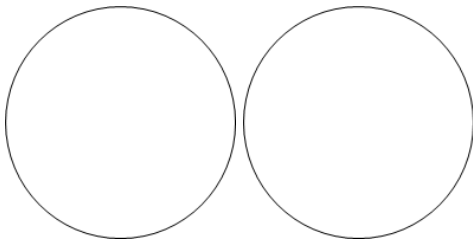
5. Loose Areolar Connective Tissue



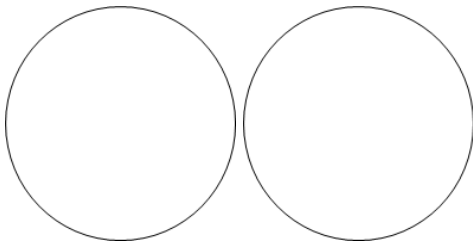
6. Reticular Connective Tissue



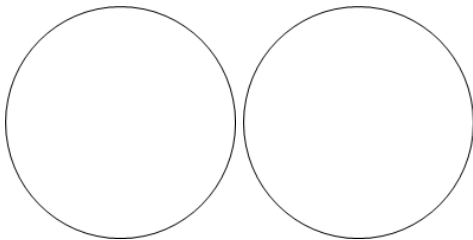
7. Elastic Cartilage



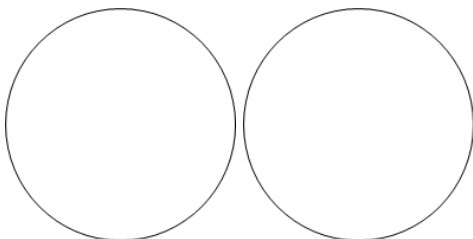
8. Hyaline Cartilage (Trachea Slide)



9. Fibrocartilage



10. Bone



11. Compare your slides and diagrams within your group.

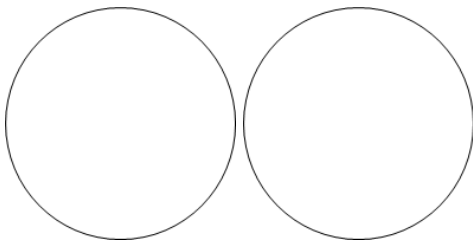
Part C: Muscle Tissue

There are three (3) different types of muscle cells that recognized in the human body. This recognition is noted by the presence of (striated) or lack of organized intracellular structures (smooth) referred to transverse tubules (T-tubules). Within this typing of cells striated muscle tissues are additionally given names based on where in the body they are located (skeletal or cardiac) in the body, figure 15. Histologically striated (skeletal) muscle is a poly-nucleated (having more than 1 nucleus) cell with elongated striated muscle that attach to the skeletal structures via tendons and with nervous system stimulation allow for movement to occur. While smooth muscle is amorphic (no regular shape) muscle tissue with no visible striations that form a ring of muscle tissue surrounding lumens and organs of the body. Within the smooth muscle, the contractile proteins are arranged in the spiral to the long axis of the cell as opposed to cylinders that parallel the long axis seen in the skeletal and cardiac muscle. Lastly the cardiac muscle is a “Y-shaped” striated muscle that forms a network of overlapping muscle tissue connected with intercalated disks to all for coordination of muscle contraction.

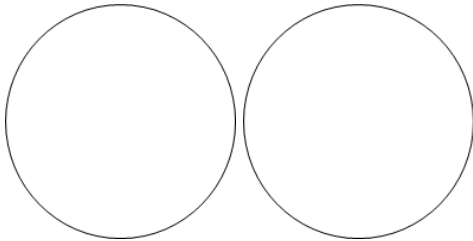
Procedures:

1. Examine the slides of muscle tissues under scanning and high magnification.
2. For each power, one person in your group will draw what is seen in the ocular of the microscope and the other person will draw the image at the other magnification.

3. Skeletal Muscle



4. Cardiac Muscle



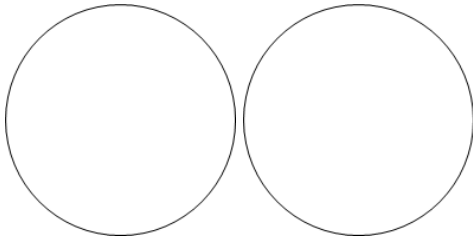
5. Compare your slides and diagrams within your group.

Part D: Nervous

Neurons are classified by shape and by function relative to that shape and number of axon projections. With the identification being unipolar (one axonal projection), bipolar (two axonal projections), or multipolar (multiple axonal projections). The key glial cells are the myelinating cells (Schwann and oligodendrocyte) that support and insult the axon of the neuron, and the astrocytes, microglia and oligoglia that support the health of the neuron via metabolic activities or functioning as immune-like cells.

Procedures:

1. Examine the slides of nervous tissues under scanning and high magnification.
 2. For each power, one person in your group will draw what is seen in the ocular of the microscope and the other person will draw the image at the other magnification.
3. Nerve Smear



4. Compare your slides and diagrams within your group.

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1.4: Skin and Integument

Learning Objectives:

At the end of the lab, you will be able to...

1. Correctly identify the type of cells comprising the integument by layer
2. Differentiate the epidermis by strata
3. Explain the role of the skin as it relates to the regulation of homeostasis of the body
4. Differentiate the types of fingerprint patterns and how to read the fingerprint

Pre-Lab Exercise:

After reading through the lab activities prior to lab, complete the following before you start your lab.

1. The layers of the epidermis from deepest to most superficial are .
2. True/False: Subcutaneous tissues are made of dense irregular connective tissues that tightly binds the skin to the underlying tissues of the body. .
3. When examining fingerprints, the print that loops toward the thumb would be referenced as a .
4. Color the images for use as a reference for identifying the models.

Materials

- Colored Pencils
- Model of Skin
- Stickers
- Felt-tip pen
- Inkpad
- Flashcard
- Microscope
- Slide of Skin

Activity 1

Layers of the Skin

The skin is comprised of three layers of tissues (**epidermis**, **dermis**, and **subcutaneous tissue {hypodermis}**). Each layer can function independently or in conjunction with each other to fulfill the generalized role of protection of the body. These layers of cells and tissues will combine with the accessory organs integrated into the integument to perform its function to help with maintaining homeostasis for the body.

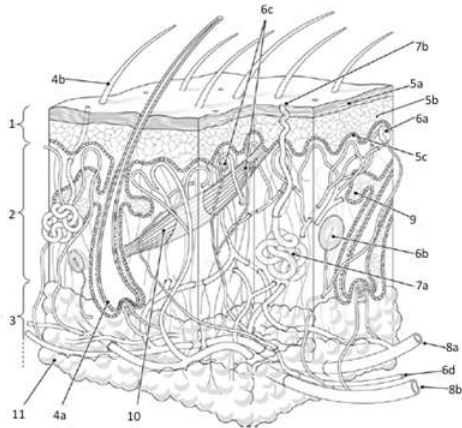
The outer most of the layers (epidermis) is made of stratified squamous epithelial tissue that is layered into 5 distinct stratas. The stratification of specialized cells (keratinocytes) establishes an impermeable membrane around the entirety of the body. Deep to the epidermis is the dermis that is primarily made of dense irregular connective tissue. Within the dermis there will be all of the accessory organs that allow for thermoregulation (hair, sudoriferous glands, and the dermal arterioles and capillaries) and an oil secretion (sebaceous glands) that protects the body for dehydrating, along with the gathering sensory information from the external environment. The deepest layer is the hypodermis, where loose connective tissue (areolar connective tissue) will bind the skin to the underlying tissues and adipose tissue that will insulate the body and protect underlying from physical injury

Methods:

1. Obtain model of the skin, felt pen and stickers from your instructor
2. On the stickers, write the names of the layers of the skin and proceed to label the structural layers of the skin
Epidermis, Dermis, Hypodermis (Subcutaneous Adipose Tissue), Dermal Arteries and Veins, Hair, Hair Follicle, Arrector Pili, Dermal Papilla
3. After labeling the layers of the skin, write the names of the structures of the skin responsible for protecting the body and obtaining sensory information from the external environment.
Ruffini Endings, Pacinian Corpuscles, Root Hair Plexus, Merkle's Discs, Meissner's Corpuscles
4. Take turns within your group labeling the structures of the skin responsible for receiving sensory information

5. Discuss in your group: Why are sensory receptors located at various depths within the dermis? *Share your thoughts with your instructor.*

6. Move the model to the side of your work area and move to activity 2



Layers and Structures in the skin:

1=Epidermis

2=Dermis

3=Hypodermis (Adipose/Subcutaneous)

4a= Hair Follicle

4b=Hair Proper

5a=Stratified Keratinocytes

5b=Stratum Basale

5c=Dermal Papilla/Ridges

6a= Meissner's Corpuscles

6b= Pacinian Corpuscles

6c=Merkle's Discs, Thermoreceptors/Nociceptors

6d=Afferent Nerve

7a=Coiled Gland of Sudoriferous (Sweat) Gland

7b=Duct of Sudoriferous (Sweat) Gland

8a=Dermal Arterioles

8b=Dermal Venuoles

9=Sebaceous Gland

10=Erector Pili Muscle

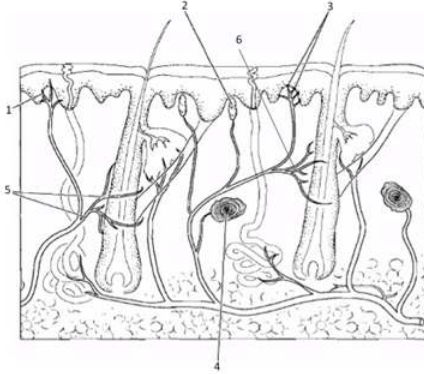
11=Adipose Tissue

Use you colored pencils to color each layer of the skin and the various structures using a different color

Layers and Structures in the skin:

- 1=Nociceptors
- 2=Meissner's Corpuscles
- 3=Merkle's Discs
- 4=Pacinian Corpuscles
- 5=Root Hair Plexus
- 6=Ruffini Endings

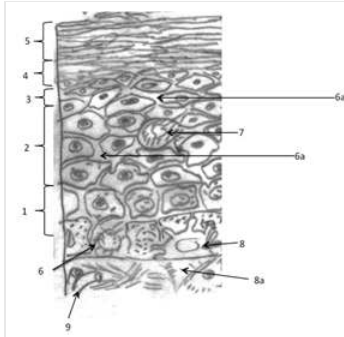
Use your colored pencils to color each of the various structures using a different color



Activity 2

The epidermis is comprised of Stratified Squamous Epithelium. The stratification is presented so that there are 5-distinct layers (strata) within the epidermis (**Stratum Basale**, **Stratum Spinosum**, **Stratum Granulosum**, **Stratum Lucidum**, and **Stratum Corneum**). The layering and density of cells within each layer can vary based on the area of the body (such as the plantar surface of the foot and palmar surface of the hand having a larger layer of spinosum).

1. Obtain microscope and slide of the skin
2. Label the image of the epidermis to show the appropriate strata

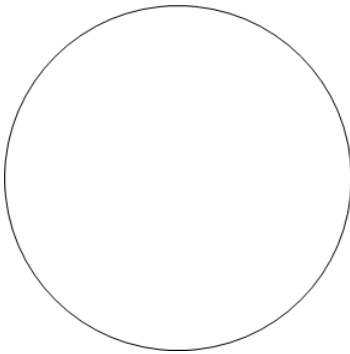


Stratum of the Epidermis:

- 1=Stratum Basale
- 2=Stratum Spinosum
- 3=Stratum Granulosum
- 4=Stratum Lucidum
- 5=Stratum Corneum
- 6=Melanocyte
- 6a=Pseudopodia of Melanocyte
- 7=Langerhans Cell
- 8=Merkle's Discs
- 8a=Neuron of Merkle's Discs
- 9=Capillary

Use your colored pencils to color each layer of cells in a different color

3. Using your microscope to exam the skin slide.
 - a. Focus to the superficial edge of the skin and magnify to highest power. Once at highest power (400x total magnification), draw and label the slide in the area provided.



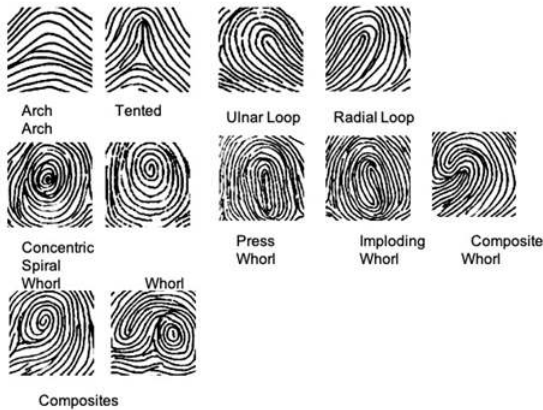
Activity 3

Fingerprints and Footprints are found on palmar and plantar surfaces of the hand and feet at the distal ends of digits. These are specialized areas that have a high density of reticular connective tissues in the dermal papilla that generates ridging within the epidermis. These ridges function to increase the surface area to allow for greater contact between the skin and the surface that they are in contact with. The ridging develops into prototypical forms that are quasi-unique among individuals.

1. Obtain materials from your instructor
2. Select the partner to be printed first.
3. The person to be printed needs to clean the end of each finger with alcohol swabs
4. While the first person being printed is cleaning their digit, the partner that is going to do the fingerprinting needs to ready the flash card by labeling areas for each finger and open the ink pad

5. The person to do the fingerprinting needs to stand to the side of your partner and grasp their hand, folding all fingers but the thumb into a fist
 - a. Controlling the distal end of the Right thumb, place the thumb onto the ink pad, and then rolling in one smooth ulna-to-radius across the flash card where “Right Thumb” is indicated.
 - b. Fold the thumb into the fist and have the person being printed extend their index finger.
 - c. Repeat the procedure to print the index finger
 - d. Repeat for the remaining fingers and then switch hands
6. The person that just got printed should now wash the ink off.
7. Repeat the procedures for the second partner.
8. Compare your prints to the examples shown below.

FINGERPRINTS



Flash Card Design for Fingerprinting

Right Thumb	Right Index	Right Middle	Right Ring	Right Little
Left Thumb	Left Index	Left Middle	Left Ring	Left Little

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1.5: Musculoskeletal Anatomy Part 1- The Skeleton and Bones of the Body

Objectives:

At the end of this lab, you will be able to...

1. Describe the general histology of the bone based on the type of bone (cortical or trabecular) tissue
2. Describe the general structure of bones of body based on classification of the shape of the bone (long, short, flat, sesmoid, or irregular).
3. Differentiate between bones of the body based on the classification of the shape of the bone.
4. Identify the bones of the body using correct anatomical terminology
5. Use correct anatomical terminology to correctly identify bone landmarks that serve as attachment points for skeletal muscles and ligaments
6. Correctly classify the articulations of the body based on amount of movement that the articulation allows or structure of the articulation
7. Correctly classify the synovial articulations based on the shapes of the bones and amount of movement allowed

Pre-Lab Exercises:

After reading through the lab activities prior to lab, complete the following before you start your lab.

1. There are approximately bones of the body.
2. The axial skeleton is made up of the .
3. The bones of the upper extremity include the .
4. The difference between the lumbar vertebrae and the other vertebrae is the size of the .
5. Color the images for use as a reference for identifying the bones and models.

Materials:

- Sagittal-Cut Long Bone Model
- Skeleton
- Bone Box with skeletal bones
- Stickers
- Felt pens

The human skeleton is comprised of approximately 206 bones (depending on whether or not you include all of the Sesamoid bones and teeth). These bones are divided into two general regions, axial skeleton and appendicular skeleton, based not on the morphology of the bone per say but the location of the bone and its overall function for the body. The axial skeletal bones tend to be flat or irregular types of bones, while the appendicular bones tend to long or short types of bones. The axial skeleton acts as an anchorage for the appendicular skeleton and provides the body with a central rigid framework for protection of what are generally referred to as vital organs. The axial skeleton is comprised of the costal cage (costal bones, clavicle and sternum), the cranium (bones of the skull), vertebrae and the pelvis, while providing the scaffolding for the erect posture that we assume during locomotion. The appendicular skeleton acts principally as levers for the muscles to pull on in order to provide force for movements of the body. The appendicular skeleton is comprised of the bones of the upper (humerus, radius, ulna, carpals, metacarpals and phalanges) and lower (femur, tibia, fibula, tarsal, metatarsal and phalanges) extremities. Based on the location of the bone, you will notice distinct morphological characteristics of the bones contained within each region of the skeleton.

Activity 1:

General Structure:

Bone Tissue

The bone is comprised of two distinct types of bones that form based on the arrangement of the tissues to establish these hollow cylinders, cortical (compact) and trabecular (spongy) that form layers of tissues (lamellae) within the osteon (region of concentric rings of lamina) that open around the osteocytes (lacunae) that protects the cells from being mineralized.

There are structures to recognize histologically within the cortical bone that provide a means for movements of cells or materials.

These histological features are referenced as canaliculi; allow the lacunae to connect with each other. Connecting to these canaliculi are various openings within the matrix that eventually link to the medullary canal of the long bone or the trabecular medulla of the flat bones. This includes the Haversian canals that form the central ring of the osteon. Within the cortical bones these canals run parallel to each other in the parallel orientation of the concentric rings, are linked by secondary openings, the Volkmann's canal to the medullar cavity of the bones, and allow for the passage of blood vessels and nerves into the bone matrix. Whereas the trabecular bone have Haversian canals that run at angles not parallel to each other and thus do not need the Volkmann's canal. Cortical, sometime referenced inappropriately as compact, bone is principally found to the lateral aspect of the bone. The tissues are arranged in concentric circular formations known as the Haversian systems and align parallel to each other along the long axis of the bone. Trabecular, mistakenly called spongy, bone are oriented at tangents to the long axis orientation of the cortical bone. This bone tissue is aligned along the center of the bone shaft based almost entirely on the lines of force application to the various axes of the bones. In response to the various axes of force, bone growth found within the trabecular bone tends to have the bone tissue resemble the formation of arches or trusses within the central region of the bone that is tangential to the neutral axis of the bone.

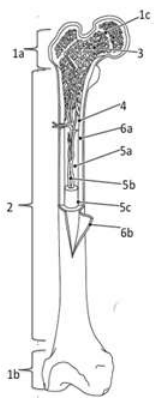
Classification of Bones Based on Structure

We have five differentiated classifications for bones based on their structure: Long, Short, Flat, Irregular and Sesmoid. The long bone is comprised on distinct regions include the Articulating Edges, Epiphysis, Diaphysis, Metaphysis and Central Medullary Canal. Within the Medullary canal, there is the bone marrow (Red, site for generating blood cells, and Yellow, lipid stores with the bone that is used for protection of vessels and nerves) and the major artery, vein and nerve for the bone that branch into the individual Haversian and Volkmann's canals. Unlike the long and short bones, the flat, irregular and sesmoid bones lack these various regions.

Procedures:

1. Obtain the sagittal-cut long bone
2. Write the regions of the long bone on the stickers

a. Regions of long bone: Cortical Bone, Trabecular Bone, Articulating Edge, Epiphysis, Diaphysis, Metaphysis, Medullary Canal, Area of Red Bone Marrow, Area of Yellow Bone Marrow



Regions of the long bone

1a=Proximal Epiphysal

1b=Distal Epiphysal

1c=Epiphysal Line

2=Diaphysal (Body of Bone)

3=Trabecular Bone

4=Cortical Bone

5a=Medullar Cavity

5b=Artery/Vein

5c=Yellow Marrow (Adipose)

6a=Endosteum (lining the Medullar Cavity)

6b=Periosteum (covering the bone)

Color each part of the bone with a different color

3. Working with your lab group:

a. Select a group leader

- i. Group leader will call of one of the region and nominate a member of the group to identify that region with the correct sticker
- ii. If the region is correctly identified ask one specific feature associated with that area and then move to the next region and new identifier. If the region is not correctly identified, the group should correct the mistake and the person will go again on the next region.
- iii. Continue to rotate through the group until all regions have been identified. Have your instructor check your work.

Activity 2: The Axial Skeleton

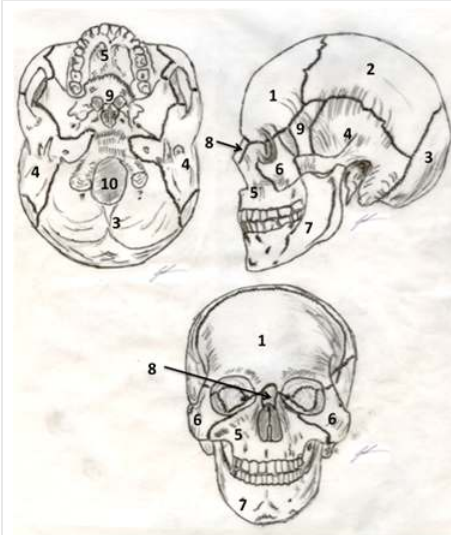
The axial skeleton is comprised of the skull, vertebrae, costal cage, and pelvis.

A) Bones and Landmarks of the Skull

The skull is the conglomeration of fused bones of the cranium and face. This region can be further broken into two distinct sub-regions that serve to protect the cerebral cortex and the special sense organs and anchor the muscles of mastication or facial movements (necessary for non-verbal cueing and communication). The first sub-region, cranial bones, makes a vault of bone that encompasses and protects cerebral cortex and contains/protects special sense of vision, auditory and vestibular organs. The second sub-region, facial bones, makes oral opening that begins gastrointestinal tract and allows for beginning of mechanical digestion and contains/protects special senses olfaction organs.

Procedures:

1. Obtain the skull from the Bone box
2. Working with your lab group:
 - a. Write the names of the bones of the cranium and face along with the landmarks that you are responsible for knowing on the stickers
 - i. Cranial Bones: Ethmoid Bone, Frontal Bone, Occipital Bone, Parietal Bone, Temporal Bone, Sphenoid Bone, Vomer
 - ii. Facial Bones: Zygomatic Bone, Nasal Bone, Maxilla, Mandible, Palatine Bone



Bones of the Skull

- 1=Frontal
- 2=Parietal
- 3=Occipital
- 4=Temporal
- 5=Maxilla
- 6=Zygomatic
- 7=Mandible
- 8=Nasal
- 9=Sphenoid
- 10=Foramen Magnum

Color each with a different color to use as a reference for labeling the skull

iii. Landmarks:

Ethmoid: Cribiform Plate and Olfactory Foramina

Occipital Bone: Foramen Magnum, Occiput, Occipital Condyle

Sphenoid Bone: Lesser Wing, Greater Wing, Sella Turcica

Temporal Bone: Styloid Process, Mastoid Process, External Auditory Meatus (External Acoustic Meatus), Internal Auditory Meatus (Internal Acoustic Meatus), Zygomatic Process

Maxilla: Alveolus, Incisive Foramen

Mandible: Mental Foramen, Alveolus, Mandibular Condyle

- b. As a group, use the bone atlas and your notes to identify the bones of the cranium and the face

i. Select a group leader

1. Group leader will call of one of the landmarks and nominate a member of the group to identify that landmark with the correct sticker

2. If the landmark is correctly identified move to the next landmark and new identifier. If the landmark is not correctly identified, the group should correct the mistake and the person will go again on the next landmark.
3. Continue to rotate through the group until all landmarks have been identified. Have your instructor check your work.

B) Bones and Landmarks of the Vertebral Column

The vertebral column is a chain of 34 bones (24 individual and 2 pairs of 5-fused bones) that performs two distinct functions. First, serves to form a protective cocoon of the spinal cord. Second serves as the vertical axis to the erect body posture. The vertebrae are subdivided into five (5) distinct regions: cervical (top 7-vertebrae, CV1-CV7), thoracic (middle 12-vertebrae, TV1-TV12), lumbar (lower 5-vertebrae, LV1-LV5), sacrum and coccygeal (2-pairs of fused vertebrae that comprise the poster surface of the pelvic bowl). Within this chain, there are two distinct functional “curves” that allow for erect posture of the thorax and thus the body. These functional curves are indicated as being kyphosis, or a ventral facing curve, and lordosis, or a dorsal facing curve. The kyphosis curve is seen in the vertebrae found in the thoracic and sacrum and coccygeal regions of the vertebrae. While the lordosis curve is seen in the cervical and lumbar regions. Together, these curves provide the mechanism for an erect posture of the thorax and thus the body. Based on postural issues and actions of muscles there are pathological curves that can develop within the vertebrae. These include scoliosis, excessive lateral curves, hyperkyphosis (humpback) or hyperlordosis (swayback). These curves can lead to kinematic pathologies and in some instances affect the functioning of the internal organs.

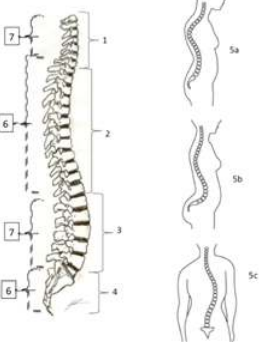
The regionalization of vertebrae leads to distinct identification based on the anatomical differences noted in the comparison between the vertebrae. The size of the body of vertebrae and processes will change based on the location, and thus type, of vertebrae that is being discussed. The anatomical differences are due to the load that the bone must withstand and the amount of muscle and ligament force that is pulling on the various landmarks. The lumbar are larger (more massive), while the cervical are the smallest. The size of the foramen for the spinal cord becomes smaller as move inferior (caudal) through the segments. The lumbar have the smallest foramen, while the cervical have the largest foramen. Another foramen difference is seen in the cervical vertebrae, where transvers process has a foramen, allowing for the passage of the Vertebral Artery, which is not seen in the thoracic or lumbar vertebrae. The angle and direction of the bony landmarks change based on the region of the vertebrae. The spinous process is bifurcated (forked) in the cervical and angled dorsally. There is no bifurcated spine in the thoracic or lumbar. Based on the associated curve, the spinous process will angle from inferiorly and dorsally to more inferiorly and then back towards more dorsally.

There are two specialized cervical vertebrae, CV1 and CV2. These bones allow for movement of the head independent of movement of the remainder of the body. The atlas (CV1) has no body, but has two large articulating processes for the occiput of the cranium to articulate. This anatomical structure allows for elevation and depression of the cranium, shaking head yes or looking upward or downward. The axis (CV2) has limited amount of a body to the vertebrae, principally a superiorly facing spine that articulates with CV1 and allows for axial rotation only, shaking head no or looking over your shoulder to the side of the body.

Procedures:

1. Obtain the set of vertebrae from the Bone box
2. Working with your lab group:
 - a. Identify the vertebrae based on the classification
 - i. Bones: Cervical, Thoracic, Lumbar, Sacrum, Coccygeal
 - b. Align the vertebrae so that you have a completed vertebral column and angle the bones to generate the 2-kinematic curves.

c. Compare your curve to the reference skeleton for your group



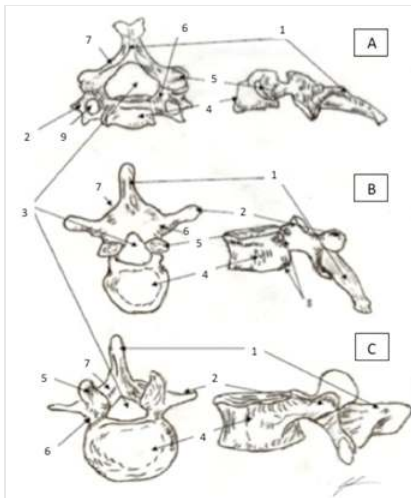
Vertebral Column and Curvatures:

- 1=Cervical Vertebrae
- 2=Thoracic Vertebrae
- 3=Lumbar Vertebrae
- 4=Sacral/Coccygeal
- 5a=Hyperkyphosis
- 5b=Hyperlordosis
- 5c=Scoliosis
- 6= Kyphosis
- 7 Lordosis

Color each with a different color to use for reference in labeling the skeleton and bones

d. Write the landmarks of the vertebrae that you are responsible for knowing on the stickers

- i. Landmarks: Pedicle, Lamina, Spinous Process, Transverse Process, Body of Vertebra, Vertebral Foramen, Transverse Foramen (Cervical Only)



Vertebrae and Landmarks:

A= Cervical Vertebrae

B=Thoracic Vertebrae

C= Lumbar Vertebrae

1=Spinal Process

2= Transverse Process

3= Vertebral Foramen

4= Body of Vertebrae

5=Articulating Facet of Vertebrae

6=Pedicle

7=Lamina

8=Costal Facets (Only in Thoracic)

9=Transverse Foramen (Only in Cervical)

Color each with a different color to use for reference in labeling the skeleton and bones

- e. As a group, use the bone atlas and your notes to identify the vertebrae

- i. Select a group leader

1. Group leader will call of one of the landmarks and nominate a member of the group to identify that landmark with the correct sticker
2. If the landmark is correctly identified move to the next landmark and new identifier. If the landmark is not correctly identified, the group should correct the mistake and the person will go again on the next landmark.
3. Continue to rotate through the group until all landmarks have been identified. Have your instructor check your work.

C) Bones and Landmarks of the Costal Cage

The costal cage is the principal anatomical feature that provides shape and morphology to the thorax. The costal cage is made of 2-clavicles, -sternum and 12-paired bones (costal) that articulate (join) ventrally with the sternum and dorsally with the thoracic vertebrae. It functions to protect the internal organs of the thorax and as an anchorage to point for the upper extremities. The costals are subdivided into three (3) distinct classification based on how costal articulate with sternum. There are the “true” costals, or the first 7-costal pairs that articulate directly with the sternum through individual costal cartilage. Then there are the “false” costals, or pairs 8-10, that will articulate indirectly with the sternum through a single costal cartilage. Last are the “floating” costals, last 2 pairs, which have no articulation with the sternum.

The sternum is comprised of the manubrium, the body of the sternum and the xiphoid process. It functions as an anchor for the

muscles of the anterior thorax (pectoral girdle), the clavicle and the costal bones. The clavicle will (along with the scapula) form a “V-shaped” anchor for the upper extremity to the thorax and the rest of the body.

The clavicle is only held to the thorax through an annular (circular) ligament at the sternum. There are two (2) articulating surfaces for the clavicle. One is between thorax and clavicle. The other will be between the clavicle and the scapula. This pattern of articulating ensures that the scapula stays anchored to the axial skeleton of the body, and is the only way to keep scapula from falling. The clavicle is generally a very weak bone (limited protective coverage also) but is secured by extremely strong ligaments (annular style), meaning that the bone is more apt to fracture than disarticulate from the sternum.

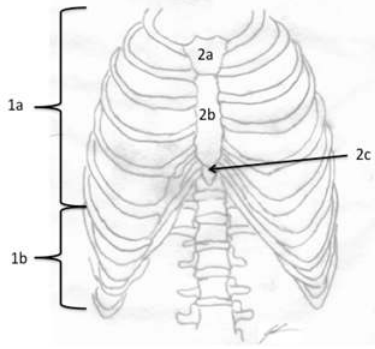
The shape of the Scapula is situated so that a smooth concave surface will face anteriorly and glide along the posterior surface of the costal gage and a posterior surface with protruding landmarks (the spine) that allows for attaching of muscles from the posterior thorax that connects the upper extremity to the rest of the body. The Scapula shape and minimal ligamentous anchors allow for the maximal mobility of the scapula and the upper extremity. There is only one (1) point of attachment through three ligaments between the scapula and the clavicle. Along with a group of ligaments and 4-muscles that forms a dynamic attachment between the scapula and humerus, the Rotator Cuff. The scapula serves as attachment points for muscles that connect the thorax to the upper extremity that occurs via the labrum of the surrounding the Glenoid fossa and the muscles of the rotator cuff. It will attach indirectly to the thorax via the muscles (trapezius, rhomboideus, and serratus muscles) with an anterior surface primarily a fossa that allows scapula to move across posterior thorax without impingement.

Procedures:

1. Obtain the set of costals, sternum and costal cartilage, scapula and clavicles from the Bone box
2. Working with your lab group:
 - a. Identify the regions of the sternum
 - i. Regions: Manubrium, Body, Xiphoid
 - b. Identify the landmarks of the scapula
 - i. Spine of Scapula, Glenoid Fossa (Cavity), Acromial Process, Coracoid Process, Supraspinatal Fossa, Infraspinatal Fossa, Subscapular Fossa
 - c. Align the costal bones with the costal cartilage and sternum so that you have a complete costal cage.
 - i. As you align the costals, note the difference in shape and lengths of the bones as you move from the 1st costal through the 10th costal.
 - ii. Be sure that you are able to name them correctly “Side of Body Costal #”

d. Align the clavicle with the Manubrium of the sternum

e. Compare your completed costal cage to the reference skeleton for your group



Thoracic Cage

1a=True Costal Bones

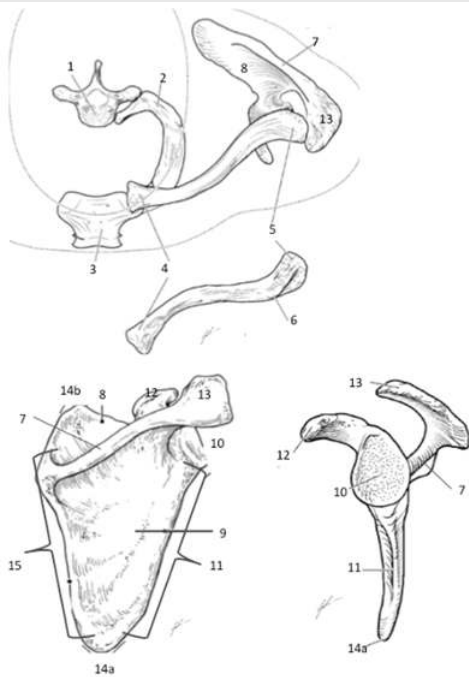
1b=False Costal Bones

2a=Manubrium of Sternum

2b=Body of Sternum

2c=Xyphoid Process

Color each a different color to use as a reference when labeling bones and skeleton



Thoracic Cage and Scapula

1=1st Thoracic Vertebrae

2=Costal #1

3=Manubrium of Sternum

4=Proximal Head of Clavicle

5=Distal Head of Clavicle

6=Neck of Clavicle

7=Spine of Scapula

8=Supraspinatal Fossa of Scapula

9=Infraspinatal Fossa of Scapula

10=Glenoid Fossa of Scapula

11=Lateral Border of Scapula
12=Coracoid Process of Scapula
13=Acromion Process of Scapula
14a=Inferior Angle of Scapula
14b=Superior Angle of Scapula
15=Medial Border of Scapula
Color each a different color to use as a reference when labeling bones and skeleton

D) Bones and Landmarks of the Pelvis

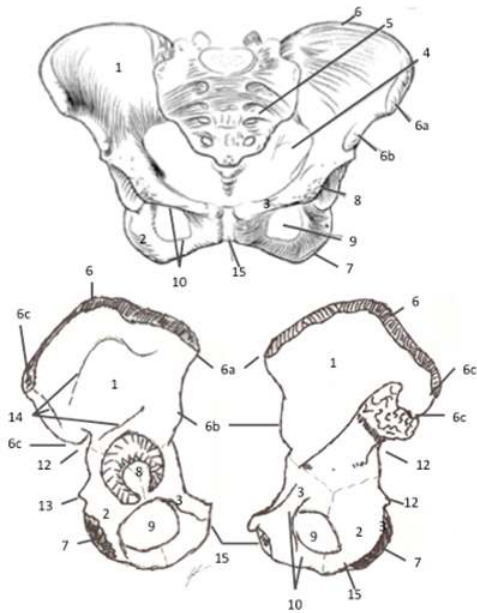
The pelvis is formed through the conglomeration of 3-fused bones (pubis, ischium, ilium) in conjunction with the sacrum and coccygeal vertebrae. The pelvis forms a platform for the axial portion of the skeleton to lie on and anchors the lower extremity to the axial skeleton. The right and left pelvis can be discussed as being fused at an anterior junction via fibrous articulation (Pubic Symphysis) that allows for independent movement and rotation around each other necessary for walking and running. The fusion and bilateral nature of the bones forms a spherical bowl structure that is sexually dimorphic between males and females based on the necessity to birth, and provides the foundation for gait locomotion (walking, running).

The pelvis, figure 17 a, is a group of fused bones that form the attachment between the lower extremity and the trunk of the body. The angulation and orientation of the pelvic bones and articulation with the sacrum and coccygeal bones develops into a 3-dimensional “bowl” structure. The 3-D bowl structure of the pelvis and bipedal walking leads to distinct anatomical changes that are seen in the femur during early childhood. The angulation and orientation ensures that the gluteals are able to stabilize the body during walking and provides a mobile attachment point for the muscles that allow for walk and running gait. Additionally, the 3-D bowl structure undergoes an orientation and angulation changes during puberty at the ilium that is gender specific. For females, the ilium growth during puberty is more laterally than superiorly, while the male growth has the ilium elongating more superiorly than laterally. The resultant growth leads to a wider pelvis for females and a narrower pelvis for males in comparison between each other. The orientation change at the ilium during puberty leads to various lower extremity kinematic issues that might arise for the female that might not be seen in males.

Procedures:

1. Observe the male and female pelvis displayed by the instructor. Note the differences in the true pelvis and the angle of the pubic symphysis that allows you to indicate a male or a female pelvis
2. Obtain the pelvis bones from the bone box
3. Working with your lab group:
 - a. Identify the three bones that make up each side of the pelvis
 - i. Ilium, Ischium, Pubis (Pubic Bone)
 - b. Write the landmarks of the vertebrae that you are responsible for knowing on the stickers
 - i. Acetabulum
 - ii. Obturator Foramen
 - iii. Ilium: Iliac Crest, Anterior Superior Iliac Spine, Anterior Inferior Iliac Spine, Posterior Superior Iliac Spine, Posterior Inferior Iliac Spine
 - iv. Ischium: Ischial Tuberosity, Sciatic Notch

v. Pubis: Pubic Symphysis



Pelvis

1=Ilium

2=Ischium

3=Pubis

4=Pelvic Bowl Opening

5=Sacrum and Coccygeal

6=Iliac Crest

6a=Anterior Superior Iliac Spine

6b=Anterior Inferior Iliac Spine

6c=Posterior Superior Iliac Spine

6d=Anterior Inferior Iliac Spine

7=Ischial Tuberosity

8=Acetabulum

9=Obturator Foramen

10= Ramus of Pubis

11=Pubic Symphysis

12=Sciatic Notch

13=Spine of Ischium

14=Gluteal Lines

Color each a different color to use as a reference when labeling bones and skeleton

c. Using the anatomy atlas and your notes

i. Select a group leader

1. Group leader will call of one of the landmarks and nominate a member of the group to identify that landmark with the correct sticker
2. If the landmark is correctly identified move to the next landmark and new identifier. If the landmark is not correctly identified, the group should correct the mistake and the person will go again on the next landmark.
3. Continue to rotate through the group until all landmarks have been identified. Have your instructor check your work.

Activity 3: Appendicular Skeleton

The appendicular skeleton is comprised of a series of bones of the paired extremities of the body (bones have a mated pair on the contralateral side of the body). The upper extremity includes the scapula, humerus, ulna, radius, carpals, metacarpals, and phalanges. The lower extremity includes the femur (and patella), the tibia, fibula, tarsals (tarsi), metatarsals, and phalanges. The upper extremity and lower extremity bony architecture mirror each other in number and patterns of movement. The bones of the lower extremity appear to be different but that is simply due to these bones being longer and more robust than the bones of the upper extremity.

A) Bones and Landmarks of the Upper Extremity

The Humerus is the proximal bone of the upper extremity. The humerus forms the principle site of attachment for the movement of the upper extremity. The convex articulating head of the humerus in the concave articulating surface of the Glenoid fossa combined with the shape and tautness of the ligaments forming the labrum allow for the humerus to have the maximal degrees of freedom of movement of all bones in the skeleton. The landmarks of the humerus serve as attachment points for the muscles of the Pectoral and Deltoid Girdles that allow for movement of the upper extremity.

The Radius and Ulna are the paired bones of the antebrachium. The bones are held in place by the interosseous membrane that tautly holds the two bone together. Even holding the bones together, the Radius and Ulna are able to independently move and the interosseous membrane allows for the movement of the Radius around the Ulna without separation of the two bones.

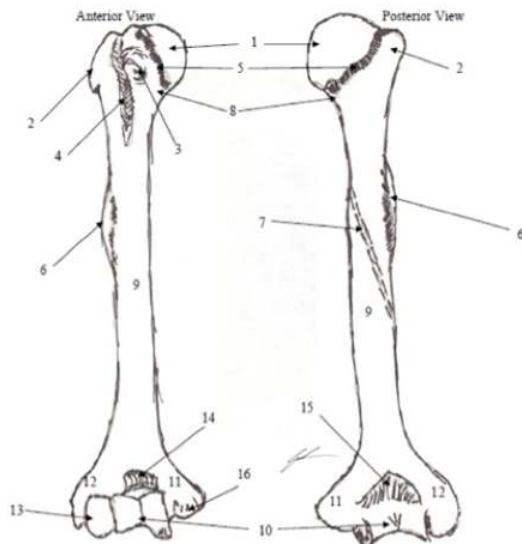
The Carpals are formed by two rows of arched bones that comprise the wrist. The arrangement of the carpals form a domed (concave) series of rows of bones that allow for a high degree of freedom in movement by allowing bones to glide and spin around each other. Stemming from the carpals are 5-rays of bones (digital rays) comprised on the Metacarpals that form the hand and the phalanges that form the fingers. The metacarpals are indicated numerically by Roman Numerals (I through V) with I is the Polis (thumb) and V being Digiti Minimi (pinky finger). The phalanges are named proximal, medial and distal for digits II through V and only proximal and distal for digit I.

Procedures:

1. Obtain the bones of the upper extremity from the Bone box (note the carpals, metacarpals and phalanges are wired together)
2. Write the name of the bones and landmarks of the bone that you are responsible for knowing on the stickers
 - a. Bones: Humerus, Radius, Ulna, Carpal Bones, Metacarpals, Phalanges
 - b. Landmarks:
Humerus: Head of Humerus, Surgical and Anatomical Neck of Humerus, Greater Tubercle, Lesser Tubercle, Intratubercle Groove, Deltoid Tuberosity, Medial Epicondyle, Lateral Epicondyle, Trochlea, Capitulum, Olecranon Fossa

Ulna: Olecranon Process, Trochlear Notch, Ulnar Styloid

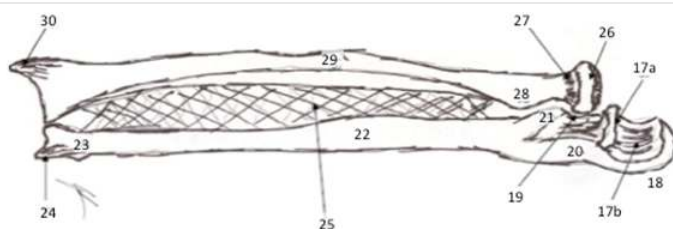
Radius: Radial Styloid



Humerus Landmarks

- 1=Head of Humerus
- 2=Greater Tubercle of Humerus (to lateral)
- 3=Lesser Tubercle of Humerus (only seen anteriorly)
- 4=Intertubercular Groove of Humerus
- 5=Neck of Humerus
- 6=Deltoid Tuberosity of Humerus
- 7=Radial Groove of Humerus (only seen posteriorly)
- 8=Surgical Neck of Humerus
- 9=Body of Humerus
- 10=Trochlea of Humerus
- 11=Medial Epicondyle of Humerus
- 12=Lateral Epicondyle of Humerus
- 13=Capitulum of Humerus
- 13=Trochlear Notch of Humerus
- 15=Olecranon Fossa
- 16=Radial Fossa

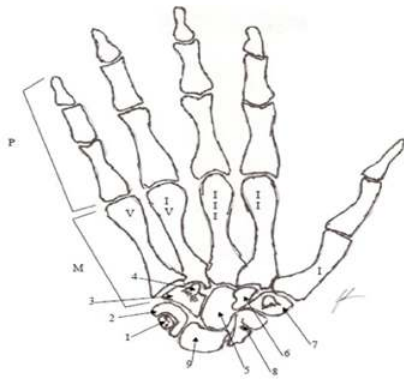
Color each a different color to use as a reference when labeling bones and skeleton



Radius and Ulna

- 17a= Trochlear Notch 17b=Coronoid Process 18=Olecranon Process 19=Radial Notch
- 20=Proximal Head of Ulna 21= Ulnar Tuberosity 22=Body Of Ulna 23=Distal Head of Ulna
- 24=Ulnar Styloid 25=Interosseous Membrane 26=Head of Radius 27=Neck of Radius
- 28=Radial Tuberosity 29=Body of Radius 30=Radial Styloid

Color each a different color to use as a reference when labeling bones and skeleton



Carpals, Metacarpals, Phalanges

P=Phalange

M=Metacarpal (Roman Numeral from digit 1 to digit 5)

1=Pisiform

2=Triquetrum

3=Hamate

4=Hook of Hamate

5=Capitate

6=Trapezoid

7=Trapezium

8=Scaphoid

9=Lunate

Color each a different color to use as a reference when labeling bones and skeleton

3. Working with your lab group:

- a. Identify the bones of the upper extremity
- b. Align the bones so that you have a complete upper extremity, determine which side of the body the extremity would be found.
- c. Compare your extremity to the reference skeleton for your group
- d. Use the anatomy atlas and your notes to identify the bones of the upper extremity
 - i. Select a group leader
 1. Group leader will call of one of the landmarks and nominate a member of the group to identify that landmark with the correct sticker
 2. If the landmark is correctly identified move to the next landmark and new identifier. If the landmark is not correctly identified, the group should correct the mistake and the person will go again on the next landmark.
 3. Continue to rotate through the group until all landmarks have been identified. Have your instructor check your work.

B) Bones and Landmarks of the Lower Extremity

Femur is the largest bone in the body. This is due to the bone acting as one of three bones in the lower extremity that is responsible for weight bearing. The bone undergoes a change in the angle of orientation during early childhood. The change is particularly seen at angulation of the femoral neck. The angle of the neck and the difference between medial and lateral condyles of the femur ensures that when standing in an erect posture the center of gravity is aligned with the mid-sagittal line (long-axis) of the body. The degree of angulation (Q-angle) is based on the breadth of the pelvic bowl, where those that have a wider pelvis also having a greater angle of change seen at the neck of the bone. The head of the femur and acetabulum of the pelvis have similar shape to what is seen at the Glenoid fossa of the scapula and head of the humerus. Yet, the amount of movement allowed is much less here, as the femur is held within the opening of the acetabulum and movement is restricted by the tautness of the capsule ligaments. This ensures that the blood vessels entering through the femoral foramen and within the neck are not disrupted. Key as disruption to

perfusion must be continuous to the bone and disruption leads to necrosis of the tissue with the neck of the femur and may necessitate replace of the hip.

The tibia and fibula are the bones that comprise the leg portion of the lower extremity. The tibia and fibula, just like the radius and the ulna, are held together medially via a taut band of fascia (interosseous membrane) that allows the fibula to move around the tibia. This is key to allowing for dexterous movement of the foot while still allowing weight bearing to occur through the tibia. Because of its role in weight bearing, the tibia is much more robust than the fibula and serves as the connection between the thigh (femur) and pelvis with the tarsi (ankle).

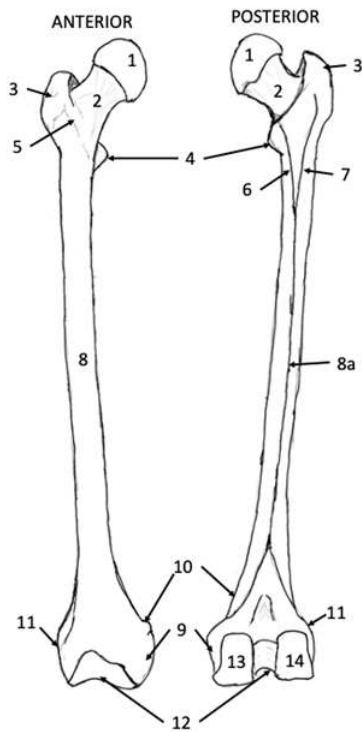
The distal end of the tibia and fibula end at different lengths relative to each other that impact the kinematics of the joint. This difference in bone lengths impact the degree of movement that can occur at the ankle that limits the amount of eversion and pronation, while allowing for a maximal amount of inversion and supination. An issue that must be remembered when looking at injuries that might occur to the leg. Additionally, the flow of blood through the interosseous membrane and the muscle lines of pull from the triceps sural can lead to inflammation issues within the fascia for runners.

The bones of the distal end of the lower extremity, the tarsal (tarsi), metatarsals, and phalanges, are comprised of rows of bones that are short and irregular in shape. The Calcaneus and Talus serve as the key bones in standing weight bearing. The bones of the tarsi and metatarsal are not only arranged into rays of bones but form a concave structure of bone that is held together via annular ligaments with the placement of the Navicular Bone (keystone of the arch) and on the plantar surface of the foot taut bands of ligament and tendon (Plantar fascia). The concavity of the arrangement of the bones longitudinally and transversely along the length of the foot form the arch of the foot. The arch of the foot forms a weight bearing, shock absorbing and spring lever system for use during locomotion. The shape and pattern of the ligaments and tendons allow for the storage of potential energy that upon the propulsion of the limb in gait provides for greater kinetic energy of motion. You can think of the arch as a flat spring, or diving board. The greater the flex in the board the higher the dive will be propelled upward and away from the board. Due to the storage and return of energy to walking and running the energy transfer to movement is greater than the energy load. This return becomes more pronounced at higher speeds and makes running more energetically efficient than walking at the same speed.

Procedures:

1. Obtain the bones of the upper extremity from the Bone box (note the carpals, metacarpals and phalanges are wired together)
2. Write the name of the bones and landmarks of the bone that you are responsible for knowing on the stickers
 - a. Bones: Femur, Patella, Tibia, Fibula, Calcaneus, Talus, Metatarsal, Phalanges
 - b. Landmarks:
Femur: Head of Femur, Neck of Femur, Greater Trochanter, Lesser Trochanter, Intertrochanteric Crest, Linea Aspera, Medial Epicondyle, Medial Condyle, Lateral Epicondyle, Lateral Condyle, Femoral (Intercondylar) Groove

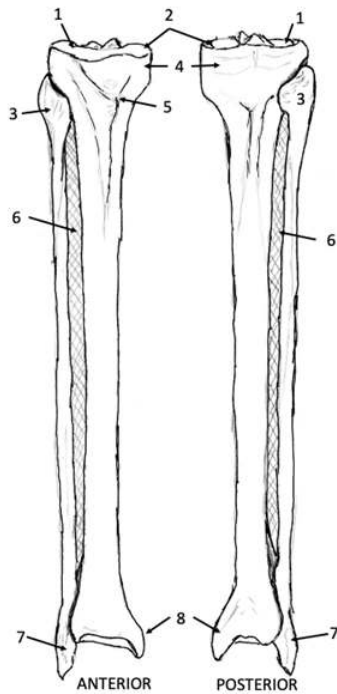
Tibia: Tibial (Medial) Malleolus, Tibial Tuberosity, Tibial Plateau (Condyles),
Fibula: Fibular (Lateral) Malleolus



Femur

- 1= Head of Femur
- 2= Neck of Femur
- 3= Greater Trochanter
- 4= Lesser Trochanter
- 5= Intertrochanteric Crest
- 6= Pectineal Line
- 7= Gluteal Line
- 8= Body of Femur
- 8a= Linea Aspera
- 9= Medial Epicondyle
- 10= Adductor Tubercle
- 11= Lateral Epicondyle
- 12= Femoral (Intercondylar) Groove
- 13= Medial Condyle
- 14= Lateral Condyle

Color each landmark a different color to assist with identification.



Tibia and Fibula

1= Lateral Condyle

2= Medial Condyle

3= Fibular Head

4= Tibial Plateau

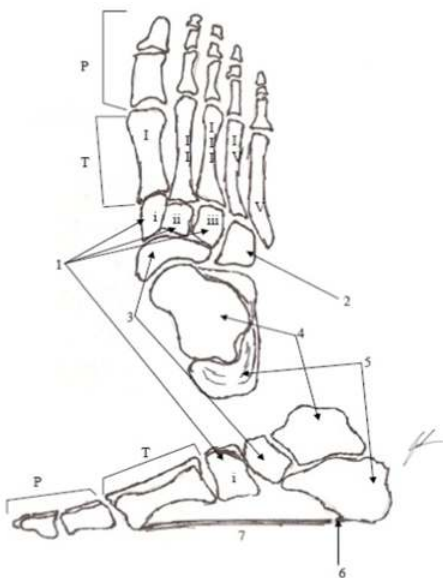
5= Tibial Tuberosity

6= Interosseous Membrane

7= Fibular (Lateral) Malleolus

8= Tibial (Medial) Malleolus

Color each landmark a different color to assist with identification.



Tarsals, Metatarsal, Phalanges

P=Phalange

T=Metatarsal (Roman Numeral from digit 1 to digit 5)

1=Cuneiforms (i: Medial, ii: Middle, iii: Lateral)

2=Cuboid

3=Navicular

4=Talus

5=Calcaneus

6=Hook of Calcaneus

7=Plantar Fascia

Color each a different color to use as a reference when labeling bones and skeleton

3. Working with your lab group:

- a. Identify the bones of the upper extremity
- b. Align the bones so that you have a complete lower extremity, determine which side of the body the extremity would be found.
- c. Compare your extremity to the reference skeleton for your group
- d. Use the anatomy atlas and your notes to identify the bones and landmarks of the lower extremity
 - i. Select a group leader
 1. Group leader will call of one of the landmarks and nominate a member of the group to identify that landmark with the correct sticker
 2. If the landmark is correctly identified move to the next landmark and new identifier. If the landmark is not correctly identified, the group should correct the mistake and the person will go again on the next landmark.
 3. Continue to rotate through the group until all landmarks have been identified. Have your instructor check your work.

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1.6: Musculoskeletal Anatomy Part 2- Skeletal Muscle

Objectives:

At the end of this lab, you will be able to...

1. Using appropriate anatomical terminology correctly identify muscles by using correct anatomical (Latin) name
2. Using appropriate anatomical terminology correctly identify type of motion generated by the muscles of importance
3. Differentiate between classifications of architecture of muscles by shape
4. Describe the agonist/antagonist relationships between muscles surrounding joints of importance
5. Correctly identify and mimic generalized movement patterns based on individual muscles or muscle groups

Pre-Lab Exercises:

After reading through the lab activities prior to lab, complete the following before you start your lab.

1. The naming rules for muscles include names based on: .
2. How many biceps muscles are found in the body?
3. The muscles on the dorsal side of the thorax will the trunk while the muscles on the ventral side of the abdominal cavity will the trunk.
4. Color the images for use as a reference for identifying the muscles and showing actions of the muscles.

Materials:

- Muscle Models
- Stickers
- Felt pens

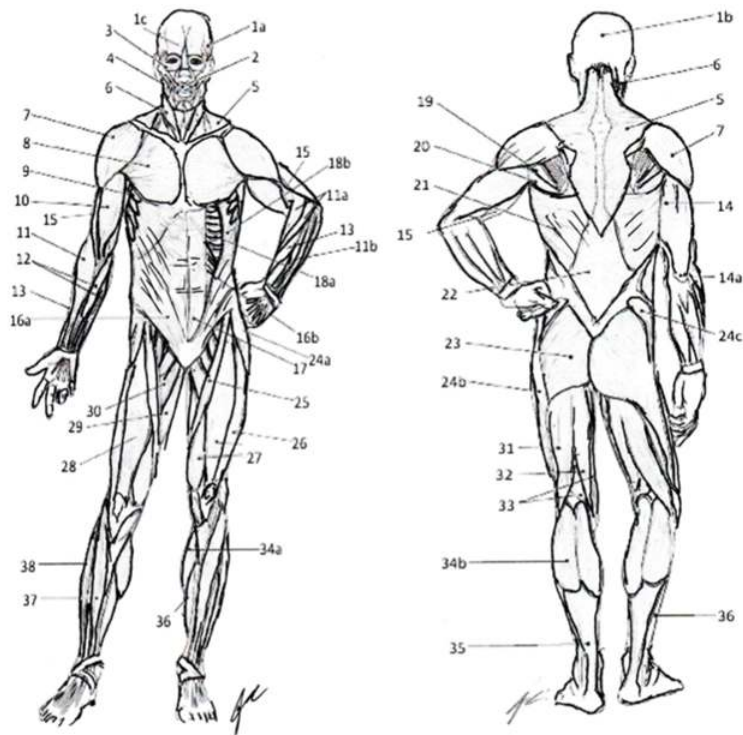
Activity 1: Naming Principles, Origins and Insertions:

The methods to name muscles include: the fiber arrangement, the location, the size, the number of origins (heads), the shape, the action, the origin and insertions or the bone that the muscle overlays. In some cases, we will combine these methods for naming as some muscles may have one or more method of classification in common. Which is why we must be very careful to include the entirety of the name of the muscle, such as biceps brachii, and not just simply use biceps. As there are multiple Bicipital muscles in the body and without the complete terminology you may have someone thinking of the different biceps (femoral) from the biceps (brachii) that you are talking about.

When we discuss by fiber arrangement you will see muscle names such as: rectus (parallel angle to long axis of body), transverse (perpendicular angle to long axis of body), or oblique (oblique angle to long axis of body). With discussion by location, you will see muscle names such as: superficial (closer to surface), profundus (deeper or underlying musculature), side of the bone (anterior or posterior) and the associated bone that underlies the muscle. We can also use the muscles comparative size within a group of muscles there is an indication for comparing three muscles maximus, minimus and medius (largest, smallest, middle of the three being compared) versus groups of two muscles major and minor (largest and smallest of the three being compared) or by the length brevis and longus (shortest and longest of the two being compared). There will also be names based on the number of origins (heads) of the muscles such as triceps (three muscle origins/heads), biceps (two muscle origins/heads), and quadriceps (four muscle origins/heads). Then we can discuss the muscle name by the shape of the muscle such as deltoid (triangular, or like Greek letter Δ), trapezius (trapezoidal), rhomboideus (rhomboid), teres (tear-drop), serratus (saw-tooth), or quadratus (quadrilateral). There is also the naming method that provides the muscles origin and the muscles insertion into a single name such as the sternocleidomastoid. Lastly, we can use the action of the muscle to names of muscles such as tensors (tenses the connective tissues), flexors (flexes the joint or articulation), extensors (extends the joint or articulation), supinator (supinates the distal end of the extremities), and pronators (pronates the distal end of the extremities).

Procedures:

1. Review the naming principles by calling out a muscle based on one of the naming rules and pointing to that muscle
2. Check your group members for completeness of the coloring of muscles necessary for completing the identifications.



ANTERIOR - POSTERIOR

1a=Temporalis 1b=Epicranial Aponeurosa 1c=Frontalis 2=Orbicularis Oris
 3=Orbicularis Oculi 4=Masseter 5=Trapezius 6=Sternocleidomastoid
 7=Deltoid 8=Pectoralis Major 9=Serratus Anterior 10=Biceps Brachii
 11=Brachioradialis 11a=Extensor Carpi Radialis Longus and Brevis 11b=Common Extensors
 12=Common Flexors 13=Extensor Carpi Radialis 14=Triceps Brachii 14a=Triceps Tendon
 15=Brachialis 16a=External Abdominal Oblique 16b=Internal Abdominal Oblique 17=Rectus Abdominis
 18a=Internal Intercostal 18b=External Intercostal 19=Teres Minor 20=Teres Major
 21=Latissimus Dorsi 22=Thoracolumbar Fascia 23=Gluteus Maximus 24a=Tensor Fascia Latte
 24b=Iliotibial Band 24c=Gluteus Medius 25=Sartorius 26=Vastus Lateralis
 27=Vastus Medialis 28=Rectus Femoris 29=Adductor Magnus 30=Adductor Longus
 31=Biceps Femoris 32=Semitendinosus 33=Semimembranosus
 34a=Medial Head Gastrocnemius 34b=Lateral Head Gastrocnemius 35=Calcaneal (Achilles) Tendon
 36=Soleus (Deep to Tendon on posterior) 37=Tibialis Anterior 38=Peroneal Muscles
 Color each muscle a different color for use as a reference when identifying muscles.

Muscles of the axilla and pectoral girdle are broken into key groups: pectoral muscles, deltoid muscles and the rotator cuff. Each muscle is involved with stabilization of the Scapula and movement of the Humerus during locomotion of the upper extremity of the body and movement of the thoracic cage during ventilation.

Pectoral Girdle Muscles

Muscle	Origin	Insertion	Action
Pectoralis Major	Clavicle; Body of sternum; Costal	Lateral lip of Intertubercular groove	Horizontal Adduct, Medially Rotate Humerus @ shoulder
Pectoralis Minor	Costal 2-5	Coracoid process	Protract Scapula Elevates Ribs 2-5 in breathing
Subclavius	Clavicle	Costal 1	Depress clavicle
Anterior Deltoid	Clavicle; Acromion of Scapula	Deltoid Tuberosity	Flex, Abduct Humerus @ shoulder
Middle Deltoid	Clavicle; Acromion & Spine of scapula	Deltoid Tuberosity	Abduct Humerus @ shoulder
Serratus Anterior	Costal 1-7	Anterior surface of Medial Border of Scapula	Stabilizes scapula during Upper Extremity movements
Intercostal	Internal: Upper Rib External: Lower Rib	Internal: Lower Rib External: Upper Rib	Internal: retracts ribs together External: protracts ribs away from each other

Rotator Cuff & Accessory Muscles

Muscle	Origin	Insertion	Action
Posterior Deltoid	Spine of Scapula	Deltoid Tuberosity	Extend, Abduct Humerus
Trapezius	Occipital; S.P. of T-vertebrae; Ligamentum Nuchae	Lateral 1/3 of clavicle, Acromion & spine of scapula	Elevation, Depression & Retract Scapula
Latissimus Dorsi	S.P. of T-vertebrae and L-Vertebrae; Iliac crest; lower 3 costal	Floor Intertubercular groove (Humerus)	Extend, Adduct, Medially Rotate Humerus @ shoulder
Supraspinatus ¹	Supraspinous Fossa	Greater Tubercle	Elevate, Abduct, Medially Rotate Humerus @ shoulder
Infraspinatus ¹	Infraspinous Fossa	Greater Tubercle	Medially Rotate Humerus @ shoulder
Subscapularis ¹	Subscapular Fossa	Lesser Tubercle	Laterally Rotate Humerus @ shoulder
Teres Minor ¹	Inferior lateral margin of Scapula	Greater Tubercle	Medially Rotate, Adduct Humerus @ shoulder
Teres Major	Dorsal surface of Inferior Angle of Scapula	Medial lip of Intertubercular groove	Adduct Humerus @ shoulder

¹Indicates the Rotor Cuff Muscles

Thorax

The muscles of the thorax are going to be involved with postural support and trunk movements that allow for an erect posture to be maintained. Along with being involved in the movement of the limbs that allow for locomotion to occur. These muscles are generally discussed in groups based on anatomical location (anterior and posterior) and then layering (superficial, intermediate, or deep). The superficial posterior muscles are involved with the movement of the limbs and scapula. The intermediate posterior muscles are involved with scapular movement and postural support. The deep posterior muscles are involved with the support and

movement of the vertebral column and individual vertebrae via the transverse group muscles. The anterior group is typically identified as being the abdominal group that is involved with postural support and movement of the pelvis and trunk around each other.

Superficial & Intermediate Posterior Muscles

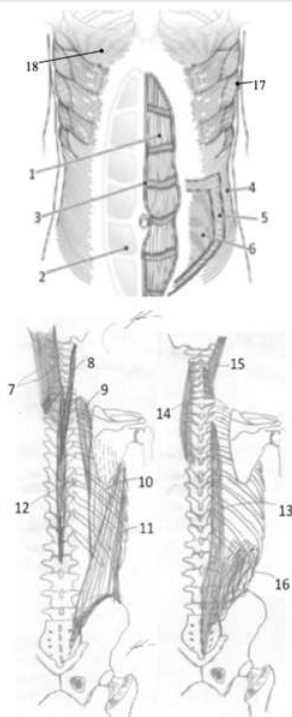
Muscle	Origin	Insertion	Action
Trapezius	Occipital; S.P. of T-vertebrae; Ligamentum Nuchae	Lateral 1/3 of clavicle, Acromion & spine of scapula	Elevate, Depress & Retract Scapula
Levator Scapulae	T.P. of C-vertebrae 1-4	Superior Angle of Scapula	Elevate & inferiorly rotate Scapula
Latissimus Dorsi	S.P. of T-vertebrae and L-Vertebrae; Iliac crest; lower 3 costal	Floor Intertubercular groove (Humerus)	Extend, Adduct, Medially Rotate Humerus Assist with Extending trunk
Rhomboideus Major	S.P. of T-vertebrae 2-5	Medial Border of Scapula (inferior to Minor)	Elevate, Retract & inferiorly rotate scapula
Rhomboideus Minor	Ligamentum Nuchae; S.P. of C-vertebrae 7 & T-Vertebrae 1	Medial Border of Scapula & base of Spine	Elevate, Retract & inferiorly rotate scapula
Serratus Posterior Superior	Ligamentum Nuchae; S.P. of C-vertebrae 4-7 & T-vertebrae 1-4	Costal 2-5	Assist w/ respiration
Serratus Posterior Inferior	S.P. of T-vertebrae 5-12 & L-vertebrae 1-2	Costal 9-12	Assist w/ respiration

Deep Posterior Muscles:

Muscle	Origin	Insertion	Action
Iliocostalis Lumborum	Iliac Crest; Sacrum	Costal 6-12	Bilaterally: Extend Vertebral Column Unilaterally: Ipsilateral Lateral flex
Iliocostalis Thoracis	Costal 6-12 (Medial to Lumborum)	Costal 1-6	Bilaterally: Extend Vertebral Column Unilaterally: Ipsilateral Lateral flex
Iliocostalis Cervicis	Costal 1-6 (Medial to Thoracis)	T.P. of C-vertebrae 4-6	Bilaterally: Extend Vertebral Column Unilaterally: Ipsilateral Lateral flex
Longissimus Thoracis	S.P. of L-vertebrae 4-5; Sacrum	Costal 4-12 & associated T.P. of vertebrae	Bilaterally: Extend Vertebral Column Unilaterally: Ipsilateral Lateral flex
Longissimus Cervicis	T.P. of T-vertebrae 1-6	T.P. of C-vertebrae 2-6	Bilaterally: Extend Vertebral Column Unilaterally: Ipsilateral Lateral flex
Longissimus Capitis	C-vertebrae 3-7	Mastoid Process	Bilaterally: Extend Vertebral Column Unilaterally: Ipsilateral Lateral flex
Splenius Capitis	Ligamentum Nuchae; S.P. of C-vertebrae 7 & T-vertebrae 1-3	Occipital & Mastoid Processes	Bilaterally: Extend Head & Neck Unilaterally: Ipsilateral Lateral flex and rotate
Splenius Cervicis	S.P. of T-vertebrae 3-6	T.P. of C-Vertebrae 1-4	Bilaterally: Extend Head & Neck Unilaterally: Ipsilateral Lateral flex and rotate
Spinal Thoracis	S.P. of T-vertebrae 11 to L-Vertebrae 2	S.P. of T-vertebrae 1-8	Bilaterally: Extend Vertebral Column Unilaterally: Ipsilateral Lateral flex
Transverse Group			
Semispinalis: Spans 4-to-5 vertebral spaces; Allow for vertebral extension and contralateral rotation of vertebrae			
Multifidus: Spans 3-to-4 vertebral spaces; Allow for vertebral extension contralateral vertebral rotation & lateral flexion of vertebrae			
Rotatores: Spans 1-to-2 spaces; Allow for contralateral vertebral rotation			

Abdominal Muscles:

Muscle	Origin	Insertion	Action
Rectus Abdominis	Symphysis Pubis; Pubic Crest	Xiphoid process; Costal Cartilage (5-7)	Flex trunk Compress Abdominal Cavity
Transverse Abdominis	Costal Arch; Thoracolumbar Fascia; Iliac Crest; Inguinal ligament	Xiphoid process; Linea Alba; Pubic Crest; Pectineal Line	Flex trunk Compress Abdominal Cavity
External Abdominal Oblique	Costal 5-12; connects w/ Serratus Anterior & Latissimus Dorsi	Iliac Crest; Pubic Crest; Pubic Symphysis; Linea Alba	Bilaterally: Flex trunk Compress Abdominal Cavity Unilaterally: Ipsilateral Trunk rotation and lateral flex
Internal Abdominal Oblique	Thoracolumbar Fascia; Iliac Crest; Inguinal ligament	Costal 7-12; Costal arch; Xiphoid process; Linea Alba; Pubic Crest; Pectineal Line	Bilaterally: Flex trunk Compress Abdominal Cavity Unilaterally: Contralateral Trunk rotation and lateral flex
Diaphragm	Lower 3 costal bones; Xiphoid process	Transverse Abdominis; Rectus Abdominis; Linea Alba	Inspiration and Forced Exhalation during breathing
Quadratus Lumborum	Iliac Crest; Iliolumbar Ligament; T.P. of lower L-vertebrae	Costal 12; T.P. of upper L-vertebrae	Bilaterally: Assist Forced Exhalation, Extend Trunk Unilaterally: Ipsilateral trunk rotation & lateral flexion



Muscles of the Thorax

1=Rectus Abdominis

2=Abdominal Sheath

3=Linea Alba

4=External Abdominal Oblique
 5=Internal Abdominal Oblique
 6=Transvers Abdominus
 7=Splenius Capitis
 8=Splenius Cervicis
 9=Iliocostalis Cervicis
 10=Iliocostalis Thoracis
 11=Iliocostalis Lumborum
 12=Splenius Thoracis
 13=Longissimus Thoracis
 14=Longissimus Cervicis
 15=Longissimus Capitis
 16= Quadratus Lumborum
 17=Serratus Anterior
 18- Pectoralis Major
 Color each muscle a different color for use as a reference when identifying muscles.

Procedures:

1. Obtain models, stickers, felt pens
2. Write the names of the trunk muscles that you are responsible for knowing on to the stickers
Rectus Abdominus, External Abdominal Oblique, Longissimus, Latissimus Dorsi, Pectoralis Major, Trapezius, Rhomboideus Major, Rhomboideus Minor, Deltoid
3. Select a “team leader” and a group member to be the “mannequin” for your group.
 - a. Using the colored images as reference have members of the group take turns labeling the muscles on your group member
 - b. As the muscle is labeled, ask the “mannequin” to demonstrate the movement that the muscle will produce.
4. Write the names of the key trunk muscles on the stickers
 - a. Pectoralis Minor, Supraspinatus, Infraspinatus, Teres Minor, Internal Abdominal Oblique, Serratus Anterior, Intercostals
5. Change “team leader” and using the images as reference, label the muscles on the torso models that your group has.
6. Have your instructor check your work and then move to the next activity.

Activity 3: Muscles that move the Upper Extremity:

Muscles of the brachium are broken into key groups the anterior group that is responsible for flexion of the brachium and antebrachium, and the posterior group that is responsible for extension of the brachium and antebrachium.

Anterior Brachium Muscles

Muscle	Origin	Insertion	Action
Coracobrachialis	Coracoid Process	Anterior mid-shaft of the Humerus	Flex Humerus @ shoulder
Bicep Brachii	Long Head: Superior Glenoid Fossa Short Head: Coracoid Process	Radius and Ulna via Bicipital Aponeurosis; Radial Tuberosity	Flex, Supinates Forearm @ elbow Flex Humerus @ shoulder
Brachialis	Mid-shaft of Humerus	Coronoid Process and Ulnar Tuberosity of the Ulna	Flex Forearm @ elbow

Posterior Brachium Muscles

Muscle	Origin	Insertion	Action
Triceps Brachii	Long Head: Inferior Glenoid Fossa Medial Head: Medial Upper 1/3-Shaft of Humerus Lateral Head: Lateral to Radial Groove of Humerus	Olecranon Process of Ulna	All Heads: Extend Forearm @ elbow Long Head: Extend Humerus @ Shoulder
Anconeus	Lateral Epicondyle of Humerus	Lateral surface of Olecranon Process of Ulna	Extend forearm @ elbow

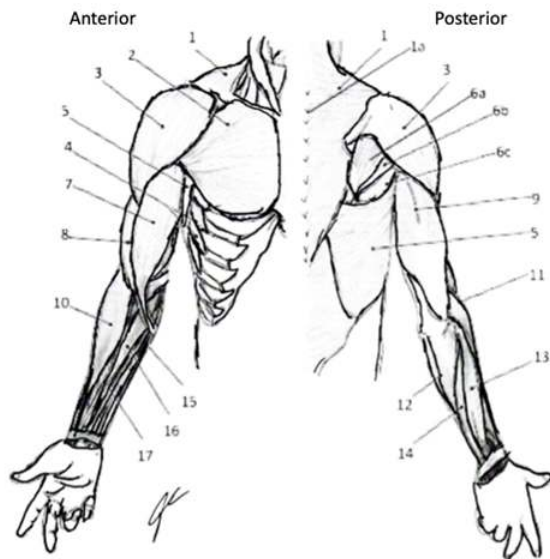
Muscles of the antebrachium are comprised of two compartments that are either anterior (or common flexors) or posterior (or common extensors). Each compartment will be responsible for movement within the antebrachium and movement of the carpals and digits of the hand in antagonistic patterns that are necessary for dexterous movements.

Antebrachium Anterior/Medial (comes from Medial Epicondyle/Medial Condyle, a.k.a. Common Flexor Tendon) Muscles

Muscle	Origin	Insertion	Action
Pronator Teres	Common Flexor Tendon (CFT)	Lateral Mid-shaft of Radius	Pronates Forearm
Flexor Carpi Radialis	(CFT)	Base of 2 nd Metacarpal	Flex & Radial Deviate Wrist & Hand
Flexor Carpi Ulnaris	CFT; Medial Olecranon process	Pisiform; hook of Hamate; Base of 5 th Metacarpal	Flex & Ulnar Deviate Wrist & Hand
Palmaris Longus	CFT	Palmar Aponeurosis	Tense Palmar Aponeurosis
Flexor Digitorum Superficialis	CFT; Coronoid Process; Proximal Radius	Margins of Middle Phalanx of medial 4 digits	Flex middle Phalange of Digits 2-5 @ IP joints Assist w/ Flex wrist & hand
Flexor Digitorum Profundus	Anterior medial surface of Ulna	Distal phalanx of medial 4 digits	Flex distal Phalange of Digits 2-5 @ IP joints Assist w/ Flex wrist & hand
Flexor Pollicis Longus	Anterior surface of Radius & Interosseous membrane	Distal phalanx of thumb	Flex distal Phalange of Digit 1 @ IP joints Assist w/ Flex wrist & hand
Pronator Quadratus	Anterior Distal end of Ulna	Anterior Distal end of Radius	Pronates Forearm

Antebrachium Posterior/Lateral (comes from Lateral Epicondyle/Condyle, a.k.a. Common Extensor Tendon) Muscles

Muscle	Origin	Insertion	Action
Brachioradialis	Lateral Supracondylar Ridge (Humerus)	Lateral Distal surface of Radius	Flex forearm @ elbow
Extensor Carpi Radialis Longus	Lateral Supracondylar ridge (Humerus)	Base of 2 nd Metacarpal	Flex forearm @ elbow Extend & Radial deviate wrist & hand
Extensor Carpi Radialis Brevis	Common Extensor Tendon (CET)	Base of 3 rd Metacarpal	Extend & Radial deviate wrist & hand
Extensor Digitorum	CET	Extensor Expansion	Extend distal Phalange of digits 2-5 @ IP joints
Extensor Digiti Minimi	CET	Extensor Expansion of Digit 5	Extend distal phalange of digit 5 @ IP joints
Extensor Carpi Ulnaris	CET	Base of 5 th Metacarpal	Extend and Ulnar deviate wrist & hand
Supinator	Lateral Epicondyle & Supinator Crest of Ulna	Posterior & Lateral proximal 1/3 of Radius	Supinate Forearm
Abductor Pollicis Longus	Posterior surface of middle Ulna/Radius/ Interosseous Membrane	Base of 1 st Metacarpal	Abduct digit 1 @ MCP Radial deviate wrist & hand
Extensor Pollicis Brevis	Middle 1/3 of Posterior Radius/ Interosseous Membrane	Base of Proximal Phalanx of Thumb	Extend proximal Phalange of digit 1
Extensor Pollicis Longus	Posterior Surface of Middle 1/3 of Ulna/ Interosseous Membrane	Base of Distal Phalanx of Thumb	Extend distal Phalange of digit 1 Assist w/ Extend wrist & hand
Extensor Indices	Posterior Surface of Ulna/ Interosseous Membrane	Extensor Digitorum tendon to Index finger	Extend distal Phalange of digit 2 Assist w/ Extend wrist & hand



Muscles of Pectoral Girdle and Upper Extremity

- 1=Trapezius
- 1a=Ligamentum Nuchae
- 2=Pectoralis Major
- 3=Deltoid
- 4=Serratus Anterior
- 5=Latissimus Dorsi
- 6a=Infraspinatus
- 6b=Teres Minor
- 6c=Teres Major
- 7=Biceps Brachii
- 8=Brachialis
- 9=Triceps Brachii
- 10=Brachioradialis
- 11=Extensor Carpi Radialis Longus
- 12=Extensor Carpi Ulnaris
- 13=Extensor Digitorum
- 14=Extensor Digiti Minimi
- 15=Flexor Carpi Ulnaris
- 16=Flexor Digitorum Superficialis
- 17=Flexor Carpi Radialis

Color each a different color to use as reference for identifying muscles in lab

Procedures:

1. Obtain models, stickers, felt pens
2. Write the names of the upper extremity muscles that you are responsible for knowing on to the stickers
Biceps Brachii, Triceps Brachii, Brachioradialis, Extensor Carpi Radialis Longus, Extensor Carpi Ulnaris, Extensor Digitorum, Flexor Carpi Radialis, Flexor Carpi Ulnaris, Flexor Digitorum Superficialis
3. Select a “team leader” and a group member to be the “mannequin” for your group.
 - a. Using the colored images as reference have members of the group take turns labeling the muscles on your group member
 - b. As the muscle is labeled, ask the “mannequin” to demonstrate the movement that the muscle will produce.

4. Have your instructor check your work and then move to the next activity.

Activity 4: Muscles that move the Lower Extremity:

Hip & Thigh:

The muscles of the hip and pelvis are involved with maintaining trunk postural support (erect posture) and movement of the lower extremity necessary for locomotion. The muscles are identified by the anatomical location (anterior/medial and posterior/lateral) and then by the actions (hip flexors, hip extensors, hip abductors, hip adductors, and rotators) that are necessary for moving the body through space.

Anterior/Medial Hip Muscles:

Muscle	Origin	Insertion	Action
Rectus Femoris	Anterior Inferior Iliac Spine (AIIS)	Tibial Tuberosity (via Patella Ligament)	Flex thigh @ Hip Extend leg @ knee
Sartorius	Anterior Superior Iliac Spine (ASIS)	Medial Plateau of Tibia	Flex, Abduct, Externally rotate thigh @ hip Flex leg @ knee
Pectineus	Pectineal line of Superior Ramus of Pubis	Pectineal line of Femur	Adduct thigh @ Hip
Iliopsoas	Iliacus: Bowl of Pelvis Psoas: Body of 5 Lumbar Vertebrae	Lesser Trochanter of Femur	Standing: Flex trunk, Posterior tilt pelvis Sitting: Flex thigh @ hip
Gracilis	Inferior Ramus of Pubis	Medial surface of Tibia (infracondylar)	Adduct and Internally rotate thigh @ Hip Flex leg @ knee
Adductor Longus	Body of Pubis	Linea Aspera of Femur	Adduct thigh @ Hip
Adductor Brevis	Inferior Ramus of the Pubis	Femur	Adduct thigh @ Hip
Adductor Magnus	Ischiopubic Ramus; Ischial Tuberosity	Linea Aspera; Adductor Tubercle	Adduct, Flex and Extend thigh @ hip

Posterior/Lateral Hip Muscles:

Muscle	Origin	Insertion	Action
Gluteus Maximus	Ilium (inferior gluteal line); Sacrum; Sacrotuberous Ligament	Gluteal tuberosity; Iliotibial Band (ITB)	Extend, Externally rotates thigh @ Hip
Piriformis	Pelvic surface of Sacrum	Greater Trochanter	Abducts, Externally rotates thigh @ hip
Gluteus Medius	Ilium (superior gluteal line)	Greater Trochanter	Abducts, Internally rotates thigh @ hip Controls Lateral tilt of pelvis in gait
Obturator Internus	Obturator Membrane	Greater Trochanter	Externally rotates, Abducts thigh @ Hip
Obturator Externus	Obturator Membrane	Trochanteric Fossa	Externally rotates, Abducts thigh @ Hip
Superior Gemellus	Ischial Spine	Greater Trochanter	Externally rotates, Abducts thigh @ Hip
Inferior Gemellus	Ischial Tuberosity	Greater Trochanter	Externally rotates, Abducts thigh @ Hip
Quadratus Femoris	Ischial Tuberosity	Intertrochanteric Crest	Externally rotates thigh @ Hip Stabilize hip during LE movements
Gluteus Minimus	Ilium (between gluteal lines)	Greater Trochanter	Abducts, Internally rotates thigh @ Hip
Tensor Fascia Lata (TFL)	Iliac Crest	Iliotibial Band (ITB), Lateral Epicondyle of Femur & Head of Fibula	Abducts thigh @ hip Controls Lateral tilt of pelvis in gait
Biceps Femoris	Long Head: Ischial Tuberosity Short Head: Linea Aspera	Fibular Head; Lateral Plateau of Tibia	Both: flex leg @ Knee Long Head: extend thigh @ Hip
Semimembranosus	Ischial Tuberosity	Medial Condyle of Tibia	Extend thigh @ Hip Flex leg @ Knee
Semitendinosus	Ischial Tuberosity	Medial Condyle of Tibia	Extend thigh @ Hip Flex leg @ Knee

Thigh

The muscles of the thigh are involved with propulsion of the body during gait and the postural support, at the tibiofemoral joint, necessary for standing. The muscles are grouped by location as being either anterior or posterior thigh muscles. The anterior group is typically identified as being comprised of the quadriceps (vastus muscles and rectus femoris) and adductors. The poster group is typically referred to as the hamstrings but will also include the adductor magnus and gastrocnemius muscles in some of its actions. Actions of flexion and extension of the lower extremity occur through a coordinated action of the anterior thigh and posterior leg muscles for extension, and posterior muscles of the thigh and anterior muscles of the leg for flexion, of the lower extremity.

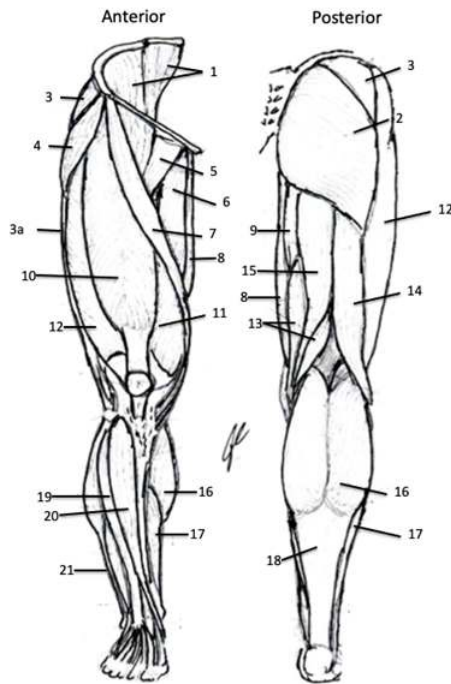
Anterior Thigh:

Muscle	Origin	Insertion	Action
Vastus Medialis ¹	Medial surface of Femur	Tibial Tuberosity (via Patella Ligament)	Extend leg @ knee
Vastus Lateralis ¹	Lateral surface of Femur	Tibial Tuberosity (via Patella Ligament)	Extend leg @ knee
Vastus Intermedius ¹	Anterior surface of Femur	Tibial Tuberosity (via Patella Ligament)	Extend leg @ knee
Rectus Femoris ¹	AIIS	Tibial Tuberosity (via Patella Ligament)	Flex thigh @ hip Extend leg @ knee
Gracilis	ASIS	Medial Plateau of Tibia; Medial Condyle of Femur	Adduct and Internally rotate thigh @ Hip Flex leg @ knee
Sartorius	ASIS	Medial Plateau of Tibia; Medial Condyle of Femur	Flex, Abduct, Externally rotate thigh @ hip Flex leg @ knee

Posterior Thigh Muscles:

Muscle	Origin	Insertion	Action
Bicep Femoris ²	Long Head: Ischial Tuberosity Short Head: Linea Aspera	Fibular Head; Lateral Plateau of Tibia	Both: flex leg @ Knee Long Head: extend thigh @ Hip
Semimembranosus ²	Ischial Tuberosity	Medial Condyle of Tibia	Extend thigh @ Hip Flex leg @ Knee
Semitendinosus ²	Ischial Tuberosity	Medial Condyle of Tibia	Extend thigh @ Hip Flex leg @ Knee
Gastrocnemius	Medial and Lateral Condyle of Femur	Calcaneus (via Calcaneal Tendon)	Assist Flex of leg @ Knee Plantarflex foot @ Ankle
Adductor Magnus	Ramus of the Pubis	Linea Aspera; Medial Plateau of Tibia	Adduct, Flex, Extend thigh @ Hip
Popliteus	Tibial Plateau	Lateral Condyle of Femur	Internally rotate femur @ Knee Assist Flex of leg @ Knee

¹ Indicates Quadriceps group; ² Indicates Hamstring group



Muscles of the Hip and Lower Extremity

- 1=Iliopsoas
- 2=Gluteus Maximus
- 3=Gluteus Medius
- 3a=Iliotibial Band
- 4=Tensor Fascia Lata
- 5=Pectineus
- 6=Adductor Longus
- 7=Gracilis
- 8=Sartorius
- 9=Adductor Magnus
- 10=Rectus Femoris
- 11=Vastus Medialis
- 12=Vastus Lateralis
- 13=Semimembranosus
- 14=Biceps Femoris
- 15=Semitendinosus
- 16=Gastrocnemius
- 17= Soleus
- 18=Calcaneal (Achilles') Tendon
- 19=Extensor Digitorum Longus
- 20=Tibialis Anterior
- 21=Peroneus (Fibularis) Longus

Color each with a different color for use as reference for identify muscles.

Leg:

The muscles of the leg are involved with movement of the tibia and fibula about the femur during postural support and locomotion. The actions are highly involved with propulsion of limb during gait and controlling limb during loading of limb upon landing. Muscles are broken into two groups the anterior group (the dorsiflexors), lateral (peroneal), and posterior (the plantarflexors). The

dorsiflexors are involved with clearing the toes and stabilizing the foot during gait. The plantarflexors are involved with propelling the limb forward in gait and assisting with the production of force necessary to stand and jump.

Anterior Muscles of the Leg:

Muscle	Origin	Insertion	Action
Tibialis Anterior	Superior 2/3 lateral surface of Tibia	Medial Cuneiform; Base 1 st Metatarsal	Dorsiflex and Invert foot @ Ankle & IT joints
Extensor Digitorum Longus	Superior 2/3 of Fibula	Middle and Distal Phalanx of lateral 4 digits	Extend distal Phalanx of digits 2-5 @ IP joints Assist w/ Dorsiflex foot @ ankle
Extensor Hallucis Longus	Middle 1/3 of Fibula	Base of distal Phalanx of Hallux	Extend distal Phalanx of digit 1 @ IP joint Assist w/ Dorsiflex foot @ ankle
Peroneus Tertius	Distal end of Fibula	Base of 5 th Metatarsal	Dorsiflex and Evert foot @ Ankle & IT joints
Extensor Hallucis & Digitorum Brevis	Sinus Tarsi (Calcaneus Bone)	Base of proximal Phalanx of Hallux & Long extensor tendons	Extend middle Phalanx of Digits 1-5 @ IP joint

Lateral Muscles of the Leg:

Muscle	Origin	Insertion	Action
Peroneus Longus	Superior 2/3 of Fibula	Base of 1 st Metatarsal; Medial Cuneiform	Plantarflex and Evert foot @ Ankle & IT joints
Peroneus Brevis	Distal end of Fibula	Base of 5 th Metatarsal	Plantarflex and Evert foot @ Ankle & IT joints
Peroneus Tertius	Distal end of Fibula	Base of 5 th Metatarsal	Dorsiflex and Evert foot @ Ankle & IT joints

Posterior Muscles of the Leg:

Muscle	Origin	Insertion	Action
Gastrocnemius	Medial & Lateral Condyle of Femur	Calcaneus (via Calcaneal Tendon)	Assist Flex of leg @ Knee Plantarflex foot @ Ankle
Soleus	Posterior Surface of Tibia & Fibula	Calcaneus (via Calcaneal Tendon)	Plantarflex foot @ Ankle Control Dorsiflex foot @ Ankle during gait
Plantaris	Lateral Condyle of Femur	Calcaneus (via Calcaneal Tendon)	Plantarflex foot @ Ankle
Flexor Digitorum Longus	Tibia	Distal Phalanx of lateral 4 digits	Flex distal Phalanx @ IP Assist w/ Plantarflex foot @ Ankle
Flexor Hallucis Longus	Fibula	Distal Phalanx of Hallux	Flex distal Phalanx of digit 1 @ IP
Tibialis Posterior	Tibia; Fibula; Interosseous Membrane	Navicular; Medial Cuneiform	Plantarflex and Invert foot @ Ankle
Popliteus	Lateral Condyle of Femur	Tibial Plateau	Internally rotate femur @ Knee Assist Flex of leg @ Knee

Procedures:

1. Obtain models, stickers, felt pens
2. Write the names of the lower-extremity muscles that you are responsible for knowing on to the stickers
Rectus Femoris, Vastus Lateralis, Vastus Medius, Tensor Fascia Lata, Biceps Femoris, Semitendinosus, Semimembranosus, Gastrocnemius
3. Select a “team leader” and a group member to be the “mannequin” for your group.
 - a. Using the colored images as reference have members of the group take turns labeling the muscles on your group member
 - b. As the muscle is labeled, ask the “mannequin” to demonstrate the movement that the muscle will produce.
4. Write the names of the key hip muscles on the stickers
Gluteus Maximus, Gluteus Medius, Gluteus Minimus, Piriformis
5. Change “team leader”.
 - a. Using the colored images as reference have members of the group take turns labeling the muscles on your torso model
 - b. As the muscle is labeled, demonstrate the movement that the muscle will produce.
6. Have your instructor check your work and then move to the next activity.

Activity 5: Muscles of the Face, Head and Neck:

Face and Neck:

The muscles of the face have a variety of roles for the human body. They are involved with the conveying of psychosocial cues (facial expressions) along with respiration, mastication and feeding behaviors. The extrinsic eye muscles are involved with movements of the eye to keep pupils centered on the visual field during tracking of object without head motions or movement of the remainder of the body. The muscles of the neck are layered in a superficial to deep fashion and are involved with movement of the head and cervical regions along with movement of the hyoid involved with vocalization.

Facial Muscles

Muscle	Origin	Insertion	Action
Epicranius	Frontal Bone (Frontal Belly) Superior Nuchal Line (Occipital Belly)	Epicranial Neurosa	Raise Eyebrows, Wrinkle forehead Hold Scalp posteriorly
Nasalis	Maxilla and alar cartilage of nose	Dorsum of nose	Flare nostrils
Buccinator	Alveolar Processes of Mandible & Maxilla	Orbicularis Oris	Press cheek against teeth, draws lips laterally Assist with chewing
Depressor Anguli Oris	Body of Mandible	Skin @ inferior corner of mouth	Opens mouth (pulls lips inferiorly/laterally)
Depressor Labii Inferioris	Body of Mandible, lateral to midline	Skin @ inferior lip	Depresses lower lip
Levator Anguli Oris	Lateral Maxilla	Skin @ superior corner of mouth	Elevates angle of mouth laterally/superiorly
Levator Labii Superioris	Zygomatic bone & Maxilla	Skin & muscles of superior lip	Elevates upper lips
Mentalis	Central Mandible	Skin of chin	Elevate & protrude lower lip
Orbicularis Oris	Maxilla & Mandible CT of other facial muscles	Encircles mouth skin & muscles @ angles of mouth	Closes & Protrude Lips Compress Lips to Teeth, forms mouth for speech
Risorius	Deep Fascia of Masseter	Skin @ angle of mouth	Pulls lips laterally
Zygomaticus Major	Zygomatic Bone	Skin @ superolateral edge of mouth	Moves lips for smiling
Zygomaticus Minor	Zygomatic Bone	Skin of superior lip	Raise lips to expose Maxillar Teeth
Corrugator Supercilli	Medial end of Superciliary Arch	Skin superior to Supraorbital Margin & Superciliary Arch	Draw eyebrow inferiorly Wrinkle forehead
Levator Palpebrae Superioris	Lesser Wing of Sphenoid	Superior Tarsal Plate & skin of superior eyelid	Opens eyes
Orbicularis Oculi	Medial Wall &/or Margin of Orbit	Skin surrounding eyelids	Closes eyes
Platysma	Fascia of Deltoid & Pectoralis Major & Acromion Process of Scapula	Skin of Cheek & Mandible	Depresses lower lip and mandible Tenses cervical fascia
Temporalis	Superior & Inferior Temporal Lines	Coronoid Process of Mandible	Elevates & retracts Mandible for mastication (chewing)
Masseter	Zygomatic Arch	Coronoid Process, Lateral Surface & Angle of Mandible	Elevates mandible Mastication (chewing)
Medial Pterygoid	Maxilla, Palatine & medial surface of lateral Pterygoid Plate	Medial surface of Ramus of Mandible	Elevates & Protracts Mandible Lateral Glide of Mandible
Lateral Pterygoid	Greater Wing of Sphenoid, lateral	Condylar Process of Mandible	Protracts & Depress Mandible (open

surface of lateral Pterygoid Plate

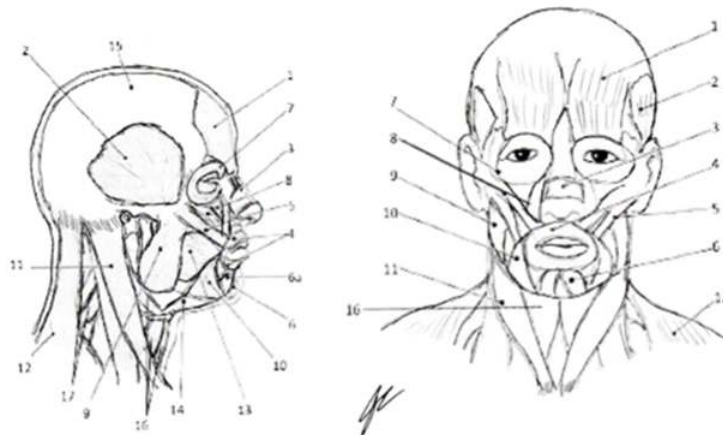
mouth)

Extrinsic Muscles of the Eye

Muscle	Origin	Insertion	Action
Medial Rectus	Common Tendinous Ring (CTR)	Anteromedial Surface of Eye	Adducts eye
Lateral Rectus	Common Tendinous Ring (CTR)	Anterolateral Surface of Eye	Abducts eye
Inferior Rectus	Common Tendinous Ring (CTR)	Anteroinferior Surface of Eye	Adducts eye, Medially rotate eye, moves eye inferiorly
Superior Rectus	Common Tendinous Ring (CTR)	Anterosuperior Surface of Eye	Adducts eye, Medially rotate eye, moves eye superiorly
Inferior Oblique	Anterior Orbital surface of Maxilla	Posteroinferior lateral Surface of Eye	Abducts eye, moves eye superiorly, Laterally rotates
Superior Oblique	Sphenoid Bone	Posterosuperior lateral Surface of Eye	Abducts eye, moves eye inferiorly, Medially rotates

Muscles of the Neck

Muscle	Origin	Insertion	Action
Scalene	T.P. of C-vert	Superior Surface of 1 st & 2 nd costal	Bilaterally: elevate ribs 1-2, assist with respiration Unilaterally: Ipsilateral lateral flexion & rotate head & neck
Longissimus Capitis	C-vertebrae 3-7	Mastoid Process	Bilaterally: extend head & neck Unilaterally: Ipsilateral lateral flex & rotate head & neck
Splenius Capitis	Ligamentum Nuchae; S.P. of C-vert 7 & T-vert 1-3	Occipital & Mastoid Processes	Bilaterally: extend head & neck Unilaterally: Contralateral rotation of head & neck
Splenius Cervicis	S.P. of T-vert 3-6	T.P. of C-Vert 1-4	Bilaterally: extend head & neck Unilaterally: Ipsilateral lateral flex and rotate head & neck
Sternocleidomastoid (SCM)	Manubrium and sternal end of clavicle	Mastoid Process	Bilaterally: flex head & neck, asst. with respiration Unilaterally: Contralateral flexion and rotation of head & neck



Muscles of the Face and Neck

1=Frontalis 2=Temporalis 3=Nasalis 4=Orbicularis Oris
 5=Zygomaticus 6=Mentalis 6a=Depressor Labii Inferioris 7= Orbicularis Oculi
 8=Levator Labii Superioris 9=Masseter 10= Triangularis 11=Sternocleidomastoid
 12=Trapezius 13=Buccinator 14=Digastricus 15=Epicranial Aponeurosa
 16=Hyoid Muscles 17=Cervical Extensors

Color each a different color for use as a reference for identification of muscles.

Procedures:

1. Obtain models, stickers, felt pens
2. Write the names of the facial and neck muscles that you are responsible for knowing on to the stickers
 - a. Orbicularis Oris, Temporalis, Masseter, Sternocleidomastoid, Scalene, Trapezius [upper fibers]
3. Select a “team leader” and a group member to be the “mannequin” for your group.

- a. Using the colored images as reference have members of the group take turns labeling the muscles on your group member
 - b. As the muscle is labeled, ask the “mannequin” to demonstrate the movement that the muscle will produce.
4. Have your instructor check your work and then clean-up your lab area.

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1.7: Musculoskeletal Anatomy Part 3- Articulation and Kinematics of movement

Objectives:

At the end of this lab, you will be able to...

1. Differentiate between classifications of articulations
2. Correctly describe the types of movements at a given articulation
3. Describe what is meant by the kinematic chain

Pre-Lab Exercises:

After reading through the lab activities prior to lab, complete the following before you start your lab.

1. The classification of articulations of the body is based on: .
2. The difference between levers is the location of the relative to force being applied and the action of the muscles contracting.
3. Movement of the hand away from body laterally is called , while movement medially is called .
4. Based on the kinematic classification of the articulations, the allow for the most movement while the have the least.

Materials:

- Skeleton
- Joint Models
- Stickers
- Felt pens

When examining the articulations of the body it is important to remember the relationship between structure and function. In this, we can use the shape of the articulation to determine the different kinematics (movements) that the articulations allow for the bones when combined with lines of pull of the ligaments, tendons and muscles that attach to the bones of the articulation.

Activity 1:

Articulations:

There are three classifications of articulations based on the ability (called or degrees of freedom) for movement to occur. The ability to move or degrees of freedom are an indication of the number of directions (or axis) that the articulating bones are able to move at that articulation. These are identified as being synarthrosis, amphiarthrosis, and diarthrosis. Synarthrosis are articulations with no movement occurring between bones, meaning 0 degrees of freedom for movement. Amphiarthrosis is the type of articulations with minimal movement provided between bones meaning 0 or 1 degree of freedom for movement. Diarthrosis articulations are typically thought of articulations, such that the bones are able to move about each other, meaning at 1-2 degrees of freedom for movement.

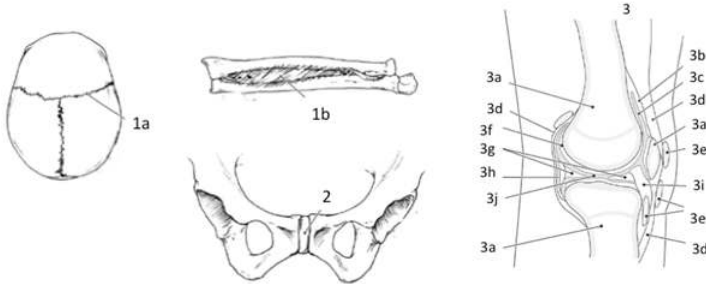
Within the Diarthrosis joints there are six types of articulations commonly called synovial joint, with each type providing a different amount and pattern of movement. Pattern of movement is determined by the shape of the articulating surfaces for bones that are meeting at an articulation.(Knudson, 2007) The amount of movement allowed because of the structure of the ligaments that surround the joint that limit the total amount of movement possible at any given articulation along with the lines of pull of the muscles on the bones that form the joint.

Additionally, there is a distinct class of articulations known as dynamic articulations. The dynamic articulations are seen primarily within ball and socket joints (especially the glenohumeral joints). These joints form due to interaction of capsular ligaments with the tendons of the rotator muscles of the joint. Provides the ability to have changing levels of tension and capsular stability via the interaction between ligamentous and tendinous units. That occurs by changes in tension about the central axis of the capsular ligament and thus modifies the degree of motion that can be obtained throughout the entire range of motion of the articulation.

Activity 1:

Types of Articulations:

1. Obtain bones, skeleton, articulation models, stickers and felt-tip marker
2. Write the names for the types and classifications of articulations on the stickers.
3. Working with your group (and using your colored images) identify the various types of articulations of the body by type and classification.
4. Taking turns within your group, label the articulations based on being fibrous, cartilaginous or synovial and then as being synarthrosis, amphiarthrosis or diarthrosis.
5. Have your work checked by the instructor and then move to activity 2.

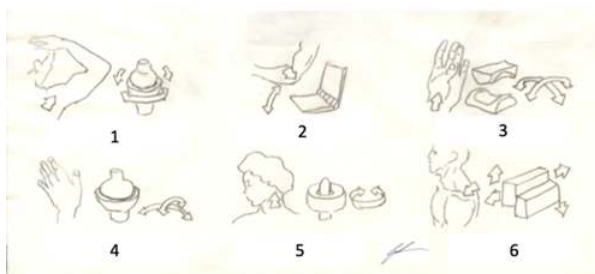


Classification of Articulations

- 1a Fibrous (Synarthrosis)
- 1b Fibrous (Amphiarthrosis)
- 2 Cartilaginous (Amphiarthrosis)
- 3 Synovial
- 3a Articulating Bones
- 3b Anterior Synovial Membrane
- 3c Synovial Fluid
- 3d Tendon
- 3e Bursa Sacs
- 3f Articulating Cartilage
- 3g Meniscus
- 3h Posterior Synovial Membrane
- 3i Sub-patellar Bursa Sac
- 3j Cruciate Ligament

Color each joint a different color for use as a reference when identifying on your skeleton

Types of Synovial Joints



- 1. Ball and Socket 2. Hinge 3. Saddle
- 4. Condylar (Ellipsoid) 5. Pivot 6. Planar (Gliding)

Color each synovial joint a different color for use as a reference when identifying on your skeleton

Activity 2:

Lines of Pull and Movements:

Lines of pull of the description of movements that can be generated by a muscle contraction. These lines of pull are based on the origin and insertion of the muscle, the anatomical location of the muscle as it crosses the articulation that is being moved and the anatomical shape of the articulation. For most of the articulations of the body, these motions will occur in the coronal or sagittal planes, however there are special movements that occur in the transverse plane. These movements are generally referred to as being horizontal movements of the appendage.

These lines of pull will be described by defined antagonistic pairs (pairs of movements that perform the opposite of each other) of movements at the joint. Most of movements will result in a paired movement patterning between agonistic muscles (muscles that allow for motion in the direction that is desired) and antagonistic muscles (muscles that allow for motion in the opposite direction to the desired direction). The agonistic muscle also will involve muscles that are furthered described as being primary or accessory to the movement. Where the primary movers are those muscles that will produce the majority of the active force needed for the movement to occur and the accessory muscles will either provide a limited amount of force to the movement or will stabilize the articulation within the pattern of movement.

The movements include:

Flexion: movement of the extremity toward the torso/thorax

Extension: movement of the extremity away from the torso/thorax

Abduction: movement away from the mid-line of the body

Adduction: movement toward the mid-line of the body

Rotation: movement around the central axis of the body or extremity

Circumduction: movement of the arm through all three anatomical planes

Deviation: movement of the hand and wrist toward the radius or the ulna

Supination: rotating hand and wrist, or foot and ankle, so that palm of hand, or sole of foot, is facing anterior (as is holding a bowl of soup)

Pronation: rotating hand and wrist, or foot and ankle, so that palm of hand, or sole of foot, is facing posterior

Vertebral/Trunk Rotation: rotating of the vertebral column (or segments of the vertebral column) about the central long axis of the body

Inversion: rotation of the foot and ankle, medially and superiorly

Eversion: rotation of the foot and ankle laterally and inferiorly

Plantarflexion: movement of the toes and foot (and ankle) toward the ground (away from the leg)

Dorsiflexion: movement of the toes and foot (and ankle) toward the anterior leg (away from the ground)

Horizontal Adduction: movement of the appendage in an abducted position toward the mid-line of the body

Horizontal Abduction: movement of the appendage in an abducted position away the mid-line of the body

1. Using the following articulations, take turns within your group to mimic the movements that would be allowed at the articulation. As you perform the movement, have one person in your group indicate a muscle that would allow the movement to occur.

- a. Shoulder (Glenohumeral)
- b. Elbow (Humeroulnar)
- c. Forearm (Proximal and Distal Radioulnar)
- d. Wrist (Radiocarpal)
- e. Head and Neck (Atlantooccipital)
- f. Head and Neck (Atlantoaxial)
- g. Vertebral
- h. Hip (Femoroacetabular)
- i. Knee (Tibiofemoral)
- j. Ankle (Tibiotalar)

Patterns of Movement and Kinematic Chain:

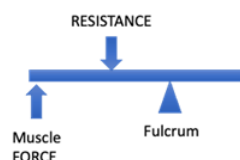
Kinematics is the description of the movements of the bones at the joints (articulations) that allow for locomotion (movement) to occur either within the limb or body segment or the body as a whole. There are two distinct features that we must remember, and both relate to what is called the kinematic chain. Kinematic chain is the linking of the articulations of the body that leads to the desired movement. In the kinematic chain you can either have an open chain or a closed chain. The open chain is where the distal (terminal) end of the chain is free to move and the proximal (initial) segment of the chain is fixed. While a closed chain will have both the distal (terminal) end and the proximal (initial) segment of the chain are fixed.

The motion that is allowed by the articulations interactions with the muscles follows the physical principles of levers. Based on where the muscles insert on the bone, three basic lever systems are developed all of which provides a level of mechanical advantage to the articulation allowing for movement to occur. In addition to the lever system, the arrangement of tendinous insertion and pennation of the muscle fascicles (fibers) within the muscle gaster summate to determine the overall mechanical advantage that each articulation provides for the kinematics of movement for the body.

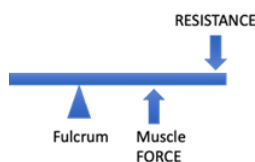
The first-class (type 1) lever system is the simplest of the lever system. It can be thought of as a teeter-totter where the muscle pull is on the opposite side of the joint from the resistance placed on the joint. This type of lever is seen at the Atlantooccipital (between CV1 and the Occipital bone of the cranium) articulation.



The second-class (type 2) lever system is more readily seen, but slightly more complex than, the type-1 lever for the human body. The system has the muscle pull is on the same side of the joint as the resistance placed on the joint but will have the resistance placed on the joint falls between the joint moving and muscle pull causing the movement, similar to the action of using a nutcracker. This type of lever is seen at the Tibiotalar and Talofibular (ankle) articulation.



The third-class (type 3) lever system is the most complex system used in the body. It is typically seen in articulation that has a moveable pivot point for the fulcrum. This is necessary to provide the maximal mechanical advantage from the lever, as the muscle pull will be closer to the fulcrum than the resistance on the same side of the joint. This lever is similar to the action of using a shovel and is seen at the Humeroulnar (elbow) articulation.



2. As you perform the movements, as a group determine the type of lever system being used and if the movement is an open chain or a closed chain pattern of movement

a. Shoulder (Glenohumeral)

i. Lever system:

ii. Movement:

iii. Kinematic Chain:

b. Elbow (Humeroulnar)

- i. Lever system:
- ii. Movement:
- iii. Kinematic Chain:
- c. Forearm (Proximal and Distal Radioulnar)
 - i. Lever system:
 - ii. Movement:
 - iii. Kinematic Chain:
- d. Wrist (Radiocarpal)
 - i. Lever system:
 - ii. Movement:
 - iii. Kinematic Chain:
- e. Head and Neck (Atlantooccipital)
 - i. Lever system:
 - ii. Movement:
 - iii. Kinematic Chain:
- f. Head and Neck (Atlantoaxial)
 - i. Lever system:
 - ii. Movement:
 - iii. Kinematic Chain:
- g. Vertebral
 - i. Lever system:
 - ii. Movement:
 - iii. Kinematic Chain:
- h. Hip (Femoroacetabular)
 - i. Lever system:
 - ii. Movement:
 - iii. Kinematic Chain:
- i. Knee (Tibiofemoral)
 - i. Lever system:
 - ii. Movement:
 - iii. Kinematic Chain:
- j. Ankle (Tibiotalar)
 - i. Lever system:
 - ii. Movement:
 - iii. Kinematic Chain:

3. Have your instructor check your answers and then clean up your lab area.

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1.8: Muscle Physiology Measures of Strength Development and Fatigue

Learning Objectives:

At the end of the lab each student will be asked to:

- 1) Determine the differences in strength development between subjects based on gender and between the concepts of “dominance” of use.
- 2) Observe, record, and correlate relative amount of total motor unit recruitment that occurs within a muscle group with increased strength production.
- 3) Distinguish between mechanical (peripheral) fatigue and cognitive (central) fatigue.

Pre-Lab:

- 1) What is the importance of a recovery period of 5-minutes for each participant?
- 2) What principle explains why strength increases when recruiting larger fibers in the muscle?
- 3) Complete your hypothesis to test in the lab.

Introduction:

Skeletal muscle is an excitable tissue made of several tubular cells (muscle fibers) that form a cylindrical collection of tissues (fascicles). These fascicles run the length of the muscle from the tendon of origin to the tendon of insertion see **figure 1**. Additionally, skeletal muscles possess unique characteristics. Skeletal muscles are voluntarily controlled tissue (needs nervous system control, whether the control is conscious or not) and exhibit electrical characteristics that make the tissues irritable (can change its membrane potential when stimulated). These two features enable us to explain the basis for the function of skeletal muscle through what is generally referred to as the excitation-contraction coupling of strength production. Additionally, skeletal muscle tissue is contractile (able to shorten when electrically stimulated), extensible (able to stretch beyond its resting length), elastic (able to return to its original shape), and plastic (able to change to meet new demands for strength, power, or work production). The principle of contractility, elasticity and extensibility explains how active (actin and myosin) and passive (connective proteins) forces form the tension within the fascicles and motor units of the skeletal muscle that results in the visible morphological changes of a muscle during active force production. The sequence events in force production, that leads to ever greater response from the muscle fiber, is based on a continuum of responses within the fascicles and motor units beginning with a twitch (due to a single contraction episode), and with continuous excitation progresses through Treppe effect (as the summation

events occur within the fascicles and between motor units due to repeated excitations), eventually leading to the full muscle Tetany (whole muscle contraction) based on the pattern of recruitment, **figure 2**.

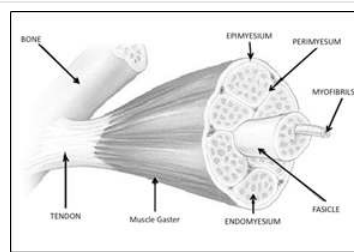


Figure 1. Anatomy of the skeletal muscle displaying the pattern of tissue interaction and divisions of the functional units of the muscle.

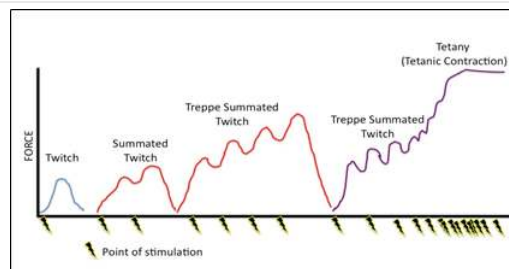


Figure 2. The relationship between timing stimulation and the contraction strength (mechanical force) development within a muscle fiber based on the Treppe effect leading to tetany of contraction that we normally associate as a muscle contraction.

Since the process of formation of a muscular contraction is under voluntary control and can be modified by cognitive desire or focus. As such, a person modulates the recruitment, and strength produced, from a muscle thereby leading to greater, or reduced, strength production based on desire for strength. All activity along the path of voluntary control is due to the excitation-contraction coupling between the skeletal muscle and the motor neuron that innervates that skeletal muscle's motor end plate, all of which begins with the release of neurotransmitter acetylcholine (ACh) onto the skeletal muscle which leads to whole muscle fiber depolarization to threshold of stimulus and initiates the contraction of the muscle gaster. The way this interaction occurs is through the motor unit, single motor neuron and all fibers it innervations. Within each of muscle there will be a varying number of motor units (m.u.); the total number of m.u. within the muscle is dependent upon the type of muscle and the type of movement that is being controlled. Generally, the finer (more dexterous) the motor movement, the greater number of m.u. are involved (fewer muscle fibers per motor neuron) in the recruitment, while less motor control fewer units (fewer motor neurons per muscle fiber) in the recruitment.

When developing contractile strength, units are selectively recruited based on a continuum of threshold for excitation (the Size Principle) from the lowest, easy to recruit, to the highest, hardest to recruit, threshold based on the amount of strength development necessary, **figure 3**. This pattern of recruitment is developed in relation to the diameter of the muscle fiber, with the larger cross-sectional area providing a greater strength capacity but also needing a higher level of stimulation to cause excitation of the membrane. This concept is referred to as Henneman's size principle. Each muscle fiber is being recruited along a gradient of a threshold potential reached by the individual muscle fibers within the muscle gaster, see **figure 4**. The selection of recruitment for different m.u. will proceed to meet the demand for strength production in such a way that a continuous contraction can be maintained throughout the length of the muscle for the duration of contraction time, referred to as the time under tension. This pattern of contraction within the muscle is based on the recruitment of individual muscle fibers beginning from the central region of the muscle gaster and traversing laterally until the entire recruited muscle is contracting to meet the demand. Because of the plasticity that muscles show, as you learn to recruit the muscle to produce a desired level of strength, you alter the way that you

recruit the muscle. Where instead of recruiting throughout the continuum, you only recruit what is needed at any point in time within the contraction for that amount of strength.

Figure 3. Graphical representation of the generalized pattern of recruitment of motor units of skeletal muscles based on fiber type, activation threshold, and force production capacity of the fiber type and motor units based on Henneman's size principle.

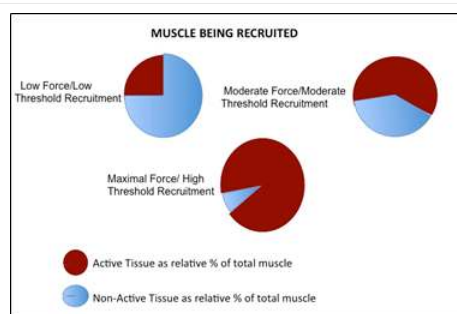
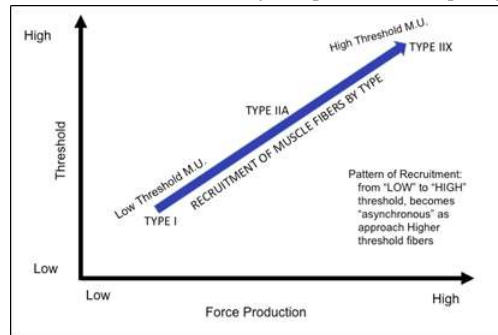


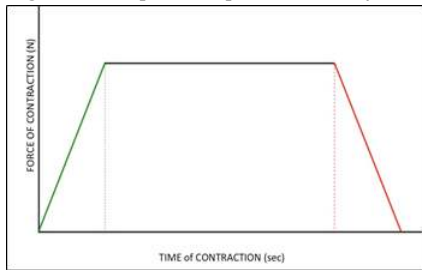
Figure 4. Overview of the relative activation/non-activation of skeletal muscle tissue) based excitation to match the demand for strength along with the relative threshold of activation of the motor unit within the skeletal muscle being recruited based on Henneman's size principle.

The pattern of recruitment throughout the muscle can be measured not only by the elicited motion, but also through the electrical activity at the muscle during activation, known as electromyography (EMG). This analysis of electrical activity gives insight into the amount of muscle recruitment that occurs during periods of rest versus periods of maximal and near maximal force production. For most clinical situations, such EMG analysis is performed via surface electrodes placed near the origin and insertion tendons of single muscles or groups of muscles. These electrodes do two things: 1) record the change in electrical activity across the muscle and 2) indicate the relative amount of muscle being recruited in relation to either the external load being applied, or the stimulation of a motor neuron linked with a nerve conduction velocity test. When coupled with a recording of force production (via dynamometry), this gives a clinician an integrated level of data to determine the amount of muscle being recruited and thus the maximal volitional contraction (MVC). This understanding of MVC provides both clinician and patient with an understanding of differential recruitment during biofeedback within a course of neurological treatment, and, in addition, provides insight into the course of degeneration and atrophy that accompanies many degenerative neurological diseases.

A combination of muscle contraction patterns is involved in most EMG studies. Typically, they involve the use of a prolonged isometric (no movement) contraction. The use of the isometric contraction allows for the recruitment of various m.u. to provide the constant state of tension throughout the length of contraction time. This graph of force production is generally noted by a gradual "ramping up" to "plateau" to rapid "ramping down" graph of strength, see **figure 5**. In creating this graph, the individual and clinician obtain an understanding of recruitment, as well understanding the general order of fiber recruitment based on the

fundamentals of the size principle. This pattern of recruitment and graph will mirror the continuum of increasing force production and the inverse relationship with respect to time needed to fatigue the fibers.

Figure 5. Graphical representation of the isometric contraction based on the time of contraction and the maximal force.



Additionally, discussion of any unit must also find the rate of twitch formation, i.e. slow-twitch and fast-twitch. Twitch formation describes the rate that the excitation-contraction coupling occurs, or how quickly the binding sites on the actin become exposed once exposed to calcium (Ca^{++}) ions and the movement of the myosin heads. The rate of twitch formation within the muscle fiber will be influenced by the metabolic process utilized to regenerate ATP necessary for the contraction. When combined, the relative thresholds, the twitch speed and the metabolic process for regenerating ATP gives rationale to how the continuum of motor units seen within the size principle and the progressive loss of strength that is demonstrated in sustained isometric contractions. As those small fibers and units have a low force capacity but is long to fatigue whereas the larger fibers and units that have high force capacity but are quick to fatigue. The skeletal muscle is thus recruited to provide the force for movement with the smaller fibers and unit continually recruited and the progressively larger ones being selectively and intermittently recruited to meet the requirement for the activity and relative to the level of fatigue, see **figure 6**.

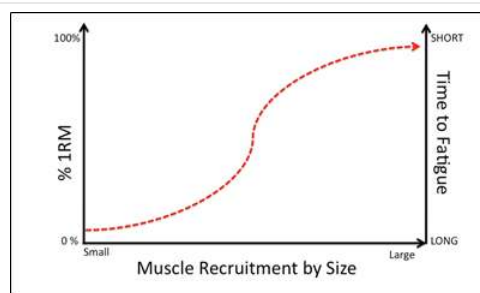
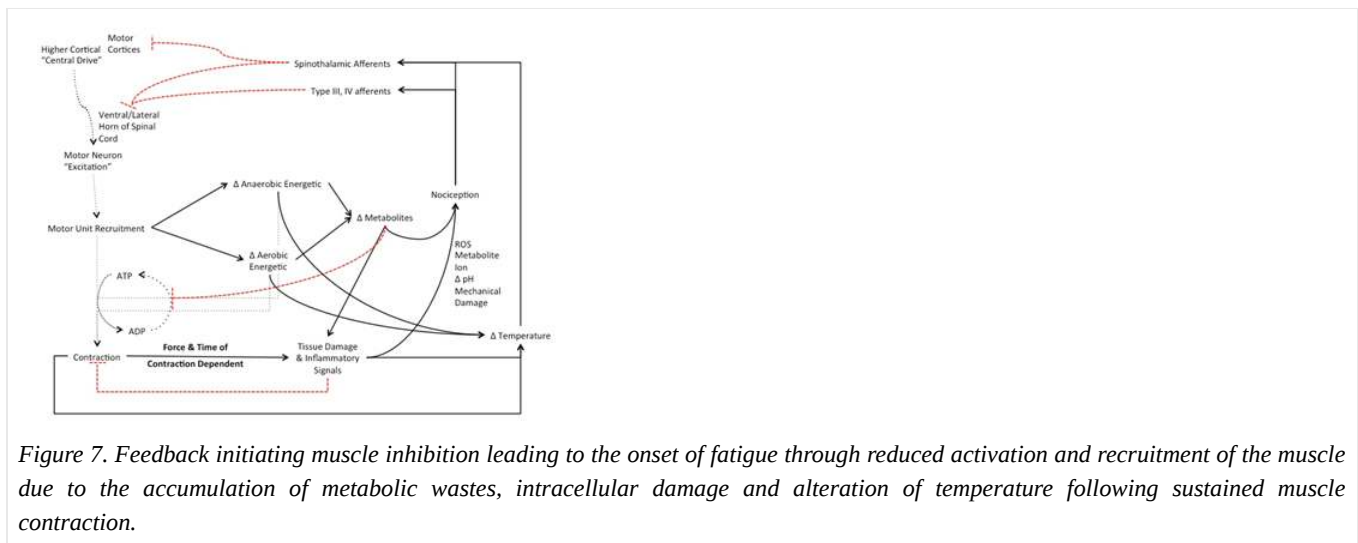


Figure 6. Description of the relationship between muscle fiber recruitment relative to the maximal force production (%1RM) and time to fatigue.

There are key aspects to responses noted in relation to EMG studies. First, there is often a relationship that shows that men are able to produce greater force than women. This gender difference is based on a) the larger muscle mass that men tend to have compared to women, and b) the basal level of testosterone and integrated testosterone response to periods of exertion leading to greater muscle excitation. Second, the cognitive involvement controlling the recruitment of the skeletal muscle means that changing cognitive involvement (or encouragement) to develop the skeletal muscle force will modulate. As such, EMG activity, force development and time to fatigue can all be adjusted; where fatigue is any reduction of force capacity across the muscle from the level of force produced at the beginning of the sustained contraction. This fatigue in contraction is based on several aspects of muscle anatomy and physiology. There is only a limited concentration of ATP within the skeletal muscle of the body (enough to perform less than a few seconds of cellular activities) and as ATP is required to sustain the energetics of the muscle contraction it must be regenerated, regardless of the type of motor unit being recruited. It begins with the use of the ATP-cP pathway and then progresses into catabolism of molecules to provide the free energy required to regenerate ATP for the cell. The very moment that the skeletal muscle changes to the use of catabolism for ATP regeneration, the muscle has entered fatigue (as there is a delay in the cycle of ATP to allow for muscle contraction to continue). This reduction of force capacity continues as the catabolic pathways of energetics proceeds into what are called the aerobic pathways. This is not due to the “accumulation of metabolic wastes” but instead due to the smaller fibers that are being recruited for force production, see **figure 6**. Since the aerobic pathways require a

high concentration of oxygen within the cell, these aerobic muscle fibers must remain relatively close to the capillaries within the skeletal muscle and thus have a limited CSA. As there is less CSA, these fiber types have a lower force capacity than the large fibers that were being recruited at the maximal level of force production; resulting in the progressive decrease in force from the maximum that is seen in sustained “isometric” contractions. Along with this issue of ATP regeneration comes the idea of cognitive recruitment (i.e. central drive) and cognitive withdrawal from exercise (i.e. central fatigue). When performing sustained contractions, these central issues focus on the sensation of wanting to do the activity. Central fatigue is due to several factors: changes in the muscle morphology (microdamage from the contraction), accumulation of heat within the muscle (byproduct of metabolic processes not being 100% efficient), or even boredom. It is not due to what some text ascribes to accumulation of metabolites (most discuss lactate, which is shuttled out of the fiber and transported to other tissues) or restriction of blood flow (which does occur but only after extremely prolonged, whole gaster isometric contraction), **figure 7**. More importantly, when there is high self-efficacy, or external motivation for the exertion, central drive will override many peripheral signals that would normally lead to central fatigue and allow for prolonged sustained contraction at moderately elevated levels from the point where fatigue first is noticed.



Strength Comparison

Along with examining the changes in strength that occurs during sustained contractions, we can also use isometric contractions for comparison of strength between individuals. In this case, we will examine how strength of contractions can vary based on the use of the limb (i.e. dominant versus non-dominant hand) as well as between genders (i.e. males versus females). In these comparisons there are several concepts of muscle physiology that are important to recall. First of which is related to the concept of the S.A.I.D. (Specific Adaptations to Imposed Demands) principle and muscle adaptations that will occur with greater use. Based on this principle, the more often we use a muscle or pattern of recruitment within the muscle, more efficient we are at recruiting the muscle and the larger the muscle will become (hypertrophy). As such, the more used a muscle is the greater the work and strength capacity the muscle will exhibit. Therefore, one might expect that the dominant hand would be more efficiently recruited than the non-dominant hand in the analysis of the handgrip strength leading to lower EMG recordings at relatively the same level of strength seen in the non-dominant hand. Secondly, there are gender differences in muscle cross-sectional areas stemming from residual effects of higher levels of testosterone. As such, males tend to have higher latent strength capacity than females. These gender differences are noted in the standardized grip-strengths used to establish aspects of fitness for individuals. Additionally, using these normative we can also gradate how individual compare to the whole population, table 1. In which, lower (i.e. “weaker”) handgrip is associated with poor musculoskeletal fitness and linked with impaired health status issues associated with overfatness. From which one can evaluate and determine one aspect of their overall relative fitness. Within these normative values, secondary demographic aspects of muscle physiology can be seen, as grip strength reduces (along with overall musculoskeletal fitness) with age. Studies show that among men, peak values of 49–52 kg/cm² are reached in the fourth decade of life, whereas females exhibit peak values of 31 kg/cm² in third to fourth decade. In which these demographic differences can be attributed to sarcomere and muscle fascicle CSA, use and disuse of digital flexors and overall robustness of anabolic and growth signals across the life span. Moreover, based

on differences in growth signals and responses to use and disuse it would not be surprising to see those that regularly stress the muscles (i.e. physical activity and recruitment of the muscle) to exhibit higher levels of strength, S.A.I.D. principle adaptations, relative to those muscles less regularly recruited.

Table 1. Grip strength (kg/cm²) norms and classifications for musculoskeletal fitness by age and gender.

Age (year)	Gender	Grip Strength		
		“Weak”	“Normal”	“Strong”
18-19	Female	< 19.2 kg/cm ²	19.2-31.0 kg/cm ²	> 31.0 kg/cm ²
	Male	< 35.7 kg/cm ²	35.7-55.5 kg/cm ²	> 55.5 kg/cm ²
20-24	Female	< 21.5 kg/cm ²	21.5-35.3 kg/cm ²	> 35.3 kg/cm ²
	Male	< 36.8 kg/cm ²	36.8-56.6 kg/cm ²	> 56.6 kg/cm ²
25-29	Female	< 25.6 kg/cm ²	25.6-41.4 kg/cm ²	> 41.4 kg/cm ²
	Male	< 37.7 kg/cm ²	37.7-57.5 kg/cm ²	> 57.5 kg/cm ²
30-34	Female	< 21.5 kg/cm ²	21.5-35.3 kg/cm ²	> 35.3 kg/cm ²
	Male	< 36.0 kg/cm ²	36.0-55.8 kg/cm ²	> 55.8 kg/cm ²
35-39	Female	< 20.3 kg/cm ²	20.3-34.1 kg/cm ²	> 34.1 kg/cm ²
	Male	< 35.8 kg/cm ²	35.8-55.6 kg/cm ²	> 55.6 kg/cm ²
40-44	Female	< 18.9 kg/cm ²	18.9-32.7 kg/cm ²	> 32.7 kg/cm ²
	Male	< 35.5 kg/cm ²	35.5-55.3 kg/cm ²	> 55.3 kg/cm ²
45-49	Female	< 18.6 kg/cm ²	18.6-32.4 kg/cm ²	> 32.4 kg/cm ²
	Male	< 34.7 kg/cm ²	34.7-54.5 kg/cm ²	> 54.5 kg/cm ²
50-54	Female	< 18.1 kg/cm ²	18.1-31.9 kg/cm ²	> 31.9 kg/cm ²
	Male	< 32.9 kg/cm ²	32.9-50.7 kg/cm ²	> 50.7 kg/cm ²

Thus, the purpose of the experiment is to examine the aspects of strength development and fatigue of forearm flexors. In which we will examine the relationship between strength and fatigue based on the gender of the participants (male/female), regularity of having to lift a heavy object each day, days of weight training (resistance training) per week, and age. In this we will have a secondary purpose of examining the role that central drive has on the development and then maintaining of maximal contraction.

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Hypothesis:

Procedures:

Materials:

Handgrip dynamometer

Stopwatch

Methods:

PART 1: Maximal Volitional Contraction:

1. Explain to the test subject that they will now be performing the strength-testing portion of the experiment. In the test, they will begin to squeeze the dynamometer without allowing for any movement or deviation from the testing position. The clench should build up over a 5-second period with a hold for 10-seconds and then a ramp down over 5-seconds

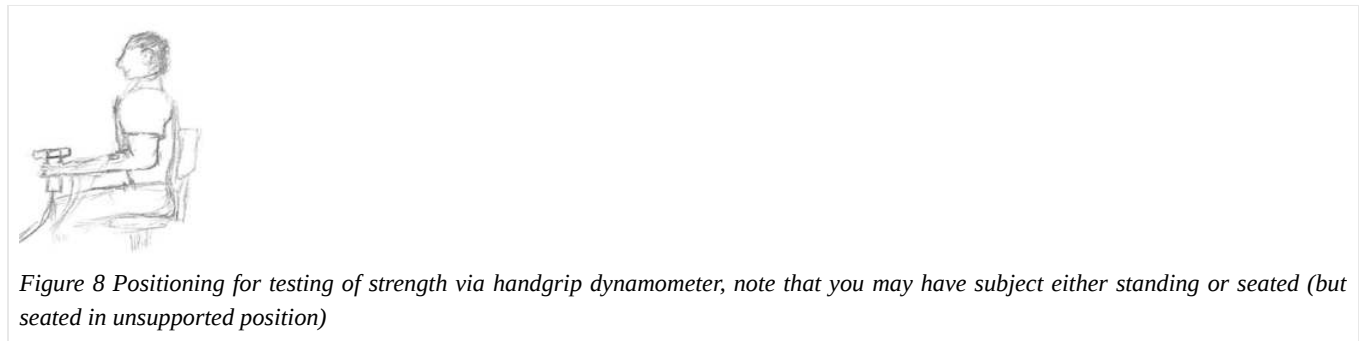


Figure 8 Positioning for testing of strength via handgrip dynamometer, note that you may have subject either standing or seated (but seated in unsupported position)

2. After explaining the process, have the test subject assume the position shown in figure 8

- Give the subject a countdown, “3... 2... 1... GO!” where on “GO” then begin to squeeze, at 5-seconds give encouragement to “squeeze as hard as possible” and then continued encouragement to “Keep holding” for the 5-second isometric hold
- Record the grip force (strength) during 5-second hold
- As they get toward 5-seconds of holding, give the cue to “slowly start relaxing” and give count down of “4...3...2...1... Relax”

3. Have subject 1 rest for 2-minutes. During the rest, have subject 2 perform their isometric grip test

4. After 2-minute rest, repeat step 2 for the non-dominant side

5. Repeat for subject 2.

6. Repeat for 3 total trials, for each hand and each subject. Average the three trials

7. Determine the 100%, 50% and 25% grip strength

- 100% is the maximal strength that was obtained during the maximal isometric hold
- 50% is $\frac{1}{2}$ of that number and 25% is $\frac{1}{4}$ of that number

SUBJECT 1:

Dominant: $100\% = \text{kg/cm}^2$; $50\% = \text{kg/cm}^2$; $25\% = \text{kg/cm}^2$

Non-Dominant: 100 % = kg/cm^2 ; 50% = kg/cm^2 ; 25% = kg/cm^2

SUBJECT 2:

Dominant: 100 % = kg/cm^2 ; 50% = kg/cm^2 ; 25% = kg/cm^2

Non-Dominant: 100 % = kg/cm^2 ; 50% = kg/cm^2 ; 25% = kg/cm^2

PART 2: Time to Fatigue

1. Following 5-minutes of rest, have the test subject grasp the handgrip dynamometer with their dominant-hand and assume the testing position that has been used throughout the experiment
2. Make sure that the instructor has started the “Workout Music” so that the testing environment provides an external motivation to allow for maximal performance
3. Explain to the test subject that they’re now going to be performing a prolonged maximal clench where they need to “squeeze as hard as possible” for the entirety of the test either until they are no longer able to continue to hold the clench or you have instructed them to relax as they are no longer able to maintain a clench strength of at least 25% of their MVC
4. Giving a countdown “3...2...1... GO!” Have your test subject now clench (keeping upper extremity in the neutral testing position) to maximal force as measured previously obtained in part 2. As they clench their fist, click “Start” on the stopwatch and give them constant encouragement “Keep Squeezing” as they ramp up to maximal strength.

a. Once maximal force had been reached start the stopwatch and continue to have test subject clench at what they perceive to be maximal force until they are unable to maintain 25% of MVC. (Note that force will waiver as contraction continues, note the number of times that the subject is able to get force above 50% MVC until force production is at 25% MVC and unable to return to 25% MVC)

i. Once the test subject is unable to maintain 50% MVC record the time from the stopwatch, ***do not stop the timer on the stopwatch*** and the grip strength

b. As contraction continues past the first few seconds, the test subject will need continuous encouragement that cannot be solely provided by the “Workout Music” in the lab room

i. (***Using positive and negative reinforcements***) provide constant positive encouragement to the test subject “You got this... don’t stop”; “Don’t let (fill-in name) beat you”

c. Remind them to breathe throughout the hold

d. As contraction continues allow the subject to get feedback from the computer screen ***as you both see a reduction in contraction strength, verbally cue them to get the strength curve back towards maximal force.***

e. Once test subject is consistently below 25% MVC, tell them to “Stop” ***note that some test subjects may have stopped before this time.*** Click “stop” on the stopwatch and record the time and grip strength and the moment that the subject stopped holding the squeeze.

5. Give your test subject 5-minutes of rest. While resting, have the second test subject complete their dominant hand grip test

6. Repeat steps 4-6 for the non-dominant hand.

7. Input data into large group data tables (Google Doc), based on where subject falls for gender and determine averages for contraction strength, EMG activity, and times to fatigue.

Results:

Demographic Information:

Gender:

Age:

Days of Weightlifting/week:

Regularly Required to Carry Objects Heavier than 20-lbs.: (Yes/No)

Table 2. Grip strength (kg/cm²) produced via handgrip dynamometer during the test for maximal volitional contraction.

	SUBJECT 1				SUBJECT 2			
Measurement Segment	Dominant Hand Strength (kg/cm ²)	Non-dominant Hand Strength (kg/cm ²)			Dominant Hand Strength (kg/cm ²)	Non-dominant Hand Strength (kg/cm ²)		
Grip 1								
Grip 2								
Grip 3								
Average Isometric								
Maximal Volitional Contraction								

Table 3. Results for the measures of maximal strength (MVC) production via handgrip dynamometer (kg/cm²) and time (seconds) for subject to degrade in force production from 100% MVC to 50 % MVC and then 25% MVC.

SUBJECT 1	100% MVC (kg/cm ²)	50% MVC (kg/cm ²)	25% MVC (kg/cm ²)	Time of contraction 100%-to-50% MVC (sec)	Time of contraction 50%-to-25% MVC (sec)	Total time of contraction 100-to-25% MVC (sec)
Dominant						
Non-Dominant						
SUBJECT 2	100% MVC (kg/cm ²)	50% MVC (kg/cm ²)	25% MVC (kg/cm ²)	Time of contraction 100%-to-50% MVC (sec)	Time of contraction 50%-to-25% MVC (sec)	Total time of contraction 100-to-25% MVC (sec)
Dominant						
Non-Dominant						

Note time is in seconds, convert each minute to 60 seconds: Time of Contraction= (# minutes*60) + seconds of the minute

Example: 3:30 contraction time has a Time= (3x60) + 30=180+30 = 210 seconds

****Upload your data to the data table in Google Documents for Analysis and Lab Report****

Discussion: Using the Google Doc Data Tables for group data and analysis.

In *at least 2 well-formulated and coherent paragraphs*, discuss the findings of the experiment based on the concepts of muscle physiology related to strength, recruitment, and fatigue. (In the analysis of results and presentation of findings think about **do not answer as individual questions**: What differences can be seen between dominant and non-dominant sides for the test subjects? To what can you ascribe these differences in observations? What gender differences are observed? What can be a possible explanation for the differences observed between genders? What are other factors that can influence the results observed in your experiment? Why would there be variability in someone's ability to produce additional force after "fatigue" has begun? What factors are involved in that variability of force production? Why?)

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1.9: Nervous System Anatomy Part 1- Functional Anatomy of the Cerebral Cortex and Spinal Cord

Objectives:

At the end of this lab, you will be able to...

1. **Correctly identify the structures of importance within cerebral cortex**
2. **Correctly identify the structures of importance within the spinal cord**
3. **Correctly name the cranial nerves and indicate general functions**
4. **Correctly and independently perform simple dissections**
5. **Use correct anatomical terminology when discussing structures of the nervous system**

Pre-Lab Exercise:

After reading through the lab activities prior to lab, complete the following before you start your lab

1. The structures of the Central Nervous System include:
2. The connective tissues that surround the cerebral cortex and spinal cord are known as the and is made of three layers: that connect to the tissues, that connects to the bones and the that contains the cerebral spinal fluid.
3. You will make two incisions during the dissection of the brain (cerebral cortex) either along the fissure to separate the brain into a right and left hemisphere and along the fissure to separate the superior from the inferior.
4. Color the images for use as a reference for identifying the models and dissected specimens.

Materials:

- Brain Models
- Spinal Cord Model
- Sagittal Head Model
- Sheep's Brain and Dissection Tools
- Prosected Human Brain and Spinal Cord
- Stickers
- Felt Pens
- Colored Pencils

The central nervous system (CNS) is comprised of the neurons and glial cells that form the neural tissue of the cerebral cortex (including the lobes, limbic system, thalamus, hypothalamus, cerebellum, pons, and medulla oblongata), and spinal cord.

Activity 1: Cerebral Cortex:

The cerebral cortex is a gelatinous mass of cells, nothing like the fixed brains that we might think of, that is divided into distinct regions that perform functional tasks for maintaining homeostasis in the body. The neuron mass within the cerebral cortex is highly invaginated (folded) forming structures known as sulcus (fold) and gyrus (cell mass). This folding is generated by the synaptic connections occurring between cells that hold layers of cells together and move the layers based on movement of neurons in and around each other in order to maintain synaptic connections. The folding and invagination is the effect of having limited volume of the cranial vault for the mass of cells that are contained within the cerebral cortex.

Hindbrain

The Hindbrain is comprised on the pons, medulla oblongata and cerebellum. This is the most conserved region of the cerebral cortex. Within its many functions the hindbrain serves as a relay network that connects cerebral cortex to the spinal cord, forms projections that develop into the cranial nerves and the extra-pyramidal tracts of the spinal cord and serves as a region for regulation of autonomic functions.

Midbrain

The midbrain is the next most conserved region of the cerebral cortex. The structures of the midbrain, figure 14a-b and 15 c, are involved with many of the regulatory functions of homeostasis along with establishing neural relays key to cognitive functions and learning. The midbrain establishes connections between forebrain and hindbrain structures along with direct paths to the spinal cord and is comprised of structures that are referred to as the Limbic cortex.

Limbic System

The Limbic structures are the midbrain structures involved with activities of memory integration and automatic/hormonal responses to somatic sensory (homeostatic) information or relays information for coding purposes to higher cortical regions or from higher cortical regions to periphery for response. These structures also include the Hypothalamus, Thalamus, Hippocampus, and various nuclei and ganglion within the central region of the brain.

Forebrain Lobes

The forebrain is comprised of the lobes and structures that are familiarly known and that is associated with controls and regulates complex activities within the body based on the individual lobe. These include the frontal, parietal, occipital and temporal lobes that are named based on the cranial bone that overlays the lobe of the cerebral cortex. The frontal lobe is associated with functions of conscious thought process, memory and emotional responses. The parietal lobe is associated with somatosensation and proprioception and interactions with the frontal lobe to allow for somatic motor control. The occipital lobe is associated with visual processing and spatial recognition. The temporal lobe is associated with auditory processing along with language and symbol recognition.

Cranial Nerves

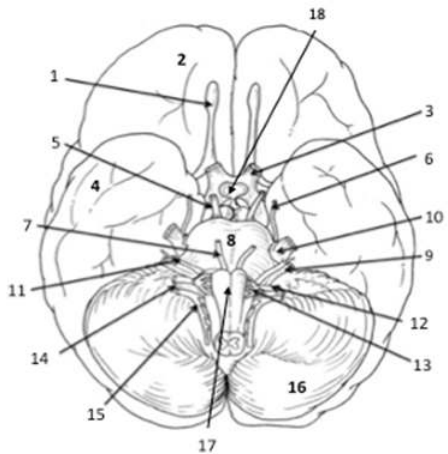
The cranial nerves are specialized peripheral nerves that originate in the hindbrain and brainstem of the cerebral cortex that provides innervations to the cranium, internal organs of the torso and are involved with autonomic, somatic sensory, visceral sensory, somatic motor and special senses of the body. The naming and identification of the cranial nerves (CN) are done either by classical name, or numerically based on where the nerve exits the cerebral cortex. Where the order of numbering of the cranial nerve is established from the most anterior superior (rostral) being the first and the most posterior-inferior nerve (caudal) being the twelfth. Using the numerical orientation, the nerves are indicated as cranial nerve (CN) and then by Roman Numeral (I-XII) to indicate the order of exiting the cerebral cortex. The site of origin for the cranial nerve (CN) and location of specific nuclei of origination indicates how specific (or diffuse) of a role that nerve has on homeostatic functions for the body. CN I through CN II originate within the proencephalon, while CN III through CN XII originate within the mesencephalon and rhombencephalon from nuclei ganglion near to the Thalamus, Pons and Medulla.

Procedures:

1. Obtain models, stickers, felt pens
2. Write the names of the key anatomical structures of the cerebral cortex on to the stickers
 - a. Frontal Lobe, Parietal Lobe, Occipital Lobe, Temporal Lobe, Cerebellum, Pons, Medulla Oblongata, Broca's Area, Wernicke's Area, Primary Motor Cortex, Primary Somatosensory Cortex
 - b. Corpus Callosum, Thalamus, Hypothalamus, Fornix, Choroid Plexus, Lateral Ventricle, Fourth Ventricle, Cerebral Aqueduct
3. Select a "team leader" and using the colored images as reference have members of the group take turns labeling the brain model with the key anatomical structures.
4. Using a pen or pencil, take turns within your group identifying the cranial nerves on the model of the cerebral cortex.
5. With your instructor, observe the prosected human brain and spinal cord. Relate the structures that you have identified on

the model and in the coloring images to what can be viewed on the human organs.

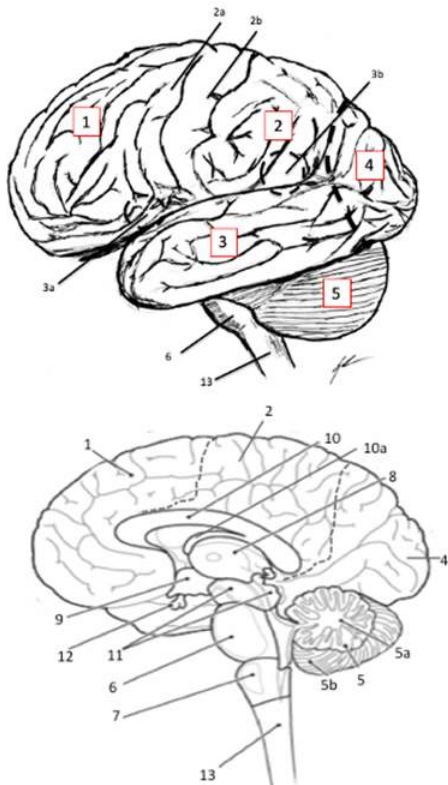
6. Have your instructor check your work and then move to the next activity.



Key Anatomical structures of the cerebral cortex:

- 1 Cranial Nerve I (Olfactory)
- 2 Frontal Lobe
- 3 Cranial Nerve II (Optic)
- 4 Temporal Lobe
- 5 Cranial Nerve III (Oculomotor)
- 6 Cranial Nerve IV (Trochlear)
- 7 Cranial Nerve VI (Abducens)
- 8 Pons
- 9 Cranial Nerve VIII (Cochleovestibular)
- 10 Cranial Nerve V (Trigeminal)
- 11 Cranial Nerve VII (Facial)
- 12 Cranial Nerve IX (Glossopharyngeal)
- 13 Cranial Nerve X (Vagus)
- 14 Cranial Nerve XI (Spinal Accessory)
- 15 Cranial nerve XII (Hypoglossal)
- 15 Cerebellum
- 17 Medulla Oblongata
- 18 Hypothalamus and Pituitary Gland

Color each structure a different color for use as a reference when identifying.



Key Anatomical structures of the cerebral cortex:

- 1 Frontal Lobe
- 2 Parietal Lobe
- 2a Primary Motor Cortex (Pre-Central Gyrus)
- 2b Primary Somatosensory Cortex (Post-Central Gyrus)
- 2c Central Sulcus
- 3 Temporal Lobe
- 3a Lateral Sulcus
- 3b Brocca's Area
- 3c Wernicke's Area
- 4 Occipital Lobe
- 5 Cerebellum
- 5a Arbor Vitae of Cerebellum
- 5b Vermis of Cerebellum
- 6 Pons
- 7 Medulla Oblongata
- 8 Thalamus
- 9 Hypothalamus
- 10 Corpus Callosum
- 10a Fornix
- 11 Tectum & Limbic System
- 12 Pituitary Glans
- 13 Spinal Cord

Color each structure a different color for use as a reference when identifying.

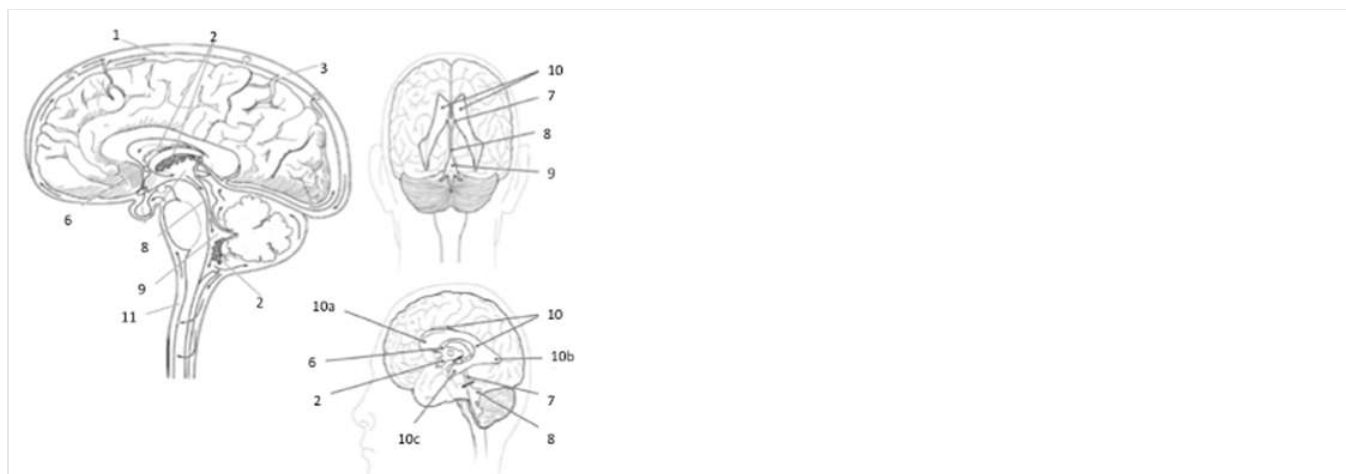
Activity 2: Connective Tissue and Ventricles:

The gelatinous mass that is the cerebral cortex is suspended in a viscous solution (cerebral spinal fluid, CSF) within the cranial vault between three fibrous membranes (mater layers) that connect it to the boney structures. The distinct type of mater layer is

identified by what the connective tissue is connecting. The pia mater is dense regular connective tissue that connects to the neural tissues of the CNS. The arachnoid is loose areolar and reticular connective tissue that connects the dura mater to the pia mater. The arachnoid allows for the passage of blood and lymph vessels into the cerebral cortex tissues and structures of the CNS. The dura mater is dense regular connective tissue that connects to the bone tissues of the cranium and vertebrae. Within these layers of connective tissues, invaginations and folds develop. These folds are the ventricles of the maters within the cerebral cortex that allows for the movement of the cerebral spinal fluid within and throughout the tissues and connects the movement of CSF to the vascular flow to ensure that the tissues are perfused correctly and materials are flushed from the CNS on a regular basis.

Procedures:

1. Obtain models, stickers, felt pens
2. Write the names of the key anatomical structures of the meninges and ventricles on to the stickers
3. Select a “team leader” and using the colored images as reference have members of the group take turns labeling the sagittal head model with the key anatomical structures.
4. Have your instructor check your work and then move to the next activity.



Key Anatomical structures of the cerebral cortex:

- 1=Pia Mater
- 2=Choroid Plexus
- 3=Subdural Space
- 4=Arachnoid Matter
- 5=Dura Matter
- 6=Interventricular Foramen
- 7=Third Ventricle
- 8=Cerebral Aqueduct
- 9=Fourth Ventricle
- 10=Lateral Ventricle
- 10a=Anterior Horn of Lateral Ventricle
- 10b=Posterior Horn of Lateral Ventricle
- 10c=Lateral Horn of Lateral Ventricle
- 11=Central Canal

Color each structure a different color for use as a reference when identifying.

Activity 3: Spinal Cord:

The spinal cord is an elongation of axons and interneurons leaving the brain stem and hindbrain of the cerebral cortex and travelling the length the vertebral column. While we may discuss the spinal cord as being a solid bundle of tissues (axons) near the inferior (caudal) aspects the spinal cord becomes slightly less bundled, forming the structure identified as the cauda equinae. This diffusion of axons typically occurs at the level of the second or third lumbar vertebrae. Within the organized axonal bundle region (from the foramen magnum through the initiation of the cauda equinae) there is a rigid structural orientation that the spinal cord

possesses.

Within this rigid structure, there exists a general organization to the neural tissues within the spinal cord. The organization is such that we are able to divide the axonal and interneurons into tracts based on a dorsal (posterior) and ventral (anterior) orientation. Where the dorsal (posterior) will primarily have neural networks and tracts that are involved with sensory issues, while the ventral (anterior) will primarily have the neural networks and tracts involved with motor issues. Additionally, the tissue can be indicated based on staining as being “gray” or “white” tissue within the spinal cord. In which the gray is an indication of cell bodies and unmyelinated regions and the white is an indication of axons and myelinated regions.

Procedures:

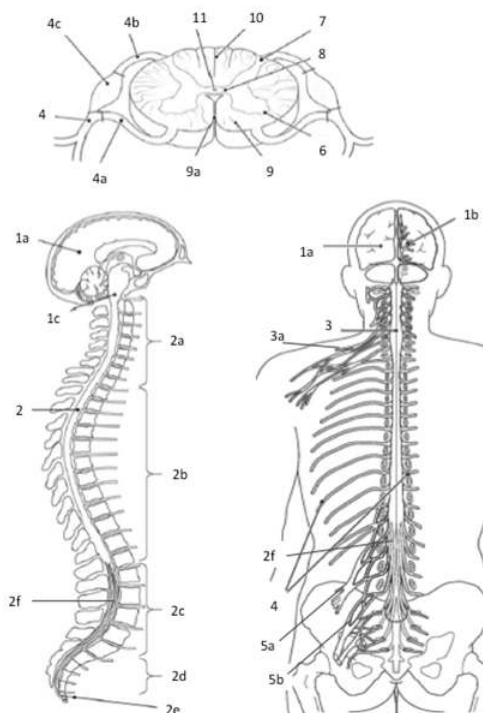
1. Obtain models, stickers, felt pens
2. Write the names of the key anatomical structures of the spinal cord on to the stickers
 - a. Dorsal Horn, Dorsal Nerve Root, Dorsal Root Ganglion, Dorsal Sensory Tracts, Commissure, Central Canal, Ventral Horn, Lateral Horn, Ventral Nerve Root, Spinal Nerve

3. Select a “team leader” and using the colored images as reference have members of the group take turns labeling the spinal cord model with the key anatomical structures.
4. Have your instructor check your work and then move to the next activity.

Key Anatomical structures of the cerebral cortex:

- 1a Cerebral Cortex
- 1b Thalamic Nuclei
- 1c Hind Brain
- 2 Spinal Cord
- 2a Cervical Nerve Roots
- 2b Thoracic Nerve Roots
- 2c Lumbar Nerve Roots
- 2d Sacral Nerve Roots
- 2e Coccygeal Nerve Roots
- 2f Cauda Equinae
- 3 Cervical Enlargement
- 3a Brachial Plexus
- 4 Spinal Nerves
- 4a Ventral Root
- 4b Dorsal Root
- 4c Dorsal Root Ganglion
- 5a Lumbar Plexus
- 5b Sacral Plexus
- 6 Ventral Horn
- 7 Dorsal Horn
- 8 Gray Matter
- 9 White Matter
- 9a Ventral (Anterior) Median Sulcus
- 10 Dorsal (Posterior) Median Sulcus
- 11 Central Canal

Color each structure a different color for use as a reference when identifying.



Activity 4: Dissection:

1. Observe the external anatomy of the brain. Identify the meningeal layers covering the sheep's brain. Note the thickening of the meninges that forms between the cerebellum and the occipital lobe.
2. As you observe, turn the brain so that you are able to examine the exterior of the brain superiorly, inferiorly and laterally. In the inferior view, note the various cranial nerves that are visible, if the pituitary is still present, the pons and medulla oblongata
3. Using your dissecting shears, make a small hole near the most anterior part of the frontal lobe in the meninges
4. Take your blunt probe and insert it into the small hole that you just cut in the meninges and carefully lift the meninges to separate it from the brain tissue.
5. Using your dissection shears, scalpel and blunt probe, carefully remove the meninges from rest of the brain. Be careful as you remove meninges from the inferior part of the brain (if necessary, get assistance from your instructor).
6. After removing the meninges, repeat the examination of the external anatomy of the brain.
7. In the posterior examination, gently displace the cerebellum to reveal the Colliculi and Pineal Gland that is now visible between the cerebellum and rest of the brain.
8. After examining the external structure, place the brain on the dissection tray and locate the medulla oblongata.
9. Move the dissection tray to the dissecting scope and adjust the magnification until you are able to clearly see the edge of the medulla oblongata.
 - a. Make a transverse cut across the medulla to separate the initial segment of the spinal cord from the rest of the brain
 - b. Lay the spinal cord flat on the dissection tray and move the tray so that the spinal cord is seen in the dissection scope.
 - c. Examine the spinal cord and note the organization of the horns, white matter, gray matter and commissure. Compare to the model that you have previously examined.
10. In your paired groupings: 1 group will perform the longitudinal dissection and 1 group will perform the superior transverse dissection.
 - a. Longitudinal Dissection:
 - i. Remove the dissection tray from the dissection scope and find the longitudinal fissure
 - ii. Dissect the brain using a sagittal (longitudinal) cut through the longitudinal fissure and the medial structures
 - iii. Continue the dissection until you have a right and left half of the brain to examine
 - iv. Examine the anatomical structures of importance that are now visible to the internal medial surface
 - b. Superior Transverse Dissection:
 - i. Remove the dissection tray from the dissection scope and find the transverse fissure ("bump" that separates temporal lobe from frontal lobe
 - ii. Dissect the brain by making a circular incision around the right and left hemispheres to remove the "top" of the brain from the remainder of the sheep's brain.
 - iii. The cut should reveal the opening to the lateral ventricles and the thalamus to the center and visible white matter (axonal pathways) through the remainder of the brain
 - iv. Examine the internal structures of importance that are now visible and then review the inferior aspects of the brain to identify structures of importance.
 - c. Combine the two groups and take turns within the groups to identify (using pins or probe) structures of importance.

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1.10: Nervous System Anatomy Part 2- Functional Anatomy of the Peripheral Nerves and Sense Organs

Objectives:

At the end of this lab, you will be able to...

1. **Correctly name the cranial nerves and indicate general functions**
2. **Correctly and independently perform simple dissections**
3. **Use correct anatomical terminology when discussing structures of the nervous system**
4. **Correctly identify the various structures of the eye and ear**

Pre-Lab Exercise:

After reading through the lab activities prior to lab, complete the following before you start your lab

1. The mapping of the peripheral nervous system that indicates sensation based on nerve roots is called , while for motor control is called the .
2. The nerves that will control the upper extremity originate in the plexus while the nerves controlling the lower extremity will originate in the , , and the plexuses.
3. The receptor in the eye responsible for vision is the while the is found in the ear and is responsible for hearing and the for the sense of movement.
4. Color the images for use as a reference for identifying the models and dissected specimens.

Materials:

- Nervous System Model
- Sagittal Head
- Eye Model
- Ear Model
- Stickers
- Felt Pens
- Colored Pencils

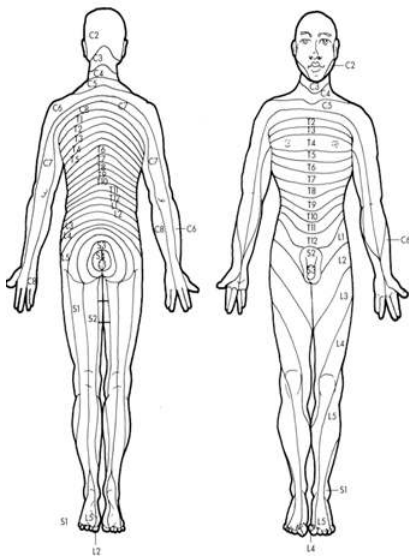
Activity 1: Dermatome and Myotomes

The myotomes and dermatomes provide the clinician with a reference map for the origin of the nerves that control movement or are responsible for conveying somatosensation. The myotome is the map that indicates the region of control of muscles for the spinal nerve and originates during fetal development as motor neurons (nerves) exit the spinal cord and innervates regions of non-differentiated skeletal muscle tissue (referred to as somites). Dermatomes are areas of sensation of the body that relate to the nerve root that forms the peripheral nerves that synapse with the receptors in that region. The dermatomes also form during fetal development and mirror the mapping that occurs with the myotomes. Using the dermatome and myotomes allow for map of origin of peripheral nerves through the body should peripheral nerve issues arise for the person.

Procedures:

1. Check your lab group for completion of the color the map of the myotome and dermatome.

2. Select a “team leader” and using the colored images as reference have members of the group take turns tracing a dermatome or myotomes themselves and then move to the next activity.



Peripheral Nervous System based on Myotome and Dermatome

CN V: Trigeminal N

C2 Cervical Nerve 2 C3 Cervical Nerve 3

C4 Cervical Nerve 4 C5 Cervical nerve 5

C6 Cervical Nerve 6 C7 Cervical Nerve 7

C8 Cervical Nerve 8 T1 Thoracic Nerve 1

T2 Thoracic Nerve 2 T3 Thoracic Nerve 3

T4 Thoracic Nerve 4 T5 Thoracic Nerve 5

T6 Thoracic Nerve 6 T7 Thoracic Nerve 7

T8 Thoracic Nerve 8 T9 Thoracic Nerve 9

T10 Thoracic Nerve 10 T11 Thoracic Nerve 11

T12 Thoracic Nerve 12 L1 Lumbar Nerve 1

L2 Lumbar Nerve 2 L3 Lumbar Nerve 3

L4 Lumbar Nerve 4 L5 Lumbar Nerve 5

S1 Sacral Nerve 1 S2 Sacral Nerve 2

S3 Sacral Nerve 3

Color each structure with a different color for use in identification.

Peripheral nerves:

The somatic peripheral system will function via two primary divisions or plexus, the Brachial Plexus and Lumbar/Sacral Plexus. The plexus all for the innervation of the extremities of the body through the convergence and divergence of the spinal nerves. While the plexus are convergences and divergence so spinal nerves, the means by which they develop are not identical. The peripheral nerves of the extremities will have their origin within each of these plexuses. In which the brachial plexus will provide the peripheral nerves to the upper extremities while the lumbar and sacral plexus will provide the peripheral nerves the lower extremities. These peripheral nerves will allow for the transmission of somatic sensation and proprioception from periphery to the spinal cord and central nervous system. While they will be involved with conveying the motor response for reflexive behavior along with cognitive control of the skeletal muscle that allows for spinal reflex, fine and gross motor control of the limb (or limb segment). Clinically, we are also able to trace the origins of motor issues to spinal nerve segment of involvement or to what extent afferent neurons are impacting the ability to convey the sensory signal based on where within the limb issues might be arising.

Activity 2: Nerves from the Brachial Plexus

The brachial plexus is built through the convergence of spinal nerves forming 3 plexus trunks (Superior, Middle, Inferior) that then converge and alter their orientation forming 2 plexus divisions (Anterior, Posterior) all within a short distance of the inferior cervical vertebrae. As the nerves move lateral toward the scapula, the division once again converge and diverge forming 3 plexus cords (Lateral, Medial, Posterior) that they diverge within the lateral scapular region forming the peripheral nerves of the upper extremities.

Peripheral Nervous System for the Upper Extremity

1 C4 Nerve Root 2 C5 Nerve Root 3 C6 Nerve Root

4 C7 Nerve Root 5 C8 Nerve Root 6 T1 Nerve Root

7a Superior Trunk 7b Middle Trunk 7c Inferior Trunk

8a Anterior Division 8b Posterior Division 9a Medial Cord

9b Posterior Cord 9c Lateral Cord 10 Median Nerve

11 Radial Nerve 12 Dorsal Scapular Nerve

13 Long Thoracic Nerve 14 Axillary Nerve

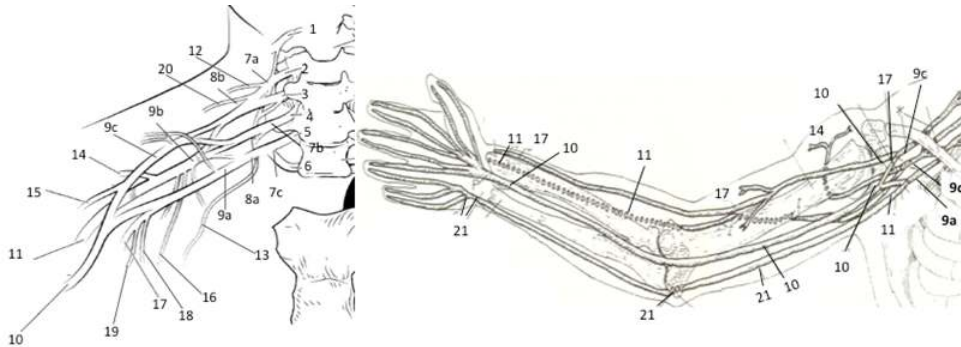
15 Subscapular Nerve 16 Lateral Pectoral Nerve

17 Musculocutaneous Nerve 18 Medial Brachial Cutaneous Nerve

19 Medial Antebrachial Cutaneous Nerve

20 Suprascapular Nerve 21 Ulnar Nerve

Color each structure with a different color for use in identification.



Procedures:

1. Obtain nervous system models, stickers, felt pens

2. On the stickers, write the regions of the plexus and major nerves of the upper extremity

Superior Trunk, Middle Trunk, Inferior Trunk, Anterior Division, Posterior Division, Lateral Cord, Medial Cord, Posterior Cord, Radial N, Ulnar N, Musculocutaneous N

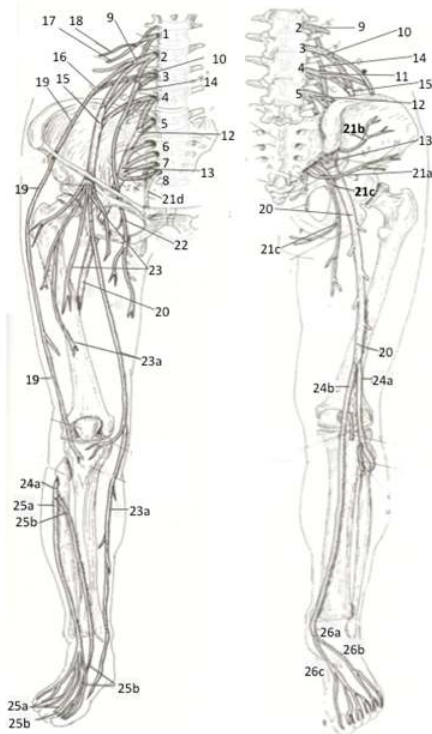
3. Select a "team leader" and using the colored images as reference have members of the group take turns labeling the model with the correct stickers.

4. Have your instructor check your work and then move to the next activity.

Activity 3: Nerves from the Lumbar, Lumbosacral and Sacral Plexus

The lumbar and sacral plexus form 3 plexus trunks from the spinal nerves converging onto each other (Lumbar, Lumbosacral, Sacral) that will then converge and diverge in order to form into 2 divisions (Anterior or Posterior) near the sacroiliac region of the

pelvis. These divisions will then converge and diverge within the posterior aspect of the pelvic bowl forming the peripheral nerves of the lower extremities.



Peripheral Nervous System for the Lower Extremity

- 1 L1 Nerve Root 2 L2 Nerve Root
- 3 L3 Nerve Root 4 L4 Nerve Root
- 5 L5 Nerve Root 6 S1 Nerve Root
- 7 S2 Nerve Root 8 S3 Nerve Root
- 9 Lumbar Plexus 10 Lumbosacral Plexus
- 11 Posterior Division 12 Lumbosacral Plexus
- 13 Sacral Plexus 14 Posterior Division
- 15 Anterior Division 16 Anterior (Lateral) Division
- 17 Ilioinguinal Nerve 18 Iliohypogastric Nerve
- 19 Lateral Femoral Cutaneous Nerve
- 20 Sciatic Nerve 21a Inferior Gluteal Nerve
- 21b Superior Gluteal Nerve
- 21c Posterior Femoral Cutaneous Nerve
- 21d Pudendal Nerve 22 Nerve to Obturator
- 23 Femoral Nerve 23a Saphenous Nerve
- 24a Fibular Nerve 24b Tibial Nerve
- 25a Superficial Fibular Nerve
- 25b Deep Fibular Nerve 26a Plantar Nerve
- 26b Lateral Plantar 26c Medial Plantar

Color each structure with a different color for use in identification.

Procedures:

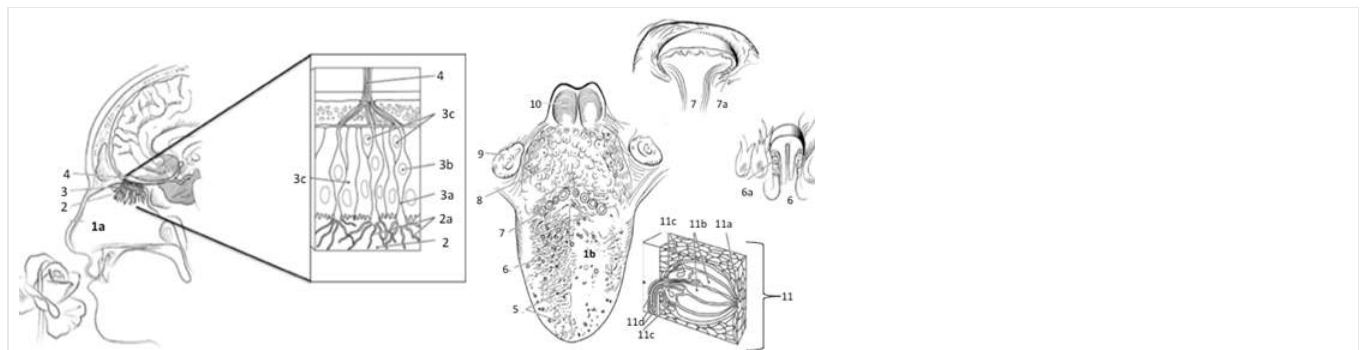
1. Obtain nervous system models, stickers, felt pens
2. On the stickers, write the regions of the plexus and major nerves of the lower extremity
Lumbar Plexus, Lumbosacral Plexus, Sacral Plexus, Anterior Divisions, Posterior Divisions, Sciatic N, Femoral N, Tibial N, Peroneal (Fibular) N

3. Select a “team leader” and using the colored images as reference have members of the group take turns labeling the model with the correct stickers.
4. Have your instructor check your work and then move to the next activity.

Activity 4: Sense Organs

Tongue and Nose:

Gustatory complexes are the receptors are located throughout the mouth and tongue and not in specialized regions that has been previously noted (due to a mistranslation and misconception of a classical study). The receptor itself is comprised of separate cells that have ligand-gated receptors within the cilia projections. The cells cluster these cilia projection along folds within the pit to form a microvilli projection along the inner surface of a pit (gustatory receptor). These will respond to chemicals that get trapped within the pit that will then link with a chemical class ligand receptor that leads to an action potential being transmitted to one of three cranial nerves, CN VII, IX and X, depending on the location that stimulation is occurring within the tongue. The olfactory epithelium is tissue lining the superior aspect of the nasal opening that has chemoreceptors embedded into the tissue. These receptors appear to be sensitive to distinct classes of chemicals and not individual chemicals. The olfactory receptors are bipolar neuron with cilia called olfactory hairs that project into the nasal concha. These will respond to chemical stimulation of a particular volatile chemical (odorant molecule) via a ligand gated channel leading the action potential being transmitted to CN I via passage through the Cribriform plate of the Ethmoid bone.



Structures of the nose and yongue related to olfactory and gustatory reception

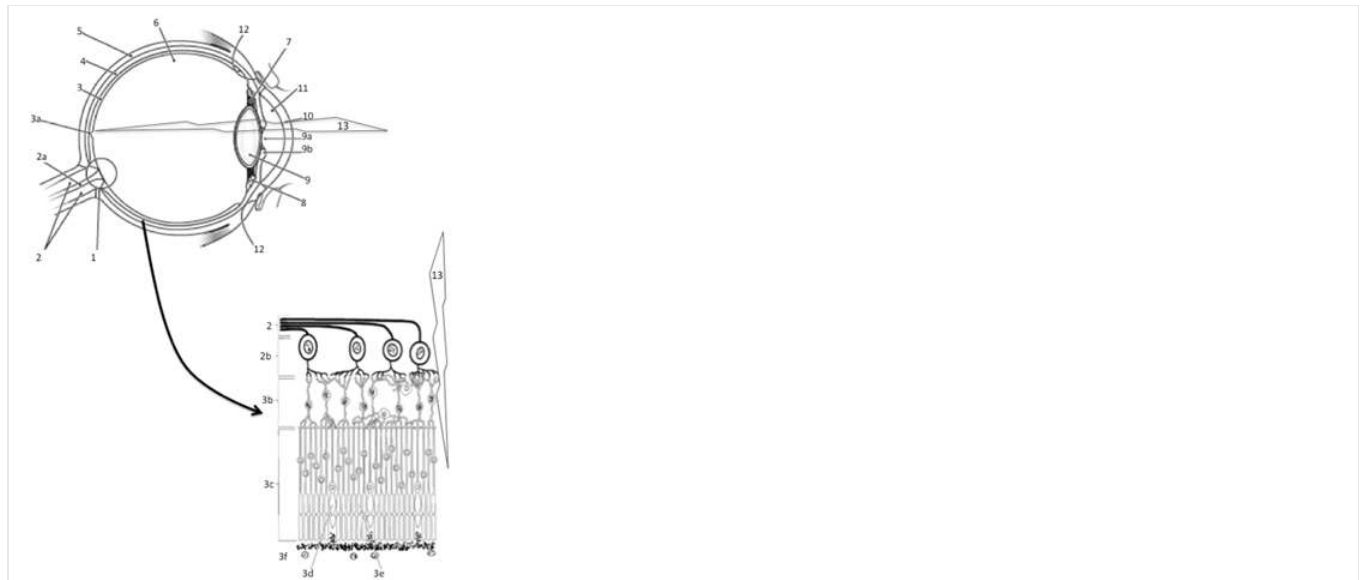
- 1a Nasal Cavity 1b Tongue 2 Olfactory Epithelium 2a Olfactory Receptors
 3 Neural 3a Olfactory Cells 3b Bipolar Cells 3c Support Cells
 4 Olfactory Nerve (CN I) 5 Filiform Papillae 6 Fungiform Papillae 6a Taste bud
 7 Circumvallate Papillae 7a Taste Bud 8 Lingual Tonsils 9 Palatine Tonsils
 10 Epiglottis 11 Taste Bud 11a Receptors 11b Gustatory Cells
 11c Support Cells 11d Nerve

Color each structure with a different color for use in identification.

Eye:

Vision is the sense that provides for reception of light energy from the environment. We perceive light energy within a spectrum of wavelength that is deemed the visible light spectrum of electromagnetic radiation. The receptor organ for vision is the retina of eye, where the structure of the eye is meant to focus light onto the fovea centralis based on the principle that light will always travel in straight lines and will bend when it passes through a medium whose density changes (such as going from air through the cornea and lens or the fluids that fill the eye, aqueous and vitreous humor). The receptors for vision are found in retina. To receive this sense, the retina will utilize 2 distinct types of photoreceptive cells that are stimulated (or inhibited) by distinct wavelengths of light. The receptors are arranged in radiations of density with the cone cells being in greatest density near the fovea and lessen as move towards the periphery of the retina (away from the fovea), while rods are greatest in density at the periphery and least at the fovea. Cone cells are in effect 3 distinct photoreceptors that exhibit a threshold based on location within retina and wavelength of light that cause “excitation”. Where the short wave-cell, aka Blue Cone, has a peak response at 437 nm of light wavelength with range of 400-550 nm. The medium wave-cell, aka Green Cone, has a peak response at 530 nm of light wavelength with range of 400-650 nm. The long wave-cell, aka Red Cone, has a peak response at 564 nm of light wavelength with rang from 450-700 nm.

The rods on the other hand are generalized photoreceptors that while having a peak response at 490 nm of light will respond with the entire spectrum of visible light.



Structures of the eye related to vision:

- 1 Optic Disk 2 Optic Nerve (CN II)
- 2a Blood Vessels 2b Ganglion Cells
- 3 Retina 3a Fovea Centralis
- 3b Bipolar Cells 3c Photoreceptors
- 3d Cone Cells 3e Rod Cells
- 3f Pigment Layer 4 Choroid Plexus
- 5 Sclera 6 Posterior Chamber
- 7 Suspensory Ligaments 8 Ciliary Muscles
- 9 Lens 9a Pupil (Iris)
- 9b Pupil (Radial/Circular Muscles)
- 10 Cornea 11 Anterior Chamber
- 12 Scleral Sinus 13 Direction of Light Travel

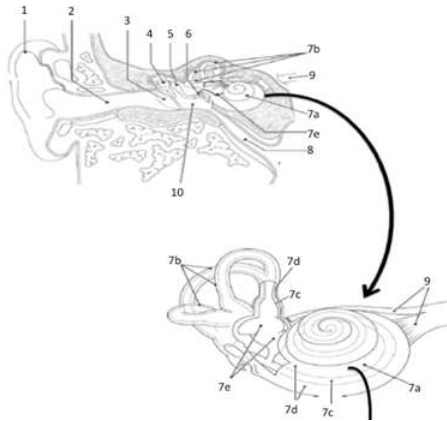
Color each structure with a different color for use in identification.

Ear (Hearing and Vestibular Organs)

The structure that is responsible for the auditory sense and response is the ear and the cochlea. The anatomy of the ear is formed in such a way as to funnel sound waves into the external auditory canal and onto the tympanic membrane. The tympanic membrane then transforms the energy wave from a sinusoidal to a compressive wave that can then transfer that energy onto the bones of the middle ear (auditory Ossicles). The energy transfer causes the Ossicles to vibrate against each other that will then provide the mechanisms to transform the compressive wave into a sinusoidal wave to transfer the same energy wave into the cochlea through the oval window. The cochlea itself is a “snail” coiled boney labyrinth within the temporal bone of the cranium. Within the cochlea are fluid filled membranous cavities (the tympanies). It is within tympanies that the receptor organ with the cochlea is located. This receptor organ, the Organ of Corti, is comprised on two membranes and a stereoscopic organization of mechanoreceptors (hair cells).

Vestibular sense provides input as to the direction of head (and body) movement relative to the force of gravity. To perceive this sense, it will utilize receptors found in the semi-circular canals that are surrounding the cochlea of the inner ear, stimulate the neurons found in CN VIII (vestibular branch). Overall, vestibular sensation gives the person the ability to sense this movement is

based on the acceleration taking place to give the “sense” of movement and speed of movement of the body in space without the need for visual or proprioceptive information.



Structures of the ear related to hearing and vestibular response:

- 1 Pina of Ear (Auricle)
- 2 External Auditory Canal
- 3 Tympanic Membrane
- 4 Malleus
- 5 Incus
- 6 Stapes
- 7a Cochlea
- 7b Semicircular Canals
- 7c Endolymph (Scala Vestibuli)
- 7d Labyrinth (Scala Tympani)
- 7e Vestibule (Saccule and Utricle)
- 8 Auditory (Eustachian) Tube
- 9 CN VIII (Vestibulocochlear)

Color each structure with a different color for use in identification.

Procedures:

1. Obtain ear, eye and sagittal head models, stickers, felt pens
2. Write the names of the anatomical structures of the ear and eye that you are responsible for knowing on to the stickers
 Eye: Fovea Centralis, Macula Lacteal, Ciliary Body, Suspensory Ligaments, Lens, Cornea, Retina, Pupil, Sclera
 Ear: Auricle (Pina of Ear), Cochlea, Tympanic Membrane, Ossicles, Anterior Semicircular Canal, Lateral Semicircular Canal, Posterior Semicircular Canal
3. Select a “team leader” and using the colored images as reference have members of the group take turns labeling the model with the correct stickers.
 - a. As you label, indicate the function of the structure that you are labeling
4. Have your instructor check your work and then move to the next activity.

1.10: Nervous System Anatomy Part 2- Functional Anatomy of the Peripheral Nerves and Sense Organs is shared under a [not declared](#) license and was authored, remixed, and/or curated by LibreTexts.

1.11: Nervous Physiology Testing Sensations- Hearing and Vision

Objectives:

At the end of this lab, you will be able to...

1. Use appropriate terminology to correctly discuss hearing and vision responses
2. Determine if a response is normal or an altered response due to overstimulation
3. Explain if responses might indicate an abnormal responses or loss, or if irregular responses due to desensitization

Pre-Lab Exercises:

After reading through the lab activities prior to lab, complete the following before you start your lab.

1. To differentiate between tonal deafness, sensorineural deafness, and conductive deafness you need conduct three tests:
2. True/False: A reading for a threshold above 50dB between 750 Hz and 4000 Hz would indicate that the person has normal hearing.
3. The Snellen eye chart is set at 20-feet because _
4. The Snellen test of 20/40 indicates that _
5. The reason for having a negative afterimage because of the while a positive afterimage occurs because of the .

Part 1: Testing Hearing

Humans hear frequencies from 20 Hz up to 20,000 Hz, but an audiogram only shows a subset of our hearing range: it focuses on the frequencies that are the most important for a clear understanding of speech (the spoken words). The volume (loudness) required to reach a person's hearing threshold is expressed in decibels(dB). dB are not absolute loudness levels but represent a difference between your hearing and the average "normal" hearing. When scoring 0 dB, you are hearing exactly matches the norm; higher values are signs of hearing loss. There are tolerances though: normal hearing is defined by thresholds lower than 15 dB at all frequencies, not strictly at 0 dB. The loudness scale goes from very soft sounds on top (-5 dB) to loud sounds at the bottom (80 dB). The test will examine the minimal threshold (energy of sound wave, decibels, or dB) for hearing in both left and right ears at the following frequencies (250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz, and 8000 Hz). At each frequency, you will determine the level at which the sound can just be heard. The level below this will not be heard and the level of above will result in a greater response in the cochlea leading to a response within the cochlea or a sense of the sound being "louder". By determining the minimal threshold, you will be able to develop an audiogram that maps the function of the cochlea or the ability for the person to hear or their level of deafness. Subjects should be able to respond at energy levels of at most 50dB between 750 and 4000 Hz, the normal range of frequencies of speech. Anything above this threshold level can be seen as an indication of receptor desensitization and can progress to deafness at the frequency.

There are several factors that can lead to changes in the responsiveness of the cochlea that include, history of loud noise exposure and age (just to name a few). Based on noise in the lab-room, results you obtain in the laboratory do not accurately reflect your hearing ability due to extraneous noise. When determining issues of deafness that might arise, there are two issues to keep in mind. Conductive deafness issues for the subject occurs when soundwaves are unable to cause the Ossicles to vibrate (due to sounds interacting with the tympanic membrane). Whereas sensorineural deafness issues for the subject occurs when the cochleae are unable to convert the soundwave that has passed through the conductive structures into neural pulses. This sensorineural deafness can be tonal (at specific frequencies) and typically occurs at higher frequency sounds as a person ages, or it can be complete sensorineural deafness that does not allow the person to hear at any frequencies. The audiometer allows us to determine if there are any tonal deafness issues occurring, but unless the person is completely unresponsive it cannot determine total deafness or the type of deafness for the person that is unresponsive. To differentiate between conductive and sensorineural we use two associated tests the Weber and Rinne tests.

Methods:

1. Follow the link to the [online audiometer](#)
2. Plug the headset into the computer's audio jack
3. Make sure that the audio output is not muted and run the calibration file making sure that the audio output is at a level that the calibration sound can be heard. This should not be at 100% maximum output.
4. Position your subject so that they cannot see the computer screen, or you when you operate the sound files.
5. In form the test subject that they will be testing hearing in both their right and left ear. When they hear the sound in the ear, they are to raise their index finger to the ear that they are hearing the sound.
6. Without telling the subject which ear you are going to test, start at a frequency (Hz) of 250, and at random intervals, trigger the computer to send a tone at the lowest energy (dB) into the headphones of your subject.
7. If the subject hears the tone have them raise the index finger of the hand to match the side that they heard the sound. If no sound was heard, increase the energy (dB) of the sound wave to the next level and repeat until the subject indicates hearing the sound.
8. Record energy (dB) necessary to hear at that frequency in table 1.
9. Repeat steps 7-9 for remaining frequencies.
10. After completing all frequencies switch and repeat steps 6-10 for the other ear.
11. Following completing tests for both ears; switch roles for within your partner group and repeat steps 2-11
12. After both partners have completed the tests, graph your results.

Results:

Table 1. Results of the threshold energy (dB) required for interpretation of sound at various frequencies (Hz) during audiogram analysis

Frequency (Hz)	Subject 1		Subject 2	
	Threshold Energy (dB)		Threshold Energy (dB)	
	R	L	R	L
250				
500				
1000				
2000				
4000				
8000				

Discussion: In a cohesive paragraph, discuss the findings of the experiment as it relates to the physiology of hearing and deafness. (Use the following think about questions to guide your discussion: What can you determine about your ability to hear? What about your partner? If there was any apparent loss, is it confined to one ear or both ears equally? If you have any apparent hearing loss describe the frequencies that are most affected? Why is there a loss at these specific frequencies? Relate the results to the other tests of the auditory responsiveness. Describe the results of this test if one of the subjects exhibited "sensorineural" versus "conductive" deafness. Can you tell from this experiment if any apparent hearing loss is due to sensorineural or conductive deafness? Why/Why not?)

Part 2: Testing Vision

Snellen Eye Test

Snellen eye test is used to examine the visual acuity at a standard distance. Visual acuity is the ability of the eye to adjust the curvature of the lens to ensure that the image will strike the retina on the fovea centralis. When performing the Snellen Test, it is important to set up the chart at 20-feet from the person. This distance is based on the curve of Earth that gives 0° horizontal inclination (appearance of flatness). When you score the test, it is about the scale difference of the images on each line of the test and not being the difference between seeing something at 20-feet versus someone else seeing at a different distance. So, if a subject has a reading of 20/40 that would mean they are reading images that are two times larger (both height and width) then would be seen at 20/20.

Materials

Snellen Eye Chart for Distance

Chair

Procedures:

1. Place a chair 20-feet from a wall
2. Have one partner sit in a chair with back fully supported, and the other partner place the eye chart at eye-level on a wall so that it is at eye level to the seated partner
3. Cover right eye and attempt to read the largest line from right to left (if all correct move to the next line below and repeat)
4. Continue until either read the complete smallest line or make more than 1 error. If more than 1-error record the line above the line with 1-error.
5. Record your score
6. Repeat steps 4-6 for the left eye.

Results:

Right Eye: /20

Left Eye: /20

Afterimage Testing

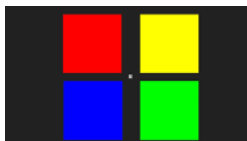
Afterimage occurs when the retina has been over stimulated and goes into a temporary state of desensitization. The state of afterimage leads to the “illusion” of seeing distinct colors based on the overstimulation of the cones of the retina not being able to respond correctly as excessive energy needs to be dissipated following the removal of a robust stimulus. The state of being over stimulated leaves the cones unable to be correctly activated and thus cannot propagate the signal through the visual pathway into the cerebral cortex when stimulated again. Based on the cones being over stimulated and the level of external stimulus two distinct afterimages can be generated, considered as either a positive or a negative afterimage. The afterimage may be positive, corresponding in color or brightness to the original image, and occurs when light is absent following overstimulation. On the other hand, a negative afterimage will occur when the eye is stimulated with light following the test and involves “seeing” colors that are deemed complementary to the original color that caused the overstimulation.

Materials

Color boards

Procedures:

1. Record the arrangement of the colors of the image



2. Play the 30-second exposure to the color board.
3. Stare at the center of the image until the image changes to a white screen. Do not blink
4. Stare at the white screen until it changes to a black screen. Do not blink.
Remember what happens to the arrangement of colors
5. Stare at the black screen until the show test ends. Do not blink.
Remember what happens to the arrangement of colors
6. Record your responses in the data table

The subject should note that the colors are no longer in the same arrangement, this is deemed the “after image” and relates to the temporary desensitization of the cone cells within the retina. The new arrangement on white paper is the “negative after image” (colors are in opposition to original) while the arrangement seen on the black paper is the “positive after image” (colors in the same arrangement to the original). This rearrangement is based on stimulus (or lack of stimulus) on the temporarily desensitized cones.

7. Repeat steps 1-6 for the second test subject

Figure 1. Position of the four distinct colors on the color board based on the original arrangement and in response to the two after images based on the white paper (Negative) and Black (Positive) following overexposure of the retina and temporary desensitization.

Subject 1

ORIGINAL ARRANGEMENT	Negative AFTERIMAGE ARRANGEMENT	Positive AFTERIMAGE ARRANGEMENT

Subject 2

ORIGINAL ARRANGEMENT	Negative AFTERIMAGE ARRANGEMENT	Positive AFTERIMAGE ARRANGEMENT

Discussion: In a cohesive paragraph, discuss the findings of the experiment as it relates to the physiology of vision. (Use the following think about questions to guide your discussion: What effect did staring at the color board have on what was seen on the white paper afterwards? How would you classify this finding (i.e. “positive” or “negative” afterimage), what is the most plausible reason for this occurring?)

1.12: Nervous Physiology Testing Reactions

Objectives:

At the end of this lab, you will be able to...

- 1) Differentiate between a reflex and reaction
- 2) Explain the impact that anticipation and learning has on the rate of reactions
- 3) Compare the differences within and between individuals based on the patterning of external stimulus leading to the reaction response.

Introduction

Reactions are an important to everyday activities. They are a reflexive behavior that we use to protect ourselves. Where we are able to use one of our senses to initiate a response to a stimulus, even without having to think about what that response will be. Because the time required for most of reactions and reflexes to occur are very short, less than one second, we use the typical measure of millisecond (msec) as opposed to using the whole second. As the numbers will always be thousandths of a whole second and whole numbers are much easier to deal with than decimals or fractions.

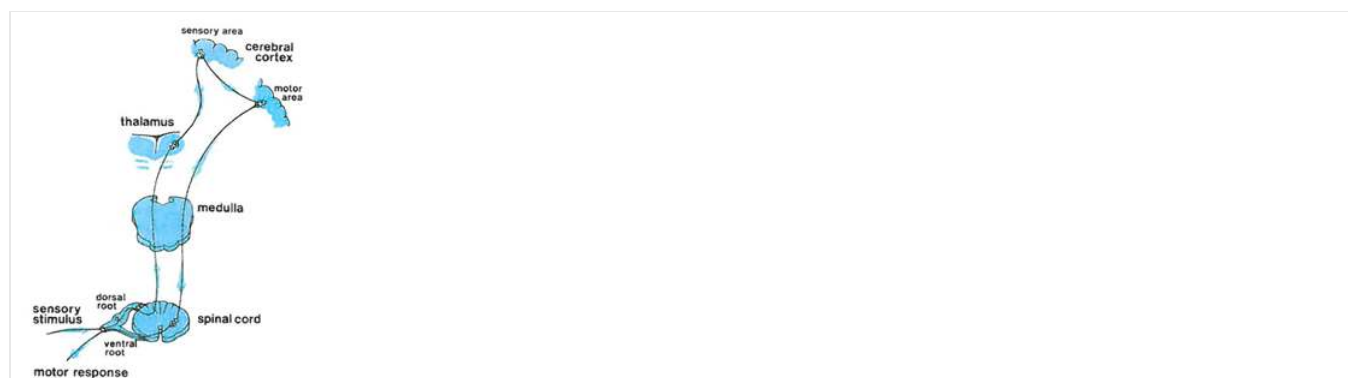


Figure 1. Pathway for a reaction response to a stimulus, note the interplay between cortical structures and the afferent and efferent pathways.

But what makes reactions different from reflexes? Reflexes are unconscious, involuntary and unintentional response to a stimulus on a receptor. While, a reaction is a deliberate conscious response to a specific stimulus that is voluntary and intentional. We can test our reflexes through use of a reflex hammer on specific tendons throughout the body. To perform this reflex test, the tester strikes the hammer on a specific spot within the tendon. The reflex response may be measured on a subjective grading scale to determine the tone of the muscle. We cannot learn how to control the response to test, the reflex just happens. This is different from the concept of reactions and testing of reactions.

While the reaction is a reflex, it is unlike the muscle tendon reflex as they are specific purposeful actions made in response to a specific stimulus. Since reactions being both cognitive and purposeful, we are able to learn how to react and thus anticipate the appropriate response. The ability to modify and modulate reactions occurs because reactions involve input from our primary motor cortex through a prolonged reflex loop. Where to speed up the response, the primary motor cortex can actually send opposing signals to the agonist and antagonist muscles of the desired movement and upon the initiation of the reaction will stop the opposing signals and allow for the coordinated actions within the reflex, see figure 1. The more often we utilize the reaction pathway, the more we can modify the speed of reaction to any given stimulus and in doing so can be seen to have “faster reactions” relative to a novice in the activity or to what we were able to react to prior to learning the appropriate response.

Reactions become very important to our successful performances in many activities we perform daily, whether it be playing a musical instrument, dancing, playing sports or doing athletic things, playing video games, or even just driving a car. The more often we are exposed to a situation; reactions to that stimulus tend to occur more quickly than when first exposed to the situation. There are different activities that can improve our reaction skills, all of which depend on the signal used to initiate the reaction, including noises (like a starting gun at a race), objects flying at you (like catching a ball before you get hit by it), or falling to the floor (like catching the plate before it hits the floor and your mom or dad gets upset). Because of what they do to our physiology,

stimulants that we consume can alter the speed that reactions form to a stimulus and will make a person appear to react much faster than if they were to react to the same stimulus when sober.

When testing reactions, we normally measure it through reaction time to respond to a stimulus through movement of limb (hand, finger, foot). It is important to remember that limb dominance and habitual utilization can influence the responses seen. As the more often we use a limb or pattern of motion, the more “ingrained” the motion becomes while the less often we use the limb or pattern of motion the more likely we are to over-exaggerate the response, as we are not certain as to the pattern for response. The over-exaggeration can be seen with the person responding prior to the stimulus or generating too large of a response than what the habitually utilized the limb would produce. Additionally, the speed by which neurons function can slow and the reduction in the speed of neuron activity can slow our reactions. This reduction in conduction speed and longer reaction time can lead to the same over-exaggeration that is seen from the non-habitually used limb and with progressive aging can lead to overall slower movements for the person so that they can ensure their ability to react to a stimulus appropriately.

The purpose of the experiment here is to test reactions to visual signals where we will examine the differences that exist between dominant (habitually used) and non-dominant (not habitually used) hands. Further we will look at differences that may exist between genders (male or female), habitual use of playing video games, acute exposure to a stimulant, and age of the volunteer.

Hypothesis:

Materials and Methods:

- Meterstick
- Stopwatch

Methods:

Part 1: Testing with the meter-stick

I. Choose slip of paper to indicate order of testing Anticipation or No Anticipation

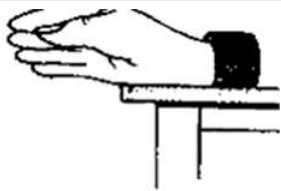
II. Based on slip of paper indicate order that you will test reactions

Test #1:

Test #2:

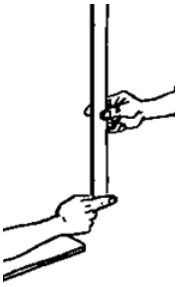
Testing with no anticipation:

1. Determine who will be tested first.
2. Have the person being the test subject to sit on a chair and place the dominant arm on the table so that the hand is off the table, but the rest of the arm is on the table. Have them turn their hand so that the thumb is facing up (toward the ceiling) and the fingers are facing forward.



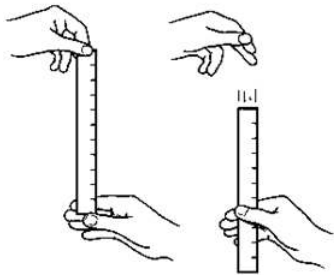
Positioning of the hand of the test subject.

3. Have the person acting as the tester, stand and face the person being tested with the meter-stick being held vertically, turn the meter-stick so that the numbers face the thumb side of the hand.



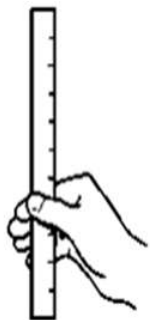
Positioning of the meter-stick for testing reaction time.

4. In that position, have the subject pinch their index finger and thumb together so that they are touching the meter-stick.
5. Have the person relax their pinch so that the meter-stick is free and being held by the tester in the air between the subject's thumb and index finger, but not touching either one of the fingers.
6. Align the zero mark of the meter-stick with the top of the subject's fingers. Ask the subject if they are ready. And tell them that once they see the meter-stick drop try to catch the meter-stick between their index finger and thumb.
7. Without warning, release the ruler and let it drop and have the subject catch it as quickly as possible as soon as they see it fall.



Process used for testing of reaction times by catching the falling meter-stick.

8. Record in centimeters the distance the ruler fell, by reading the distance at the top of the subject's finger in the correct results table.



Identification for where to read the mark for distance that meter-stick fell prior to being caught.

9. Repeat steps 6-9 for a total of 5 times. Following the fifth trial, switch partner roles.
10. Repeat steps 3-10 for the next partner and then for the other (non-dominant) arm of each partner.

Testing with anticipation: This time after asking them if they are ready, you will give them a countdown to the drop of the meter-stick.

11. Have the person being the test subject to sit on a chair and place the dominant arm on the table so that the hand is off the table, but the rest of the arm is on the table. Have them turn their hand so that the thumb is facing up (toward the ceiling) and the fingers are facing forward.
12. Have the person acting as the tester, stand and face the person being tested with the meter-stick being held vertically, turn the meter-stick so that the numbers face the thumb side of the hand.
13. In that position, have the subject pinch their index finger and thumb together so that they are touching the meter-stick.
14. Have the person relax their pinch so that the meter-stick is free and being held by the tester in the air between the subject's thumb and index finger, but not touching either one of the fingers.
15. Align the zero mark of the meter-stick with the top of the subject's fingers. Ask the subject if they are ready. And tell them that once they see the meter-stick drop try to catch the meter-stick between their index finger and thumb.
16. Countdown from 5 to 1, and on "1" release the ruler, let it drop and have the subject catch it as quickly as possible as soon as they see it fall.
17. Record in centimeters the distance the ruler fell, by reading the distance at the top of the subject's finger.
18. Repeat for a total of 5 times. Following the fifth trial, switch partner roles.
19. Repeat steps 14-18 for the next partner and then for the other (non-dominant) arm of each partner.

Table 1. Conversion of average time (msec) for reaction based on the distance that the meter-stick fell prior to be caught.

Distance (cm)	Time (msec)	Distance (cm)	Time (msec)	Distance (cm)	Time (msec)	Distance (cm)	Time (msec)
1	45	26	230	51	323	76	394
2	64	27	235	52	326	77	396
3	78	28	239	53	329	78	399
4	90	29	243	54	332	79	402
5	100	30	247	55	335	80	404
6	111	31	252	56	338	81	407
7	120	32	256	57	341	82	409
8	128	33	260	58	344	83	412
9	136	34	263	59	347	84	414
10	143	35	267	60	350	85	416
11	150	36	271	61	353	86	419
12	156	37	275	62	356	87	421
13	163	38	278	63	359	88	424
14	169	39	282	64	361	89	426
15	175	40	286	65	364	90	429
16	181	41	289	66	367	91	431
17	186	42	293	67	370	92	433
18	192	43	296	68	373	93	436
19	197	44	300	69	375	94	438
20	202	45	303	70	378	95	440
21	207	46	306	71	381	96	443
22	212	47	310	72	383	97	445
23	217	48	313	73	386	98	447
24	221	49	316	74	389	99	449
25	226	50	319	75	391	100	452

Part 2: Reaction to the Stopwatch

I. Select paper to indicate order of testing: Dominant/Non-dominant

II. Record Testing Order: 1st 2nd

1. Using the same order for testing of partner as in Part 1 get the stopwatch
2. Tester will explain that the test subject will click start and try to stop the timer as close to 1.00 seconds as possible. The only times that will be officially recorded will be times after 1.00 seconds (meaning 0.99 second does not get recorded as an official trial but as an No Score)
3. Demonstrate the test to the test subject by holding the stopwatch in dominant hand so that thumb is able to press the "Start/Stop" button. Click "Start/Stop" and once "1.00" is seen on the stop watch hit "Start/Stop" and write down the

numbers that follow the decimal (such that 1.20 on the stop watch becomes 200 milliseconds (msec) on the data table).

4. Reset the stopwatch and hand the stopwatch to the test subject
5. Have test subject assume the test position with the 1st hand
6. Give countdown “3..2..1..Go!” and have the test subject press “Start/Stop” and then stop the timer by pressing “Start/Stop” as close to 1.00 second as possible.
7. After the test subject has stopped the timer, collect the stopwatch and record the time in table 4, reset and pass the stopwatch back to the test subject and repeat steps 4-6 for 5 total trials.
8. Repeat the stopwatch test for the opposite hand
9. Switch partners and repeat the entire stopwatch test

Upload data to the Google Document data table for completion of the lab report

Subject Demographics:

Age:

Gender:

Did you consume a stimulant within 1-hour of testing reactions? YES / NO

Average Hours per week you play video games:

Do you play a sport that forces you to quickly react to the ball? YES / NO

Results:

Table 2. Distance that the meter-stick fell for each of the trials, with no anticipation, and the time to react for the dominant hand and non-dominant hand

Dominant Hand			Non-Dominant Hand		
Trial #	Distance (cm)	Time (msec)	Trial #	Distance (cm)	Time (msec)
1			1		
2			2		
3			3		
4			4		
5			5		
Average			Average		

Table 3. Distance that the meter-stick fell for each of the trials, with anticipation, and the time to react for the dominant and non-dominant hand.

Dominant			Non-Dominant		
Trial #	Distance (cm)	Time (msec)	Trial #	Distance (cm)	Time (msec)
1			1		
2			2		
3			3		
4			4		
5			5		
Average			Average		

Table 4. Time (msec) past 1.00 second to stop the stopwatch as a measure of reaction for the dominant and non-dominant hand.

Dominant Hand		Non-Dominant Hand	
Trial #	Time (msec)	Trial #	Time (msec)
1		1	
2		2	
3		3	
4		4	
5		5	
Average		Average	

Based on your hypothesis produce the appropriate graph to show the relationship between your testing factor (x-axis) and reaction times (y-axis).

Discussion: In 1-2 well formatted paragraphs, discuss your results based on your understanding of reactions and the relationship of data to supporting or refuting your specific hypothesis (Use the following think about questions ***don't answer these as individual questions but use them to guide your analysis***: What is seen in the differences in reaction times between individuals? What is seen between group members based on demographics? What is a plausible rationale for such differences? What happens to reaction times as the person progresses from the first to last test for each condition? Why did certain types of individuals have different reaction times versus other types of individuals? How do the findings relate to the principles of reactions?)

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1.13: Neuroendocrine System

Objectives:

At the end of this lab, you will be able to...

1. **Correctly name and locate the organs and tissues of the neuroendocrine system**
2. **Correctly identify feedback regulation mechanisms in hormone physiology**
3. **Correctly perform and interpret responses to a glucose tolerance test.**

Pre-Lab Exercises:

After reading through the lab activities prior to lab, complete the following before you start your lab.

1. Correctly define feedback: .
2. Endocrine tissues are described as being either or tissues.
3. True/False: When performing the glucose tolerance test, anyone in the group will perform the blood test on the group's volunteer.
4. True/False: The volunteer in your group should come to lab fasted (no food within 6-8 hours prior to lab).
5. Color the images for use as a reference for identifying the organs and structures of the neuroendocrine system.

Materials:

- Torso Model
- Glucose Meters
- Lancets
- Safety Release Form
- Sharps and Biohazard Containers
- Stickers
- Felt Pens
- Colored Pencils

Activity 1: Organs and Tissues

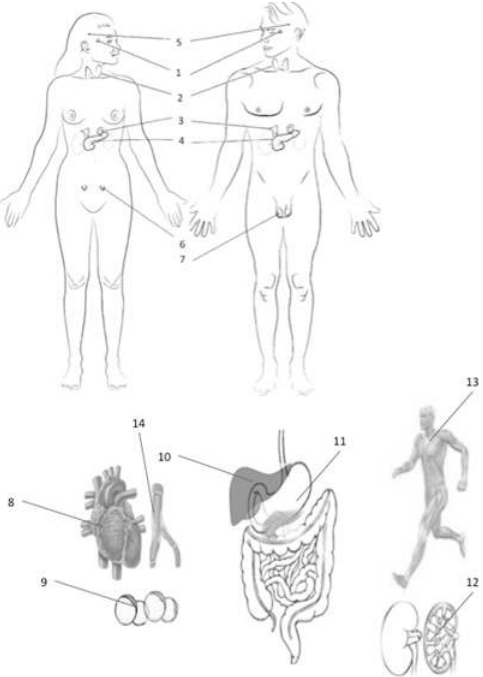
The neuroendocrine system utilizes chemical messengers for various functions. These chemical messengers serve as a means for cells to communicate between each other using chemical signals, regulate a number of metabolic processes throughout the body, and attempt to induce precise responses only affecting specific target cells. Because every cell will release chemicals based on metabolic activities, any cell and tissue of the body can have an impact as a part of the neuroendocrine system. In order to have a precise impact, these messengers will only interact where a specific receptor (membrane protein) is present for that specific chemical. The tissues and structures are divided into two classifications, the glandular tissues and non-glandular tissues. The glandular organs will utilize the endocrine and exocrine glandular functions to perform the majority of its functions. These glandular tissues and organs include the hypothalamus, pituitary gland, pineal gland, thyroid gland, parathyroid glands, pancreas, adrenal glands, and gonads (testes and ovaries). All of the glandular organs, except the parathyroid and pancreas, are directly regulated by tropic hormones released from the hypophysis (the combined structure of the hypothalamus and pituitary gland). Along with the glandular tissues that are regulated by tropic and trophic signals, there are tissues that possess neuroendocrine functions independent of the hypophyseal signals. These tissues release hormone messengers not based on tropic regulation, but due to metabolic activity of the tissues of the body. Based on metabolic activity, almost all tissues can produce a chemical signal that can serve as a hormone, but the review here will focus on the major tissues (and cells) that produce hormones that have a wide-ranging effect.

Procedures:

1. Obtain torso models, stickers, felt pens
2. Write names of tissues, organs and structures that will produce hormones on the stickers
3. Select a "team leader" and use the colored images and reference materials to take turns labeling the torso model

a. As structures are labeled, indicate a hormone that will be produced by the tissue. If more than 1 hormone is produced, take turns identifying the various hormones

4. Have your instructor check your progress and finish activity two.



Structures, tissues and organs involved with neuroendocrine functions.

1 Hypophyseal (Pituitary Gland and Hypothalamus)
 2 Thyroid Gland 3 Adrenal Gland
 4 Pancreas 5 Pineal Gland
 6 Ovary (Female only) 7 Testicle (Male Only)
 8 Heart 9 Adipose Cells
 10 Liver 11 Gastrointestinal
 12 Kidney 13 Musculoskeletal
 14 Blood Cells

Color each structure, tissue or organ with a different color to assist with identification

Activity 2: Glucose Tolerance Tests

This activity needs to be started prior to the beginning of activity 1. Select 1 participant in your group to be the test subject. Test subjects must come to lab in a fasted state (no food, alcohol or caffeine within 8-hours of lab) and should be selected during the previous lab.

Test subject must agree to participate and sign the agreement to be the test subject and willingness to follow all rules for testing their own blood glucose levels for lab purposes.

Background

Glucose tolerance is the ability for the person to withstand a large ingestion of glucose without having prolonged episodes of excessive blood glucose, hyperglycemia. Normal, metabolically healthy, individuals will have a fasting glucose level between 80 and 100 mg glucose/dL plasma that is maintained by tissues of the body (e.g., skeletal muscle, liver and adipose cells) having normal sensitivity to the hormone insulin. Through normal insulin action at these tissues, any increase in blood glucose will be met with a compensatory rise of insulin that will be able to move glucose into these tissues to lead to a reduction in glucose and thus reduction in insulin, through normal feedback regulation.

We are able to test this normal feedback regulation in the laboratory and clinic through glucose tolerance tests. The glucose tolerance test determines how the body responds to ingesting a large amount of glucose (sugar) in a very short period time. The

process involves comparing the levels of glucose in the blood before and after drinking a sugary drink. Typically, the test is performed in a laboratory setting to determine the level of insulin sensitivity that the individual has, and allows medical professionals to detect susceptibility to having diabetes, i.e. showing an impaired glucose tolerance. In healthy people, glucose levels in the blood always rise after a meal but they soon return to normal over the next hour during a challenge and 2-3 hours during an actual oral glucose tolerance test (OGTT).

To ensure that the individual is at a fasting level of glucose in the blood, the test subject is asked not to eat for at least 5-8 hours prior to taking the test. Following consumption of the glucose sample there will normally elicit a spike in insulin. That spike ensures that glucose is rapidly cleared from the blood, moving into the insulin sensitive cells (e.g., skeletal muscle, liver and adipose cells). As a result, the amount of glucose found in blood samples taken over the length of the test will slowly return to normal levels (table 1). However, if there is a problem with either producing insulin (from the β -cells of the pancreas) or cells responding to insulin, there will be a continued elevated reading of glucose in the bloodstream.

Table 1. Sample readings of blood glucose and categorization of distress and dysfunction.

Test Indication	Fasting	Post-Meal	1-hr Post-Meal	2-hr Post-Meal
“Normal”	80-100 mg/dL	170-200 mg/dL	140-170 mg/dL	80-140 mg/dL
“Pre-Diabetic”	100-120 mg/dL	190-230 mg/dL	160-200 mg/dL	140-170 mg/dL
“Diabetic”	>120 mg/dL	230-300 mg/dL	250-270 mg/dL	200-250 mg/dL

Graphing the time response of glucose readings in the plasma over the length of the test will provide a means to diagnosis metabolic issues for the person, i.e. exhibiting metabolic syndrome or having diabetes. The result of which will be the glucose tolerance curve for the individual. This curve can be tracked over the period of weeks, months and years to examine how a person suspected of having impaired glucose metabolism (or impaired insulin response) behaves to ingesting glucose. While the glucose tolerance challenge can be used as a diagnostic tool, a single testing outcome cannot be used a differentially diagnosis a person to being a diabetic. That is where the OGTT, or the more complex intravenous glucose tolerance test (IGTT) will be used; as it compares not only the ability to clear glucose from the blood, but also examines the response of insulin (insulin tolerance test) over the length of the 2-3 hours for the tolerance test.

Materials and Methods

Materials

- Glucose solutions
- Alcohol Swabs
- Lancets
- Blood Glucose Monitors and Test Strips Biohazard Bag
- Sharps Container
- Bandage

Methods

Ensure that your test subject has not eaten, drank anything beyond water, or exercised within the last 5-hours prior to testing of blood glucose.

1. Make glucose solution by dissolving 50g glucose into 250mL of chilled water
2. Have test subject test their blood glucose levels
 - a. Obtain a lancet, alcohol swab, paper towel, glucose test strip and glucose monitor
 - b. Place the test strip into the monitor and turn monitor on so that it will read the test-strip
 - c. Have your test subject swab clean the distal edge of the ring finger on their non-dominant hand
 - d. Following which perform a lance of their non-dominant ring finger with a lancet
 - e. Immediately after lancing finger, place lancet into sharps container
 - f. Milk the finger by squeezing and rolling fingers from the proximal end of the digit to the area of the lancing until a large drop of blood is visible

- g. Place the drop of blood on the test strip and allow Blood Glucose Monitor to analyze
- h. Record reading in Table 2.
3. Have your test subject seated for the remainder of the test. Once seated, have them consume the entirety of the glucose solution in a 5-minute period of time
4. Upon consuming all of the solution, wait 2-minutes
 - a. Obtain Blood Glucose Reading
 - i. Have the test subject “milk” the ring finger to see if able to draw blood droplet prior to repeating the lancing of the digit.
 - ii. Record data in Table 2 (this is your 0-min reading)
 - b. Set timer for 20-minutes
 - c. Repeat step 4a every 20-minutes for 1-hour following consumption of glucose solution. i. Record the data in table 1 in corresponding time (20-min, 40-min, 60-min).

Analysis

1. Determine the initial change in glucose (Δglu) based on initial concentration of glucose $[\text{glu}]$ relative to post-consumption
 - a. $\Delta \text{glu} = [\text{glu}]_{\text{post-consumption}} - [\text{glu}]_{\text{pre-test}}$
2. Calculate glucose clearance at each time point over the length of test relative to the initial reading following consumption
 - a. Clearance (C) = $([\text{glu}]_{\text{at time point}} - [\text{glu}]_{\text{at 0-min}}) / ([\text{glu}]_{\text{at 0-min}} \times 100\%)$
 - b. Graph C to time
 - c. Graph $[\text{glu}]$ to time

Results

Table 2. Readings of blood glucose concentrations (mg/dL) throughout the glucose tolerance challenge.

Time	Pre-Test	Post-Consumption	20-min	40-min	60-min
Concentration of Glucose (mg/dL)					
Δglu					
Clearance					

Discussion

In examining the results think about:

How do responses correlate to the concept of feedback regulation and homeostatic balance? What hormones are involved in the response and what do the results indicate about the individual’s ability to tolerate consuming glucose? How would you use this test to determine metabolic issues for a person?

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1.14: Cardiorespiratory System Anatomy-Part 1- Heart and Lung Anatomy

Objectives:

At the end of this lab, you will be able to...

1. **Correctly name and locate the great vessels (Vena Cava, Aorta, Pulmonary Trunk, and Pulmonary Veins)**
2. **Correctly identify and indicate the functions of the various chambers of the heart and valves**
3. **Correctly identify the structures of the respiratory tract and lungs.**
4. **Correctly dissect a Sheep's heart and identify the major structures following dissection.**

Pre-Lab Exercise:

After reading through the lab activities prior to lab, complete the following before you start your lab

1. The right atrium receives blood from the _____ and the left atrium receives blood from the _____, while the right ventricle will eject blood to the _____ and the left ventricle will eject blood to the _____.
2. There are _____ lobes in the right lung and _____ lobes in the left lung.
3. Color the images for use as a reference for identifying the models and dissected specimens.

Materials:

- Torso Model
- Heart and Lung Models
- Sheep's Heart
- Dissection pan and dissecting tools
- Stickers
- Felt Pens
- Colored Pencils

The cardiovascular system is one of the most important systems for the body to maintain homeostasis. As it will function to transport materials throughout the body and is highly integrated with all systems of the body, none more so than the respiratory, immune and endocrine systems. Functionally, the cardiovascular system is comprised of a 4-chamber pump (the cardiac organ or heart) and a closed tubular network that traverses the body.

Activity 1: Heart Gross Anatomy

The heart functions within the system as a hydraulic pump, a pump moving fluids, by generating enough compressive force to overcome the fluid pressure of resistance in the vessels. The organ is located within the mediastinum of the thoracic cavity between the pleural cavities of the lungs. The heart is held within the mediastinum by a fibrous "bag" of connective tissue (pericardium) that allows for the heart to change its volume within a very limited range, changes of volume of heart is typically limited to 75-500 mL. Additionally, the heart has a long axis that is tangential (at an angle) to the long axis of the body, because of the anatomical changes during development. This means that even though we talk about having "left" heart structures and "right" heart structures we can just as easily state we have superior (left) and inferior (right) heart structures.

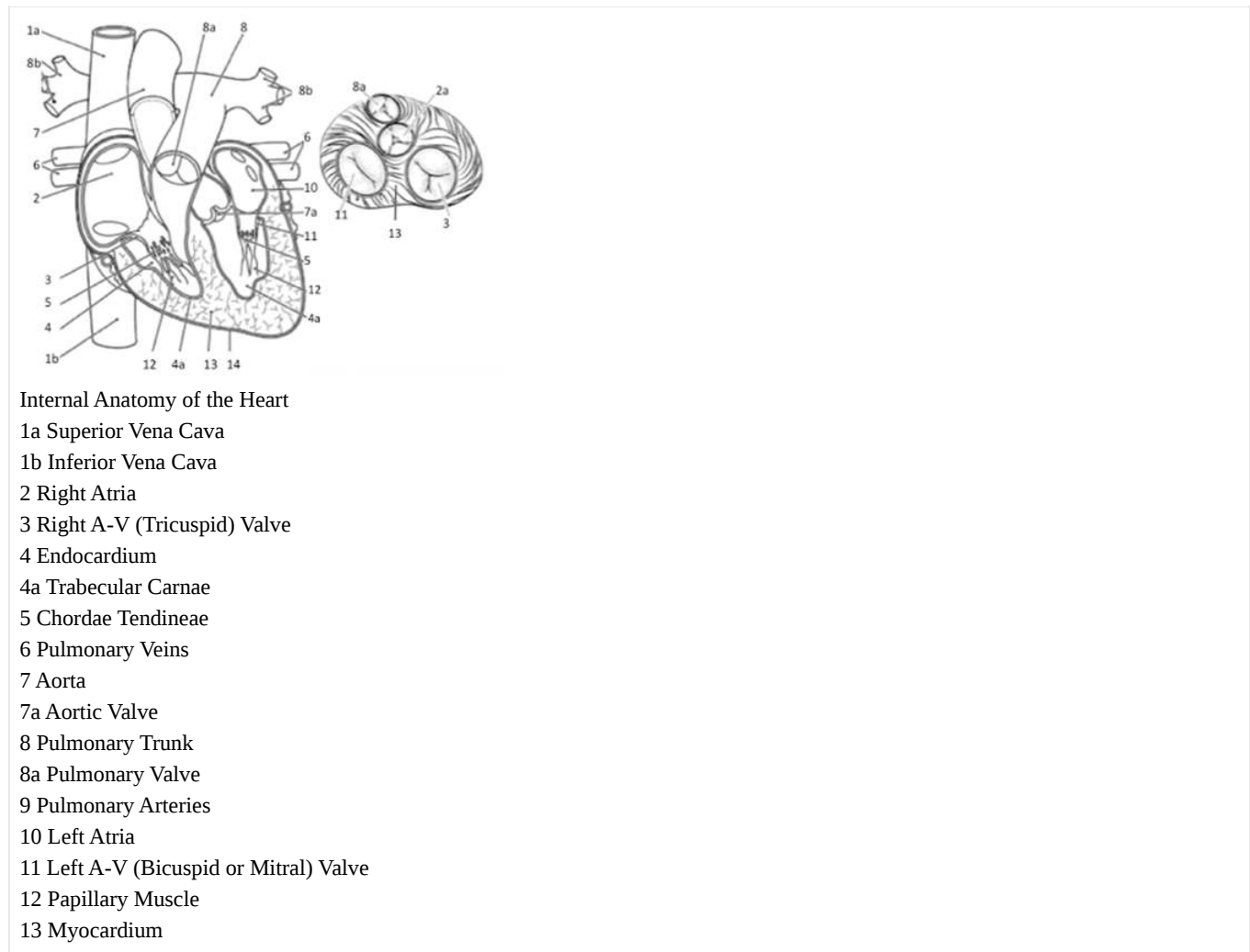
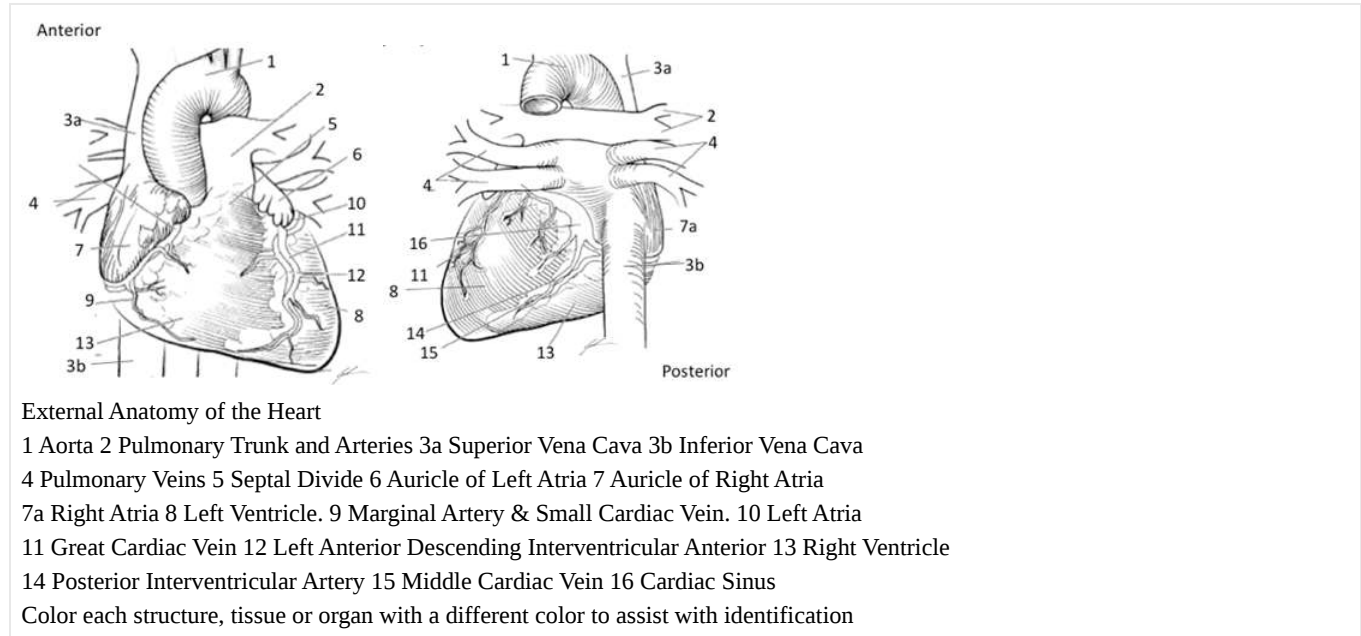
When examining the heart, there are three distinct anatomical features that can be considered the external structures of the heart. These include the great vessels, the aorta and aortic arch and the pulmonary trunk to the superior and medial aspect of the heart allowing blood to move to the body and lungs, and the vena cava (superior and inferior) and pulmonary veins to the posterior aspect of the heart allowing blood to return from the body and lungs. You will notice that there is an extension of the atrium above the coronary arteries on both the right and the left side of the heart, these are the auricles of the atria and are important in allowing for additional venous return to the heart from either the body (right atria) or lungs (left atria). This additional return provides for greater volume being moved with each contraction of the heart. There is also the pericardium and fat pad that provide protection and anchorage of the heart within the mediastinum of the thoracic cavity. These fat pads serve a second function as being a fuel reserve for the cardiac tissues to do work during periods of prolonged effort.

Because of the aerobic obligated nature of the cardiac muscle, there is an extensive network of blood vessels to allow perfusion within the heart, the coronary vessels. The coronary arteries arise from branching points of the aorta just distal to the aortic valve,

but at a point where the valve can easily cover the vessels when open during movement of blood out of the left ventricle. This means that blood will only flow into the coronary vessels when the aortic valve is closed and if the heart contracts too rapidly the valve limits the amount of blood being able to get to the tissues of the heart.

Internally the heart is an organ structured to allow for constant changes in its internal volume without undergoing damage to the organ. Some of these changes are seen as myocardium layer intermingles with the endocardium pressing into the internal regions of the chambers and becomes visible forming into the specialized structures of the septum, trabeculae carneae and papillary muscles of the heart. Along with the structures meant to change volume of the heart there are 2 sets of valves that ensure blood will only flow in one-direction through the heart. These are the atrial-ventricular valves (right and left) that are held in place by the chordae

tendinea and papillary muscles and prevent backflow to the atria during ventricular contraction (systole) and the semi-lunar valves (pulmonary and aortic) that prevent backflow to the ventricle during the ventricular relaxation (diastole).



14 Epicardium

Color each structure, tissue or organ with a different color to assist with identification

Procedures:

1. Obtain torso and Heart models, stickers, felt pens
2. Write names of great vessels and structures of the heart that you are responsible for knowing and identifying on the stickers
Aorta, Inferior Vena Cava, Superior Vena Cava, Pulmonary Trunk, Pulmonary Veins, Right Atrium, Right Ventricle, Left Atrium, Left Ventricle, Bicuspid (Mitral) Valve, Tricuspid Valve, Papillary Muscle, Chordae Tendineae, Myocardium, Septum
3. Select a “team leader” and use the colored images and reference materials to take turns labeling the model
 - a. As structures are labeled, indicate a function of the structure being labeled. If more than 1 function have members of the group take turns identifying the other functions not mentioned when structure was initially labeled
4. Have your instructor check your progress and finish activity two.

Activity 2: Respiratory Tract and Lung Anatomy

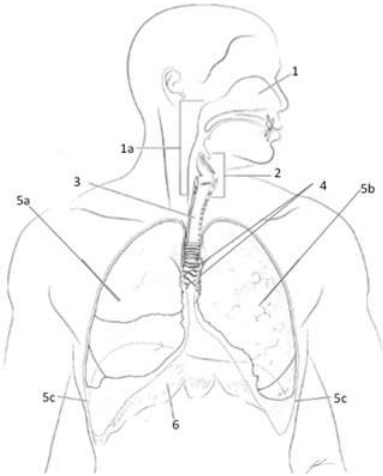
The respiratory system is comprised of two primary organs that are at the terminus of an open lumen (alveoli) that provides an access for air movement from the external environment into the body. The pathway begins in the cranium (the nasal and oral cavity) and traverses through the ventral/anterior cervical region into the thoracic cage. The upper tract of the system is responsible for exchange of materials between the body and the external environment, defense against pathogens and harmful particles, and vocalization (speech and sound production) from specialized structures in the larynx (the region of the trachea between the Nasopharynx and the bronchiole branches). The lower tract of the system is responsible for passage of air from the environment to the alveoli, exchange of gasses between the alveoli and the pulmonary capillaries within the lungs. The pathway of air flow within the system is divided into the trachea, bronchi, bronchial branches, bronchioles, and alveoli.

While most people associate respiration (ventilation) with the need to “get Oxygen” for their body. Oxygen (O_2) does not regulate the system, carbon dioxide (CO_2) or more importantly bicarbonate (H_2CO_3 or $H^+ HCO_3^-$) regulates the system. The action of the respiratory system is termed ventilation and is broken into two distinct components, the inspiratory (inhalation) and expiratory (exhalation) action that leads to the lungs inflating and deflating (they do not expand and contract) proportionally to the movement the thoracic cage. This inflation and deflation are based on the changes in pressure within the thoracic cage leading to either a pressure less than the environment (inhalation) or pressure greater than the environment (exhalation).

Procedures:

1. Obtain torso and Heart and lung models, stickers, felt pens
2. Write names of structures of the respiratory tract and lungs that you are responsible for knowing and identifying on the sticker
Nasal Conchae, Larynx, Trachea, Primary Bronchi, Secondary Bronchi, Superior Lobe of Right Lung, Middle Lobe of Right Lung, Inferior Lobe of Right Lung, Superior Lobe of Left Lung, Inferior Lobe of Left Lung, Horizontal Fissure, Oblique Fissure, Diaphragm
3. Select a “team leader” and use the colored images and reference materials to take turns labeling the model
 - a. As structures are labeled, indicate a function of the structure being labeled. If more than 1 function have members of the group take turns identifying the other functions not mentioned when structure was initially labeled

4. Have your instructor check your progress and finish activity two.



Anatomy of the Respiratory System

1 Nasal Opening

1a Nasopharynx

2 Larynx

3 Trachea

4 Bronchi

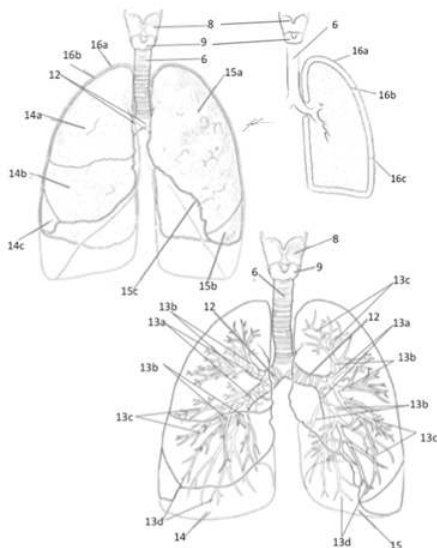
5a Right Lung

5b Left Lung

5c Pleural Cavity

6 Diaphragm

Color each structure, tissue or organ with a different color to assist with identification



Anatomy of the Lower Respiratory Tract

12 Bronchi

13a Primary Bronchial Branches

13b Secondary Bronchial Branches

13c Tertiary Bronchial Branches

13d Bronchioles

14 Right Lung

- 14a Upper Lobe Right Lung
 - 14b Middle Lobe Right Lung
 - 14c Lower Lobe Right Lung
 - 15 Left Lung
 - 15a Upper Lobe Left Lung
 - 15b Lower Lobe Left Lung
 - 15c Lingula of Left Lung
 - 16a Pleural Parietal Lining
 - 16b Pleural Visceral Lining
 - 16c Pleural Cavity Space
- Color each structure, tissue or organ with a different color to assist with identification

Activity 3: Dissection of Sheep's Heart

Obtain the heart, dissection tray and tool.

1. Examine the external anatomy of the heart.
 - a. Find the great vessels (Aorta, Vena Cava, Pulmonary Trunk and Pulmonary Veins) as the junction with the heart.
 - b. Place probes into the vessels and see where you are able to press inside of the heart to determine location of atrium and ventricle of the right and left side of the heart
 - c. Locate the anterior side of the heart and note the interventricular sulcus (you will see the Left Anterior Interventricular Descending Artery and Greater Cardiac Vein in the sulcus). Note the amount of fat around the sulcus and covering the external anatomy of the heart. Can you think about why the heart might have this level of fat? Discuss in your group and once you have an answer call your instructor over to see how correct your thinking might be.
2. Orient so that anterior is facing you and place onto dissection pan so that the right-side of the heart is facing you.
3. Dissection of the Right Side:
 - a. Make a coronal incision (along the lateral margin of the heart) with the scalpel through the right side of the heart
 - i. Start the incision at the entrance of the Superior Vena Cava into the Right Atrium
 - ii. Continue along the lateral margin through the atrium and ventricle of the heart
 - iii. Stop when get to the interventricular septum
 1. The muscle is “thick” but don’t saw. Glide the scalpel through the muscle, have your partner use the forceps and probe to open the slit being made to assist with opening the right ventricle
 - b. Once the incision has been made, press the base and apex of the heart toward each other and use the shear to widen the incision to allow for examination of the internal right atrium and ventricle
 - c. Examine the internal anatomy of the right atrium and ventricle identifying the important anatomical structures that you are responsible for knowing.
4. Continue the dissection to the left side.
 - a. Make a coronal incision (along the lateral margin of the heart) with the scalpel
 - i. Start the incision at the Apex of the heart
 - ii. Continue along the lateral margin through the left ventricle of the heart
 - iii. Stop when get to pulmonary trunk and aorta
 1. The muscle is “thick” but don’t saw. Glide the scalpel through the muscle, have your partner use the forceps and probe to open the slit being made to assist with opening the left ventricle
 - b. Once the incision has been made, open the left side of the heart so that the internal anatomy is visible, but the heart is still a single organ being held at the septum.

- c. Examine the internal anatomy of the left atrium and ventricle, identifying the important anatomical structures that are responsible for knowing.
- d. What do you notice about the difference in the structures between the right and left chambers of the heart? Why would the heart have these anatomical differences? Discuss in your group and once you have an answer call your instructor over to see how correct your thinking might be.

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1.15: Cardiorespiratory System Anatomy-Part 2- Arteries and Veins

Objectives:

At the end of this lab, you will be able to...

1. **Correctly identify and locate the major arteries and veins of the extremities**
2. **Correctly identify and locate the major arteries and veins of the head, neck and thorax.**
3. **Correctly locate peripheral pulse points for determining heart rates and blood pressures.**

Pre-Lab Exercise:

After reading through the lab activities prior to lab, complete the following before you start your lab

1. The pulse points in the upper extremity are found on the following arteries: .
2. The pulse points in the lower extremity are found on the following arteries: .
3. When taking a peripheral pulse, you should never use your .
4. Color the images for use as a reference for identifying the models and dissected specimens

Materials:

- Torso Model
- Cardiovascular Models
- Stickers
- Felt Pens
- Colored Pencils

Blood Vessels (Arteries, Veins and Capillaries)

The cardiovascular vessels function as closed tubular network to propel a viscous fluid, blood, throughout the body via a combination of positive and negative propulsive pressures in the arteries and veins, respectively. Movement of blood within the vessels is based on the principle of bulk flow (where all materials within a solution will move as one unit), through two distinct closed loops (pulmonary and systemic). Where the pulmonary loop involves the exchange of materials at the lungs with the environment and the systemic loop involves exchange of materials with the tissues and cells of the body. The flow of blood through the heart flows atrium to ventricle with systemic flow of the blood moving from left ventricle to right atrium while pulmonary flow of blood is moving from right ventricle to left atrium. When we discuss the vessels as being arteries (blood moving away from the heart) and veins (blood moving back to the heart) between these vessels are elaborate networks of smaller vessels contained in the tissues and organs of the bodies, arterioles and venuoles, that are linked with even more elaborate networks of even smaller vessels, capillaries. While gases and materials easily diffuse from the blood the surrounding tissues, within the tissues of the lumen there is very poor exchange. This leads to the development of a cyanotic hue (blue color) of the vessels and gives the misconception that blood may be blue, when in fact blood is red.

The artery and vein are lumen organs comprised of three major tissue layers that function to provide the pressures necessary to move fluid throughout the vessels. These tissues are identified as tunics and are named based on the relationship of the tissue to the lumen center. With tunica interna (intima) being the closest to the lumen and tunica externa (adventitia) being the furthest and between the two extremes the tunica media. The amount of tunics and tissues within each tunica will vary based on the type of vessel (artery, arteriole, venuoles, vein or capillary). Each tunica is comprised of different types of tissue that indicate the function that the layer has to the overall function of the vessel. Tunica intima is principally comprised of endothelial tissue, squamous epithelium, running continuously from the endothelial tissue of the endocardium of the heart. Within the artery the tunica intima will have the same folded (ridged) structures that we find in all organs that change their internal volume that allows the artery to change its diameter as the volume of fluid moving through the lumen changes. While the intima of the vein is relatively smooth indicating that the volume of fluid within the lumen remains relatively stable. Surrounding the intima is normally a layer of elastic connective tissue that is continuous with basal membrane to the endothelium of the intima. It is the intima and the elastic connective tissue surrounding it limit the rate of movement of materials from the blood into the tissues of the lumen. Superficial to the elastic tissue is the tunica media, larger in the artery than the vein and larger in the muscular artery than the elastic artery. This is a smooth muscle and connective tissue layer that displays the greatest variation among all of the vessels and serves to actively

regulate the diameter of lumen, primarily in the arteries. The outer most, tunica adventitia, consists of elastic and collagen fibers and serves to regulate the overall diameter that the vessel can have, regulating the compliance, and anchors the vessels to surrounding tissues.

Activity 1: Arteries and Veins of the Upper and Lower Extremities

Procedures:

1. Obtain models, stickers, felt pens
2. Write names of vessels of the upper extremity that you are responsible for knowing and identifying on the stickers
Brachial Artery, Basilic Vein, Cephalic Vein, Subclavian Artery, Subclavian Vein, Antecubital Vein, Radial Artery, Ulnar Artery, Radial Vein, Ulnar Vein, Femoral Artery, Femoral Vein, Greater Saphenous Vein, Small Saphenous Vein, Posterior Tibial Artery, Dorsal Pedal Arch (Pedal Artery)
3. Select a “team leader” and use the colored images and reference materials to take turns labeling the model
 - a. As structures are labeled, indicate if it can be used to obtain a peripheral pulse or not.

4. Have your instructor check your progress and move to activity two.

Major Arteries and Veins of the Upper Extremity

1 Aorta

1a Left Common Carotid Artery*

1b Left Subclavian Artery

1c Right Brachiocephalic Artery (Trunk)

2 Right Common Carotid Artery*

3 Right Subclavian Artery

4 Artery to Supraspinatus

5 Axillary Artery*

5a Lateral Thoracic Artery

6 Humeral Circumflex Artery

7 Brachial Artery*

8 Deep Brachial Artery

9 Nutrient Artery to Humerus

10 Radial Artery*

11 Ulnar Artery*

12a Deep Palmar Arch Artery

12b Superficial Palmar Arch Artery

12c Digital Artery

12d Principia Polis Artery

13 Cephalic Vein

14 Deltoid Vein

15 Brachial Vein

16 Basilic Vein

17 Axillary Vein

18 Antecubital Vein

19 Medial Median Antebrachial Vein

20 Radial Vein

21 Ulnar Vein

22 Middle Median Antebrachial Vein

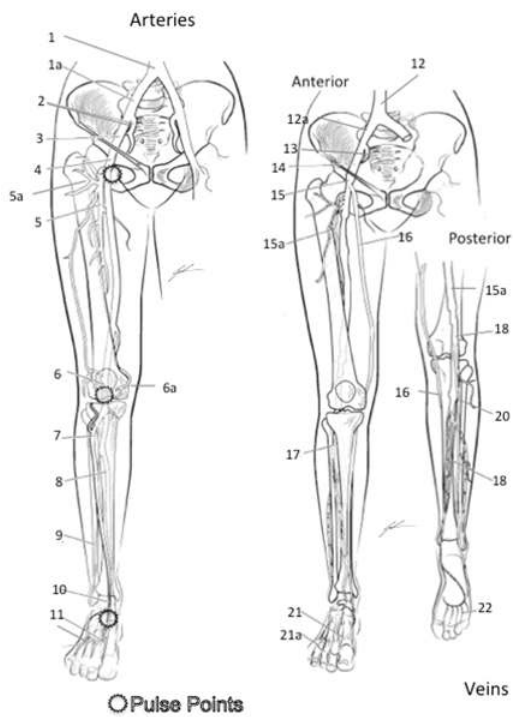
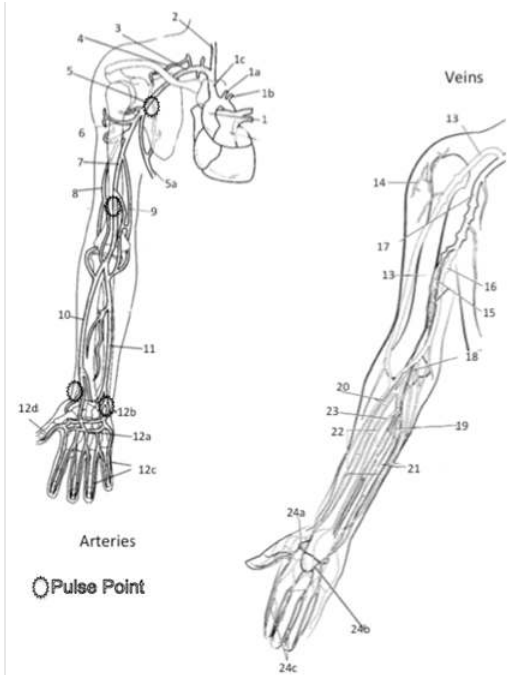
23 Lateral Median Antebrachial Vein

24a Deep Venal Ach

24b Superficial Dorsal Venal Arch

24c Digital Veins

Color each structure, tissue or organ with a different color to assist with identification



Major Arteries and Veins of the Lower Extremity

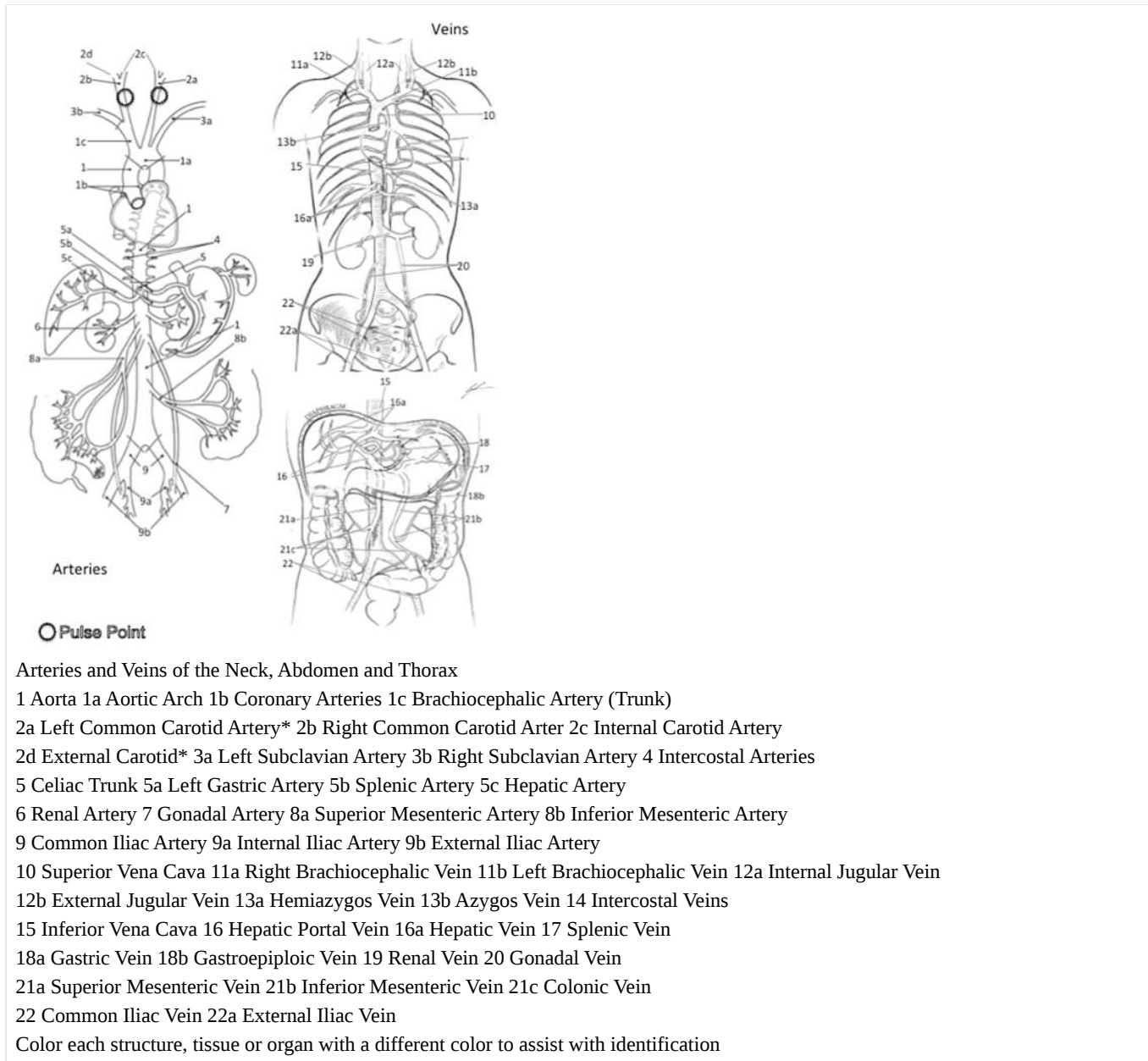
- 1 Common Iliac Artery
- 2 Internal Iliac Artery
- 3 External Iliac Artery
- 4 Femoral Artery*
- 5 Deep Femoral Artery
- 5a Femoral Circumflex Artery (to head of Femur)
- 6 Popliteal Artery*
- (on posterior side)

6a Geniculate Artery
7 Anterior Tibial Artery
8 Posterior Tibial Artery*
9 Peroneal Artery
10 Dorsalis Pedis Artery*
11 Dorsal Metatarsal Artery
12 Inferior Vena Cava
12a Common Iliac Vein
13 Internal Iliac Vein
14 External Iliac Vein
15 Femoral Vein
15a Deep Femoral Vein
16 Great Saphenous
17 Anterior Tibial
18 Popliteal
19 Smaller Saphenous
20 Posterior Tibial
21 Dorsal Venal Arch
21a Digital Veins
22 Plantar Venal Arch
Color each structure, tissue or organ with a different color to assist with identification

Activity 2: Major Arteries and Veins of the Head, Neck and Thorax

Procedures:

1. Obtain models, stickers, felt pens
2. Write names of arteries and veins that you are responsible for knowing and identifying on the stickers
Aorta, Vena Cava, Common Carotid, Internal Jugular, External Jugular, Renal Artery, Renal Vein, Hepatic Portal Vein



3. Select a “team leader” and use the colored images and reference materials to take turns labeling the model
 - a. As structures are labeled, indicate if the artery can be used of a peripheral pulse or not.
4. Have your instructor check your progress and move to activity three.

Activity 3: Determining Peripheral Pulse Points

Procedures:

1. Using the reference image for pulse points, find 5 different pulse points on yourself
2. Palpating the Radial artery, determine your pulse rate using a 15-second count

1. Set a timer for 15-seconds and hold the stopwatch/timer in your left hand
2. Find and press onto the left Radial artery with your index and middle finger of the right hand
3. Once you have found the pulse, use your left hand to start the stopwatch timer for 15-seconds and begin counting each pulse until the timer stops
4. Once the timer stops record the count
5. Multiple by 4
6. Pulse Rate= beats/min

Activity 4: Blood Typing and Transfusion

Blood cells are examined based on the ABO system used to identify blood types. The idea of the ABO system is used to reference the presence or absence of distinct antigens on the erythrocyte. Which is very valuable method of identification for antigen compatibility necessary for medical transfusions. The ABO blood type system is developed to identify which antigen version you have, or do not have, and the associated antibody. The associated antibody is to the erythrocyte antigen that you are lacking, and incorrect transfusion of blood type can lead to agglutination reactions between the antigen and the antibody. The establishment of the blood types comes from the research of Karl Landsteiner that revolved around issues of immune reactions of donors of blood transfusions to the donated blood. In which, Landsteiner established a system of four major blood types (A, B, AB, and O) based on the premise that individuals of various blood types exhibit distinct antigen markers (A or B) that will interact with antibody proteins (IgM) for that distinct antigen (anti-A or anti-B). From this line of research, it was surmised that individuals for a distinct blood type would have the antigen for that blood type and an antibody for opposite blood type, table 1. What is interesting is that the genetics of the blood types and human evolution have led to population demographics based on blood types, Table 2.

Table 1. The summary of ABO Blood Type Groups based on presence of antigens and circulating antibodies.

Blood Type	Antigen	Circulating Antibody
A	A antigen	Anti-B
B	B antigen	Anti-A
AB	A and B antigens	NONE
O	Non-A antigen, Non-B antigen	Anti-A and Anti-B

Table 2. Summary of blood type percentages within the population of the United States and by demographic group. Source American Red Cross, 2018.

Blood Type	Entire Population	Caucasian	African American	Hispanic	Asian
O+	37.4%	37%	47%	53%	39%
O-	6.6%	8%	4%	4%	1%
A+	35.7%	33%	24%	29%	27%
A-	6.3%	7%	2%	2%	0.5%
B+	8.5%	9%	18%	9%	25%
B-	1.5%	2%	1%	1%	0.4%
AB+	3.4%	3%	4%	2%	7%
AB-	.6%	1%	0.3%	0.2%	0.1%

Knowing the antigen and circulating antibody for an individual is essential for transfusions and emergency, or operative, care. Based on the antigen and circulating antibody, safe transfusions can only occur when there is a non-binding match between the

individual's circulating antibody and the blood that is transfused. As such, a person with type AB blood is able to receive blood for any other person, while type O blood is able to donate to every person.

There is a secondary antigen marker that was discovered following the work of Landsteiner that led to the establishment of the Rh-factor in blood typing. The Rh antigen is a relatively weak antigen marker and will seldom induce an immune response that is seen with other erythrocyte antigens. Unlike the major blood types with only three distinct antigen markers, there have been over 49 distinct antigen markers of the Rh factor. The indication of presence, or absence, of one Rh factor none to induce a stronger antibody match on blood gives the us the blood typing designation of "+" (presence) or "-" (absence) of this antigen, the D antigen. Given the three major antigen markers and one strong Rh factor, we are able to develop a table of blood transfusion compatibility that is used when collecting and distributing donated blood to individuals, table 3. From this table, we are able to determine the likelihood of mismatch immune reactions due to blood type incompatibility. Another issue of incompatibility that can arise is the Rh incompatibility between a pregnant female and the fetus, *erythroblastosis fetalis*. An issue that occurs when an Rh- female is pregnant with an Rh+ fetus leading to immune sensitivity to the D antigen and production of anti-D IgM. Subsequent pregnancies with Rh+ fetuses can lead to immune reactions and necessitates treatment to sequester the pregnant female's immune response.

Table 3. Summary of compatibility of blood types between donor and recipient. Note that N indicates mismatch and possible immune response, while C indicates no mismatch and compatible blood type

	Donor's Blood Type								
		O+	O-	A+	A-	B+	B-	AB+	AB-
Recipient's Blood Type	O+	C	C	N	N	N	N	N	N
	O-	N	C	N	N	N	N	N	N
	A+	C	C	C	C	N	N	N	N
	A-	N	C	N	C	N	N	N	N
	B+	C	C	N	N	C	C	N	N
	B-	N	C	N	N	N	C	N	N
	AB+	C	C	C	C	C	C	C	C
	AB-	N	C	N	C	N	C	N	C

Understanding of the blood types and blood compatibility is essential to modern health care. This lab will examine the responses of your own blood to the three distinct antibody proteins (anti-A, anti-B and anti-D) that will thus allow you to determine your own blood type.

Materials and Methods:

Materials

- Paper towel
- Blood Test Card
- Lancet
- Alcohol Swab
- Release Form
- Anti-sera (anti-A, anti-B, anti-D)
- Toothpicks
- Band-Aid

Methods

1. Obtain release form from instructor and consent to participation in the study
2. Obtain lancet, alcohol swab, blood card, toothpicks from designated area

3. Place lancet, toothpicks and blood card on paper towel at your lab station
4. Glove your dominant hand with disposable medical examination glove
5. Scrub tip of middle or ring fingertip on non-dominant hand with the alcohol swab
6. Remove the sterile lancet from its wrapper and firmly press onto the freshly cleaned fingertip about 1 cm from the distal edge of the digit.
7. Gently squeeze the sides of the finger that was just lanced forcing a small droplet of blood to the surface, place the droplet of blood coming to the surface on to the most left region marked “BLOOD” on the Blood Test Card.
8. Repeat step 6 for the remaining two “BLOOD” regions on the Blood Test Card.
9. Clean finger with alcohol swab and place Band-Aid over the lanced region of the fingertip.
10. Place bloody materials into the biohazard bag and the lancet into the sharps container
11. Place a drop of anti-A into ring indicated as “anti-A” and a drop of anti-B into the ring indicated “anti-B”.
12. Following the anti-A and anti-B, place a drop of anti-Rh into the ring indicated as “anti-D”
13. Using the coloring matching toothpick mix the blood droplet with the anti-sera droplet, stirring the two droplets until the mixture covers both circles in each region of the blood card.
14. Dispose of toothpicks into the biohazard bag
15. Gently rock the Blood Test Card in gloved hand for 1-minute (be careful not to mix blood from different regions of the card), allowing the blood and the anti-sera to continue to interact.
16. Tilt the card slightly allowing the blood and anti-sera to drain towards one side (but kept in the appropriate regions of the card) and examine appearance of mixture (compare to reference image and summary in table 4).
 - a. If granular film as developed within the mixture, agglutination has occurred and serves as indication for having that type of antigen on your erythrocytes.
 - b. If a uniform film, with no granulations occur, appears then there is no agglutination and therefore that antigen is not present on your erythrocytes.
 - c. Record results in data table

Table 4. Agglutination responses based on blood type

Blood Type	Anti-A Reaction	Anti-B Reaction	Anti-Rh Reaction
O+	No reaction	No Reaction	Agglutination
O-	No reaction	No reaction	No reaction
A+	Agglutination	No reaction	Agglutination
A-	Agglutination	No reaction	No reaction
B+	No reaction	Agglutination	Agglutination
B-	No reaction	Agglutination	No reaction
AB+	Agglutination	Agglutination	Agglutination
AB-	Agglutination	Agglutination	No reaction

17. Wait 4-minutes and repeat step 16 for reading the Rh only (as the reaction can take up to 5-minutes)

- a. Record results in data table

18. Tabulate your blood type in group data table (use the Google Doc link) and compare your group’s results to the population norms for your group.

Results

Agglutination in:

Anti-A:

Anti-B:

Anti-Rh:

Blood Type:

Within your group discuss which blood type could you always transfuse? What happened if the wrong type was used? Why would it be important to know your blood type or a patient's blood type?

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1.16: Cardiovascular Physiology- Heart Rate Responses

Objectives:

At the end of the lab you will be able to...

1. Be able to associate observed changes in rate, rhythm of the heart along with changes in cardiac functions associated with altered fluid flow from changes in body position, thoracic volumes (impact breathing has on amount of volume heart can achieve) and physical exertion.
2. Be able to explain how modifiable and non-modifiable factors impact the observed changes.
3. Understand the issue of norms within a population and the factors of associative analysis.

Pre-Lab

1. What factors will change heart rate?
2. What is the relationship between the volume of blood returning to the heart and the volume of blood that can be ejected from the heart?
3. Why does fluid pressure change when someone goes from supine to standing?
4. What is the principal reason that heart rate will change during exercise?
5. Develop your hypothesis.

I. INTRODUCTION

Examination of heart function and cardiac cycles allows you to compare the electrical output of the heart to the morphological changes associated with the movement of blood through the chambers of the heart. These changes reflect the fluid movement throughout the blood vessels of body and are influenced by the level of resistance to flow through the vessels. This pattern of activity and the timing of mechanical events under normal conditionals last approximately 600 msec from the depolarization of the SA node through the contraction within the ventricular systole. A contraction pattern that is then be followed by a period of limited electrical activity as the heart is deemed to be in the intercycle refractory period that allows for venous return to the heart (finalized atrial diastole) and thus allow for complete venous return and “filling” of the heart. Each full cycle of the heart from the resting “fill” through the contraction of the ventricles and ejection of blood into the arteries of the body is deemed a *heartbeat* or one cardiac cycle occurring every 900 msec to 1.2 seconds for adults. The cadence that the heart uses over time is thus referenced as *heart rate*. The means by which the cycle is regulated and modulated is based on several physiological and anatomical factors. These factors include the volume of blood being moved, the resistance to blood leaving the heart (i.e. blood pressure), and the relative amount of autonomic nervous stimulus at the SA node and throughout the heart. All of these factors will impact how a contraction will take place and the effectiveness of the contraction. In which we know that as volume of load increases, the strength of contraction will increase, and this will generate a greater amount of blood being moved. Whereas as resistance to flow increases (more total peripheral resistance) a larger contraction is necessary to move a smaller volume.

Peripheral Resistance and Impact on “Blood” Pressures:

The flow of blood through the blood vessels (arteries and veins) is explained by the physics of fluid flow through a tube. In the case of the vessels, the tubes will offer varying degrees of resistance to flow and force upon the fluid within the blood vessels as blood moves through them. All in all, there are three factors that ultimately determine the resistance to flow and total pressure within the vessels of the cardiovascular system: vessel diameter, blood viscosity (how well it can flow/or not flow) and the total amount of vessel that fluid is having to move through to get around the system, see Haigen-Pousalt equation. These factors contribute to establishing a fluid pressure that the blood exerts onto the vessels, i.e. blood pressure. Typically, this pressure is discussed in relationship to the pulses of blood ejecting from the heart during ventricular systole (systolic pressure) and diastole (diastolic pressure). The combination of fluid pressure with anatomical changes (referred to as compliance) in the vessels establish a resistance of flow that impacts the propulsion of blood through the arteries, and veins, throughout the circuit of the vessels within the body and ultimately impacts the pressures measured clinically.

Haigen-Pousalt Equation: $P = \frac{8\eta LQ}{\pi r^4}$; where P is pressure within the vessel, L is length of vessel, Q is volume of flow through vessel, r is radius of the vessel and η is the viscosity (resistance to flow) of the fluid.

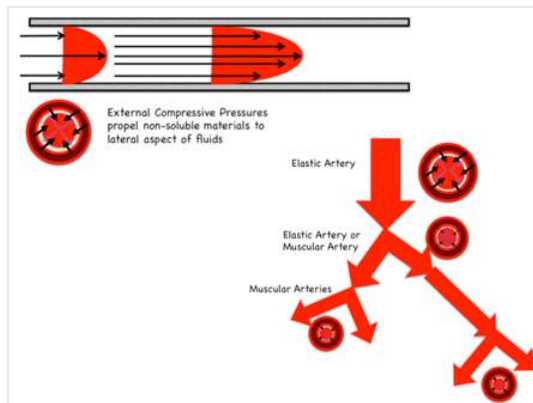


Figure 1. Combination of the compressive force of tunica media and the branching of arteries leading to a change in the external compressive force and resulting internal blood pressures within the lumen.

Due to anatomical and physiological differences, the amount of pressure within vessels will vary. As such, arteries exert a higher resistance to flow than veins due to the constant tension of the tunica media which means that the pressures will be higher in the blood while on the arterial side of flow and lessens to near zero as the fluid moves through the venal side of flow. The pressure within the lumen of the artery is controlled and regulated by the muscles and elastic connective tissue within the tunica media that when compliant will generate an inward force, pressing onto the fluid within the vessel (a positive pressure). This positive pressure thus propels the fluid forward when there is no propulsive force of the pulse of blood being ejected from the heart, figure 1. As fluid moves through the arteries the amount of propulsive force from the ventricle diminishes (from the highest pressure at the aortic valve) and the only forward pressure that is imparted on the fluid will come from the positive pressure of the vessel lumen. This drop in propulsive force is accompanied by an increase in the length of lumen (due to the branching of the arteries) and reduction in volume within the lumen that results in the phenomenon of gradual decrease of blood pressure as blood moves through the branching network of vessels. Additionally, this pressure will vary based the diameter of the vessel and the ability to be compliant to meet the change in fluid pressures as volume shifts with each pulse of blood ejecting from the heart. Ultimately this relationship between the ability for the lumen to adjust to the pressure with the lumen develops resistance to flow where any increase in compliance leads to a reduction in pressure, while and decrease in compliance leads to an increase in blood pressure and indicates the functionality of the vessels. An issue we see with individuals in normal compensatory responses to everyday stresses and can be witnessed regarding issues of compliance and tension responses to orthostatic challenges, e.g., individuals when moving rapidly from a lying to a standing position; or in response to exercise at very high levels of exertion; or even within ventilation, as increased lung volume and/or intra-abdominal pressures restrict volume compliance within the arteries of the thorax. Regardless of the reason, any excessive pressure changes lead to a feedback loop that triggers a baroreceptive reflex, an alteration of systemic peripheral resistance and a resulting change in heart rate to accommodate for an alteration in stroke volume, figure 2.

Norms and Variability in Measures:

The cardiac cycle (Heart Rate, HR) is influenced by several factors that relate to the homeostatic regulation of cardiac output, the determination of volume of blood moved per minute based on the product of heart rate, HR (beats/min) and stroke volume, SV (mL/beat). The values for individuals are highly variable based on everything from body position, to ventilation (figure 2), to factors such as age, gender, and several health and fitness factors (principally controlled by the amount of activity) that change the rate and volume of venous return that directly impacts the amount of blood circulated per cardiac cycle. Most of this modification is based on the concept known as the Frank-Starling Law, which indicates the relationship between venous return (VR) with end systolic volume (ESV), end diastolic volume (EDV), stroke volume (SV), and thus heart rate (HR) and ejection fraction (EF). Simply stated, the Frank-Starling Law (i.e. length-tension relationship) of cardiac function indicates that a slower HR allows for

increased filling of both atrium and ventricle and thus provides for an increase in EDV and SV as well provides a stronger contraction of the cardiac muscle.

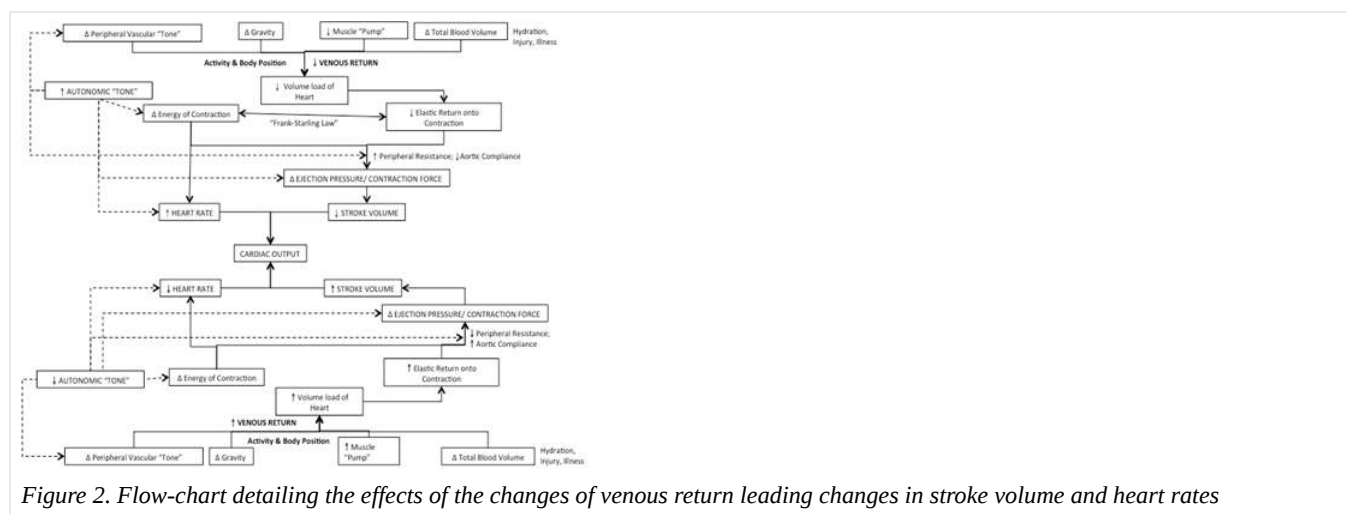


Figure 2. Flow-chart detailing the effects of the changes of venous return leading changes in stroke volume and heart rates

Thus, there is a direct relationship between VR with SV (i.e. increase in VR leads to a proportional increase in SV) and an inverse relationship with HR (i.e. increase in VR leads to a proportional decrease in HR) and vice versa when VR diminishes, as seen with physical activity, changes in body position, or the simple action of ventilation. The relationship when seen in response to any type of activity leads to the compensatory response of changes in HR, or a cardiac drift. The degree of drift is dependent on adaptations that occur within the cardiovascular system to repeated bouts of activity. In which improved arterial compliance and greater pressure reservoirs that generates greater venous return leading to an increased SV thus a lowering HR and improved cardiovascular function both acutely (during the activity) as well as chronically (due to adaptations) regardless of the type of physical activity that is employed for training and creates improvements in EF as SV increases and EDV decreases within each cardiac cycle. Thus, it would be expected that those who are more active would have lower HR and pressures than those who are less active.

Acutely, this relationship can be exhibited through a response of cardiac shift inducing cardiac drift. A rapid change in VR is typically associated with a systemic hypotensive response (i.e. rapid drop in peripheral resistance/blood pressure) that is accompanied by a rapid drop in SV and a rapid increase in HR, referred to a baroreceptive reflex. Additionally, there is a neural and neuroendocrine modification that is associated with the concept of autonomic tone, primarily because of epinephrine and norepinephrine have on a tissues ability to depolarize any increased exposure to either chemical increases the likelihood for depolarization at the SA node and along the conductive pathways, along with the rate of force development within the contractile tissues of the myocardium of the heart. Thus, combining to increase the rate of cardiac cycles. Antagonistically, exposure to acetylcholine reduces the rate of depolarization at the SA node and along the conductive pathway thus reducing the rate of depolarization waves and the associated frequency of the cardiac cycles. As such, we must indicate the type of measurement being obtained and referenced. The most common references are the **non-exertional** ($HR_{non-exertion}=HR$ when not actively involved in physical activity) with a normal for intrinsic rate of 72-92 bpm (range from 45-140 bpm), **resting** ($HR_{rest}=HR$ at complete rest without external/internal stressor, i.e. supine in quite dark room after at least 15-minutes following initiation of the test). There is sometimes confusion between the idea of "resting" and "non-exertional" HR, but these are two separate measures based on the testing conditions under which the cardiac cycles are being sampled. Additionally there are the for measurements for exertion or physical activity such as: **minimal exertion** ($HR_{min}=HR$ at minimal exertion, but always given in relation to the maximal exertion for the person); **maximal exertion** ($HR_{max}=maximal$ sustainable HR (based on 180-second of stable response), related to maximal exertion or maximal oxygen consumption, VO_{2max} , and typically obtained with a stress test or test of aerobic fitness); **age-predicted maximal** ($HR_{APM}=age$ -predicted maximal HR based on the equation of $HR_{APM}=220-age$ or $HR_{APM}=208-.8*age$ (in whole yr.)); and the **reserve to maximal** ($HR_{reserve}=percentage$ of difference between HR_{max} (or HR_{APM}) and HR_{min} that is then added to the $HR_{non-exertion}$, is usually used in order to determine HR range for training or rehabilitative purpose).

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Purpose:

Therefore, the purpose of this experiment is to examine the differences in heart rates and changes to a non-exertional situations, so as to compare differences between individuals based on modifiable and non-modifiable factors known to impact heart functions.

Hypothesis:

EXPERIMENTAL OBJECTIVES

At the end of the experiment students should

- 1) Be able to use a stethoscope to correctly auscultate sounds for distinct Korotkoff sounds to measure blood pressure.

MATERIALS

- Heart Rate Monitor
- Steps and Risers
- Stop-watch/timer

METHODS

1. Place the heart rate monitor on the test subject, you need to place it so that it can read whenever you obtain a pulse count
2. Have your subject move from the seated position on to the floor in front of your lab station and lay down in the supine position. Ensure that head, shoulders, and torso are supported and that lower extremities are not extended at the knee (ask subject to slightly bend at the knee and place feet flat on the floor).
 - a. If subject needs to reposition, allow them to do so, but encourage them to remain in a supine position with head and neck completely supported.
 - b. Wait 60 seconds before starting the tests
3. Testing Heart Rate Responses
 - a. Supine Test
 - i. Make sure your subject is in the most comfortable position
 1. Ensure that your subject is breathing normally without large inhalations/exhalations and minimal to no movement.

ii. After 30-seconds in the supine position, obtain the pulse rate by reading the heart rate monitor by watching the monitor (without your test subject moving) for 15-seconds

1. Record the reading at the end of the 15-seconds

b. Supine-to-Stand-to-Sit

i. With your test subject still in the supine position, take a lab chair and place it next to the test subject

ii. Now give a countdown, “3...2...1...stand” have your subject stand-up as quickly as possible and then sit on the chair provided.

iii. Immediately upon sitting check the heart rate monitor and continue to check the monitor as they sit down. Record heart rate at the end of the transition in “Change of Position”

1. Ensure that your test subject safely sits on the chair provided and is breathing normally without large inhalations/exhalations for 60-seconds

c. Ventilation Test

i. With your test subject seated comfortably, instruct them that for the next segment of the experiment they will change their inhalation/exhalation pattern based on verbal cues to “Breathe deeply and slowly, and then hold their breath until told to exhale.” Use the example of taking breaths for the doctor during an examination and to only breathe when instructed.

ii. Have your subject practice this breathing cycle through 3-ventilation cycles so that both of you are comfortable with the test

iii. Wait 30-seconds and watch the heart rate monitor, instruct the test subject to inhale as deeply as possible

i. Obtain the pulse rate at the end of inhalation but before you have them exhale

ii. Repeat 3 times, average HR obtained, record data in data table for “Inhale”

a. Now repeat the breathing exercise but instead of recording the heart for inhaling you will record exhalation

i. Record data in data table for “Exhale”

d. Valsalva test

i. Obtain the pulse rate by reading the heart rate monitor, record data in data table “Pre-Valsalva”

ii. Have the test subject place themselves into a comfortable seated position with their back fully supported in the chair. Once ready, indicate that you are performing the Valsalva test as instructed the test subject to breath on the cue

1. Tell your subject that they are going to take a very deep breath and then will held the breath. While holding the breath tell them that you will ask them to squeeze their abdomen, press their tongue into the hard palate of their mouth, and hold the contraction for 25-seconds.

2. Make sure that you can view the heart rate monitor while also keeping the test subject directly in your line of sight for safety. Give them a countdown and then have the subject hold their breath while squeezing their abdomen and pressing the tongue into the hard palate of the mouth.

3. At 15-seconds into the hold:

a. Obtain the pulse rate by reading the heart rate monitor for 5-seconds, record data in data table “Valsalva”

4. As soon as 25 seconds have elapsed, have your subject relax and begin breathing normally for 5-seconds at 5-seconds, obtain a pulse rate from the heart rate monitor and record in “Post-Valsalva”

e. Response to Brief Physical Exertion

i. Clear the area in front of the seated position place an aerobic step with 1-2 risers under the top (approximately 6-8 inches).

ii. Have the test subject face the step and place their right foot on top of the step with left foot on the ground.

1. With the test subject standing facing the steps, obtain the pulse rate by reading the heart monitor and record data in data table “Pre-Exertion”

iii. Have the test subject exert themselves by using the following cadence have the subject stride onto the step continuously for 60-seconds at a pace they can comfortably keep without pause or termination of striding, stepping up on the right foot every second:

1. Right foot on step; stride forward with left foot and place left foot on top of step.
2. On contact of left foot, transfer weight to left limb and stride right foot to floor (move limb backwards) once in contact with floor (but without stopping) stride forward with right foot and place right foot on top of step.
3. On contact of right foot, transfer weight to right limb and stride left foot to floor (move limb backwards) once in contact with floor (but without stopping) stride forward with left foot and place left foot on top of step repeating the initial movement.
4. Continue without stopping for 60-seconds.
5. At the 60-second mark of exercise, check the heart rate monitor and then give the subject a countdown of “3...2...1...stop”
6. Record the heart rate obtained immediately at the end of exercise in “Post-Exertion”

iv. Have the subject will stop stepping and stand in place on the floor without excessive movement for 20-seconds. During this time keep watch of the test subject to ensure that they are safe following the exertion. After 20-seconds, have your subject sit comfortably in their chair

****Make sure to upload results to Google Document for use in lab report****

RESULTS:

Designation of Level of Physical Activity: (based on average weekly activity level over the last 3 months only)

Low: Less than 3 days of activity at moderate intensity for at least 30-minutes

Moderate: Between 3 and 5 days of activity at moderate intensity for at least 30-minutes

High: More than 5 days of activity at moderate intensity for at least 30-minutes

Demographics Subject 1

Gender:

Age:

Subject is classified as:

Days per week physically active:

Demographics Subject 2

Gender:

Age:

Subject is classified as:

Days per week physically active:

Table 3. Table of heart rate (BPM) responses for each of the testing conditions based on the individual test subject within each of the testing scenarios.

	Supine	Change of Position	Inhale	Exhale	Pre-Valsalva	Valsalva	Post-Valsalva	Pre-Exertion	Post-Exertion
Subject #1									
Subject #2									

Upload your results to the group data table for analysis

Table 4. Change in heart rate (bpm) from the supine position based on each of the testing scenarios.

Calculations are always Condition-Supine for each of the measurements

	Change of Position	Inhale	Exhale	Pre-Valsalva	Valsalva	Post-Valsalva	Pre-Exertion	Post-Exertion
Subject #1								
Subject #2								

For lab report, provide graph of responses based on relationship of heart rate (measured variable) with condition deemed to be manipulated variable

Discussion: **In 2-to-3 coherent paragraphs** discuss your findings based on your test subjects and the class averages based on the demographic identifiers and your understanding of the regulation of the cardiac cycle. Make sure to explain the reason for the change. (In this discussion think about (***do not answer questions as individual assessment questions, use to help formulate your interpretation of the data***): comparison of kinematics between testing situation and the responses within each of the groups based on demographics and factors that influence heart functions. What impact does body posture, changes to intrathoracic pressures, changes due to exertion, impact of gender and level of activity (Why is activity given based on a “high”, “moderate”, or “low” identifier?) have on responses seen? Make sure that you’re attempting to explain the WHY and the HOW of the WHAT {give #'s} occurred. What do changes in sounds of the heart indicate is occurring? How do the changes in heart rates correlate with changes in the pressures that would be experienced in the vessels and the volume of blood returning to the heart?)

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1.17: Gastrointestinal Anatomy and Digestion

Objectives:

At the end of this lab, you will be able to...

1. **Correctly use anatomical terminology to identify the organs and tissues involved with the overall digestion of materials being consumed**
2. **Explain why mechanical digestion only occurs in the mouth by teeth and muscle activity**
3. **Describe process of chemical digestion and reason for process requiring enzymes**
4. **Determine the role of the tissue and /organs of the gastrointestinal system for overall regulation of homeostasis**

Pre-Lab Exercises:

After reading through the lab activities prior to lab, complete the following before you start your lab.

1. The sections of the alimentary canal are the: .
2. The pattern of teeth we have is considered to be and includes incisors, canines (cuspid), pre-molars (bicuspid) and molars.
3. Color the images for use as a reference for identifying the organs.
4. Highlight key steps to the chemical digestion of carbohydrates and proteins
5. How long will chemical digestion of carbohydrates last?
6. How long will chemical digestion of proteins last?

Materials:

- Torso, Head and Mouth Models
- Stickers
- Felt Pens
- Colored Pencils
- Chemical Digestion Kits

The gastrointestinal system has been refined to transfer organic nutrients, minerals and water from the external environment into the internal environment. This process is specialized within the various organs and tissues within the system with a four-stage process utilized in order to accomplish the general function based on the interaction between three distinct segments of organs. The entire process takes place within an elongated opening within the body that while contained with the body, encapsulates a lumen (alimentary canal) that is can be thought of as being external to the body. The length (28-feet) and histology (high level of surface area) ensures complete digestion and absorption of all materials that enter the lumen within approximately 24-hours following initial digestion in the mouth.

The first-stage is the mechanical digestion, taking the large bolus and breaking it into smaller bolus prior to entering the stomach, and takes place within the first segment of the system (the oral opening) via mastication (use of teeth and muscles of jaw). The end of mastication results in swallowing and the initiation of peristalsis, the coordinated contraction of muscles (circular and longitudinal smooth muscles) of the alimentary canal to propel food materials from the mouth to the anus in roughly 24-hours.

The second-stage is the transportation and initial chemical digestion of the food material. This stage occurs in the second segment (esophagus and stomach) where the smaller food boluses that were swallowed is then exposed to a low pH (acidic) solution liquefies the material. This liquefaction is necessary for the third-stage in the next segment (small intestines) for the further chemical digestion by specific enzymes into the individual components (e.g., fats, carbohydrates, amino acids, nucleic acids, inorganic and organic salts). The fourth-stage takes place in the small and large intestines and is responsible for the absorption of the individual food components that have been digested so far within the system. This final segment is also responsible for the reabsorption of water and removal of undigested and nondigestible materials out of the system.

The anatomy of the alimentary canal (esophagus, stomach, small and large intestines) and accessory organs (liver, gall bladder and pancreas) of the system function to maximize the amount that can be digested and absorbed based on blood flow through the tissues. Most organs will function based solely on the ingestion of materials and are not regulated to alter the amount of any individual type of material that can be absorbed. Any material that is not digested (non-digestible) or incompletely digested will not be absorbed and will be removed as fecal matter via defecation, along with any excretions in the lumen. Of the material in the lumen, only 1% will be excreted in the form of fecal matter. The rate at which materials move through the system is based on the regulatory that the material is eaten, the amount that is eaten and the level of hydration. For most meals, materials that will be digested, absorbed and fecal waste removed within 24-hours.

The system is also involved with the regulation of when and how much we eat via the coordinated signals from hormones (LEPTIN,

ghrelin, pancreatic hormones (PYY, insulin, glucagon), neurohormones (NPY, POMC, endocannabinoids), gut hormones (gastrin, secretin, CCK), and AMPkinase) along with stretch receptors within the alimentary canal that either initiates the pull-to (“I need to eat”) or push-away (“I’m full”) feeding responses through signals from the hypothalamus.

****Set-up Chemical Digestion in Activity 3 before completing the rest of the lab****

Activity 1: Organs of Digestion

Procedures:

1. Obtain torso and head models, stickers, felt pens
2. Write names of organs and structures that you are responsible for knowing and identifying on the stickers
Esophagus, Stomach, Liver, Pancreas, Gallbladder, Duodenum, Small Intestine, Large Intestine, Rectum



Organs and Structures of the Digestive System

- 1 Oral Opening (Mouth)
- 2 Salivary Glands
- 3 Oropharynx with Epiglottis and Glottis
- 4 Esophagus
- 5 Stomach
- 6 Liver
- 7 Pancreas
- 8 Gallbladder
- 9 Colon (Large Intestine)
- 10 Duodenum, Jejunum, Ileum (Small Intestine)
- 11 Rectum
- 12 Anus

Color each structure, or organ with a different color to assist with identification

3. Select a “team leader” and use the colored images and reference materials to take turns labeling the torso model

a. As structures are labeled, indicate a function of the organ or structure for digestion.

Structure	Function
Teeth	
Salivary Glands	
Glottis and Epiglottis	
Esophagus	
Stomach	
Duodenum	
Small Intestine	
Liver and Gallbladder	
Pancreas	
Large Intestine	
Rectum	

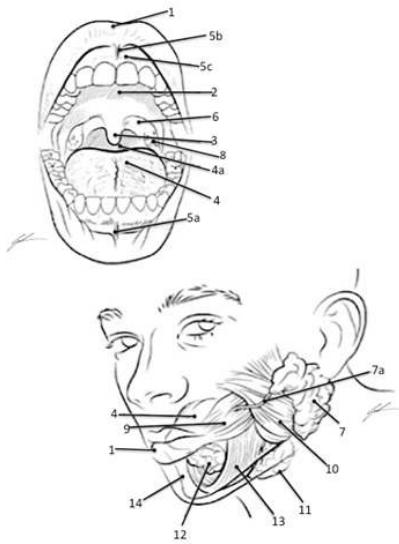
4. Have your instructor check your progress and move to activity 2.

[Activity 2: Anatomy of the Oral Opening and Teeth](#)

Procedures:

1. Obtain torso and sagittal head models, stickers, felt pens
2. Write names of structures of the mouth that you are responsible for knowing and identifying on the stickers

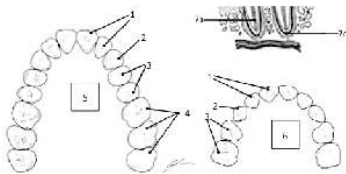
Tongue, Incisor, Canine (Cuspid) Pre-Molar (Bicuspid) Molar, Parotid Salivary Gland, Masseter, Temporalis



Structures of the Oral Opening Associated with Digestion

- 1 Labia (Lips)
- 2 Hard Palate
- 3 Uvula
- 4 Tongue
- 4a Esophagus
- 5a Inferior Labial Frenulum
- 5b Superior Labial Frenulum
- 5c Gingiva (Gums)
- 6 Palatopharyngeal Arch
- 7 Parotid Gland
- 7a Duct of Parotid Gland
- 8 Palatine Tonsils
- 9 Buccinator
- 10 Masseter
- 11 Submandibular Gland
- 12 Sublingual Gland
- 13 Mylohyoid
- 14 Mandible

Color each structure, tissue or organ with a different color to assist with identification



TEETH PATTERN (Omnivore Pattern of 2 Incisor:1Canine (Cuspid):2 Pre-Molar (Bicuspid):3 Molar per side of jaw and per bone of jaw)

- 1 Incisor
- 2 Canine (Cuspid)
- 3 Pre-Molar (Bicuspid)
- 4 Molar
- 5 Permanent (Adult)
- 6 Deciduous (Juvenile)

Color each type of tooth a different color to assist with identification

3. Select a “team leader” and use the colored images and reference materials to take turns labeling the sagittal head and mouth models

a. As structures are labeled, indicate the function of the structure or tooth being labeled.

Structure/Tooth	Function
Masseter Muscle	
Sublingual Gland	
Parotid Gland and Duct	
Submandibular Gland	
Tongue	
Incisor	
Canine (Cuspid)	
Pre-Molar (Bicuspid)	
Molar	

4. Have your instructor check your progress and clean-up your lab area.

ACTIVITY 3: Chemical Digestion of Foods

Purpose:

The following experiment will use various digestive enzymes and environmental conditions to examine the chemical digestion of foodstuff macromolecules (carbohydrates, lipids and proteins) into the smaller molecules that comprise the macromolecules that we consume within our food.

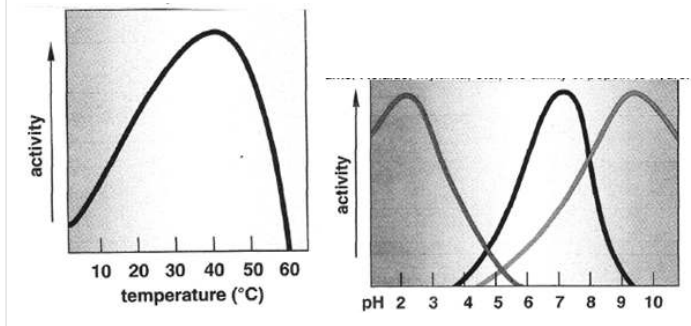
Background:

The function of the digestive system is to break down large food molecules (carbohydrates, proteins, lipids) into the smaller subunits that make them up. This process ensures molecules following digestion are small enough to be absorbed within the intestines and then transported through the vasculature of the body to the tissues and cells where those molecules can then be used. The means by which food is broken down following mastication and chemical digestion.

One must remember that enzymes are proteins and since enzymes are proteins, the environment that they are found will affect their effectiveness. For humans, digestive enzymes function the best at temperatures of 37°C and will be drastically impacted by temperatures above or below this temperature. Being heated above 60°C will lead to the protein being denatured and thus will no longer function properly. Conversely being cooled will progressively decrease activity for some enzymes to the point of no activity once a temperature of 0°C is reached. Additionally, enzymes will function within an optimal range based on pH sensitivity of the molecule. This pH sensitivity is an indication as to where within the pathway of digestion the enzyme will principally function. An example of this would be pepsinogen that must be exposed to the acidic pH (2.0) within the gastric secretions to become active and digest proteins into short-

polypeptide chains. Lastly, the ability for the enzymes within the polar environment of the alimentary canal to interact with non-polar substances will be dependent upon the emulsification that comes about through the exposure and interaction with bile salts.

Figure 1. The impact that changes in temperature and pH has on the activity of the digestive enzymes.



The Importance of Enzymes in Chemical Digestion

There are many different substances that are secreted into the different segments of the alimentary canal. Many of these substances facilitate the breakdown of food (i.e. mucus, bile salts, bilirubin, hydrochloric acid (HCl), and sodium bicarbonate (NaHCO₃)). However, the most important substances secreted for the purpose of digestion are the digestive enzymes. Digestive enzymes greatly enhance the rate at which the covalent bonds that link subunits together to form polymeric biomolecules are broken. Indeed, without the presence of these enzymes, chemical digestion would essentially not occur. Although substances such as HCl and NaHCO₃ can alter non-covalent bonding patterns within and among biomolecules, they typically cannot break down covalent bonds.

These enzymes within the alimentary canal (stomach and intestines) and secreted by the accessory organs (liver, pancreas, salivary glands, gall bladder) will perform the action of digestion based on specificity to a substrate. Where some enzymes will digest complex carbohydrates (polysaccharides) into simpler carbohydrates (disaccharides and monosaccharides), while others will only digest lipids (large fatty acids and triglycerides) into glycerol and free-fatty acids, and others will digest proteins into their amino acid units. In which an enzyme that digest the carbohydrate will not digest the lipid or the protein, and the enzyme for the lipid will not digest the carbohydrate or protein, nor will the enzyme for protein digestion digest the carbohydrate or lipid.

Carbohydrates are the first type of biomolecule to be chemically digested in the alimentary canal, as chemical digestion begins in the oral cavity through a salivary enzyme called salivary amylase (or ptyalin). Salivary amylase begins the breakdown of the polysaccharide amylose (starch, the principal storage carbohydrate in plants) into the disaccharide maltose. However, when food is swallowed and transferred to the small intestine, chemical digestion of carbohydrates effectively stops. Only when the chyme passes into the small intestine will carbohydrate digestion resume. In the small intestine the chyme is exposed to pancreatic amylase (which continues the process of breaking down starch and glycogen into disaccharides and oligosaccharides) and certain brush-border enzymes (e.g., lactase, sucrase, and maltase) that break down specific oligosaccharides into the monosaccharides that are absorbed by the intestinal epithelium.

Chemical digestion of protein begins in the stomach. The stomach produces a mixture of fluids called gastric juice in response to neural stimulation (induced by smell, site and taste of food), by distension of the stomach as food enters, and by pH changes induced as the more neutral pH food enters the acidic stomach. Gastric juice contains a number of substances, but the two most important for initiating protein digestion are hydrochloric acid (HCl) and the protease pepsin. HCl is secreted by parietal cells in the gastric mucosa. The low pH (~2) of the gastric juice aids protein digestion in a couple of ways. First, the low pH denatures the tertiary structures of ingested protein, making them easier to digest enzymatically. Secondly, the low pH is required for the activation of pepsin. Pepsin is produced by chief cells of the gastric pit in the molecule's inactive form called pepsinogen, but once it diffuses into the lumen of the stomach the acidic conditions enable it to have a weak proteolytic activity). Pepsinogen can digest some ingested protein, but more importantly pepsinogen molecules will partially digest one another, removing inhibitory segments of the polypeptide chain and thus converting each other into the fully active enzyme pepsin. Pepsin breaks peptide bonds between amino acids with hydrophobic side chains in the middle of polypeptides, thus it cleaves long polypeptides into shorter polypeptides.

Although the chemical digestion of protein begins in the stomach through the actions of pepsin, most of the digestion of protein takes place in the small intestine. Indeed, individuals with complete gastrostomies can still completely digest protein, although the homogenization of chyme through chemical and physical digestion in the stomach aids this process. The proteases that function in the small intestine comes from two major sources: membrane bound enzymes on the brush-border of the intestinal mucosa, and enzymes secreted into the small intestine from the pancreas. The pancreatic enzymes, along with bicarbonate salts, are components of pancreatic juice that is secreted primarily when food enters the small intestine through the pyloric sphincter. Chemicals in the chyme induce cells in the small intestine to secrete the hormones secretin, which stimulates water and bicarbonate secretion in the pancreas, and

cholecystokinin (CCK), which stimulates enzyme secretion in the pancreas. These hormones, in turn, cause the pancreas to release pancreatic juice through the duodenal papilla. A number of different proteases are found within pancreatic juice, but most are released as zymogens (inactive enzymes). Enzymes in the brush-border activate these zymogens, which ultimately digest the polypeptides into a combination of free amino acids, dipeptides, and oligopeptide that are absorbed by intestinal epithelium.

Lipids are a particularly challenging group of molecules to chemically digest, as fats being hydrophobic tend to aggregate into large droplets within the water environment of the alimentary canal. The result of the aggregation minimizes the surface area of contact between the fat and the surrounding water. Since the digestive enzymes are water soluble, they can only come into contact with and digest those triglyceride molecules at the surface of the droplets. Thus, for fat digestion to be efficient, the large droplets must be broken into much smaller droplets and held in these smaller droplets in order to increase surface area and enable enzymes (lipases) adequate contact with their substrate. Although there is a gastric lipase secreted in the stomach that causes a small amount of fat digestion, and infants produce a salivary lipase, almost all of the digestion of fat takes place in the small intestine. Like protein digestion, fat digestion is achieved through the activity of both pancreatic and intestinal brush border lipases. However, efficient fat digestion also involves the secretion of bile from the liver and gall bladder. Bile contains a mixture of bilirubin, cholesterol, phospholipids, inorganic ions, phospholipids, and negatively charged cholesterol derivatives called bile salts that functions to emulsify the lipids in the water of the alimentary canal assisting the digestion of the large fat droplets. The interaction with bile in the small intestine greatly increases the surface area over which lipases can come into contact with the triglycerides and hydrolyze them into amphipathic free fatty acids and monoglycerides, both of which can be absorbed by the intestinal epithelium. The liberation of free fatty acids, which are acids, would lead to a decrease in the pH of the fluid passing through the intestine, although normally the presence of bicarbonate in the pancreatic juice's buffers against a decrease in pH.

Hypothesis: Generate a hypothesis regarding conditions that would best allow for digestion to occur.

Materials and Methods:

Test-tubes Wax Pencils Test-tube Rack pH paper	Reagents: Distilled H ₂ O 5% Starch Solution 5% Maltose /Dextrose Solution Egg White (Boiled)	Digestive Enzymes & Regulators: Saliva (or 5% Amylase) 5% Pepsin 0.2 M HCl 0.2 M NaHCO ₃	Indicators: IKI-solution Benedict's Solution
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Methods:

Complete the digestion activity as assigned by your instructor. Following completion of the digestion you will share results with the other members in your group.

Activity 1: Assessing Starch Digestion by Salivary Amylase.

1. From the general supply area, pipette distilled water, maltose, amylase and starch solutions as indicated into the appropriate test tube as indicated in Table 1A
2. Once all tubes have been made, add the appropriate HCl or NaHCO₃ solutions into test tubes 6A-11A as indicated in Table 1A

Table 1A. Set-up for each test-tube for digestion of starch by amylase.

Tube	Reagent and Amount	Reagent and Amount
1A	5 mL- Starch Solution	
2A	5mL-Distilled Water	
3A	5 mL- Maltose/Dextrose Solution	
4A	5 mL- Starch Solution	
5A	5 mL- Starch Solution	
6A	5 mL- Starch Solution	5 mL- HCl
7A	5 mL- Starch Solution	5 mL- HCl
8A	5 mL- Starch Solution	5 mL- NaHCO ₃
9A	5 mL- Starch Solution	5 mL- NaHCO ₃
10A	5 mL- Maltose/Dextrose Solution	5 mL- HCl
11A	5 mL- Maltose/Dextrose Solution	5 mL- NaHCO ₃

3. From your supplies, obtain your pH indicator paper. Get 1 strip for each test tube and place 1 drop of each solution on the test strip. Record pH of solutions in Table 3.
4. Using a clean transfer pipette, transfer 5-mL of the collect saliva into test tubes 4A, 5A, 6A, 7A, 8A, and 9A (Make sure not to touch the solutions with the pipette that you are using to transfer the saliva)
5. Cap the test tubes and shake to mix for 30-seconds
6. Set timer for 30-minutes
7. Transfer test tube into test tube rack in incubation temperature as indicated in Table 1B. Make sure to submerge the test tube in the incubation bath, for ice this may mean making a small hole in the ice with your finger. Once all test tubes are submerged start your timer.

Table 1B- Incubation temperature for chemical digestion of carbohydrates by salivary amylase.

Test Tube	1A	2A	3A	4A	5A	6A	7A	8A	9A	10A	11A
Incubation Condition	Warm Water Bath	Warm Water Bath	Warm Water Bath	Warm Water Bath	Ice Water Bath	Warm Water Bath	Ice Water Bath	Warm Water Bath	Ice Water Bath	Warm Water Bath	Warm Water Bath
Temperature (°C)	37°C	37°C	37°C	37°C	0°C	37°C	0°C	37°C	0°C	37°C	37°C

8. While the solutions are incubating, from the general supply area, obtain a test tube rack, 11 test tubes, IKI, Benedict's solution
9. Label tests as indicated 1A, 2A, 3A, 4A, 5A, 6A, 7A, 8A, 9A, 10A, 11A
10. After 30-minutes, remove the tubes from the water bath or ice bath
11. Divide the contents of each tube into two using the second test tube that you just labeled.
12. For each pair of test tubes:
 - a. Take the original test tube and add 2-to-3 drops of IKI
 - i. Agitate the test tube to mix the solution with the IKI and record the color in Table 3.
 - b. In the second test tube add 5-drops of Benedict's solution.
 - i. Place test tube in the boiling water bath for 5-minutes (should see color change within the solution)
 - ii. Carefully using the test tube holders remove the test tubes and return to your work area, record your results in Table 3.

As a group, think about: Why do you need to test dextrose (maltose) solution in IKI and Benedict's Solution? *Share your thoughts with your instructor*

Activity 2: Assessing Protein Digestion by Pepsin.

1. From the general supply area obtain 8 clean test tubes, and pipettes
2. Label test tubes 1P, 2P, 3P, 4P, 5P, 6P, 7P, 8P
3. Cut the cooked egg white into small slices (approximately 1 mm thick)
4. Using a toothpick, carefully transfer 5 slices and place into test tube 1P, tamp down into the test tube so that the egg is suspended in the solution.
5. Repeat for each test tube until all 8 have egg (Make sure that you are using a different toothpick for each test tube)
6. Fill test tubes as indicated in Table 2A
7. Using a different transfer pipette for each solution or reagent transfer the correct amount into each tube based on the following table for amounts of solutions and reagents to place in each test tube. Make sure to shake to ensure that the solution is homogenous. When drawing solution, begin from the bottom and continuously draw into the pipette as you pull the pipette out of the bottle.

Table 2A. Set-up for each test-tube to perform the digestion of proteins by pepsin.

Tube	Reagent and Amount	Reagent and Amount
1P	10 mL- DiH ₂ O	
2P	5 mL- Pepsin	
3P	5 mL- Pepsin	5 mL- HCl
4P	5 mL- Pepsin	5 mL- NaHCO ₃
5P	10 mL- DiH ₂ O	
6P	5 mL- Pepsin	
7P	5 mL- Pepsin	5 mL- HCl
8P	5 mL- Pepsin	5 mL- NaHCO ₃

8. When dispensing Pepsin into test tubes 2P, 3P, 4P, 6P, 7P, 8P.
 - a. Make sure to shake the bottle with Pepsin to ensure solution is homogenous
 - b. When drawing, begin to draw from the bottom and continue to draw in Pepsin as you slowly pull pipette from bottle.
 - c. When dispensing into the test-tube, be careful to not allow the pipette to touch the solution in the test tube.
9. From your supplies, obtain your pH indicator paper. Get 1 strip for each test tube and place 1 drop of each solution on the test strip. Record pH of solutions in Table 4.
10. Cap the test tube and shake for 30-seconds to mix the solution
11. Set timer for 15-minutes.
12. Transfer test tube into test tube rack in incubation temperature as indicated in Table 1B. Make sure to submerge the test tube in the incubation bath, for ice this may mean making a small hole in the ice with your finger. Once all test tubes are submerged start your timer.

Table 2B- Incubation temperature for chemical digestion of carbohydrates by salivary amylase.

Test Tube	1P	2P	3P	4P	5P	6P	7P	8P
Incubation Condition	Warm Water	Warm Water	Warm Water	Warm Water	Ice Water	Ice Water	Ice Water	Ice Water
Temperature (°C)	37°C	37°C	37°C	37°C	0°C	0°C	0°C	0°C

13. After 15-minutes, remove the tubes from the water bath or ice bath and examine the eggs for indication of digestion. Record your observations in table 4.
14. Return to the correct incubation.
15. Repeat the timer for 15-minutes examining the egg at 15-minute intervals for signs of digestion for a total of 1-hour.
16. At the end of the incubation period, remove test tube for the ice or warm water
17. Do a final examination of the eggs for signs of digestion. Record your results in the table 4.

As a group, think about: Why do you need to test a control solution in the experiment? What test tube is the control solution in this activity? *Share your thoughts with your instructor*

Results

Table 3 Results of the digestion of starch by amylase based on testing condition.

Test Tube	pH of Solution	IKI Test (Color)	Indication of Digestion of Starch (yes/no)	Kind of carbohydrate-solution do you have after 30-minutes of digestion
1A				
2A				
3A				
4A				
5A				
6A				
7A				
8A				
9A				
10A				
11A				

*Note that the digestive enzyme solution has glucose present within the solution. **TEST COLOR INDICATOR: IKI:** Purple=Starch, Red=Dextrin, Tan/Yellow=Maltose; **Benedict's Solution:** Orange/Yellow = disaccharide present (low, moderate, high), Green= trace amounts of disaccharide, Blue= no disaccharide (negative)

Table 4. Results of protein digestion based on different conditions.

Test Results	1P	2P	3P	4P	5P	6P	7P	8P
pH of solution								
Initial Observation (Time: 0-min)								
Observation (Time: 15-min)								
Observation (Time: 30-min)								
Observation (Time: 45-min)								
Observation (Time: 60-min)								
Determination of digestion of egg protein at the end of 60-minutes (Yes/No)								

If digestion has occurred, egg white will begin to fray and dissolve within the test tube. You will notice fraying at the edges and “bubbles” within the solid egg white, there may also be “wisps” of white material (looks like clouds) with the solution in the test tube. To evaluate digestion, you may need to agitate test tube by gently shaking side-to-side for a few seconds.

Discussion: In a coherent paragraph discuss your results (Think about: What can you conclude about the impact that environmental conditions had on the enzymes, relative to their functionality? How will the results for digestion by the various enzymes allow you to determine the area of activity within anatomy of the gastrointestinal system for each enzyme? In your discussion, address how temperature of the reaction, addition of co-factors of the enzyme each affected the direction of the reaction and what this means about where activity of the enzymes might be highest/lowest within the totality of the alimentary canal.)

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1.18: Excretory System and Urinalysis

Objectives:

At the end of this lab, you will be able to...

1. Correctly use anatomical terminology to identify the organs and tissues associated with urine formation
2. Determine the role of the tissue and /organs of the excretory system for overall regulation of homeostasis
3. Correctly dissect kidney and identify tissues, regions and structures using appropriate anatomical terms
4. Differentiate hydration status based on USG and norm values
5. Perform urinalysis and determine abnormal versus normal values and infer probable causes

Pre-Lab Exercise:

After reading through the lab activities prior to lab, complete the following before you start your lab

1. The organs associated with the excretory system are the , the_, the_, and the .
2. The normal pH range for the body is to .
3. A normally hydrated person should have colored of urine and a Urine Specific Gravity (USG) of between and .
4. Color the images for referencing when labeling models and performing the dissection.

Materials:

- Torso Model
- Kidney Model
- Stickers
- Felt Pens
- Colored Pencils
- Kidney
- Dissection Tray and Tools
- Urinalysis Kits

The excretory system is a complex system that integrates a number of organs (kidney, liver, lungs, skin/sudoriferous glands) from various regions of the body that all function together to transform and remove toxins and metabolic wastes, regulate pH of the body, and regulate hydration and electrolyte balance. the two principal sites of action are in the lobules of the liver (via hepatocytes) and the nephron of the kidney.

The system is responsible for several homeostatic regulation processes that ensure that plasma chemistry remains stable. That is done through monitoring concentrations of metabolites (substances produced in a reaction that are released from the site of origin, but can be used in metabolic reactions), excreting waste products (substances produced in a reaction that are released from the site of origin that can no longer be used in metabolic reactions), transforming and excreting endotoxins and exotoxins (substances that are either produced within the body or ingested that can disrupt normal physiological functions), buffering changes in pH (via accumulation or excretion of acids and bases that act as buffers to each other), and monitoring levels of electrolytes (ions responsible for membrane functions) and osmolarity (concentration of solutes within the plasmal water).

Within the overall functions, the liver is responsible for the removal of solid and aqueous toxins, lipids, and any solid waste products (non-water soluble) from the blood. The lungs are responsible for the removal of gaseous (volatile) substances from the blood. The kidneys and sudoriferous glands are responsible for the removal of any aqueous (water soluble) toxins and waste products from the blood.

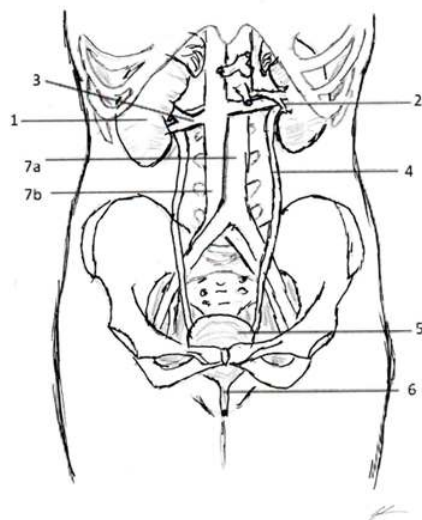
The system functions so that each organ in the system works in conjunction with, and independent of, the other organs. This interaction and independence ensure that blood chemistry remains relatively stable and within homeostatic ranges for the varies substances. Resulting in a plasmal pH RANGE of 7.35-7.45 (average 7.42) using the buffer systems (bicarbonate, ammonia, phosphates and proteins) that can be used either as weak acids, or weak bases to quickly and temporarily bind H^+ (do not remove H^+). Typically, the buffers will act as Lewis Bases (willing to accept electrons or H^+) to the Lewis Acids (willing to give electrons or H^+) in the aqueous environment of the cell or plasma until the H^+ ions can be excreted from the body. Maintain both water and ion concentrations within the tissues and fluids of the body at a homeostatic level so that membrane potentials are homeostatically maintained to keep functions of all cells normal and along with that hydration balance. That coordinates hormone and nervous

signals from the hypothalamus to initiate the desire to consume water (drink) or reabsorb water during the process of forming urine from the filtrate. Water and ion balance is also important in the buffering and pH balance of the body through coordinating the anion gap, difference between anions (negative ions including HCO_3^- , Cl^-) and cations (positive ions including Na^+ , K^+ , Ca^{++}) concentrations. These ions and water balance are regulated hormonally by aldosterone, vasopressin/antidiuretic hormone (ADH), atrial natriuretic peptide (ANP), angiotensin ii, calcitonin, calcitriol, and parathyroid hormone (PTH).

Activity 1: Anatomy of the Excretory System

1. Obtain torso model, stickers and felt pen.
2. Write the organs and structures that you should be able to identify on the stickers
Lungs, Liver, Kidney, Ureter, Urinary Bladder, Urethra
3. Take turns within your group to label the structures. As you label indicate the function of the organ or structure for the excretory system

Organ/Structure	Function
Liver	
Lung	
Kidney	
Ureter	
Urinary Bladder	
Urethra	



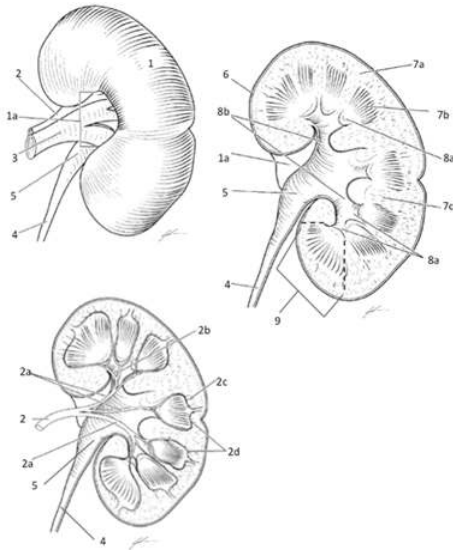
Organs of the Excretory System associated with urination

1. Kidney
2. Renal Artery
3. Renal Vein
4. Ureter
5. Urinary Bladder
6. Urethra
- 7a. Aorta
- 7b. Inferior Vena Cava

Color each organ and structure a different color to assist with identification

4. Have your instructor check your labeling before moving to Activity 2.

Activity 2: Anatomy and Dissection of the Kidney



Anatomy of the Kidney

1 Kidney

1a Hilum of Kidney

2 Renal Artery

2a Segmental arteries

2b Interlobar arteries

2c Interlobular arteries

2d Arcuate arteries

3 Renal Vein

4 Ureter

5 Renal Pelvis

6 Renal Capsule

7a Renal Cortex

7b Renal Medulla

7c Renal Column

8a Minor Calyx

8b Major Calyx

9 Renal Pyramid (between dashed lines)

Color each structure a different color to assist with identification

1. Obtain kidney model, stickers and felt pen
2. Write the structures that you should be able to identify on the stickers
3. Take turns within your group to label the structures.
4. Have your instructor check your labeling before moving to the dissection.
 - a. Once the model has been labeled, move to the side to allow for dissection of the kidney.

Dissection of Kidney:

1. Obtain the Sheep's kidney, Dissection Tray and Tools from your instructor
2. Review how to hold dissection tools and select members of your group that will dissect and members that will be responsible for identifying structures
3. Find the Ureter, Renal Artery and Vein

4. Using the scalpel. Hold the kidney so that the hilum is facing you
5. Start at hilum and make coronal incision towards the apex of the kidney
 - a. Make sure the cut is with some pressure as the capsule may be difficult to cut through.
6. As you reach the apex, turn the kidney so that hilum is facing the dissection mat
 - a. Continue incision along the lateral margin of the kidney
 - b. Your partner will need to apply pressure to “spread” the incision allowing you dissect through the cortex and into the medulla of the kidney
7. Continue incision past the base of the kidney and flip the kidney so that the hilum is facing you once again
8. Once back at the hilum, lay kidney flat and reflect the kidney
 - a. Note that you may need to repeat the incision made around the lateral margin and through the entirety of the medulla to allow for the kidney to be reflected in two
9. After reflecting the kidney
 - a. Find a renal pyramid and at the base of the pyramid, make a transverse incision on one-side of the reflected kidney
 - a) This incision will free a region of one lobe of the kidney from the rest of the organ
10. Inspect the kidney and take turns within your group to identify the various anatomical regions, structures and blood vessels of importance that you are responsible for knowing.
11. Place the kidney under the dissection microscope and examine the kidney looking for blood vessel and renal interactions.
 - a. Can you see the glomerulus and Bowman’s capsule? Why or Why not? Discuss in your group and once you have an answer call your instructor over to see how correct your thinking might be.

Activity 3: Urinalysis

Purpose

The purpose of the lab is to examine 6 different urine samples from individuals that have all changed something within their diet, level of hydration or exercise over the last 24 hours. Where you are going to attempt to determine if by urinalysis you are able to determine what changes were made by each person being analyzed.

Background

Analysis of urine is used to determine the chemical composition of excretions (typically collected over 24-hour period OR at the second voiding of bladder) found in urine. Observation can reveal a lot about the chemistry of the urine and the chemistry of the fluids of the body for the person based on their hydration and metabolic status. A person that is normally hydrated and following a normal diet (not restricting any macronutrients or over consuming drugs or alcohol) should produce about 500-1500 mL urine per day that is a color of pale to straw yellow with no turbidity (able to see through the liquid). Whereas those that are dehydrated can produced $\frac{1}{2}$ to $\frac{1}{4}$ that volume of urine with a color may become darker yellow or amber in color and those that are overconsuming alcohol or drugs may have a turbidity, or cloudiness, that hinders the ability to see through the urine sample. Regardless of the total volume of urine being produced 95-96% will be water (H_2O). Even though yellow is generally seen as normal, many things that are eaten or drunk can cause the color to change to every hue of color in the rainbow. In addition to color and volume, things that we consume can impact the concentration of volatile chemicals being excreted in urine. These volatile chemicals being excreted within the urine can be observed in the odor of the urine, the most common volatile chemical that can be observed would be ammonia, a chemical excreted as a buffer to help stabilize metabolic acids that are being excreted. Along with the general observations of urine, urinalysis can provide insight into the metabolic state of the person through chemical analysis of the urine sample. This chemical analysis will examine pH, Urine Specific Gravity, concentrations of wastes (i.e. urea, creatinine, acids and nitrites), concentration of metabolites (i.e. ketones, glucose, and proteins) or electrolytes (i.e. Na^+ , K^+ , Cl^- , Mg^{2+} , Ca^{2+} , PO_4^{3-}). When discussing these chemical values there are two units given, either millimolarity (mmol/L, mM) or milliequivalent (mEq)/L. The mEq is the indication of the ionic charge provided by the ion in the solution relative to the total amount of ion present (mg of salt).

Table 1. Standard norm urine concentration of electrolyte, metabolic wastes, metabolites and other factors typically seen in urinalysis

	Substance	Concentration (per day)
Electrolytes	Na ⁺	50-130 mEq/L
	K ⁺	20-70 mEq/L
	Ca ²⁺	5-12 mEq/L
	Mg ²⁺	2-18 mEq/L
	Cl ⁻	50-130 mEq/L
	PO ₄ ³⁻	20-40 mEq/L
Wastes	Urea	200-400 mM
	Uric Acid	0.2-1.0 mEq/L
	Nitrated-Urea	5-10 mEq/L
	Creatinine	6-20 mM
	Nitrites	0 mM
	NH ₄ ⁺	30-50 mEq/L
	Organic Acids	10-25 mM
	Bilirubin	0 mM
Metabolites	Glucose:	0-0.8 mM
	Amino Acids	0 mM
	Ketones	< 2 mg/dL
	Proteins (all)	< 10 mg/dL
Cells	Erythrocytes (Blood)	0 cells
	Leukocytes	0 cells

Urine Dipstick Chemical Analysis

pH: The glomerular filtrate of blood plasma is usually acidified by renal tubules and collecting ducts from a pH of 7.4 to about 6 in the final urine. However, depending on the acid-base status, urinary pH may range from as low as 4.5 to as high as 8.0. The change to the acid side of 7.4 is accomplished in the distal convoluted tubule and the collecting duct. In general, people with high protein (meat) diets, low carbohydrate diets, or who are being metabolically stressed should have a urine pH in the acid range and a person who is a vegetarian may have a urine pH in the alkaline range.

Urine Specific Gravity (USG): Urine Specific Gravity (USG) is a measure of density that is proportional to urine osmolality which measures solute concentration relative to di-water. This measure indicates the ability of the kidney to concentrate or dilute the urine relative to plasma, thereby providing a solution that is closer to di-water (1.00) or more solutes than di-water (>1.00) per volume, typically 10 µL on the laboratory urine-refractometer, that uses the refraction of light as a measure of solids in the urine (thus providing density). In this lab we will use a urometer/hydrometer to measure USG, where we will use a float to determine the relative density of the sample of urine to di-water. If USG is not > 1.022 after a 12-hour period without food or water, renal concentrating ability is impaired and the patient either has generalized renal impairment or nephrogenic diabetes insipidus. Any urine having a USG over 1.035 may be contaminated or possibly contains very high levels of glucose or other dissolved substances.

Table 2. Relationship of Urine Specific Gravity to Hydration Status. *Euhydrated is normally hydrated. Hyperhydrated is an indication of too much water consumption. Dehydrated is an indication of acutely under consuming water, while Hypohydrated is a chronic state of under consuming water.*

USG value	Label of Hydration Status	USG value	Label of Hydration Status
< 1.004	Hyperhydrated (Overhydrated)	1.025-1.029	Mildly Dehydrate/Hypohydrated (just beyond limits for Euhydrated)
1.004-1.015	Euhydrated (Normal Hydrated)	1.030-1.034	Dehydrated/Hypohydrated
1.020-1.025	Mildly Dehydrate/Hypohydrated (still within limits for Euhydrated)	> 1.035	Severely Dehydrated

Protein: Normally, only small plasma proteins filtered at the glomerulus are reabsorbed by the renal tubule. However, a small amount of filtered plasma proteins and protein secreted by the nephron. Normal total protein excretion does not usually exceed 150 mg/24 hours or 10 mg/100 ml in any single specimen. More than 150 mg/day is defined as proteinuria. Proteinuria > 3.5 gm/24 hours is severe and known as nephrotic syndrome. Albumin is a protein that can cause turbidity of the urine and can be tested to provide positive results (which represent a slightly hazy appearance in urine) are equivalent to 10 mg/100 ml or about 150 mg/24 hours (the upper limit of normal). 1+ corresponds to about 200-500 mg/24 hours, a 2+ to 0.5-1.5 gm/24 hours, a 3+ to 2-5 gm/24 hours, and a 4+ represents 7 gm/24 hours or greater.

Glucose: Less than 0.1% of glucose normally filtered by the glomerulus appears in urine (< 130 mg/24 hr.). Glycosuria (excess sugar in urine) can be thought of as a symptom of diabetes mellitus, yet consumption of a large sugar meal prior to providing the urine sample or if the person is sick or excessively stressed can also result in an indication of glycosuria.

Ketones: Ketone bodies (acetone, acetoacetic acid, β -hydroxybutyric acid) resulting from someone following a ketotic diet (low carbohydrate) or some other form of calorie deprivation (starvation), are easily detected using urine dipsticks. Ketonuria may result from starvation or diets low in carbohydrates since the body is forced to use fat stores. Ketonuria and glycosuria together, is one of the diagnostic indicators for a condition associated with diabetes mellitus known as diabetic ketoacidosis.

Nitrite: A positive nitrite test indicates that bacteria may be present in significant numbers in urine. Gram negative rods such as E. coli are more likely to give a positive test. Presence of bacteria in urine (bacteriuria) may be confirmed by observing the urine microscopically.

Leukocyte: A positive leukocyte esterase test results from the presence of white blood cells either as whole cells or as lysed cells. Pyuria can be detected even if the urine sample contains damaged or lysed WBC's. A negative leukocyte esterase test means that an infection is unlikely and that, without additional evidence of urinary tract infection, microscopic exam and/or urine culture need not be done to rule out significant bacteriuria.

Erythrocytes (Blood/Hemoglobin): The urine dipstick can detect whole red blood cells as well as lysed RBC's. A positive result for blood may be verified by observing the urine specimen under the microscope.

References:

Armstrong LE. (2007) Assessing hydration status: the elusive gold standard. J Am Coll Nutr. 26: 575S-584S

Bouatra S, Aziat F, Mandal R, Guo AC, Wilson MR, et al. (2013) The human urine metabolome. PLOS ONE 8(9): e73076. <https://doi.org/10.1371/journal.pone.0073076>

Materials:

Urine Collection Cup
Urometer/Hydrometer
15 mL Conical Tube
Urine Test strip and Reference

Methods:

1. Obtain urine collection cup

2. Using the restroom, collect urine sample and return to lab with collection cup sealed
3. Carefully pour sample of urine into the hydrometer container and obtain the Urine Specific Gravity (USG) for sample by reading the line of the hydrometer at the bevel of the liquid within container. Record results.
4. Examine the physical characteristics of the urine (volume, color, and odor) and record results.
 - a. For testing of odor, follow the wafting technique that is demonstrated by your instructor
5. Using a 1-mL transfer pipette, carefully transfer 5-mL of sample of urine using into the appropriate test tube
6. Dispose of urine in collection cup in the urinal of the restroom and wash hydrometer and hydrometer container with soap and water and then rinse with deionized water
7. Using a white piece of paper assess sample for turbidity. Record results
 - a. To test turbidity, draw a large + on the piece of paper and then hold it behind your test tube of urine
 - i. A positive test for turbidity will result in urine that you are unable to see the + that you drew on the piece of paper due to a cloudiness of the urine.
 - ii. A negative test for turbidity will result in you being able to see the + that you drew on the piece of paper
8. Remove a test strips from the canister of urinalysis reagent strips, placing on paper towel on your lab bench
9. Place test strip into test tube of urine, making sure that each of the reagent area of the strip is submerged
10. Allow strip to react with urine for 20-seconds and then remove from the urine sample
11. Carefully remove the strip and allow any excess urine to drip back into test-tube. Place strip on a piece of paper towel (do not dry the test strip)
12. Note the color changes that occur on each reagent area of the strip and compare them to the indications on the canister (be certain to read reactions within 60-seconds of removal from the urine). Record results. Note: leukocytes may take up to 120-seconds for reaction to be readable.
13. Dispose of urine from test-tube in urinal in the restroom.
14. Obtain the survey results for group members to see dietary and hydration history for the last 24 hours.

Results:

Table 1. Urinalysis results of examination of physical and chemical characteristics of urine samples

Characteristic	Urine sample					
	#1	#2	#3	#4	#5	#6
Urine Specific Gravity (USG)						
Volume (mL)						
Turbidity (Yes/No)						
Color						
Odor						
pH						
Protein (g/L)						
Glucose (mmol/L)						
Ketones (mmol/L)						
Bilirubin (μmol/L)						
Nitrates (Positive/Negative)						
Urobilinogen (μmol/L)						
Blood (cells/μL)						
Leukocytes (cells/μL)						

Dietary Changes for samples:

#1:

#2:

#3:

#4:

#5:

#6:

Discussion:

Summarize the findings for the urinalysis of the members of your group. In this summary indicate the continuum of hydration status from the most hypohydrated (dehydrated) to the closest to being euhydrated (normal hydration), provide evidence for your statement of hydration. And discuss how the urinalysis values changed based on the hydration of the person or the diet that each person followed for the day prior to urine collection.

1.18: Excretory System and Urinalysis is shared under a [not declared](#) license and was authored, remixed, and/or curated by LibreTexts.

1.19: Reproductive System

Objectives:

At the end of this lab, you will be able to...

1. Correctly use anatomical terminology to identify the organs and tissues associated with the male reproductive system
2. Correctly use anatomical terminology to identify the organs and tissues associated with the female reproductive system
3. Determine the role of the tissue and organs of the reproductive system for overall regulation of homeostasis

Pre-Lab Exercises:

After reading through the lab activities prior to lab, complete the following before you start your lab.

1. The organs of the male reproductive system include: .
2. The organs of the female reproductive system include: .
3. The reproductive system will begin to differentiate at weeks of fetal development when a spike in the hormone occurs.
4. Color the images for use as a reference for identifying the organs.

Materials:

- Torso Model
- Reproductive Models
- Stickers
- Felt Pens
- Colored Pencils
- Traits Tables
- Coins

The reproductive system is a dimorphic system that is “gender specific” and has differential functions for each gender. System begins to develop around week 5-6 as prototypical gonads and then when a spike of Testosterone occurs, male gonads begin to develop, and differential morphology is seen at 10 weeks. While, within the developing female the initial cell division of the gametes are taking place leading to the development of primordial follicles.

Functionality of system doesn't occur until puberty when a spike in testosterone leads to male development and estrogen/progesterone leads to female development. For the female, the development and acquisition of ornamental (subcutaneous) fat deposits are needed for developing a functional reproductive system that also is associated with musculoskeletal adjustments within pelvic bowl necessary for gestation and birthing. While both morphologies have the primarily responsibility for the generation of gametes and structures that allow for the fusion of gametes for the production of viable offspring, each provides different stimulus for morphology changes throughout the lifespan of the individual.

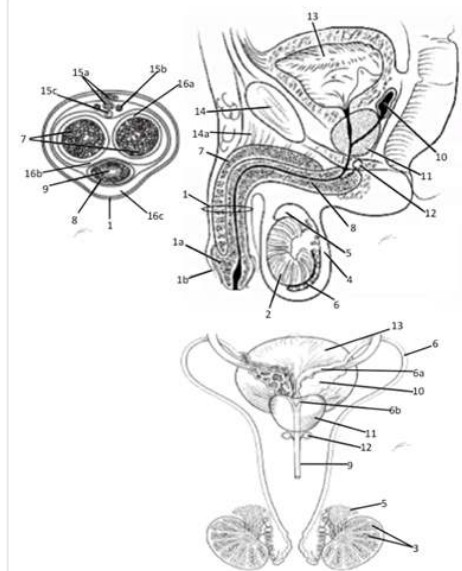
The principal organs of the female reproductive system are the uterus, ovaries, external genitals, and mammary glands. System provides the organs and secretions that provide protection and support during gestation (the growth, development and maturation) of the offspring. the principal organs of the male reproductive system are the testes, penis, and prostate gland. Where regardless of the individual all hypothalamic regulation is based on estradiol feedback on gonadotropic cells of the hypothalamus, with for males some involvement with testosterone as well. These gonadotropic cells are principally found in the Anterior, Lateral, Paraventricular, Pre-optic, Ventromedial Nuclei and Mammary Body of the hypothalamus. These same nuclei are also sensitive to thermoreceptors, which is one of the rationales for “hot flash” issues females have during the menopause sequence or during hormone replacement therapy. All of which also have involvement with psychological and somatic responses and modulation of oxytocin and prolactin production & release from pituitary along with a regulation and modulation from Agouti-Related Protein, NPY and Leptin via the regulated release of Kisspeptin that modulates GnRH release.

Reproduction will lead to fertilization and then gestation of the fetus. Gestation is the period of offspring development that includes the stages of (fertilization and formation of zygote, embryogenesis and neurulation, morphogenesis and maturation of the fetus and birthing) during which the offspring not only grows (from single cell to billions and billions of cells) but also elaborates and undergoes cell specialization in both structure and function in the offspring.

Additionally, reproduction deals with the ideas of genetics and inheritance of traits from parents by the offspring child that is best described by reviewing the mendelian laws of genetic inheritance and issues of genetic modifications that influence the development

of the offspring both during gametogenesis and following fertilization (during the period of gestation). Beyond these laws of inheritance, there are issues during development that can influence the morphological development of the offspring that are known as **teratogens**. Lastly, over the last decades we have built a better understanding regarding the issues of what a female (and male) can, or cannot, do that influence the development of functional gametes, fetal development and health of the offspring following gestation.

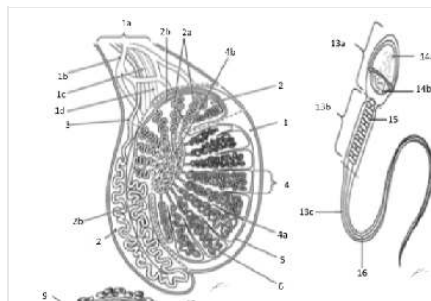
Activity 1: Male Reproductive Anatomy



Male Reproductive Anatomy

- 1 Penis 1a Glans Penis
- 1b Head of Penis 2 Testicle
- 3 Seminiferous Tubule 4 Scrotum
- 5 Epididymis 6 vas Defrens (Ductus Defrens)
- 6a Ampulla of Seminal Vesicles
- 6b Ejaculatory Duct
- 7 Corpus Cavernosum 8 Corpus Spongiosum
- 9 Urethra 10 Seminal Vesicles
- 11 Prostate Gland 12 Cowper's (Bulbourethral) Gland
- 13 Urinary Bladder 14 Pubic Bone
- 14a Suspensory Ligament 15a Dorsal Penile Vein
- 15b Dorsal Penile Artery 15c Penile Nerve
- 16a Tunica Albuginea 16b Buck's Fascia
- 16c Areolar Tissue

Color each structure or organ a different color to assist with identification



Testicular and Sperm Anatomy

- 1a Spermatocord 1b Gonadal Vein
- 1c Gonadal Artery 1d Nerve to Testicle
- 2 Epididymis 2a Efferent Duct
- 2b Epididymal Duct 3 vas Defrens (Ductus Defrens)
- 4 Lobule of Testis 4a Septum of Lobule
- 4b Rete Testis 5 Capsule

6 Seminiferous Tubule
13a Head of Sperm 13b Midpiece of Sperm
13c Tail of Sperm 14a Acrosomes
14b Haploid Nucleus 15 Mitochondria
16 Flagellum
Color each structure or organ a different color to assist with identification

1. Obtain torso and reproductive models, stickers and felt pen.
2. Write the organs and structures that you should be able to identify on the stickers
Testicle, Epididymis, Spermatocord, vas Defrens (Ductus Defrens), Scrotum, Prostate Gland, Seminal Vesicles, Penis, Glans
Penis, Corpus Cavernosum, Corpus Spongiosum
3. Take turns within your group to label the structures. As you label indicate the function of the organ or structure for the excretory system

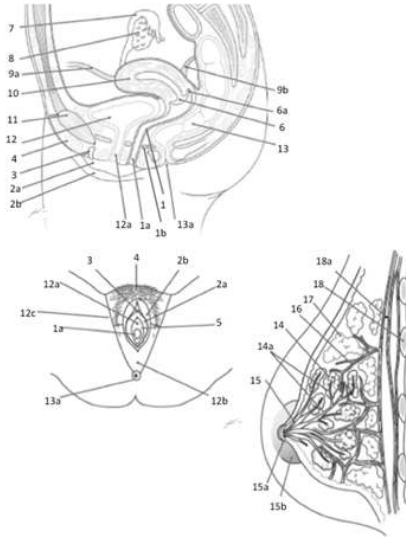
Organ/Structure	Function
Testicle	
Vas Defrens (Ductus Defrens)	
Scrotum	
Prostate Gland	
Seminal Vesicles	
Corpus Cavernosum	

4. Have your instructor check your labeling before moving to Activity 2.

Activity 2: Female Reproductive Anatomy

1. Obtain torso and reproductive models, stickers and felt pen.
2. Write the organs and structures that you should be able to identify on the stickers

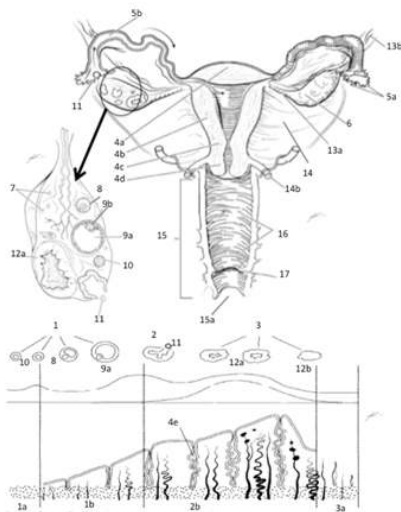
Ovary, Fallopian (Uterine) Tube, Uterus, Cervix, Vagina, Mammary Gland, Lactiferous Sinus, Nipple, Areola (and glands)



Female Reproductive Anatomy

- 1 Vagina 1a Vaginal Orifice
- 1b Skene's Gland 2a Labia Minora
- 2b Labia Majora 3 Clitoris
- 4 Mons Pubis 5 Vestibule
- 6 Cervix 6a Fornix
- 7 Fimbriae & Fallopian Tube 8 Ovary
- 9a Round Ligament 9b Uterosacral Ligament
- 10 Uterus 11 Pubic Bone
- 12 Urinary Bladder 12a Urethra
- 12b Anal Triangle 12c Urogenital Triangle
- 13 Colon 13a Anus
- 14 Mammary Gland (Lobes) 14a Lobular Duct
- 15 Lactiferous Sinus 15a Nipple
- 15b Areola. 16 Blood Vessel
- 17 Adipose Tissue 18 Costal
- 18a Pectoralis Major

Color each structure or organ a different color to assist with identification



Ovarian and Uterine Anatomy

1 Follicular Phase

1a Menstruation of Endometrium

1b Endometrial Proliferation Phase

2 Ovulation 2b Endometrial Secretory Phase

3 Luteal Phase 3a Endometrial Sloughing Phase

4a Fundus of Uterus 4b Body of Uterus

4c Isthmus of Uterus 4d Cervix of Uterus

4e Endometrial Gland 5a Fimbriae

5b Fallopian/Uterine Tube 6 Ovary

7 Primordial Follicle 8 Primary Follicle

9a Mature Follicle 9b Secondary Oocyte

10 Primary Follicle 11 Ovulate

12a Corpus Luteum 12b Corpus Albicans

13a Ovarian Ligament 13b Ovarian Suspensory Ligament

14 Broad Ligament 14b Uterosacral Ligament

15 Vagina 15a Vaginal Orifice

16 Rugae of Vagina

Color each structure or organ a different color to assist with identification

3. Take turns within your group to label the structures. As you label indicate the function of the organ or structure for the excretory system

Organ/Structure	Function
Ovary	
Fallopian (Uterine) Tubes	
Uterus	
Vagina	
Mammary Gland	
Nipple and Areola	

4. Have your instructor check your labeling before cleaning up your area.

Activity 3: Heredity and Reproduction

The formation of gametes occurs via the process of meiosis, where at the end of the process cells that are formed will contain $\frac{1}{2}$ the allotment of chromosomes as the original cells in the process. So that when they interact and form the zygote, the cell will have the correct allotment of chromosomes. The key steps during the formation of gametes lead to variability of the genes (and physical characteristics) seen in offspring, relative to parents.

The stages of gametogenesis that lead to this genetic diversity are based on Mendel's laws of inheritance. The two that are very important remember are the laws of independent assortment and the segregation of the alleles (genes). Which indicates that genes can be "assigned" independent of all other genes to any of the gametes and can be exchanged between chromosomes independent of any other gene on the chromosome during both the formation of the gametes. Not only will the genes be "assigned" independently during the process of forming the gamete, but they can also assemble in the zygote independently, too. We can examine the likelihood of genes being passed from the parent to the offspring through the development of the Punnett Square.

The Punnett Square is the process by which we indicate the various possible genes that each parent can contribute for given physical traits and then the possible combinations that each possible contribution can be seen in the offspring. All these chances of how genes separate and then coalesce in the zygote gives us distinct probability charts that we can use for predicting what the child might express. In examining these probabilities there are two things that we always must remember. First, the chance of getting any single gene from a parent is random (a flip of the coin). Second, the chance of having the gene being expressed is based on the concept of

dominance. Where the child has equal chance of getting any copy of any gene that the parent has but will express those genes based the resulting combination of genes from both parents. In which, dominant traits will always have some degree of being expressed (depending on being fully dominant or having a co-dominance or an incomplete dominance expression) while the recessive traits are only expressed when the person has two identical recessive genes (homozygous recessive).

To examine this concept, we will be exploring the genetic inheritance and probability of expressing traits for one's facial features.

1. Determine the genotype for your facial features

Characteristic	Dominant (Phenotype)	Heterozygote (Phenotype)	Recessive (Phenotype)
Mouth	QQ (Wide)	Qq (Average)	qq (Narrow)
Lip (Thickness)	JJ (Thick)	Jj (Thick)	jj (Thin)
Dimples	KK (Present)	Kk (Present)	kk (absent)
Face (Freckles on Cheeks)	(\$)(%) (Present)	(\$)% (Present)	\$\$ (Absent)
Face (Freckles on Forehead)	(A)(A) (Present)	(A)@ (Present)	@@(Absent)
Face (Shape)	RR (Round)	Rr (Oval)	rr (Square)
Face (Chin-Prominence)	LL (Prominent)	Ll (Less Prominent)	ll (not Prominent)
Face (Chin-Shape) — Linked with Prominent Chin	SS (Round)	Ss (Oval)	ss (Square)
Face (Chin-Cleft) — Linked with Prominent Chin	CC (Cleft Present)	Cc (Small Cleft Present)	cc (Absent Cleft)
Nose (Shape)	UU (Rounded)	Uu (Rounded)	uu (Pointed)
Nose (Size)	NN (Big)	Nn (Medium)	nn (Small)
Ears (Lobe Attached)	ZZ (Free)	Zz (Free)	zz (Attached)
Ears (Hairy)	DD (Present)	Dd (Present)	dd (Absent)
Eyes (Color)— Polygenic	FFBB (Dark Brown)	FFBb (Brown)	ffbb (Pale Blue)
		FFbb (Brown)	
		FfBB (Brown)	
		FfBb (Dark Blue)	
		Ffbb (Dark Blue toward Green)	
		ffBB (Light Blue or Gray)	
		ffBb (Light Blue toward Gray-Green)	
Eyes (Size)	Ii (Large)	Ii (Medium)	ii (Small)
Eyes (Shape)	VV (Almond)	Vv (Almond)	vv (Round)
Eyes (Distance between)	OO (Close)	Oo (Less Close)	oo (Far Away)
Eyes (Eyebrow Thickness)	TT (Thick)	Tt (Thick)	tt (Thin)
Eyes (Eyebrow Placement)	EE (Far Apart)	Ee (Near but not touching)	ee (Touching @ midline)
Eyelash (Length)	MM (Long)	Mm (Long)	mm (Short)

Eyes (Lash Style)	MM (Prominent & Robust)	Mm (Prominent & Thin)	mm (Non-Prominent & Thin)
Hair (Style/Type)	WW (Curly)	Ww (Wavy)	ww (Straight)
Hair (Widow's Peak)	PP (Present)	Pp (Present-less pronounce)	pp (Absent)
Hair (Color)— Polygenic	HHHH/HHHH (Black)	HHHH/HHHh (Dark Brown)	HHHH/hhhh (Blond)
		HHHH/HHhh (Dark Brown)	hhhh/hhhh (Platinum Blond)
		HHHh/HhHh (Brown)	
		HhHh/Hhhh (Light Brown)	
		Hhhh/Hhhh (Dark Blond)	
Hair (Red Color Presence)	GG (Red Present)	Gg (Blended Red)	gg (Absent)
Skin (Color)— Polygenic	AAA/AAA (Very Dark Brown or Black)	AAA/AAa (Very Dark Brown, not Black)	aaa/aaa (Very Light Tan or Pale)
		AAA/Aaa (Dark Brown)	
		AAA/aaa (Medium Brown)	
		AAa/aaa (Light Brown)	
		Aaa/aaa (Light Tan, not Pale)	

2. Create a table of phenotypes and genotypes that are possible for each parent in your pairing.

a. Use yourself as 1 parent and your lab partner as the other parent.

TRAIT	Father's Genotype	Mother's Genotype	Child's Genotype	Child's Phenotype
SEX/GENDER	Father flips a coin to determine child's gender			
	XY	XX	X	
Mouth				
Lip (Thickness)				
Dimples				
Face (Freckles on Cheeks)				
Face (Freckles on Forehead)				
Face (Shape)				
Face (Chin-Prominence)				
Face (Chin-Shape) —Linked with Prominent Chin				
Face (Chin-Cleft) —Linked with Prominent Chin				
Nose (Shape)				
Nose (Size)				
Ears (Lobe Attached)				
Ears (Hairy)				
Eyes (Color)				
Eyes (Size)				
Eyes (Shape)				
Eyes (Distance between)				
Eyes (Eyebrow Thickness)				
Eyes (Eyebrow Placement)				
Eyelash				
Eyes (Lash Style)				
Hair (Style/Type)				
Hair (Widow's Peak)				
Hair (Color)-- Polygenic				
Hair (Red Color Presence)				
Skin (Color)-- Polygenic				

3. Determine the Genotype for the child:

a. To determine the gender of the child, have the father will flip the coin

- i. HEADS=Girl, TAILS=Boy

Think about Question: WHY THE MALE IS THE ONLY PARENT TO FLIP A COIN TO DETERMINE THE SEX OF THE CHILD.

Think about question: EXPLAIN WHAT THE COIN REPRESENTS

- b. If the parent is heterozygous for a trait, then that person will have to flip a coin to determine which allele is passed to the child.

- i. Designate HEADS=Dominant and TAILS=Recessive

- ii. If both parents are heterozygous, each will flip the coin (simultaneously) for each of the trait that is heterozygous on the chart.

- 1. Results of the allele assortment is as follows:

- a. Two tails indicate homozygous recessive trait expressed.
 - b. One head and One tail indicate heterozygous trait expressed
 - c. Two heads indicate homozygous dominant trait expressed.
 - d. For Polygenic traits flip the coin each time for the individual genes within the polygenetic trait.

- c. If the parent is homozygous then simply write the only allele that can be passed to the child in the designated area

- d. Record the outcome of genotype for the child based on the results of the coin flips

- 4. Record the phenotype that the child

- a. Based on results of the combination of alleles, compare the child's genotype with the indicate characteristic for facial features

- b. Write the phenotype that is expressed based on the results of the genotype combination.

- 5. To the best of your ability, draw a representation of the outcome of all flips to create a drawing of the child that results from the two parents in this lab.

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