Science

Anatomy and Physiology

Second Edition

High School Teacher Edition

Oak Meadow

Anatomy and Physiology

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Teacher Edition

Oak Meadow

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ISBN 978-1-68427-250-1
Item #b9530-TE
v.2025

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Teacher Edition Introduction

This teacher edition is designed to help you guide your student through *Anatomy and Physiology*.

In this course, students 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 18 lessons and is designed to be completed in 18 weeks. In addition to the textbook, students will be using online sources, which can be easily accessed at oakmeadow.com/curriculum-links.

There are six required labs in this course and six additional labs that are optional. In order for this to qualify as a lab course, students will need to choose at least two of the optional labs to complete, for a total of eight labs required in this course.

Safety note: Some of the labs require the use of boiling water, chemicals, knives, and other potentially hazardous items. Adult supervision is highly recommended.

This teacher edition includes factual answers to assignment questions, 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.

Each lesson includes a rubric that can be used to assess one or more of the assignments. You might want to add to these rubrics or develop your own. Students can use the rubrics to clarify expectations, guide their work, and focus their skill-building. You can use these rubrics to provide specific feedback about what the student is doing well and what they need to work on.

In this teacher edition, you will find the full content of the student coursebook. Teacher edition answers are shown 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 can be approached

as a learning opportunity. Make sure your student is familiar with when and how to properly attribute sources. (Refer to the appendix for more information.)

Content warning: The textbook contains photographs of bodies and body parts from deceased people who donated their bodies to science. It's important to view these graphic images with respect for each human being. Students who have concerns about viewing these images are advised to discuss the matter with you.

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.

A Note About the Workload

Oak Meadow courses are designed to be flexible. Teachers can require all assignments to be completed or designate some assignments as required and others as optional. This lets teachers adapt the course for a wide range of student abilities, goals, and skills.

Students vary greatly in terms of their ability to absorb information and communicate their ideas. Some might find the reading in this course takes longer than expected; others might find the writing assignments take a great deal of time. In general, students can expect to spend about five to seven hours on each weekly lesson. If your student needs more time to complete the work, you can modify lessons to focus on fewer assignments or allow them to complete some of the written assignments orally. Modifications like these can allow students to produce work that is of a higher quality than if they have to rush to get everything done.

Each lesson in this course can be customized to suit your student's needs. Use your judgment in skipping, substituting, and adjusting assignments as needed so that your student can meet the course's main objectives while devoting an appropriate amount of time to their studies. Keep an eye on the workload as your student progresses through the course and make adjustments so they have time for meaningful learning experiences.

Coursebook Introduction

Have you ever thought about what an amazing machine your body is? Think for a minute about all the things you love to do every day. Perhaps you play sports, create art, or make music. Do you like to read or cook? Do you like to talk to your friends? Whatever you are passionate about, you rely on your body to experience or participate in these things. Even simple experiences like listening to music actually require a lot of different parts of your body to function and coordinate perfectly.

When you took a course in biology (which is a prerequisite for this course), you were given an introduction to some of the inner workings of your body, including cellular processes, genetics, and the important molecules involved. At times, it might have been confusing, and rightly so! Researchers are learning more every day about the human body, including the chemical reactions that occur at the cellular level, how the systems of the body work together, and why they sometimes don't work perfectly.

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 need to have a solid understanding of the delicate balance of chemical interactions happening at the cellular and tissue level.

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

Stop and think about this for a minute.

How long do you think it took you to read the sentence above? 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 a staggering 37 × 1,021 chemical reactions occurring 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.

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. Prepare to be amazed!

What Is Anatomy? What Is Physiology?

Pacific sea nettle, Monterey Bay Aquarium, Monterey, California (Image credit: Dan90266)

While we will only be studying humans in this course, every life-form has specific anatomy and physiology that has adapted over millions of years 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.

The study of anatomy includes learning about the structure of the different parts of the body and how they interact. 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. ***Anatomy*** is defined as the "morphology of the body"—*morph* means "shape or form." Here are some 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).

You might use the word *morph* on its own 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.

Physiology comes from the word roots *phys*, meaning "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 and how 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* and how the structure of something supports its function. This occurs in every species no matter how simple or complex. Both the jellyfish and the human have bodily structures that perfectly support their functions. In this course, we will explore this relationship between anatomy and physiology.

Human Bodies Donated to Science

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

Bodies are still used today in medical studies, 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, 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, handling human remains helps medical 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.

The Unity and Diversity of Life

The study of anatomy involves an ongoing exploration of the ways that humans are similar to and different from each other. Biologically, our differences are extremely minor. At the level of our organs, tissues, cells, molecules, and even genetics, humans are incredibly similar. One famous study even calculated that a single troop of 55 chimps has more genetic diversity than 7 billion humans. On the other hand, we have the emerging field of personalized medicine that recognizes that each person's physiology is subtly unique and uses this to create individualized approaches for medical procedures such as cancer treatments.

Historically, there have been many instances where insignificant differences between sexes or races were used to promote the superiority of one group over another. At the same time, there are also instances of inappropriate overgeneralization of human similarities. For example, up through the 1990s, it was not uncommon for medical trials in the United States to involve only white males with the assumption that everyone else would respond similarly to treatments. While this worked sometimes, in other cases, it could take years before doctors noticed a pattern of underrepresented groups having poor outcomes to a medication or procedure. As we learn more about anatomy and physiology, it is critical to understand when human unity and diversity is significant and when it is not.

One important area of human diversity relates to the sexes. We recognize that the terms "male" and "female" do not capture the full range of human bodies and experiences when it comes to sex and gender. However, we have decided to use these terms in this course for two reasons. First, this language is what is found in currently available textbooks, and we wanted to match the terms to avoid confusion. Second, male and female represent the two most common anatomic forms, and these terms make it easy to discuss trends. That being said, scientists and educators alike are working to learn more about this topic and what terminology best reflects the diversity of human anatomy.

Learning Outcomes for This Course

Upon successful completion of the course, you will:

- Be able to ask meaningful questions and conduct careful investigations.
- Formulate explanations by using logic and evidence.
- Analyze situations and solve problems that require combining and applying concepts from more than one area of science.
- Understand that as a result of the coordinated structures and functions of organ systems, the internal environment of the human body remains relatively stable (homeostatic) despite changes in the outside environment.
- Be able to explain how feedback loops regulate conditions throughout the systems of the body.

Course Materials

This coursebook contains complete instructions for all the assignments and activities you will be doing throughout this course. The labs are fully explained in the accompanying lab manual. You will have many opportunities to exercise your imagination, curiosity, creativity, and scientific and critical thinking faculties.

In addition to this coursebook, the following materials are used in this course:

- *Hole's Human Anatomy & Physiology*, 16th ed., by Charles J. Welsh and Cynthia Prentice-Craver (McGraw Hill 2022)

- *Anatomy and Physiology Lab Manual*
- Anatomy and Physiology Lab Kit

Content warning: The textbook contains photographs of bodies and body parts from deceased people who donated their bodies to science. It's important to view these graphic images with respect for each human being. If you have concerns about viewing these images, please discuss the matter with your teacher.

There are several online resources included in this course. All online resource links can be found at oakmeadow.com/curriculum-links. Locate this resource and bookmark the page for future reference.

Here are three important online resources you'll be using:

Innerbody: Each body system is illustrated and described in detail along with 3D interactive images.

TeachPE: This site gives helpful general overviews of various structures and processes and also provides quizzes if you want to self-assess your understanding of material.

Crash Course: You may be familiar with Crash Course's fast-talking, funny way of explaining things. One helpful aspect of these videos is that you'll learn the correct pronunciation of the many terms you'll be seeing. 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 of the video the make it easy to absorb everything. Make frequent use of the pause button and replay sections as needed.

The resources described above will sometimes be a required part of the lesson, but usually they will be an optional resource for you to explore. This is helpful if you want to learn more about a topic or need help understanding it. 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 help you gain a better understanding of how the human body is put together.

How the Course Is Set Up

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

This course is designed for independent learning, so hopefully you will find it easy to navigate. However, it is assumed you will have an adult (such as a parent, tutor, or school-based teacher) supervising your work and providing support and feedback. We will refer to this person as "your teacher" in this course. If you have a question about your work, ask them for help.

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

- The **Assignment Checklist** gives a summary of the lesson assignments. Use it to keep track of your progress and check off assignments as you complete them.
- 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.
- **Reading and Viewing** sections direct you to read and/or watch materials that help you learn the lesson content and often include optional resources for additional learning.
- **Comprehension Assignments** are designed to help you solidify key concepts and knowledge.
- **Critical Thinking Assignments** 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. In some lessons, there will be multiple options to choose from. Make sure you read each option before picking one to complete.
- **Labs** give you a way to explore, experiment, and discover how the concepts you are learning relate to real life. They involve collecting and organizing data, analyzing the data, and drawing conclusions. All labs are found in the lab manual.
- **Rubrics** are found in each lesson and provide criteria that can be used to guide and assess your work. These rubrics can help clarify the skills you are working on and expectations regarding the quality of your work.
- **Share Your Work** sections provide a reminder of what to share with your teacher at the end of each lesson.

Each lesson is designed to take one week to complete. To manage your time well, look through the reading and assignments before you begin each lesson so you can create a timetable for the week.

At the end of the course, you will be doing a final project in lessons 16–18. You might want to read through the project options, which are described in lesson 16, early in the course so you can be thinking about your final project as you work through the course.

This course does not require animal dissection. While taking apart an animal is a useful learning experience, it is not necessary to destroy a living being to understand its basic anatomy. Even in medical schools, models are used more and more often these days. That said, if you feel that a dissection is in line with your interests and you want to pursue it on your own, there are many dissection kits available online, and this is one of the options for the final project in the course. When working with living things, it's important to do so with the utmost respect, recognizing that humans don't own nature; we are simply a part of it.

Lab Requirements

There are six required labs in this course and six additional labs that are optional. You should choose at least two of the optional labs to complete, for a total of eight labs required in this course.

The labs are listed below and described in full in the lab manual.

Lesson	Required Labs
1	Are You Vitruvian?
7	Primary Sensory Cortex
9	Determining Blood Type
10	Homeostasis and Exercise
12	Modeling the Function of Bile
12	Testing the Effects of a Digestive Enzyme

Lesson	Optional Labs (choose two to complete)
4	The Effect of Temperature on Fingerprints
6	Chicken Muscle Dissection
10	Testing Lung Capacity with a Spirometer
11	Influencing Bacterial Growth
13	Osmosis Demonstration
16	Design an Experiment

Labs need specific materials, which are listed in the appendix of this coursebook as well as in the lab manual. Some of these materials are found in the lab kit, and others will need to be procured in advance. Please check the materials list so you can plan to have everything on hand when you need it.

Academic Expectations for Students

In this course, it is important to follow the assignments in order. Students are often tempted to skip over certain assignments, planning to return to them later. While this might feel easy or time efficient in the moment, it can mean that you are moving on with misconceptions and will earn lower scores or will need to go back and fix work. Additionally, when you come back to do the skipped components, the material is no longer fresh in your mind and you will need to take extra time to review things. It's actually better for your time management and learning to do the course in order.

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.

Throughout the course, keep in touch with your teacher and share your comments, ideas, questions, and challenges. Your teacher is eager to help you!

A Note About the Workload

Students vary greatly in terms of reading speed, reading comprehension, and writing ability. Some might find the reading in this course takes longer than expected; others might find the writing assignments take a great deal of time. In general, you can expect to spend about five to seven hours on each weekly lesson.

Keep an eye on the workload as you progress through the course. If you find you are struggling to complete the work in a reasonable time frame, discuss your options with your teacher, who might modify certain lessons depending on particular learning goals or challenges you are facing.

Lesson 1

Anatomy and Physiology: The Big Ideas

Learning Objectives

- Practice applying overarching concepts like characteristics of life, feedback loops, and structure and function.
- Reflect on personal connections and meaning in studying anatomy and physiology.

ASSIGNMENT CHECKLIST

- ☐ Read the lesson introduction.
- ☐ Complete the reading and viewing assignments.
- ☐ Complete the comprehension assignments.
- ☐ Complete the critical thinking assignments.
- ☐ Lab: Are You Vitruvian?

Lesson Introduction

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 sprinter on the cover of your textbook. Think about all the things the sprinter's body must do while running. Think about all the muscles and joints that need to operate together and all the sensory information that the body must collect and send to the brain to keep the runner oriented. Think of something you do that requires a high degree of focus and coordination. What would it be like if you had to concentrate on every process in your body while you did this activity?

At first, when you do a new set of movements (such as learning a new piece of music, a new dance, or a new 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 "muscle memory" and how does it work? 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 together smoothly without our conscious knowledge or effort, but what happens when these things go awry?

Let's dig in and explore!

Reading and Viewing

1. Read the coursebook introduction on the previous pages, if you haven't done so already.
2. Read the box below, How to Read Your Textbook.

3. In your textbook, read chapter 1, "Introduction to Human Anatomy and Physiology," which includes the following sections:
    - 1.1 Origins of Medical Science
    - 1.2 Anatomy and Physiology
    - 1.3 Levels of Organization
    - 1.4 Core Themes in Anatomy and Physiology
    - 1.5 The Characteristics and Maintenance of Life
    - 1.6 Organization of the Human Body
    - 1.7 Life-Span Changes
    - 1.8 Anatomical Terminology

    Note: Pay close attention to sections 1.2–1.5 and 1.8. You can skim the other sections. You may skip the Career Corner and Clinical Application boxes in the chapter.

    Make sure you are familiar with the big ideas in each section, but don't worry if you don't understand all the things they mention. We will revisit these topics throughout the course.

    Remember, there are places where information is presented both as text and in the images, so if you are struggling with the text, you can try looking at the figures instead.

How to Read Your Textbook

There is a lot of information and new vocabulary in your textbook, and it can get complicated. Don't worry though—you don't need to read every section in depth. Here are some guidelines to keep in mind.

1. Before you start the textbook reading, look over the lesson objectives, questions, and activities to get a sense of what you need to learn from the textbook.
2. Then, go to the chapter and look through the different headings, boxes, sidebars, and sections of text to get a sense of what the chapter covers.
3. Take note of the sections that are assigned reading for the lesson. Some textbook sections are not used in this course, so make sure you understand what you are required to read and what you can skip.
4. Study the images and diagrams. Complex structures and processes can often be best explained through visuals. Examine the visuals slowly, paying special attention to the labels and captions, which will help you understand what is being shown.

It's important to note that the textbook often provides the same information in multiple ways. For instance, there are many descriptions of specific structures and their locations, but you can often quickly get that same information by looking at the images that go with the text. Similarly, technical sections about processes or types of cells are usually summarized in a quick, easy-to-read table. You may be able to skip sections of the text when you are able to get the same ideas from the pictures, tables, and diagrams, so take your time studying the visuals first.

5. Finally, begin reading the chapter content. Reading a chapter straight through is not always the best approach. Read one section at a time, go back and forth between sections as needed, and read some parts two or three times if necessary. Skim some parts and read other parts in depth.

Here are some essential study tips:

- **Take good notes.** The act of writing things down with a pen and paper can improve your retention and understanding. This is especially useful when reading dense text (such as a textbook). There is a section on note-taking in the student resources section of the textbook, or you can use the Cornell note-taking system, which has easy-to-use templates that you can find online.
- **Use your notes!** Taking notes is helpful, and referring to them for study will help even more.
- **Keep a list of new vocabulary terms.** There is a lot of specific terminology. It is similar to learning a new language, so you might find it helpful to keep a vocabulary list. Define new terminology and practice proper pronunciation of the terms.
- **Use the textbook resources.** Use the index and glossary to look up terms or find them in the book. Check out the Understanding Words box at the start of each chapter, which shows the meaning of common root words. This can be a big help as you navigate new terms. Each chapter ends with an overview of how that body system interacts with others. Pay attention to these useful resources.

Comprehension Assignments

1. Scientists need shared terms to describe where body parts are in relation to one another, regardless of how the body is moving or positioned. These terms are in section 1.8 of the textbook and will come up often throughout the course, so it's important to be familiar with them. For each description below, identify a body part that meets the criteria.

   a. Identify a part of the face or head that is lateral to your left eye.

   The left ear is the most obvious answer, but anything between the left eye and the left side of the head is fine.

b. Name a joint that is distal to the hip and proximal to the ankle.

The knee

c. What is superficial to your brain and deep to your scalp?

The most obvious answer is the skull; other answers include the blood vessels of the head and the cerebrospinal fluid.

d. Use the terms in section 1.8 to write your own description of the position of a mystery body part. (For fun, you can see if someone else can correctly guess the body part.)

Answers will vary, but students should use words from section 1.8 correctly to describe the location of a body part.

2. Anatomy and physiology terms can often be deciphered if you are familiar with some of the common word parts. For example, if you know that *cardi* means "heart," then you can have a good idea of what a cardiologist studies or the general location of the pericardium.

   Every chapter in the textbook begins with a list of word parts that are common in that chapter. It's good to get in the habit of looking at this list before you start reading so you have a head start with all the new vocabulary. To challenge yourself, you might like to try to figure out what a new term means using the roots before you read the definition. (Feel free to keep score and give yourself little rewards!)

   Using the Understanding Words box on page 10, list at least three terms you found in the chapter reading that contain these word parts. (Do not use the examples from the box.)

   Answers will vary. They could include peritoneal membrane, cardiovascular system, dermatology, etc.

3. How is anatomy different from physiology? Give an example of each in your explanation.

   Anatomy is the study of the structures in the body, and physiology explores how those structures work. For example, brain anatomy includes the different regions of the brain, and brain physiology looks at what each region controls and how.

Critical Thinking Assignments

1. Are viruses alive? Viruses vary but generally share these characteristics:

   - Viruses are small (usually 20–200 nm).
   - They contain simple genetic material (DNA or RNA) surrounded by a protein capsule.
   - On their own, viruses cannot absorb or excrete anything and have no metabolism.
   - They do not change over time but can reproduce by attaching to a cell and forcing the cell to produce new viruses.

   Using what you learned in section 1.5 of your textbook on the characteristics of life, explain your position on whether viruses are alive or not.

While viruses are generally considered to be nonliving, students can take the opposite position here as long as they have thoughtful reasoning based on several of the following characteristics of life: response to surroundings, growth, reproduction, metabolism, and movement.

2. Take a look at the photos on pages 30 and 31 of tissues from actual human bodies. This textbook includes many photos of actual tissues from humans who chose to donate their bodies to science (including numerous reference plates on pages 47–58). Reflect on the donation of one's body to science by addressing the following questions in one or two cohesive paragraphs.

   - Why do you think the textbook chose to use photographs instead of drawings?
   - Would you consider donating your body to science? Why or why not?
   - If you did donate your body, how would you want your body (or photos of your body) to be treated by others?

   Answers will vary. Check that the student has addressed all parts of the prompt. There are several possible reasons that the textbook uses actual images of human anatomical structures. For example, there are limitations to any model or representation of an organ, so showing an actual image can provide a more accurate picture of structure. This topic may make a student feel squeamish, but these images will appear regularly in the textbook, so it is important for students to think about the educational value of these images and humanize them. Each image is from a human being, and we should be respectful while viewing and learning from the images of their body.

3. This lesson has introduced some of the big ideas of anatomy and physiology. Based on what you've learned so far, write a paragraph reflecting on how you think this course may be relevant to your life. Include anything you are particularly excited to learn about. If you have any concerns, you can bring them up as well.

   Understanding how the body works is critical in taking care of your own health, evaluating the safety of various products such as medications or cosmetics, and dealing with medical conditions. It's helpful information for athletes as well as artists, who can use anatomy knowledge to depict bodies more accurately. These are just a few real-world connections.

   It's important for students to see how this course matters for them personally. This question is also a good opportunity to check in with the student about their interests or concerns to make sure the course is set up to support their needs. If a student is struggling to see the relevance of this course, you may want to ask some follow-up questions about their passions, career plans, etc., and suggest some ways anatomy and physiology might help.

4. This course culminates with a three-week project in lessons 16–18. Skip to lesson 16 and take a few minutes to skim through the project ideas so that they are in your mind as you work through the course. You don't need to pick one now, but you can start thinking about what might interest you (especially if you are thinking about a project that requires materials you want to start assembling in advance).

Jot down three project ideas that interest you at this point. (Your interests might change by the time you choose your project.)

Check that students wrote down options that interest them. They do not need to end up doing one of these. For some project options, the student might want to do things like get materials in advance or perhaps bring a relevant book with them to read on a trip. Students are welcome to choose their project before they get to lesson 16.

Donating Your Body to Science

If you are 17 or older in the United States, you can choose to donate your body to science after you die. Donated bodies can be used in many different ways. They are critical for medical students to study anatomy or practice surgical procedures. The bodies could also be used in biomedical studies or in forensic science.

One fascinating option is to donate your body to a body farm. To learn how studying a decaying body can contribute to science and crime-solving, you might like to read the article below. (This is optional.) Note: Be prepared for some graphic images.

"Down on the Body Farm: Inside the Dirty World of Forensic Science"

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

If this topic piques your interest, check out the book *Stiff: The Curious Lives of Human Cadavers* by Mary Roach.

Lab

Complete the following lab:

- Lab: Are You Vitruvian?

This is a required lab. All labs are found in the lab manual.

The sections of the lab shown below are those with teacher edition answers. For the full lab procedure, see the lab manual.

LAB

Name _____

Are You Vitruvian?

The Question

Write the question that you will be investigating.

Questions will vary but will probably be along the lines of "How do my body proportions compare to those of others and to the Vitruvian proportions?" or "What are the proportions of my body?"

Analysis and Conclusion

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

   Answers will vary based on the data. Students might find that the variations within the group were larger than the variations from the Vitruvian proportions because some people measured a bit more or less than Vitruvian, which kept the mean close to the model.

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

   Answers will vary. Encourage students to perform additional calculations to investigate their questions or theories.

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 are some practical uses for the information?
   - 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 the perception of symmetry, perfection, and beauty?
   - What do you think of the 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.

Anatomy and Physiology—Lesson 1 Lab : Are You Vitruvian?

Submit your question, data table(s), and responses to the Analysis and Conclusion questions.

Look for students to stretch their thinking beyond the lab itself to real-world applications.

Learning Assessment Rubric

The single-point rubric below (like those in each lesson) indicates skills and elements that your work should demonstrate. You and/or your teacher can use these rubrics to evaluate your work and help develop your skills. There may be other criteria that you or your teacher will want to use to evaluate your work as well.

Evidence of Meeting or Exceeding Expectations	Expectations	Areas for Growth
	Investigation and experimentation Mathematics are applied to help interpret data, identify patterns, and draw conclusions.	
	Investigation and experimentation Models and theories are used and referenced as scientific representations of phenomena, and their limitations are identified.	
	Investigation and experimentation Appropriate tools and technology are used to perform tests, collect data, analyze relationships, and display data.	

SHARE YOUR WORK

When you have completed this lesson, share the following with your teacher:

- Comprehension assignments
- Critical thinking assignments
- Lab: Are You Vitruvian?

Check with your teacher to clarify their expectations about what you are required to do. Your teacher will let you know the best way to submit your work. If you have any questions about the lesson content, assignments, or submission methods, contact your teacher.

Lesson

2

Reviewing the Biology Basics

Learning Objectives

- Review key concepts from cellular biology.
- Identify areas of interest and relevance in anatomy and physiology.

ASSIGNMENT CHECKLIST

- ☐ Read the lesson introduction.
- ☐ Complete the biology review quiz.
- ☐ Complete the reading and viewing assignments.
- ☐ Complete the comprehension assignments.
- ☐ Complete the critical thinking assignments.

Lesson Introduction

The term *interdisciplinary* describes situations where multiple disciplines or types of knowledge are used together to create a more complete understanding. In this course, we will use many science disciplines to explore anatomy and physiology. For example, in order to make sense of our complex anatomy, it is important to start with an understanding of cells and the biological processes that keep them alive. Likewise, in order to understand physiology, we must understand things like the complex chemical reactions that control your blood pH or trigger hormonal responses. We will look to physics to help us understand the electrical impulses in our neurons, our blood pressure, and the movements of our joints. You might be surprised at how many other disciplines intersect with anatomy and physiology.

In this lesson, we will review some biology concepts and basic chemistry that we will use in this course. Throughout the course, look for connections to other disciplines (even ones outside the sciences) to help you deepen your understanding.

Biology Review 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 to prepare for your study of 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. The quiz is simply a tool to guide students in identifying and filling in gaps in their knowledge of cell biology.

1. Describe the four types of molecules that living things are made of.

   Proteins are made of amino acids and are responsible for many of the tasks that occur in a cell. Examples include hemoglobin, collagen, and insulin.

   Carbohydrates are made of monosaccharides and are mainly for structure and energy storage. Examples include starch, cellulose, glucose, and glycogen.

   Lipids are made of fatty acids and have a variety of functions including long-term storage of energy, structure, and signaling. Examples include phospholipids and cholesterol.

   Nucleic Acids are made of nucleotides and hold genetic information. Examples are DNA and RNA.

2. Explain what acids and bases are and give an example of each.

   Acids are chemicals that are proton (H+) donors and have a pH below 7. Examples include hydrochloric acid, peptic acid, citric acid, etc.

   Bases are proton receptors and have a pH above 7. Examples include sodium hydroxide, baking soda, ammonia, etc.

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

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

4. What is a cell?

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

5. How do cell membranes use processes such as osmosis and active or passive transport to be selectively permeable? Why is this important?

   Cell membranes are structured so that only certain molecules can cross. Osmosis is the diffusion of water molecules across a semipermeable membrane down its concentration gradient (meaning from an area of high-water concentration to an area of lower water concentration).

   Passive transport includes diffusion and facilitated diffusion. It doesn't require energy from the cell because the molecules are moving with the concentration gradient. Active transport is the movement of molecules against the concentration gradient, which requires energy. These processes are critical in allowing certain substances to enter or exit the cell while keeping other substances in or out so the cell can maintain homeostasis.

6. 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 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.

7. What is an enzyme?

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

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

   Cellular respiration

9. What is lactic acid fermentation? In what kind of situation would this process occur in your muscles?

   Lactic acid fermentation, or anaerobic respiration, 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.

10. Give an example of why a human cell might undergo mitosis and when a cell might do meiosis.

    Mitosis creates an exact copy of the parent cell, such as when making new skin cells to replace ones that are sloughed off or when a child's growing body makes new cells.

    Meiosis produces gametes such as eggs and sperm, which have half the genetic material of the parent cell. This occurs in the ovaries or testes for reproduction.

11. What are stem cells, and why are they significant?

    Stem cells are not differentiated (specialized) and are able to keep dividing into new undifferentiated cells that can develop into various body cells. This is critical for growth and cell renewal. Medical treatments with stem cells can be used for cancers and other conditions. Students might mention the ethical controversy around stem cell research.

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

    The traits a person inherits are a result of the combination of genes received from the parents. Genetics determines your height, body composition, and hair color. There are many medical conditions that are passed down from parents as well. For example, knowing that colorblindness is a sex-linked trait (and what that means) can help a person predict whether their own children might inherit the trait.

13. How does DNA impact the characteristics of a living thing?

    The DNA is transcribed into mRNA which is read or translated by ribosomes to make proteins. These proteins are responsible for determining genetic characteristics. For instance, an eye color gene in the DNA codes for a protein that gives the eye a particular

color. If that eye color gene has a different code, then a different protein would be made and would cause a different eye color.

14. Can you describe a system that is in your body? How about one that is not in your body? In your description, include some of the parts that make the system function.

    Answers will vary. A system is an organized group of related parts that interact to form a whole that has one or more functions. Body systems include muscular, circulatory, nervous, skeletal, etc. Examples of systems outside the body include 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, such as "I have a system for getting ready for bed." This is not the usage we are using here.

15. There are many chemical reactions that happen in the body. Explain why this is necessary, using an example of homeostasis in your answer.

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

Reading and Viewing

1. Based on how you did on the biology review quiz, look through chapters 2–4 and read sections that relate to any topics you are unclear about.

    - Chapter 2: "Chemical Basis of Life"
    - Chapter 3: "Cells"
    - Chapter 4: "Cellular Metabolism"

    For example, if you didn't remember much about acids and bases, you should read that section in detail (perhaps while taking notes). If you felt confident about cells and organelles, you could skip that section entirely or just skim through it.

2. Optional: If you find videos helpful to your learning or if you need to review a lot of biology material and are feeling overwhelmed about the amount of reading, you can select videos from the Crash Course Biology series about any topics you want to review.

    "Biology"

    This playlist (and all online resources used in this course) is easily accessed at oakmeadow.com/curriculum-links.

Comprehension Assignments

1. After reviewing chapters 2–4, complete the following assignments.

   a. Correct any quiz answers that need adjustment using a different color ink from your original answer. Remember, you won't be graded on your original quiz answers but on the completion of the quiz and your corrections.

   Check that students revised all incorrect or incomplete answers.

   b. Write a brief statement about how the review of cellular biology material went for you.

   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 fine if the student needs a lot of review.

2. Look over the resources below (if you haven't already) to familiarize yourself. Write a brief comment acknowledging you have done this and noting anything that especially interests you. Let your teacher know if you have questions or need help.

   - Lab kit: This course includes labs that use the materials in the lab kit. A list of lab kit materials is included with the kit. Make sure you have everything on the list.
   - Crash Course Anatomy & Physiology: These videos can help you understand the information presented in the textbook. The host speaks quickly, but you can slow down the video speed or add subtitles. You will be directed to specific videos throughout the course.
   - Innerbody: This resource lets you click on different body systems and structures to see images, locations, and read more about function. Explore the site for a minute or two so that you know what kind of information is available.

     "Human Anatomy Explorer"

   Students should let you know that they have looked through all the materials. Answer any questions or concerns that come up.

Critical Thinking Assignments

1. Take a few minutes to reflect and connect to the course so far by choosing one of the following options to respond to.

   a. Family medical imaging: Talk to your family members to find out what types of medical imaging they have had done. You can also ask about medical imaging you had done when you were a baby or small child. Find out what the experience was like. Write a few sentences about what you learned. You do not need to share personal medical information—respect the privacy and wishes of those you interview.

b. Textbook relevance sections: The textbook includes sections such as the following, which describe ways the chapter content is relevant or applied in the real world:

   - Career Corner
   - Clinical Applications
   - From Science to Technology

   Pick one section from chapters 1–4 that seems interesting to you and read it in depth. Write a brief description about what you learned and why it interests you. No outside research is required, but you are welcome to do this if you want.

c. Questions: Brainstorm a list of ten specific questions or areas of interest that you want to explore in this course. Go beyond basic questions like "What is anatomy?" or "What makes a heart healthy?" Formulate questions that are thoughtful and detailed.

   For instance, if you have a personal interest in a particular disease, injury, or related topic, you might ask questions such as these:

   - How do diet and exercise influence whether or not a person is likely to get diabetes?
   - Why do some people decide not to vaccinate their children when Western science promotes vaccinations?
   - Are food allergies caused or prevented by the foods a baby eats?

   If you like video gaming, you might ask questions such as these:

   - What body systems are involved in hand-eye coordination, and how can knowledge of anatomy and physiology increase response time?
   - How can an understanding of anatomy help prevent common repetitive stress injuries and eye strain?

   If you are considering a medical profession, you might ask questions such as these:

   - Which body systems share the strongest connections and which systems are more loosely linked?
   - How does physical therapy increase healing and reduce recovery time after an injury or surgery?

   There are no wrong questions, so brainstorm about any topics you are interested in.

Formulating questions activates the student's curiosity and engages them as an active partner in the learning process. The goal is for students to explore ways that this course is interesting or relevant to them personally. Questions can be brief but should show that the student is making a meaningful connection. If a student struggles with this, you can prompt them by asking what they are interested in and how their body is connected to it.

Learning Assessment Rubric

Evidence of Meeting or Exceeding Expectations	Expectations	Areas for Growth
	Building knowledge Areas of interest are used as the basis of investigations.	
	Building knowledge Accurate scientific terminology is used when describing phenomena or conveying information.	
	Building knowledge Research questions are formulated and/or information is summarized that focuses on key details.	

SHARE YOUR WORK

When you have completed this lesson, share the following with your teacher:

- Biology review quiz
- Comprehension assignments
- Critical thinking assignments

If you have any questions about the lesson content, assignments, or submission methods, contact your teacher.