# Human Anatomy and Physiology

## Teacher Edition

Oak Meadow

Oak Meadow, Inc.
Post Office Box 615
Putney, Vermont 05346
oakmeadow.com

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# Teacher Edition Introduction

This teacher edition is designed to help you guide your student through Oak Meadow's course, Human Anatomy and Physiology.

All humans on the planet are made of the same cells, tissues, and organs. There are some very slight differences, but for the most part, we are all genetically the same. In fact, "A single troop of 55 chimps has more genetic diversity than 7 billion humans." (Pascal Gagneux, 1999)

As students progress through this course, they will learn about their miraculous bodies. Some of this material is quite complex, and students will benefit from having the opportunity to discuss what they are learning with you.

The student's coursebook contains all the instructions and assignments for this single semester course, which includes 11 lessons spread over 18 weeks. Throughout the course, students will be doing research and reading using additional online sources. A list of these curriculum resources can be found online at oakmeadow.com/curriculum-links.

This teacher edition includes not only factual answers to assignment questions, but also tips on how to assess student responses, and suggestions for ways to guide your student's learning. You may want to look over the teacher edition answers before your student begins work on a lesson. There are notes on how to support your student and alternate options that may be helpful.

In this teacher edition, you will find the full content of the student coursebook. Teacher edition answers are seen in **orange**. When a student gets a factual answer wrong, you can share the correct answer and address any underlying misconceptions. Several incorrect answers related to a particular topic point to an area the student will benefit from revisiting.

For obvious reasons, it is best not to share this teacher edition with your student. Each student is expected to produce original work, and any incidence of plagiarism should be taken very seriously. If you notice a student's answers matching those of the teacher edition word for word, a discussion about plagiarism and the importance of doing original work is necessary. While students in high school are expected to be well aware of academic honesty, any discussion about it should be approached as a learning opportunity. Make sure your student is familiar with when and how to properly attribute sources (please refer to the appendix for more information).

We encourage you and your student to explore the topics of this course together. Our bodies can be amazing, confusing, mysterious, and wondrous. We hope you and your student enjoy this exploration of human anatomy and physiology.

# Coursebook Introduction

Have you ever given thought to what an amazing machine your body is? When you took biology, you got an introduction to some of the inner workings of your body, including cellular processes, genetics, etc. At times, it was likely very confusing to you. And rightly so! Researchers are learning more and more about our amazing bodies every day. It all starts with the chemical reactions that occur all the time in your cells—some of which you learned about in biology—and it goes on from there to include all the systems of your body, how they work together, and why they sometimes don't work perfectly.

We are all made of the same stuff. All humans on the planet are made of the same cells, tissues, and organs. There are some very slight differences with skin color and race, but for the most part, this study transcends race, culture, history, and politics. We are all genetically the same. In fact, "A single troop of 55 chimps has more genetic diversity than 7 billion humans" (Pascal Gagneux, 1999). So relax and understand that billions of other humans have the same body processes going on as you have!

As we study our complex body systems, keep in mind that those cellular processes are the foundation for what is happening at all levels of organization in the body. Researchers and medical professionals who work with the body need to have a solid understanding of the delicate balance of chemical interactions happening at the cellular and tissue level.

Stop and think about it for a minute.

How long do you think it took you to read that sentence? Maybe one second? There are many different estimates, but we'll be conservative and say that one billion chemical reactions are happening in every body cell every second. Scientists have made a rough estimate that there are about 37.2 trillion cells in the human body.

Do the math, and you end up with the staggering number: 37 × 1,021 chemical reactions went on in your cells in the time it took you to read that short sentence. That's at least 37,000,000,000,000,000,000,000 reactions . . . in one second. That's just the beginning of what is going on in your body.

**Michelangelo sketched hundreds of poses as he studied the intricate form and motion of the human body. (Image credit: Metropolitan Museum of Art)**

# What is anatomy? What is physiology?

Let's look at some word roots. The Greek word root *ana* means "up," and the root *tomy* means "to cut or dissect." Early anatomy studies were heavily based on dissection. The study of anatomy includes learning about the structure of the different parts of the body and how they interact. ***Anatomy*** is defined as the "morphology of the body"—*morph* means "shape or form." Think of other words with the root *morph*.

- **metamorphosis:** to change shape, as when tadpoles turn into frogs and caterpillars turn into butterflies
- **amorphous:** having no clear shape or form
- **anthropomorphism:** conferring human form or traits onto animals or objects (we try to avoid that in science)

And you probably use the word *morph* all the time on its own as a verb, as slang for changing form. You probably know that the suffix *-ology* means "the study of," so put it all together, and ***morphology*** is the study of the shape or structure of something.

## Human Bodies Donated to Science

In the early days of studying the human body, dissection was the main method. Coming up with bodies to dissect was a challenge. For starters, they would use executed criminals. As medical schools became more popular, there was a need for more and more bodies. The practice of "body snatching" became more common during the eighteenth and nineteenth centuries. Because there were no preservation methods yet, bodies needed to be fresh. People were employed by some medical schools to dig up graves in order to study the bodies. The business became quite lucrative. Also, in London, deceased people from the poor workhouses were used, and some impoverished families even sold their deceased relatives for dissection. As we moved into the twentieth century, preservation methods improved, medical science became more respectful, and those barbaric practices disappeared.

Now bodies are still used, but they come from voluntary donations. If you donate your body to science, it could be used for education and examined by medical students. Many human bodies have been replaced by plastic models nowadays, but medical students still need to experience tactically the way a real human body feels; this cannot be learned any other way. There is also huge variation in human bodies that can be observed in a room full of cadavers. Equally or even more important, it helps students deal with the profound emotions that come up when working with an actual human who was somebody's loved one. It is a necessary step in nurturing a sensitive medical practice, understanding that each person is a unique and complex being.

***Physiology*** comes from the word roots *phys*, the body, and *-ology*. It is defined as the study of the functions of the body and its parts. In studying human physiology, we learn all about the biochemical, mechanical, physical, and electrical processes going on in our bodies. We learn the ways in which our organs and body systems interact to allow us to be living, breathing, thinking, and feeling humans.

Anatomy and physiology have different meanings, and it is important that you understand the difference between them, but also understand that they work together. We will be studying them in an integrated way. In previous science courses, you likely learned about the terms *structure* and *function*. Every different life-form has a structure that has adapted over millions of years to be just the way it is in order to function optimally in its environment. Why are there "simple" life-forms such as jellyfish or moss, and more complex life-forms such as bears, humans, and giant oak trees? Why doesn't everything evolve toward complexity? We could answer that with a simple question: Why should they? If the structure allows the organism to function perfectly in its environment, there is no reason to evolve. For this reason, we have the incredible diversity of life that exists on our amazing planet.

# Course Materials

This coursebook contains complete instructions for the wide variety of assignments and activities you will be doing throughout this course. Sometimes you will be completing all the activities in a lesson, and sometimes you will have a choice of assignments. It is hoped that these projects and assignments will exercise your imagination, curiosity, creativity, and scientific and critical thinking faculties.

Your main textbook for this course is *Biology* by Stephen Nowicki (Holt McDougal).

A customized lab kit is available for this course. It contains the following materials:

- flexible plastic tubing, about $\frac{1}{2}$" diameter
- funnel
- beakers, 250 mL (2)
- beakers, 100 mL (4)
- alcohol wipes (5)
- pipettes, 6 disposable plastic pipettes, 1 mL graduated
- stirring rod
- graduated cylinder, 100mL
- hydrochloric acid (HCl) solution, 30 mL 0.1 M
- pepsin powder, 0.6 grams
- digital scale
- metric ruler

- tweezers
- magnifier
- thermometer
- gloves (2 pairs)
- safety goggles

An online source we will be using frequently is the Innerbody Research website, under the section "Human Body Explorer." Every body system is illustrated and described in detail, with 3D interactive images as well. Another source we'll use is the "Crash Course" video series on anatomy and physiology (found on YouTube). You may be familiar with Crash Course's fast-talking, funny way of explaining things. One helpful aspect of these videos is that they help you with pronunciation of the many terms you'll be learning. These videos are packed with so much information that sometimes it's necessary to watch them more than once. You can also reduce the speed by going to the settings gear in the lower right corner and reducing the speed to 0.75. Make frequent use of the pause button and replay sections as needed. These videos will likely prove more useful for you after you have done the lesson reading in the coursebook and textbook. All online resource links can be found under the Anatomy and Physiology tab at oakmeadow.com/curriculum-links.

Throughout the course, you are encouraged to use additional videos, animations, and illustrations that you find online to help you understand the human body. Using visuals can really help you gain a better understanding of how we are put together.

## How to Read Your Textbook

First, look through the key concepts, section headings, and main ideas. Then fill in your reading with the content. Reading a chapter straight through is not always the best approach. Skip around, go back and forth between sections, reading some parts two or three times. Skim some parts, and read other parts in depth, as needed.

Here are some other things to keep in mind:

- **Pay special attention to the images and diagrams.** There is a reason that "a picture is worth a thousand words." They might be especially helpful for you if you are a visual learner. It is also important for you to continue practicing with graph and chart interpretation, as you have been doing in science so far.
- **Become familiar with the "student resources" section at the back of the book.** There is a lot of helpful information there.
- **Take good notes!** The act of writing things down with a pen and paper can improve your retention and understanding. There is a section on note-taking in the student resources section of the textbook. Another recommended method is "Cornell notes." You can look that up online. Find a way that works for you.

- **Use your notes!** Taking notes is helpful in its own right, but referring to them for study will help even more.
- **Keep a list of new vocabulary terms.** The highlighted terms in the textbook are a good start, but there will be other terms as well. Work on proper pronunciation of the terms you are learning by practicing aloud.

## How the Course Is Set Up

This course is arranged by body system. As you learn each body system, you are encouraged to understand how this system is linked to every other system.

Lessons include the following sections to guide your studies and deepen your understanding of the material:

- The **lesson introduction** provides a brief overview of the topic.
- **Learning Objectives** outline the main goals of the lesson and give you an idea of what to expect.
- **Before You Begin** gives you a little to think about or try before you start the lesson, just to test your current knowledge and spark your interest.
- **Think About It** encourages you to explore topics in more depth by discussing them with family or friends to deepen your understanding, educate others, and add perspective.
- **Comprehension questions** are designed to help you solidify key concepts and knowledge.
- **Critical Thinking questions** encourage you to think deeper about the material and make important connections by applying your knowledge and your best scientific reasoning skills.
- **Activities** provide a wide range of research options and hands-on ways to explore the topics you are studying.
- **Labs** give you a way to explore, experiment, and discover how the concepts you are learning play out in real life. They involve collecting and organizing data, analyzing the data, and drawing conclusions.

Pay attention to the recommended amount of time to spend on each lesson. Some are much longer than others, and you are expected to take more time. When you start a lesson, look through the reading and assignments and lay out a timetable for yourself.

| Suggested Lesson Timetable (based on 18 weeks of study) | |
|---|---|
| Lesson 1 | 1 week |
| Lesson 2 | 1 week |
| Lesson 3 | 3 weeks |
| Lesson 4 | 2.5 weeks |
| Lesson 5 | 1.5 weeks |
| Lesson 6 | 2 weeks |
| Lesson 7 | 1 week |
| Lesson 8 | 1 week |
| Lesson 9 | 1 week |
| Lesson 10 | 1 week |
| Lesson 11 | 3 weeks |

In several of the lessons, you are given a choice of activities. Be sure to read through each option and choose carefully. At the end of the course, you will be doing one or more final projects. You may use one of the activities you didn't choose from earlier lessons or choose from the list found in lesson 11. Alternatively, you are welcome to come up with your own project(s) for those final weeks.

You may wonder why there are no dissections in this course. At Oak Meadow, we have chosen not to use dissections for a few reasons. We feel that although taking apart an animal is a great learning experience, it is not necessary to destroy a living animal to understand its basic anatomy. Even in medical schools, models are used more and more often these days. When working with living things, we would like to do so with the utmost respect, recognizing that we don't own nature; we are a part of it. It is in line with Oak Meadow's philosophy to approach education in new, environmentally conscious ways. That said, if you feel that a dissection is in line with your interests and want to pursue it on your own, there are many dissection kits available online.

## Academic Expectations for Students

If you are enrolled in Oak Meadow School, you'll find reminders about when to submit your work to your teacher. Continue working on your next lesson while you are waiting for your teacher to send lesson comments. At the end of the course, you will receive a final evaluation and grade.

Please follow the assignments in order, and whenever possible, place your responses to the assignments in the Google Drive course doc provided by your teacher. Your teacher will give you feedback on your work in this shared Google doc, so the more work that can be put there, the better. Some labs and activities have blank spaces or data tables for you to fill in. If possible, scan these pages and attach them to the shared doc so that all your work stays in one place. Details about how to do this can be found on the Google Drive help page.

You are expected to meet your work with integrity and engagement. Your work should be original and give an authentic sense of your thoughts and opinions, rather than what you think your teacher wants to hear. When you use other sources, you are required to cite them accurately. Plagiarism, whether accidental or intentional, is a serious matter.

The appendix of this coursebook includes complete details on Oak Meadow's academic expectations and original work guidelines. It is your responsibility to make sure you understand these academic expectations and abide by them.

Please remember to stay in touch with your teacher and share your comments, ideas, questions, and challenges. Your teacher is eager to help you!

## Prepare to Be Amazed

The human body is an incredibly complex machine. It can be amazing, confusing, mysterious, and wondrous, all at the same time! Through your study of human anatomy and physiology, you will gain a greater understanding of yourself.

Lesson

1

# Getting Started with Anatomy and Physiology

We will start our study of the human body with a broad exploration of how our body systems work together to maintain life.

Look at the picture of the ice climber on page 797 of your textbook. Think about the careful concentration and coordination the climber must use to be successful at this activity. What activities do you do that require a high degree of focus and coordination? Perhaps you dance, skateboard, play an instrument, or play tennis. Whatever you do, imagine what it would be like if you had to concentrate on every step you took or every hand movement, as an ice climber does.

At first, when you do a new set of movements (learn a new piece on your cello, a new dance, a new skill set in your sport), your movements might feel clumsy and not in sync with one another. But as you become familiar with the new movement, your muscles seem to remember. What is this thing we call "muscle memory"? How does it work? Or think about when you are sick. How does your body identify a "foreign invader" to be fought off by your immune system? Our body systems usually work smoothly together without our conscious knowledge or effort. But what happens when these things go awry?

It's time to dig in and explore!

(You can expect to spend 1 week on this lesson.)

**ASSIGNMENT CHECKLIST**

- ☐ View an introductory video on anatomy and physiology.
- ☐ Take a biology quiz to test your prior knowledge.
- ☐ Review textbook chapters 1–6.
- ☐ Note corrections to your biology quiz.
- ☐ Identify and define 10–15 root words used in anatomy and physiology.
- ☐ Begin a vocabulary list.

## Learning Objectives

At the end of this lesson you will be able to:

- Understand the meaning of anatomy and physiology and the relationship between structure and function.
- Refamiliarize yourself with cell biology concepts.
- Understand anatomical and directional terms.

# Viewing

Watch the following Crash Course video (click on the Anatomy and Physiology tab at oakmeadow.com/curriculum-links for the online links):

"Introduction to Anatomy & Physiology: Crash Course A&P #1"

Let your teacher know you have watched this video.

**It is helpful to encourage your student to explain what the video was about, to describe one or more key concepts, or to share something that surprised them. Watching the videos assigned to your student can make it easier for you to discuss, guide, and evaluate your student's work.**

# Before You Begin

Do an internet search for "word roots in medicine" or "root words in anatomy or physiology." Make a list of 10–15 words that you might have heard before, but you weren't sure of their meanings. Using the word roots, describe the meaning of each word. (As you continue through this course, try to figure out what a new term means using the roots before you look it up. Consider making this a game for yourself. Come up with a little reward for yourself every time you get one right, even if it's just a prefix or suffix. Keep score, and work to constantly improve your score.)

**Students will complete this activity as explained.**

# Biology Quiz

Take the following quiz to see what you remember from biology. The results of this quiz will not count toward your grade for this lesson. This is a tool to help you decide how much review you should do this week before we really dive into anatomy and physiology. Do not look in the textbook or online for any of these answers! This is just to gauge where you are now.

**Students should put a good effort into this quiz. The lesson grade is not dependent on the number of correct answers on the quiz. This is simply a tool to guide students in identifying information about cell biology they need to review.**

1. What is a cell?

   **A cell is the smallest structural unit of an organism—the basic unit of life.**

2. Can you describe a "system" that is in your body? How about one that is not in your body?

   **Answers will vary. A system is an organized group of related parts that interact to form a whole. Body systems include the muscular system, circulatory system, nervous system, etc. Examples of systems outside the body are a computer, a kitchen, a car, etc. Students should describe some of the parts that make the system function. Note that a common usage of the word "system" is to describe a routine ("I have a system for getting ready for bed," for example). This is not the usage we are using here.**

3. What is homeostasis? Give an example of homeostasis in your body.

   **Homeostasis is the maintenance of constant internal conditions in an organism. Examples will vary, and may include body temperature, blood sugar, acidity, etc.**

4. What is the genetic material called that determines the characteristics of any organism?

   **DNA**

5. Give two examples of medical imaging technology that can help "see" inside our bodies.

   **Medical imaging techniques include ultrasound (to view an unborn baby), X-ray imaging (dental X-rays, broken bones, etc.), MRI (other injuries), CT scan (internal injury, abnormalities), PET scan, etc.**

6. Your body is made of mostly **water**.

7. Why are there so many chemical reactions that take place in the human body? Relate this to your answer to #3 above.

   **The maintenance of homeostasis in the body requires constant chemical reactions. We digest food, regulate our body temperature, put demands on our muscles—these are just a few examples of processes that involve chemical reactions. Even if we are "doing nothing," chemical reactions are constantly occurring to keep us alive and maintain homeostasis.**

8. What is an enzyme?

   **An enzyme is a protein that catalyzes chemical reactions in an organism.**

9. Name at least three organelles that are found in your cells. Can you explain the function of each?

   **Answers will vary, but some of the basic organelles that students are likely to think of are the nucleus (houses the DNA), mitochondria (supply energy to the cell), and ribosomes (help form proteins). Others are the endoplasmic reticulum (where proteins and lipids are produced), vesicles (for transporting substances), and lysosomes (destroy worn out cell parts as well as invaders). If the student mentions organelles such as chloroplasts and vacuoles, remind them that these are only in plant cells, not animals.**

10. Why do cell membranes need to be "selectively permeable"?

    **This is very important because it allows only certain substances to move into and out of the cells, as they are needed or as wastes are produced. Selective permeability helps maintain homeostasis.**

11. What is the difference between active and passive transport?

    **Passive transport includes diffusion and facilitated diffusion. It doesn't require energy from the cell, as the molecules are moving with the concentration gradient. Active transport is the movement of molecules against the concentration gradient, and requires energy.**

12. What is osmosis?

    **Osmosis is the diffusion of water molecules across a semi-permeable membrane down its concentration gradient (meaning from an area of high water concentration to an area of lower water concentration).**

13. What is the process called that occurs in all cells and provides energy in the form of ATP?

    **Cellular respiration**

14. Do you know what "lactic acid fermentation" is? In what kind of situation would this process occur in your muscles?

    **Lactic acid fermentation is otherwise known as *anaerobic respiration*. It is a process that takes the products of glycolysis (pyruvates), and converts them into lactic acid. This recycles NAD+ so glycolysis can continue to produce ATP. It produces a small amount of ATP (unlike aerobic respiration) and occurs when there is not enough oxygen available to the muscles for aerobic respiration, such as when heavier demands are put on the muscles than a person is used to. Lactic acid is produced as a byproduct, which causes temporary burning in the muscles. Students might have no idea what this is, but everyone has felt that muscle burning sensation!**

15. Discuss a few reasons why it could be important to understand genetics when learning about anatomy and physiology.

    **This could be as simple as understanding that your height, body composition, or hair color are inherited from your parents. There are many conditions that are passed down from parents as well. The traits a person inherits are a result of the combination of genes received from the parents. For example, knowing that colorblindness is a sex-linked trait (and what that means) can help a person have a better understanding of the big picture, and help them predict whether their own children might inherit the trait.**

# Assignments

1. After you complete the biology quiz, review chapters 1–4 in the textbook. As you review these chapters, pay special attention to the section headings and the "main ideas" that are in blue. There is no written assignment here, although taking notes is always recommended.

   **Students should give a thorough and honest assessment about how much they retained from biology. Notice the student's attitude toward how much review is necessary. Students who had trouble recalling information may need extra time for review before moving forward. It is absolutely okay if the student needs a lot of review.**

2. After reviewing chapters 1–4, correct any of your quiz answers that need adjustment, using a different color ink or font after your original answer. Finish by adding a few statements on this experience. Were you pleased with your results? Do you feel like you have a lot to review? Remember that you have this textbook available to you and can review these basic concepts at any time.

   **Students will share their in-progress vocabulary list. This list will be developed throughout the course; check in periodically with your student to make sure new words are being added.**

# Reading

Review the following chapters in the textbook:

- Chapters 5 and 6 (pay special attention to sections 5.5 and 6.6)

These concepts are covered in the beginning of a biology course because they are broad concepts that are present in all eukaryotic life-forms. We will revisit some of these in more detail in this course. Take notes as needed. Let your teacher know you have reviewed these chapters.

It is estimated that the amount of new vocabulary learned in a high school biology course is similar to that learned in an introductory language course. Anatomy and physiology may have even more new vocabulary than biology! As you go through this course, please keep a vocabulary list. This can be either handwritten in your notebook, or on a separate document that is organized by lesson or topic. The act of writing down definitions can help you learn the terms better than you would just by reading them. And of course, now you will have a go-to place to look up the terms that you forget as we go along. Begin your vocabulary list by writing down 6–10 words from your review of chapters 1–6.

## Anatomical Position and Directional Terms

Look at the image on the next page. Do you see the position the woman is standing in? This is called the *anatomical position*. When learning anatomy, this is the standard position used to explain body parts in reference to one another, regardless of the position the body happens to be in at the time. Notice particularly the position of the hands, with the palms forward and the thumbs to the side. The following are the directional terms commonly used by medical professionals. As you go through the course, you will see these terms often.

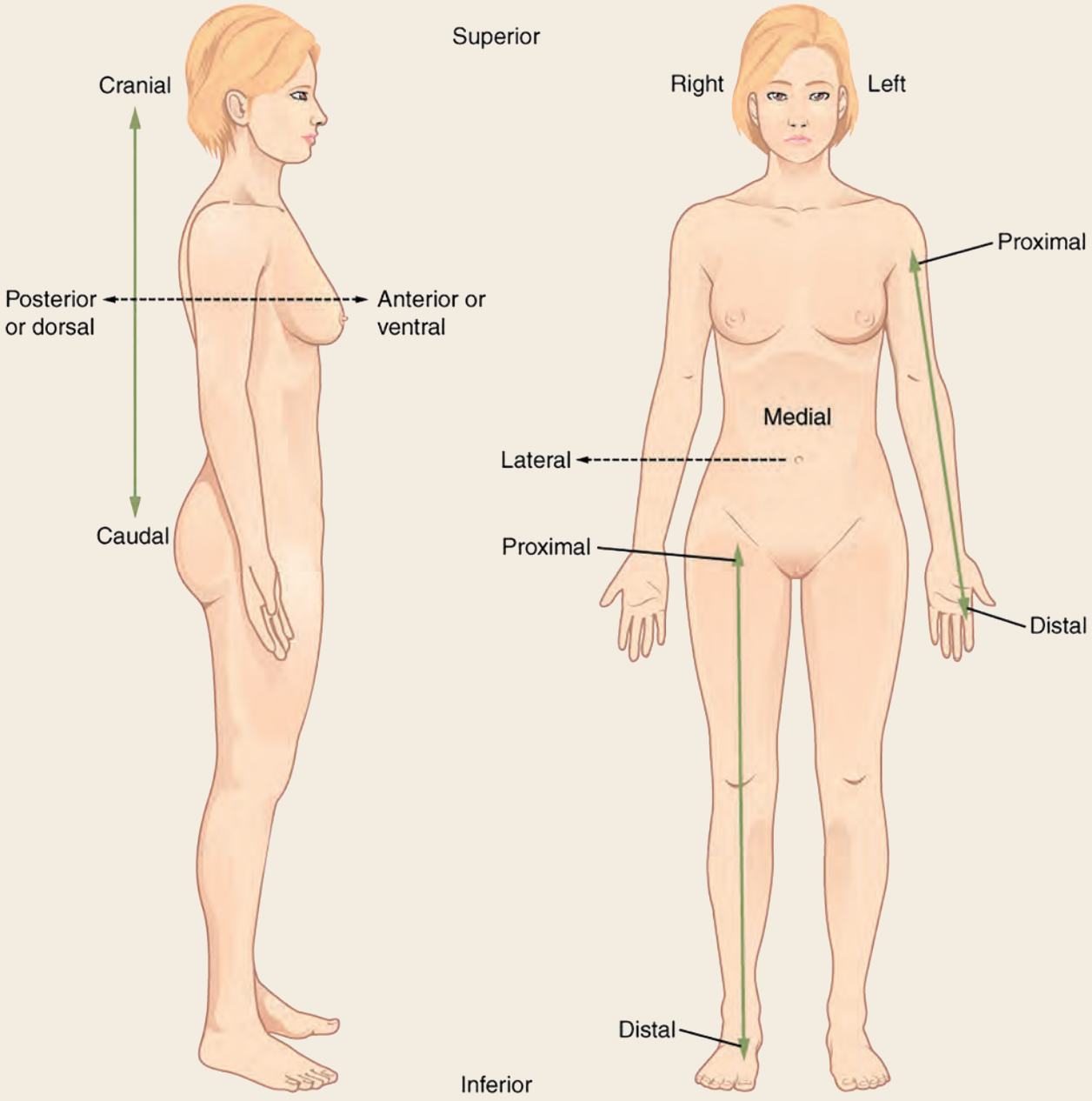
- Superior (or cranial) = above, or toward the head end
- Inferior (or caudal) = below, or toward the lower end
- Anterior (or ventral) = in front of, or toward the front of the body
- Posterior (or dorsal) = behind, or toward the back of the body
- Medial = toward the midline of the body
- Lateral = away from the midline of the body
- Proximal = closer to the point of attachment to the trunk
- Distal = farther from the trunk
- Superficial = closer to the body surface
- Deep = farther from the body surface; more internal

*(Continued on next page)*

Using these directional terms and the anatomical position, you can see that the head, for example, is superior to the heart even if the person is doing a handstand or lying on a bed. Familiarize yourself with these terms and use them, when appropriate, in your responses.

You can see more images on this website:

Visible Body: Anatomical Position and Directional Terms




**(Image credit: OpenStax College)**

## The Other Side of Anatomy: Forensics

If you donate your body to science, you can choose to donate it to a body farm. Find out how studying a decaying body can contribute in many ways to science and crime solving.

Check out this video on body farms:

> "The Body Farm—National Geographic"

**NOTE:** Be prepared for some graphic images.

Here's an interesting article:

> "Down on the Body Farm: Inside the Dirty World of Forensic Science" by Monica Raymunt

(All online links can be found at oakmeadow.com/curriculum-links.)

### SHARE YOUR WORK

You will submit your work to your teacher at the end of the next lesson.

Lesson

2

# Human Body Systems

In order to make sense of our complex anatomy, it is important to start with a study of the organization of the human body. This will help everything that comes afterward fall into place. Likewise, in order to understand physiology, we must understand that every chemical reaction, nerve impulse, or movement of substances around the body is happening for one reason: to maintain homeostasis.

(You can expect to spend 1 week on this lesson.)

**ASSIGNMENT CHECKLIST**

- ☐ Review textbook chapter 1, section 1.2, and read chapter 28.
- ☐ Answer comprehension questions.
- ☐ Answer critical thinking questions.
- ☐ Complete the following activities.
  - Activity A. Quick Lab
  - Activity B. Tissues Concept Map
  - Activity C. Drawing a Neuron
- ☐ Lab: Are You Vitruvian?

## Learning Objectives

At the end of this lesson you will be able to:

- Describe the levels of organization in the human body, and how they make up the major organ systems.
- Recognize homeostasis in the body and the feedback loops that maintain it.
- Use analogy to explore how body systems interact.

## Before You Begin

Time for some science trivia!

Do you know what the largest organ of the human body is? Write it down, guessing if you need to. Then look at the end of this lesson for the answer. Did you get it right?

**Students will include this with their work for this lesson.**

## Reading

Review chapter 1, Section 1.2, in your textbook: "Unifying Themes of Biology."

Read chapter 28, "Human Systems and Homeostasis."

# Comprehension

1. What is a zygote?

   **A zygote is a single cell formed by the union of an egg and sperm cell.**

2. Contrast cell determination with cell differentiation. About how far into embryonic development does differentiation start?

   **Cell determination occurs first, and is when stem cells commit to develop into only one type of cell. Differentiation is the process by which cells develop the structures and functions that make them specialized cells. Cell determination occurs within a few weeks of development, and differentiation starts as soon as the cell is committed. It loses its ability to develop into any other type of cell. It is an ongoing process.**

3. What organ systems must work together to bring oxygen to the body's cells? (Hint: there are more than two!)

   **The respiratory system brings in the oxygen, and the circulatory system transports it to the body's cells. The muscular system coordinates the movements of the lungs.**

4. If a person's circulatory system is not functioning well, what might happen to thermoregulation in the person's body? Use the word *homeostasis* somewhere in your answer.

   **Thermoregulation would not work well without a well-functioning circulatory system. The person would be less able to conserve heat or lose heat in order to maintain homeostasis.**

5. Why is it so important for a person with type 1 diabetes to monitor insulin levels very carefully, and take synthetic insulin when needed?

   **In Type I diabetes, no insulin is made by the body. A person with Type I diabetes depends on synthetic insulin. If insulin is not monitored carefully, a whole chain of negative effects can occur, including altered pH of the blood, disrupted metabolism, heart disease, blindness, and more.**

# Critical Thinking

1. Analogies are an excellent way to understand a process. Consider the four control systems that exist in the body. Think about an air traffic control tower and the following scenario: A plane is circling and getting ready to land. A strong wind comes up, and air traffic control sees this on the weather radar. Air traffic control tells the pilot to abort the landing because of the wind shear, and gives instructions for the pilot to follow. Describe what body control system each of the different parts of this situation is analogous to.

   **The sensors in this situation are the weather radar, which detects the wind. The control center is air traffic control. It receives information from the sensors, and sends a message through a communication system (the radio), telling the pilot to abort the landing. The pilot/plane is responding to the message, so it is the target.**

2. Answer the following:

   a. Why are most of the body's functions controlled by negative feedback rather than positive feedback? Again, use the word *homeostasis* in your answer.

   **Negative feedback is the means by which the body maintains homeostasis, which is a state of "sameness." It is the mechanism through which the body restores normal conditions. Positive feedback occurs when a change is needed.**

   b. Give an example of a negative feedback loop in your body that is different from the one in figure 2.2 of your textbook (806).

   **Answers will vary. Examples include the following: when the body is cold, we shiver, and when we are warm, we stop shivering; when the body is hot, we sweat until we cool down, at which point we stop sweating; when we feel thirsty, we drink water until a signal is transmitted to our brains that the thirst is quenched, and we stop drinking. Students should describe the whole loop, not just the first part. The negative feedback part occurs when the message is received that normal conditions are restored and the action can stop.**

3. Review the pit crew image (figure 3.1) on page 808. Using analogy, think of another system that you are aware of. It could be small or large, and part of your life or not. It could be made up of moving parts, or not, and may or may not involve people. You might even use the system that you described in the biology quiz in lesson 1. Systems are everywhere! Describe how each part of the system is vital to the functioning of the whole. Choose one part of the system and explain what could happen if that part malfunctions or is missing.

   **Answers will vary. Examples are a sports team, an ecosystem, or even a solid structure like a house. Students will describe the parts of the system and how they are essential for the whole. Also, students will address what might happen if one part is missing or malfunctioning (an absent coach, an extinct animal, no insulation in the house, a broken furnace, etc.).**

# Activities

Complete all three of the following activities.

- Activity A. Quick Lab
- Activity B. Tissues Concept Map
- Activity C. Drawing a Neuron

## Activity A. Quick Lab

Do the "Quick Lab" on page 807, and answer question #1, giving a detailed description of the negative feedback loop.

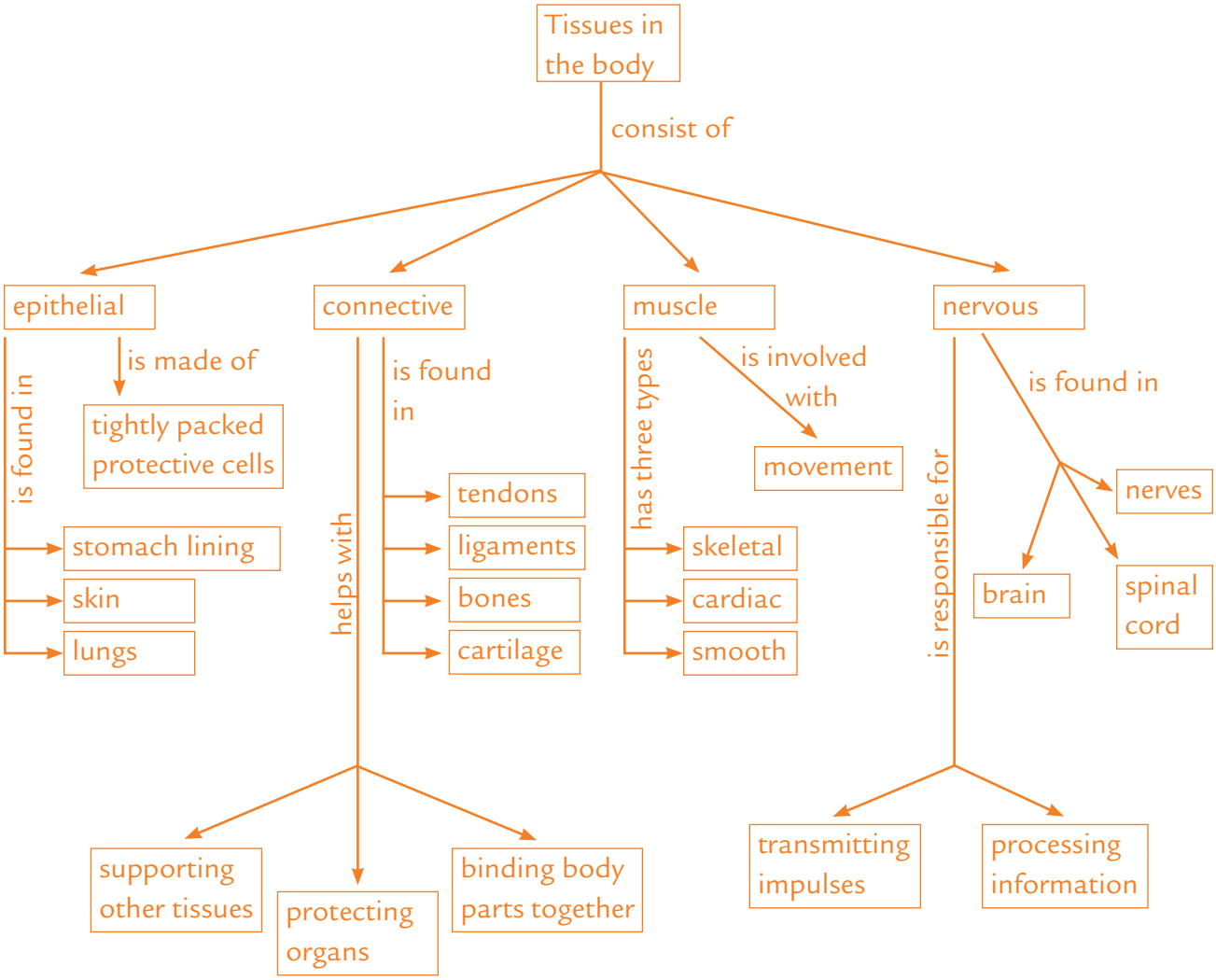
**Sensors in the scalp detected changes in the book's position, and sent messages to the muscles to make adjustments. With eyes closed, students lost sensory information about body position in relation to the surroundings. This likely (but not necessarily) made the balancing task more difficult.**

## Activity B. Tissues Concept Map

Create a concept map illustrating the four types of tissue in the body. If you need a review on the structure of a concept map, see p. R24 in your textbook, or do an internet search for concept maps. For each tissue type, the concept map should include the basic structure, function, and examples of where it is found in the body. You may do additional research on this if needed.

**Students' concept maps should contain the key terms and elements asked for.**

**Here is a sample concept map:**



## Activity C. Drawing a Neuron

In this activity, you'll be creating a visual image based solely on a description. Please do it after you are done with the rest of this lesson.

Draw an image of a neuron based on the following description. Use pencil, so you can make changes later.

> A neuron is a very large, odd-shaped cell. There are neurons in your body that can be 1.5 meters long! The *cell body* is the part of the neuron that looks most like a "normal" cell. It contains the nucleus and organelles. Most cell processes happen in the cell body.
>
> *Dendrites* are branch-like extensions of the cytoplasm and the cell membrane of the cell body. Neurons often have many dendrites, and each dendrite can have many branches. The dendrites receive chemical signals from neighboring cells or other neurons, convert them into electrical signals, and transmit them toward the cell body.
>
> Every neuron has a single *axon*, which is a long process extending from the cell body. The axon carries electrical messages away from the cell body and passes them to other cells. It is covered with a *myelin sheath*, which is a fatty outer layer that works as an electrical insulator to speed up the transmission of the nerve impulse. (How is this familiar to you? You are making use of something right now that has this structure.)
>
> The axon eventually branches, and each branch ends in several *axon terminals*. These axon terminals are somewhat enlarged and club-shaped (they are sometimes called *terminal buttons*). This is where the neuron transmits the signal across the *synapse* (space between neurons) to the dendrites of another neuron or to effector cells.

When you are done, draw arrows to represent the direction the electrical signal moves through the neuron. (Hint: the prefix of dendrite has two meanings, both of which can help you remember the direction the nerve impulse goes: *dendro* is from the Greek *dendron*, meaning "tree," and *dendr-*, meaning "earlier.")

Save this drawing—you will make adjustments to it in the next lesson. Take a photo or scan of this rough draft so that in the next lesson you can share both versions.

**Students will draw a neuron based on the description above.**

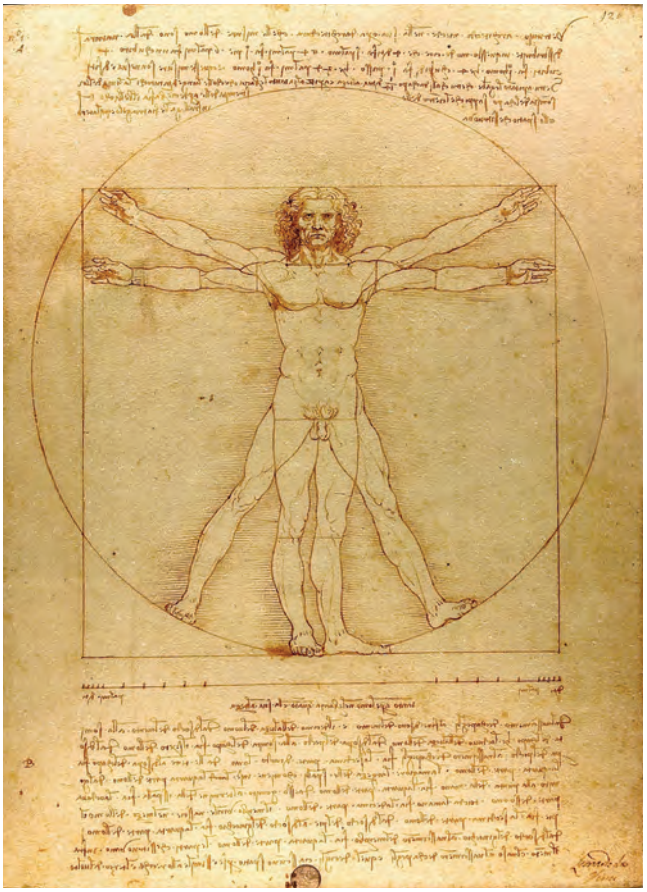
LAB

Name _____

# Are You Vitruvian?

Marcus Vitruvius was an ancient Roman architect, born in 85 BCE. He is famous for his ten-volume treatise *De Architectura* (*On Architecture*), the oldest architect's manual to survive to modern times. Vitruvius had a keen eye for form. In volume III of his work, he discusses symmetry of both temples and the human body.

"Vitruvian Man" (pictured right) was drawn by Leonardo da Vinci in about 1490. Da Vinci created this to pay tribute to the work of Vitruvius. The drawing is based on the correlations of the ideal human proportions with geometry described by Vitruvius. Vitruvius believed that the human body was a model of natural proportional perfection. Here are some of the proportions that are described in the text:



**Leonardo da Vinci's *Vitruvian Man* shows "natural proportional perfection" as described by Vitruvius. (Image credit: Luc Viatour)**

- the length of the outspread arms (arm span) is equal to the body height
- the distance from the hairline to the bottom of the chin is one-tenth of the body height
- the distance from the top of the head to the bottom of the chin is one-eighth of the body height
- the distance from the elbow to the tip of the hand is a quarter of the body height
- the distance from the elbow to the armpit is one-eighth of the body height
- the length of the hand is one-tenth of the body height
- the length of the foot is one-sixth of the body height

# Anatomy and Physiology—Lesson 2 Lab: Are You Vitruvian?

In this lab, you'll map your own body proportions with the help of a partner, and compare them to the Vitruvian Man.

## Materials

- tape measure
- floor space to lie down with arms outstretched
- calculator

## The Question

Write the question that you will be investigating.

**How close are we to Vitruvian proportions? (Student should write something similar.)**

## Procedure

**Data tables will include space for the calculated proportions. It is the proportions that are important for comparison, not the actual measurements. They might calculate averages for each proportion.**

Read the entire procedure before you begin.

1. Set up a data table with enough room for the seven sets of measurements listed above. You will be recording measurements of yourself and your partner. Feel free to include more people in your study, or to seek data from other students (you can share yours with them as well).
2. Remember, it is the *proportions* you are after, not just the measurements, so you might want a separate data table with the measurements, from which you calculate the proportions to put in your main data table. Find a way that works for you to keep organized. Be sure to put a title on each data table.
3. You and your partner will take turns measuring each other. All measurements should be in centimeters, or converted to metric if your tape measure isn't a metric rule.
4. Keep track of the gender and age of the person you are collecting the data from. What other information might you want to record? For instance, if you and your subjects are biologically related, that could be a relevant piece of information.

Name _____

# Anatomy and Physiology—Lesson 2 Lab: Are You Vitruvian?

## Analyze and Conclude

1. Look at your data for patterns. How close was each person to Vitruvian proportions? How close is the group as a whole? How much variation is there within the group?

   **Students will describe their data, addressing the questions above.**

2. Are there any more calculations you think you should do to form a conclusion?

   **Additional calculations could be done, separating data by age or gender. Students might have more ideas.**

3. Conclude your exploration by discussing the usefulness of this knowledge. What other questions could be investigated regarding body proportions? Here are some ideas to consider in this discussion:

   - What other disciplines could this knowledge be useful for? What practical uses?
   - What do you think Vitruvius means by "natural proportional perfection"? How does this relate to the concept we might call beauty? What role do you think culture plays in this perception of symmetry, perfection, and beauty?
   - What do you think of this idea of symmetry being applied to both man-made structures, such as buildings, and natural structures, such as the human body? What about other parts of nature?

   Write at least one paragraph.

   **Students should write a narrative paragraph addressing the points mentioned (as opposed to listing their answers in order). This information could be very useful in any art involving the human body, such as drawing or sculpting. It might be useful to help clothing designers as well. Other questions might include whether body proportions run in families, what some other proportional relationships are (Vitruvius had many more), how they change from babies to adulthood, etc.**

   **Students might also note that Vitruvius never considered women in this concept of "natural proportional perfection." Or perhaps it might be brought up that different cultures have radically different perceptions of what is perfect, and what is beautiful. There are many open-ended questions that could be addressed to extend this concept. Encourage creative thinking "outside the box."**

### SHARE YOUR WORK

Submit the following assignments to your teacher.

#### Lesson 1

- Original and correction answers to biology quiz, plus reflection
- List of 10–15 word roots related to medicine, anatomy, or physiology
- In-progress vocabulary list

#### Lesson 2

- Answers to comprehension questions
- Answers to critical thinking questions
- Activities:
    - Quick Lab
    - Tissues Concept Map
    - Drawing a Neuron
- Lab question, data table(s), and analysis and conclusion

## Answer to Before You Begin (science trivia)

The skin! Adults have about 1.7 square meters of skin. Your body produces an entirely new layer of skin every month. Every minute about 30,000 to 40,000 dead skin cells are shed from the body!

Lesson

6

# The Digestive and Excretory Systems

You are what you eat! In this lesson, we will explore nutrients and how our bodies break down and absorb food. We will focus on the mechanisms of digestion and excretion and the roles of nutrients.

Note that in lieu of extra questions in this lesson, you are being asked to be very thorough and detailed with your story or comic for Activity C. Give that assignment a good effort.

(You can expect to spend 2 weeks on this lesson.)

## Learning Objectives

At the end of this lesson you will be able to:

- Explain the roles of nutrients in maintaining homeostasis.
- Describe the processes of and organs involved in digestion, absorption, and excretion.
- Model the function of bile.
- Test digestive enzymes

## Reading and Viewing

Read chapter 32, "Digestive and Excretory Systems" in your textbook. You may skim section 1. Be sure you understand the six types of nutrients and how they maintain homeostasis. As always, throughout the reading, pay attention to the diagrams—a picture is worth a thousand words!

Read and explore the "Digestive System" and the "Urinary System" on Innerbody Research. Be sure to check out the text sections below the images.

View the video "Urinary System, Part 1: Crash Course A&P #38." As always, slow it down and pause it if you need to. Watch this after reading section 32.4 in your textbook and it will make more sense.

### ASSIGNMENT CHECKLIST

- ☐ Read chapter 32.
- ☐ Explore the "Digestive System" and the "Urinary System" on Innerbody Research.
- ☐ View the video "Urinary System, Part 1: Crash Course A&P #38."
- ☐ Answer comprehension questions.
- ☐ Answer critical thinking questions.
- ☐ Activity A: Explore "The Marvels in Your Mouth"
- ☐ Activity B: Video Demonstrating Digestion
- ☐ Activity C: Digestion Story
- ☐ Demonstration Lab: Modeling the Function of Bile
- ☐ Investigation Lab: Testing the Effects of a Digestive Enzyme

When you watch this Crash Course video, you will get a clear sense that there is a *lot* going on in the kidneys. Much of it has to do with the various methods of transport that you learned in biology: active and passive transport (including osmosis). If you need to review those, go back to chapter 3 of your textbook and take a look. The excretory system will all make more sense with a better understanding of these homeostatic mechanisms.

**Optional:** View "Urinary System, Part 2: Crash Course A&P #39." This second video is specifically about urine, the bladder, and the mechanisms that control urination. You might find it very interesting!

### Know the Difference

*Elimination* and *excretion* are often used synonymously, but they refer to very distinct biological processes. Elimination refers to the removal of solid wastes through the large intestine. Excretion refers to the removal of nonsolid wastes by the kidneys (through the bladder), lungs, and skin. The excretory system is also referred to as the urinary system. However, the urinary system specifically refers to the kidneys, bladder, etc., and doesn't include the skin (sweat) and lungs as excretory organs.

*Organic* and *inorganic* often have differing meanings as well. In chemistry and biology, organic refers to compounds that contain carbon (in nutrition: vitamins). Inorganic refers to compounds or molecules that do not contain carbon (in nutrition: minerals).

## Comprehension

1. Explain the roles vitamins, minerals, and water play in maintaining homeostasis.

   **Vitamins work with enzymes to regulate cell functions, growth, and development. Minerals help carry out cellular processes, such as muscle contraction and nerve transmission, and build or repair tissues. They are also necessary for fluid balance. Water maintains blood volume and fluid balance, transports substances, and regulates body temperature.**

2. What is the process by which food is kept moving in only one direction in the digestive tract?

   **peristalsis**

3. Compare and contrast mechanical and chemical digestion.

   **Both processes break food down into smaller particles. Mechanical digestion involves chewing or smooth muscle contractions to grind and churn the food. Chemical digestion involves enzymes, hydrochloric acid, and bile to chemically break the bonds of nutrients.**

4. The liver is one of the largest organs in the body, and it is crucial to life. Describe two important functions of the liver.

   **The liver produces bile, which helps digest fats in the small intestine. Also, it is extremely important as it filters blood, processing nutrients (and other chemicals, including drugs or alcohol). It stores nutrients for future use, and uses some nutrients to build more complex molecules.**

5. Why don't blood cells, proteins, and platelets diffuse into the glomerulus of the nephron?

   **They are too large to diffuse through the capillary walls.**

## Critical Thinking

1. A person has a small intestine that has villi but a reduced number of microvilli. Would you expect this person to be underweight or overweight? Explain.

   **The person will be underweight, as more food will pass out as waste rather than being absorbed. The person also might be malnourished.**

2. When you exercise, what organs of the excretory system are eliminating wastes?

   **The lungs eliminate $CO_2$ and water vapor, sweat glands release water and salts, and kidneys clean the blood of metabolic wastes.**

3. Describe the processes of filtration and reabsorption in the nephrons of the kidneys. Filtration happens under pressure, and reabsorption occurs through active and passive transport. How do you think these factors contribute to the fact that filtration is relatively nonselective, and reabsorption is selective?

   **During filtration, any molecule small enough to pass through the capillary wall diffuses out of the blood. During reabsorption, most of these materials are reabsorbed back into the blood, and the rest will make up the urine. Because filtration occurs under pressure, everything small enough will pass into the nephron tubule. Reabsorption, then, can be much more selective, taking back into the blood only what it needs.**

4. Did you know that there are about one million nephrons in a human kidney? And that they filter 180 liters of blood plasma each day? With this kind of volume, it's a good thing that 99 percent of the filtrate is reabsorbed. Notice in figure 4.3 (927) that the capillaries outside the glomerulus are very intertwined with the nephron tubule. Why do you think this is the case? Relate structure to function.

   **They are intertwined in order to increase contact, allowing for more reabsorption.**

# Activities

Complete the following activities.

- Activity A. Explore "The Marvels in Your Mouth"
- Activity B. Video Demonstrating Digestion
- Activity C. Digestion Story

Links for these activities can be found at oakmeadow.com/curriculum-links.

## Activity A. Explore "The Marvels in Your Mouth"

Author Mary Roach is well known for her humorous perspective on science topics. If you took Oak Meadow Biology, you might have read her book *Stiff: The Curious Lives of Human Cadavers*. Another of her well-known books is *Gulp: Adventures on the Alimentary Canal*, in which she explores the digestive system. If you want to read some fun science, along with the bizarre history of digestive system research, this book is highly recommended.

In this activity, you will listen to an interview with Mary Roach, read an excerpt from her book, and answer a few questions.

1. Try this quiz from the *New York Times*:

   "Gulp! The Quiz"

   How did you do? Comment on your results. Did any of the answers surprise you?

   **Students will take the quiz, and report and comment on their results. There are fun trivia questions in this quiz that are not covered in this lesson on digestion, but are very real parts of life.**

2. Now watch the following interview with Mary Roach:

   "The Inside Scoop on Your Insides"

   **Students will watch the interview with Mary Roach. She has a way of making obscure and sometimes unpleasant things very interesting and human. Her passion for these details about the topics she writes about is clearly evident.**

3. Follow that up by reading this article, which is an excerpt from Roach's book:

   "The Marvels in Your Mouth"

   Then answer the following questions:

   a. Mary Roach describes how we tend to view food as a "wonderful, sensual thing. Yet as soon as it crosses the threshold, it becomes this object of taboo and disgust." What do you think of that statement? How comfortable are you talking about what food becomes as it travels through your body?

      **This is a personal question. Students should share their comfort level with the topic.**

b. What is the purpose of the study in which people chew on silicone cubes? What have scientists learned?

**Scientists are able to study the mechanisms of chewing, and specifically, the "neuromuscular elements of chewing." This includes the direction and speed of chewing, of which there is a lot of individual variation. The jaw is a very fine-tuned instrument, which puts tremendous pressure on food and stops the pressure at the right time so we don't shatter our own teeth. Students might describe even more information learned in the lab called "The Department of Head and Neck."**

c. What are some of the applications of the study of bolus formation and swallowing?

**This information is important as the process is very fine-tuned, and some conditions that cause the timing of swallowing to be off (a condition known as *dysphagia*) include stroke, degenerative neurological conditions, and tumor irradiation. This can lead to choking, which in turn can lead to a whole new set of health issues, such as pneumonia.**

d. Why are we evolutionarily programmed to prefer crunchy foods?

**When food is stale or is rotting, the cell walls break down and it can lose its crunch. The adaptive (evolutionary) value of desiring crunchy foods could be that the food is likely safer. If a person eats food that is going bad, they might get ill. It is likely that this preference for crunch started long ago in human evolution.**

e. Describe at least two connections between this study of chewing and swallowing and physics.

**Studying the force exerted by the teeth when chewing is a direct application of physics. The study of the "crack speed" of the crunchy food in order to get the sound is also some impressive physics. In addition, physics is applied when learning the sensitivity of teeth.**

## Activity B. Video Demonstrating Digestion

Watch this video demonstration of the digestive system of a pig:

"Demonstrating Biology—It Takes Guts"

This is as close as you are going to get to handling a digestive system in this lesson!

Note that at one point the instructor asks the student if they eat "faggots." There are many meanings for that word, but in this case, he is talking about a British food made of pig heart, liver, and belly meat, chopped up and wrapped in the fat layer that he is demonstrating.

There are no questions to answer here. Just write a comment on whether this video was informative for you. If you could, would you do a hands-on examination of a digestive system like this?

**Students will write a few comments, and describe if they would like to do a live, hands-on examination of a digestive system.**

### Activity C. Digestion Story

Write a story or create a comic strip about the following scenario: You are a piece of cheese pizza, about to be eaten by an eager human. Describe your journey through the body, from the mouth to the toilet.

Name and describe the different organs and substances that influence you on your journey through the digestive system. Be sure to include what parts of you are digested, and how, at different points along the way. Make your story or comic strip detailed, informative, interesting, and entertaining.

**(Image credit: Max Pixel)**

**The story should include a thorough description of all the parts and functions of the digestive system. Look for detail, and reward creativity.**

## Labs

Complete the following labs.

- Demonstration Lab: Modeling the Function of Bile
- Investigation Lab: Testing the Effects of a Digestive Enzyme

Name _____

# Demonstration Lab: Modeling the Function of Bile

In this lab, you will use detergent and cooking oil to simulate the effect bile has on breaking up (emulsifying) fats during digestion.

## Materials

- 2 250 mL beakers
- water
- cooking oil
- dish detergent
- stirring rod (spoon handle or table knife)
- graduated cylinder

## Procedure

1. Label one beaker A and one beaker B. Fill each beaker halfway with water.
2. Add 10 mL of cooking oil to each beaker.
3. While stirring, slowly add 10 drops of dish detergent to beaker B only.

## Analysis

1. Describe how oil reacts with water.

   **The oil spreads away from the water, floats to the surface, and the oil droplets clump together.**

2. Describe what happened to the oil when the dish detergent was added.

   **The oil was broken up into smaller droplets and dispersed.**

3. Compare the effect of dish detergent on oil with the effect of bile on fats.

   **Detergent breaks up oil like bile breaks up fat.**

4. Do the detergents and bile increase or decrease the surface area of oil? In the case of bile, how does this help the digestive process?

   **They both increase surface area. This speeds up the breakdown and absorption of fats.**

Name _____

# Investigation Lab: Testing the Effects of a Digestive Enzyme

In this lab, you will test the effects of the digestive enzyme pepsin under varying conditions. Pepsin is an enzyme that breaks some chemical bonds between the amino acids in proteins in the stomach. Gastric juice (hydrochloric acid) is also in your stomach, and has a role in protein breakdown.

You will be given clear instructions to follow throughout this lab. This is not a "design your own" investigation. Start this lab early in the day, as you will need to collect the data for several hours.

## The Question

Under which conditions is pepsin most effective?

## Hypothesis

Review the procedure below, and predict what your results will be. Note that you are working with three different foods in four different solutions. You need to be specific about which foods might digest the most in which solutions.

**Predictions will vary. Students will need to read the entire lab, however, in order to create a prediction.**

## Materials

- 4 100 mL beakers
- 100 mL graduated cylinder
- 30 mL 0.1 M hydrochloric acid (HCl) solution
- 0.6 grams pepsin powder
- stir rod
- 4 pecans or walnut halves
- 4 pieces of potato
- 4 pieces of beef jerky or cooked beef
- tape
- marker pen
- digital scale
- metric ruler
- tweezers
- magnifier
- warm water bath
- thermometer
- clock
- gloves
- safety goggles

# Anatomy and Physiology—Lesson 6 Investigation Lab: Testing the Effects of a Digestive Enzyme

## Procedure

### Part A: Preparing the Solutions

1. Label the beakers A, B, C, and D. Put on the gloves and safety goggles.
2. Add 15 mL of water to beakers A and C.
3. Add 15 mL of 0.1 M HCl solution to beakers B and D.
4. Using the digital scale, measure 0.3 grams of pepsin powder and put it in beaker C. (See instructions below for an easy way to mass a powder.)

### Massing a Powder

Cut a piece of paper in a circle or square, small enough to fit on the digital scale tray. Fold it in half so it is creased, and then half again. Unfold, and place it on the scale. Push the "T" button to tare the scale so it reads 0.0 g with the paper. Take a very small measuring spoon and place powder on the scale very slowly. As you get near your desired mass, add smaller increments until it just reaches the amount you need. Use the crease in the paper as a spout to pour the contents into the beaker.

5. Repeat step 4 and mass out another 0.3 grams of pepsin, putting it in beaker D.
6. Using the stir rod, carefully stir the pepsin in beaker C until it is completely dissolved. Rinse and dry the stir rod, and repeat with beaker D. Now the beakers contain the following:
    - A: water
    - B: hydrochloric acid solution
    - C: pepsin solution
    - D: hydrochloric acid and pepsin solution

### Part B: Preparing the Food Pieces

As you likely know very well, parents often tell their children to "chew your food well!" This is good advice because food breakdown depends on surface area. In preparing the pieces of food to test, try to get the pieces as close to similar size as possible. The pieces should be no larger than 1 cm × 1 cm, and can be as small as 0.5 cm × 0.5 cm. Use the digital scale to compare items of the same kind of food (i.e., all the potato pieces), but not foods of different types. Walnuts are much less dense than potatoes, for example, so you cannot compare the masses. Remember, similar surface area is what we are after. The scale is a secondary tool to help determine the piece size. Your first tool is your metric ruler.

Name _____

# Anatomy and Physiology—Lesson 6 Investigation Lab: Testing the Effects of a Digestive Enzyme

1. Cut each food item into small pieces or blocks that are the same size, as described above.
2. Place one piece of each food in each of the beakers A, B, C, and D.
3. Place the beakers in a warm water bath of about 37°C. Using a small picnic cooler will help hold the temperature. You will need to exchange some of the water periodically to maintain the temperature as best as you can.
4. Observe and record the condition of the food in each beaker after 15 minutes, 30 minutes, 1 hour, 3 hours, and 6 hours. Fill out the appropriate data table for each beaker. Use descriptive words such as "no change," "beginning to dissolve," "partly dissolved," "mostly dissolved," or "completely dissolved." Feel free to use other descriptive terms that you feel work better.

## Beaker A—Water: Conditions of Food Pieces

| Time (from start) | Potato | Nut | Beef |
|---|---|---|---|
| **15 min.** | | | |
| **30 min.** | | | |
| **1 hour** | | | |
| **3 hours** | | | |
| **6 hours** | | | |

## Beaker B—HCl: Conditions of Food Pieces

| Time (from start) | Potato | Nut | Beef |
|---|---|---|---|
| **15 min.** | | | |
| **30 min.** | | | |
| **1 hour** | | | |
| **3 hours** | | | |
| **6 hours** | | | |

## Beaker C—Pepsin: Conditions of Food Pieces

| Time (from start) | Potato | Nut | Beef |
|---|---|---|---|
| **15 min.** | | | |
| **30 min.** | | | |
| **1 hour** | | | |
| **3 hours** | | | |
| **6 hours** | | | |

# Anatomy and Physiology—Lesson 6 Investigation Lab: Testing the Effects of a Digestive Enzyme

### Beaker D—Pepsin and HCl: Conditions of Food Pieces

| Time (from start) | Potato | Nut | Beef |
|---|---|---|---|
| **15 min.** | | | |
| **30 min.** | | | |
| **1 hour** | | | |
| **3 hours** | | | |
| **6 hours** | | | |

## Analysis and Conclusion

1. What were the dependent and independent variables in this investigation? Which beaker was the control?

   **The independent variables were the food samples, the different solutions in the beakers, and time. The dependent variable was the condition of the food pieces over time. The control was the beaker with water only.**

2. Why were the beakers placed in a warm water bath, and why specifically 37°C?

   **The warm water bath was to simulate conditions in the stomach; 37°C is body temperature.**

3. Describe your results by comparing the conditions of the different foods in the different beakers. Which piece of food in which beaker was the most digested?

   **Students will describe their results. The beef in beaker D should be digested the most. Beaker A should show little change with any of the foods, and the potato will be digested the least in any beaker.**

4. What conclusion can you draw about the relationship of pepsin and pH?

   **Pepsin works best at a low pH.**

5. Potatoes are about 90% carbohydrates and 10% protein. Pecans are about 87% fat, 5% protein, and 8% carbohydrates. Walnuts are just slightly higher in protein and lower in fat than pecans. Beef is about 80% protein and 20% carbohydrates. Given this information, which molecule does pepsin act on?

   **protein**

6. If you were to repeat this experiment, replacing pepsin with amylase, the enzyme in saliva, what results would you predict? The pH of saliva is about 7.4. As before, predict which food(s) would digest best and which beaker(s). Explain your reasoning.

   **The potato in beaker C would show the most digestion, as amylase digests carbohydrates.**

# Anatomy and Physiology—Lesson 6 Investigation Lab: Testing the Effects of a Digestive Enzyme

7. Antacids are substances that raise the pH in the stomach, as the name implies. How do you think taking antacids on a regular basis would affect your digestion?

   **The digestion of protein could be slowed or inhibited if the acidity of the stomach is constantly lowered by taking antacids.**

8. In this lab, you conducted qualitative observations to obtain your results. How could you turn this into a quantitative investigation? Describe two ways.

   **A better unit to use for comparison would be surface area. It is fairly easy to keep a relatively constant surface area for the beef and the potato pieces, but nuts have an odd shape and a lot more surface area per unit of mass or volume. Students might suggest using a constant mass, but since the density of each food item varies, using a constant mass would necessarily mean different size pieces, depending on the food.**

As always, please submit all data tables with your lab report.

**The student's data tables should show data for each substance and each time increment.**

## SHARE YOUR WORK

Share the following work with your teacher.

- Answers to comprehension questions
- Answers to critical thinking questions
- Activity A: Explore "The Marvels in Your Mouth"
- Activity B: Video Demonstrating Digestion
- Activity C: Digestion Story
- Demonstration Lab analysis
- All work from Investigation Lab