Human Anatomy and Physiology

Oak Meadow Coursebook

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Item #b096110
v.071719

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Lesson

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.)

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.

ASSIGNMENT SUMMARY

- ☐ 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.

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.

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.)

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.

1. What is a cell?

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

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

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

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

6. Your body is made of mostly _____.

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

8. What is an enzyme?

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

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

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

12. What is osmosis?

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

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

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

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.
2. After reviewing chapters 1–4, correct any of your quiz answers that need adjustment, using a different color 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? If you need review, remember that you have this textbook available to you; you can review these basic concepts at any time.

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

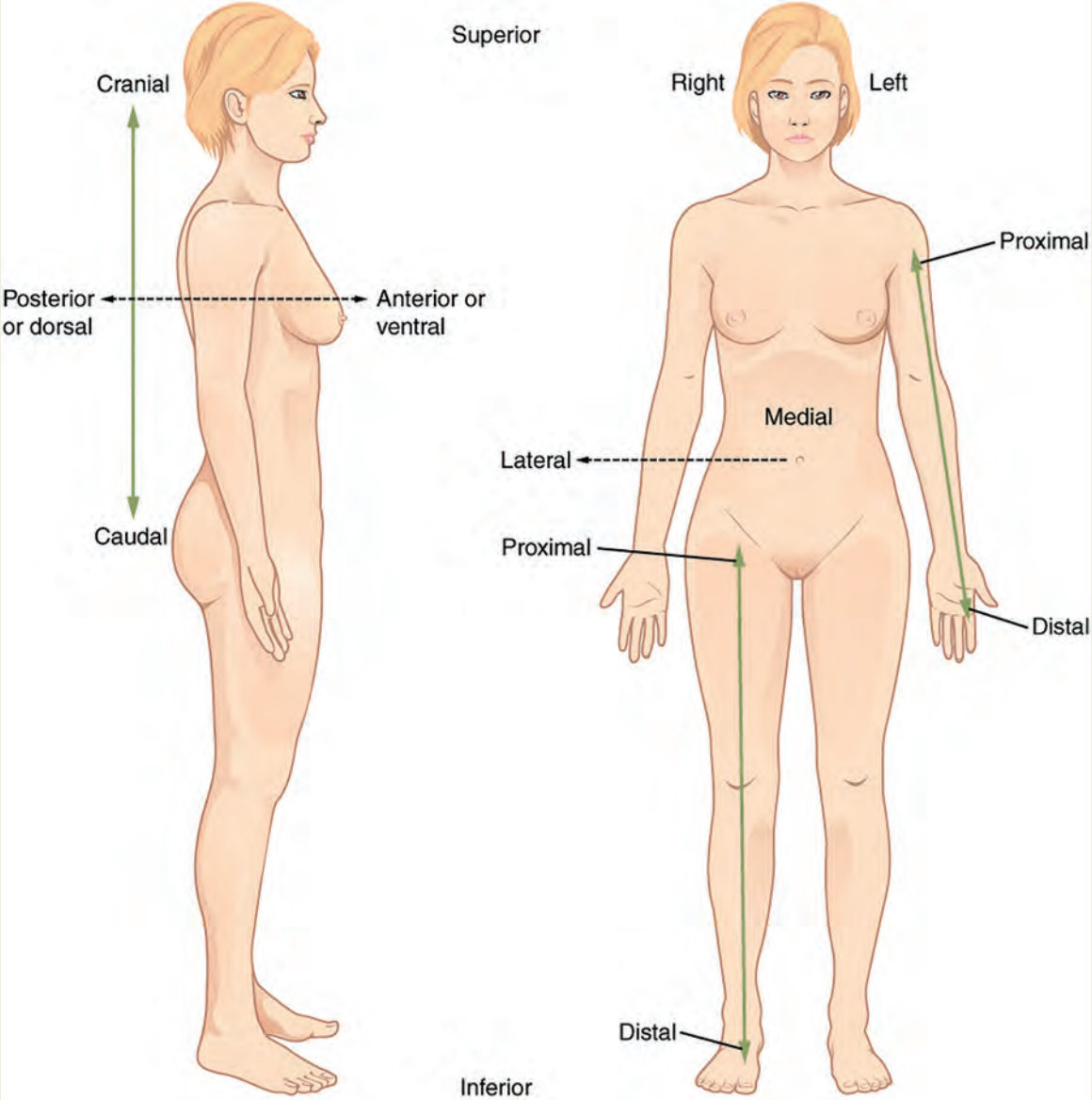
Look at the image on the next page. Do you see the position the woman is standing in? This is called the *anatomical position*. When learning anatomy, this is the standard position used to explain body parts in reference to each other, regardless of the position the body happens to be in at the time. 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

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:

Body Farm - National Geographic Video

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/.)

FOR ENROLLED STUDENTS

You will submit your work to your Oak Meadow 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.)

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?

Reading

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

Read chapter 28, "Human Systems and Homeostasis."

ASSIGNMENT SUMMARY

- ☐ 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?

Comprehension

1. What is a zygote?
2. Contrast cell determination with cell differentiation. About how far into embryonic development does differentiation start?
3. What organ systems must work together to bring oxygen to the body's cells? (Hint: there are more than two!)
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.
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?

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.
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.
   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).
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.

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.

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 you need.

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.

Helpful 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."

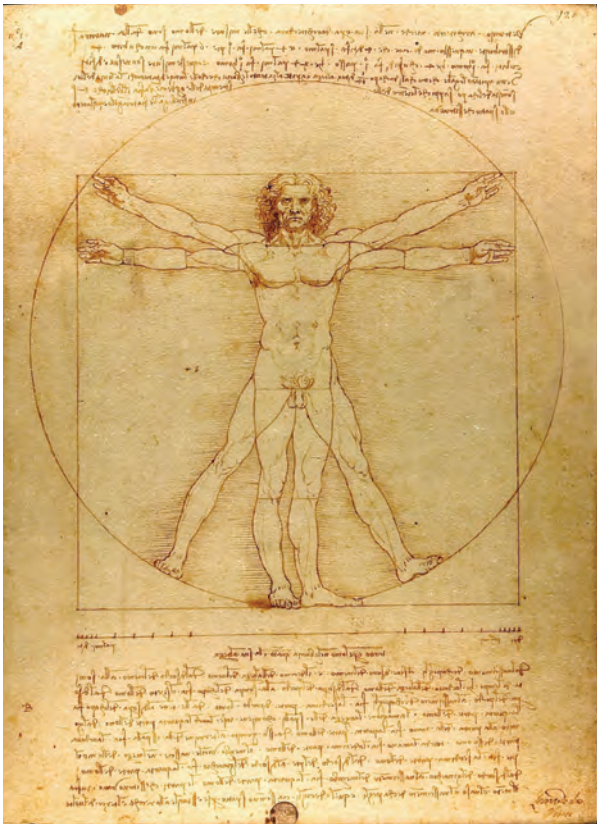
Save this drawing; you will make adjustments to it in the next lesson. Take a photo or scan of this rough draft so that in the next lesson you can share both versions.

Lab: Are You Vitruvian?

Marcus Vitruvius was an ancient Roman architect, born 85 BCE. He is famous for his 10-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:

- 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



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

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

Materials

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

The Question

Write the question that you will be investigating.

Procedure

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.

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

FOR ENROLLED STUDENTS

Please 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

The Nervous and Endocrine Systems

> There is no fixed physical reality, no single perception of the world, just numerous ways of interpreting world views as dictated by one's nervous system and the specific environment of our planetary existence.
>
> **Deepak Chopra**

In what order should we learn the body systems? It doesn't really matter, as they all work together and communicate with each other. However, the nervous and endocrine systems are the means of communication between every organ in your body, and also with the outside world, so we'll start with them.

The ***nervous*** and ***endocrine*** systems control everything that goes on in our bodies; they are the body's communication systems. As you read the chapter, pay attention to the many ways that the nervous and endocrine systems work together, and how they are interconnected with all the other body systems. Both systems involve complex feedback loops that dramatically affect a person's well-being. If you get overwhelmed with the information you are learning, take a moment to step back and wonder about it all. Thanks to your nervous system, you have senses that are constantly detecting what is happening around you and eliciting responses. Imagine your body as an actively vibrant, pulsing electrochemical machine. Signals are rapidly firing and crisscrossing throughout your body every nanosecond, and you don't even have to think about it.

ASSIGNMENT SUMMARY

- ☐ Read chapter 29.
- ☐ Explore the "Nervous System" and the "Endocrine System" on the Innerbody.com website.
- ☐ Answer comprehension questions.
- ☐ Answer critical thinking questions.
- ☐ Revisit Activity C from lesson 2, modifying your drawing.
- ☐ Complete the following activities.
  - Activity A. Endocrine System Quiz
  - Activity B. The Teenage Brain and Hormones
  - Activity C. Brain Science Exploration
  - Activity D. Quick Lab: The Blind Spot Test
  - Activity E. Quick Lab: The Stroop Effect
  - Activity F. The Possible Future of Brain Science
- ☐ Lab: The Primary Sensory Cortex

In the first two decades of life, the brain is radically changing. You've probably heard discussion about the "teenage brain," or maybe you've heard adults say you are acting unpredictably "because of your hormones." There are some unique things going on in your brain during the teen years as your hormones change the way your brain works and develops.

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

The prefrontal cortex (seen in red) is responsible for the "executive function" aspects of the brain, such as decision-making and judgment; this area of the brain is still developing in teenagers. (Image credit: Database Center for Life Science)

Learning Objectives

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

- Explain how the nervous and endocrine systems are the communication systems of the body and regulate homeostasis.
- Describe the structure and functions of the components of the nervous and endocrine systems.
- Demonstrate how your senses operate.
- Describe recent brain science research.

Before You Begin

Since this is a long lesson, take a few minutes to look through the entire lesson before you start and set up a timetable to organize your time in order to complete it within three weeks. Here is a suggested timetable (yours might vary):

Week 1: Reading, neuron drawing, comprehension and critical thinking questions

Week 2: All activities (A–F)

Week 3: Lab, review all lesson work and edit as necessary

Reading and Viewing

1. In your textbook, read chapter 29, "Nervous and Endocrine Systems."
2. Read and explore the "Nervous System" and the "Endocrine System" on the Innerbody.com website (found under Read and Learn/Human Anatomy). Be sure to check out the text sections below the images.

Reading Hints: Some of the reading in this textbook chapter might be familiar to you, and you will be able to skim those parts. We will be connecting some of this material to cell biology covered at the beginning of the textbook, so you might need to brush up a little on cell membranes.

Helpful resources

There are eleven Crash Course videos (found on YouTube) about the nervous system: A&P #8–18. These are not required, but you might find some of them helpful. The more complex processes you will be learning include nerve impulses and action potential, and the action of synapses, so **"The Nervous System, Part 2"** and **"The Nervous System, Part 3"** will be particularly helpful. The Crash Course videos on the endocrine system might also prove helpful to you. Make frequent use of the pause button and replay sections as needed.

Comprehension

1. Both the endocrine and nervous systems are important communication systems in the body. Describe the differences in how each system works.
2. Figure 2.2 on page 822 of your textbook summarizes much of what you are reading in section 29.2. When you read the section, also take a close look at figure 2.2. If possible, teach a family member how a nerve impulse is transmitted through and between neurons. Describe each step of the process while you look at the diagram. Also, search on YouTube for "nerve impulse transmission" for some helpful animations of the process. Then answer the following questions:
   a. When a neuron is at rest, what is the charge of its inner cell membrane?
   b. What causes an area of the inner membrane to become positively charged? How does this happen?
   c. How does the impulse (area of positive charge) move down the axon?
   d. How is the negative charge of the axon's inner membrane restored?
   e. What is the role of neurotransmitters in nerve transmission?
   f. Extra credit question: By what process are neurotransmitters released from the presynaptic neuron? (Hint: review chapter 3).
3. In what part of the eye is light transmitted to an electrical impulse?
4. Suggest a possible defect of the retina that would cause color blindness, a condition in which a person cannot distinguish between certain colors.
5. To which senses do mechanoreceptors contribute?
6. Why does a human brain have so many folds?
7. Why is a reflex arc more rapid than a voluntary movement?
8. Compare and contrast the autonomic and somatic nervous systems. Include the two divisions of the autonomic nervous system.
9. Describe three important neurotransmitters in the brain.
10. How do releasing hormones of the hypothalamus connect the nervous and endocrine systems?

Critical Thinking

1. Why is it beneficial for neurons to have many dendrites?
2. For some invertebrates that live in water, taste and smell are the same. Why do you think separate organs for taste and smell might have evolved in animals that live on land? In your answer, mention the type of receptor involved in these senses.
3. Go back to the "control systems" described in chapter 28. Relate each of the parts of the nervous system to the parts of the control system as you explain what happens when you perceive a stimulus with your senses. Include the following terms in your answer: sensory neurons, interneurons, motor neurons, PNS, CNS, brain, spinal cord, nerve impulse, and neurotransmitter.
4. Review the complex structure of the ear illustrated in Figure 3.3 on page 826 of your textbook. Also check out the ear on the Innerbody.com website. Knowing that the ear's functions include not only hearing, but also balance, notice the three semicircular canals. Each canal lies in a different plane: vertical, horizontal, and sideways. How do you think this orientation of the fluid-filled semicircular canals (the structure) contributes to the function of the canals?
5. In your textbook reading, the action of cocaine on the axon terminal is described. Connect what is happening to the explanation of how neurons adapt (found on the previous textbook page). Is this an example of sensitization or desensitization? How does the receiving neuron respond? How does this contribute to addiction?
6. Review the "Correlation or Causation" data analysis practice activity on page 839. Answer the two questions.
7. Respond to the following (you might want to review parts of chapter 3 about how molecules cross cell membranes):
   a. Name some structures on the cell membrane that might ensure that the endocrine system's signals only affect the cells for which they are intended.
   b. Why can a steroid hormone diffuse through the phospholipid bilayer of the cell membrane easily, whereas a nonsteroid hormone cannot? (Hint: consider what a steroid hormone is made of—which molecule is polar and which is nonpolar.)

Activities

Revisit Activity C from lesson 2: Drawing a Neuron. Check your neuron drawing against figure 2.1 on page 820. How did you do? Use your eraser and pencil to make any adjustments to your drawing. Include this final version and your original with the rest of your work for this lesson. You will not be graded on artistic ability, only on effort and completeness.

Afterward, complete the following activities:

- Activity A. Endocrine System Quiz
- Activity B. The Teenage Brain and Hormones
- Activity C. Brain Science Exploration
- Activity D. Quick Lab: The Blind Spot Test
- Activity E. Quick Lab: The Stroop Effect
- Activity F. The Possible Future of Brain Science

Activity A. Endocrine System Quiz

Study figure 6.3 on page 843 and browse the endocrine system section of the Innerbody.com interactive website. Then close your book and take the following quiz to see how well you understand the endocrine system in your body. When you are done, refer back to the textbook and grade your work using a different color font. Correct any mistakes. How did you do? Give yourself a grade and submit your graded quiz with your lesson work. (The grade won't count toward your lesson grade; only completing the quiz and correcting your own work will.)

Endocrine System Quiz

Name the gland that regulates the following processes in your body. Also name the hormone(s) that the gland produces.

1. controls the "fight-or-flight" reaction _____
2. responsible for blood sugar regulation _____
3. causes facial hair and deeper voice to develop in males _____
4. causes white blood cells to mature _____
5. regulates the release of other hormones, is part of the CNS, and is now considered the master gland _____
6. controls cell growth, and regulates water concentration in the blood _____
7. controls egg production and menstrual cycle in females _____
8. regulates metabolism _____

Activity B. The Teenage Brain and Hormones

There are many hormonal changes going on in your teenage body. For starters, there is a huge surge in growth hormone. The female hormone estrogen (yes, in both boys and girls) is closely linked to the surge in growth hormone. During puberty, females have more estrogen, and therefore mature faster than males. Interestingly, the release of growth hormone occurs during sleep, making sleep extremely important in the teenage years. Complicating this, your sleep patterns have changed, and your body

clock is set to want to sleep from sometime in the middle of the night to late morning or noon (sound familiar?). What causes this? An increase in melatonin, another hormone that is connected to sleep patterns.

There is also an increase in testosterone in both sexes. This is the hormone that causes some of the big changes in the brain. Unfortunately, the increase in testosterone is also what causes acne! Not chocolate, not fatty foods, not the fact that you aren't washing enough, but plain old hormones.

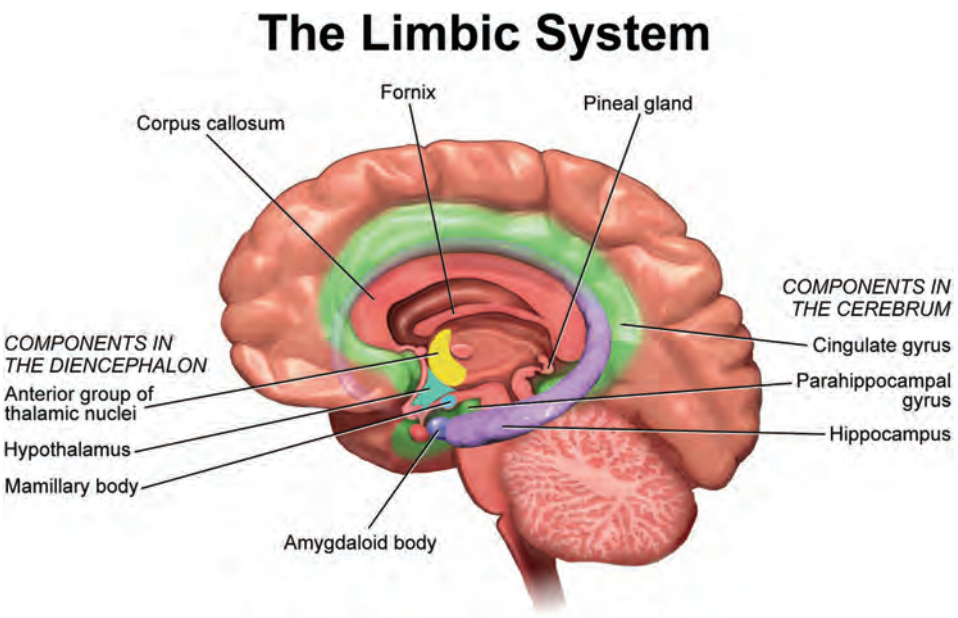
What is the effect of testosterone on the brain? It is commonly thought that testosterone is what causes the risk-taking behavior in teens. In fact, it is more likely to be stress hormones (such as cortisol), especially those released early in life, that initiate the risk-taking behavior.

The endocrine system is complex, and more is being learned about it all the time. The human brain does not reach maturation until the late teens or early 20s. Each person's timetable is slightly different. The prefrontal cortex is the area of the brain that is still developing in teenagers. It is responsible for the "executive function" aspects of the brain: decision-making, moderating social behavior, judgment (including identifying emotions in others), planning, etc. The limbic system of the brain is involved in gut reactions and emotional responses. Emotional responses are reined in by the prefrontal cortex, but the prefrontal cortex is slow to mature. (See the image of the prefrontal cortex at the beginning of this lesson.)

Read the following article:

"Hormone Affects How Teens' Brains Control Emotions" by Bethany Brookshire

Write a paragraph or two, commenting on the article. Was this new information for you? Was it interesting? Does it help you understand some of the emotional "drama" or mood swings that you might be experiencing? Can you see the stages of brain development in yourself, your friends, or your siblings? (At the very least, when you have an emotional outburst, you can now blame it on an overactive amygdala!)



The limbic system of the brain is involved in emotional responses.
(Image credit: Blausen.com staff, 2014)

Activity C. Brain Science Exploration

Brain science is one of the fastest growing fields of science. Every day, researchers learn new information about the brain and how it works. If you pay attention to the news, you will hear or read about new findings with brain research almost every day.

Visit the website BrainFacts.org. It is the "all about" website for brains! If you are interested in a career related to biology, medicine, chemistry, engineering, physics, psychology, child development, aging, education, or computer science (or just about anything else!), there is some aspect of brain research that will appeal to you. You can use this website as a "go to" place to find information about many topics you will need to research during your educational journey, so bookmark it. Here are some examples of what you can find there:

- the structure and function of the brain
- the chemistry of how drugs affect the brain
- how learning works
- why being physically fit when you're young can help your brain work better when you're old
- the latest research about sleep
- that fascinating condition called synesthesia where the senses mingle and sounds or numbers are experienced as colors
- language and the brain
- musical training and the brain

- brain development, including what is going on in the adolescent brain
- technologies used in brain research, including computer science developments

Spend some time exploring the site and checking out articles that interest you. Choose two articles to summarize, writing about a half page for each. In your summary, include the author, the research that the article is about, and the original publication that the article appeared in.

Finally, write a half page about what aspect of brain science most interests you, and why.

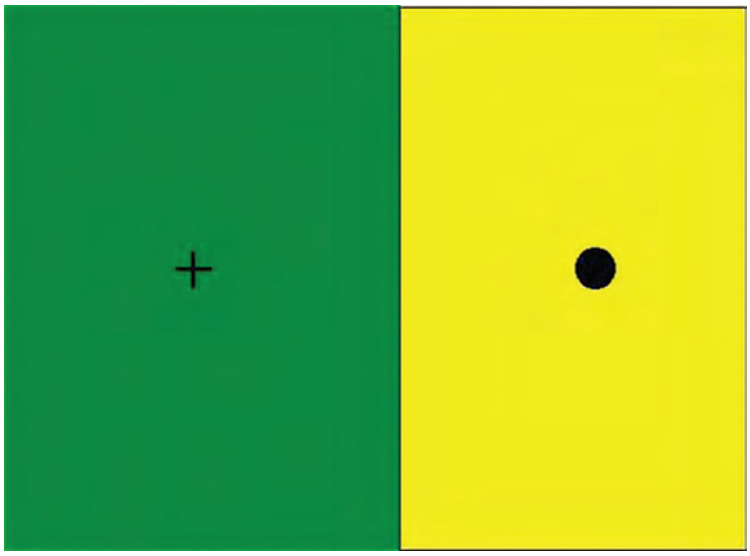
Activity D. Quick Lab: The Blind Spot Test

Look at the image of the eye, figure 3.2 on page 825 of your textbook. The retina is where the photoreceptors are located, which generate nerve impulses when light strikes them. Notice that where the optic nerve exits the back of the eye, there is a gap in the retina. At this spot, there are no rods or cones, and when light reflected off an image falls on that spot, you will not be able to see it. You don't notice this, because your brain "fills in" the missing part with information from your other eye. Follow the procedure below to find the blind spot in each of your eyes.

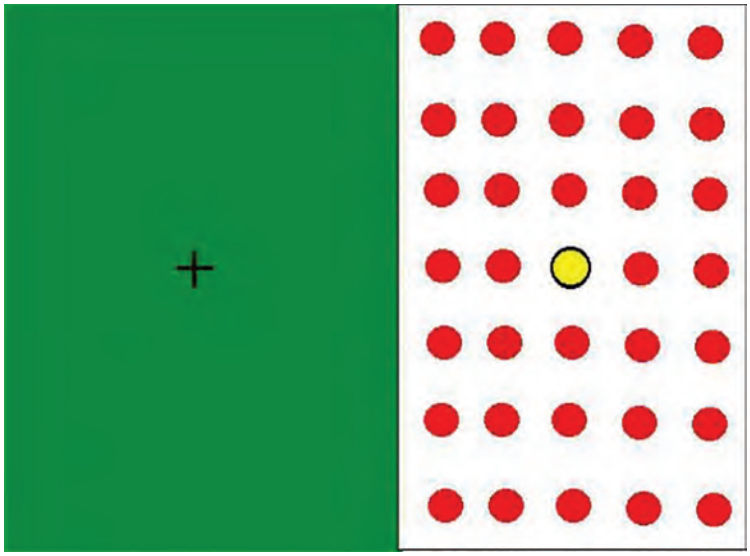
1. Lift this page so the graphic above is right in front of your eyes, almost at arm's length.
2. Cover your left eye with your hand, and focus only on the cross with your right eye. Really concentrate on only looking at the cross!
3. Slowly move the image closer to your face, while still staring at the cross with your right eye. At some point, about 10–14 inches from your face, the circle will disappear from view. It will reappear as you keep bringing the image closer.
4. Now cover your right eye with your hand, and repeat the process while focusing on the circle with your left eye.
5. Did you find your blind spot with both eyes? If not, you were peeking at the cross or circle when you were supposed to be entirely focusing on the other image. Everyone has an optic nerve, so everyone has a blind spot!

Try these other fun tests to see how the brain will fill in missing information:

Do the same test again with the image below. Do you find that the cross or circle disappears, as usual, but the space where it was is now filled in with the color of the surrounding area? This is your brain filling in missing information!



Try it now with the green and polka dot image below. Cover your left eye, and stare at the cross with your right eye. Do you notice that the yellow circle disappears, but it is replaced with a red circle? Once again, your brain is taking the surrounding information and completing the picture for you!



Comment on your experience with this test (write two or three sentences).

Activity E. Quick Lab: The Stroop Effect

Have you ever noticed that when you are counting something, and a friend starts stating random numbers to confuse you, it is very hard to keep on task with your counting? In this lab, you will investigate how conflicting information received by your brain affects the completion of a task.

In the 1930s, psychologist John Ridley Stroop studied the processing of words and how these thought processes affected other mental tasks. He found that the brain must override an automatic response when it receives conflicting information, which is known as *interference*. This effect is now commonly called the Stroop Effect. (For more information, you can read Stroop's work, "Studies of Interference in Serial Verbal Reactions.")

Try it out for yourself! Visit this website (you can access the link at oakmeadow.com/curriculum-links/).

Demonstration of Stroop Effect—"Name That Color" Test

Start with the first test, the "easy test." Read each row from left to right, naming the colors that the words are written in. Use the timer to record your time.

Then do the "hard test," where the color that the word is written in is not the color that the word says. Remember, you are naming the color, not reading the word!

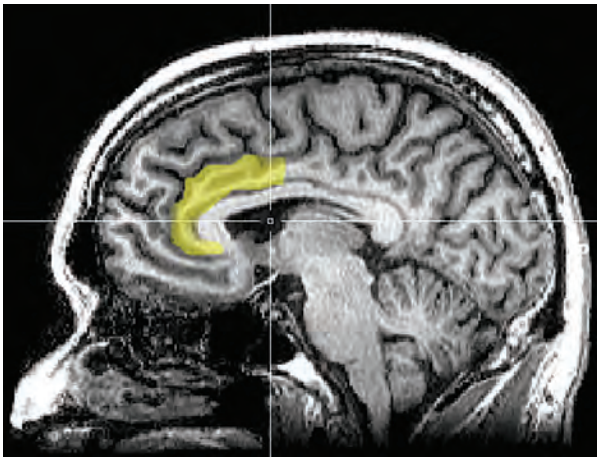
What is the difference in your times for the two trials?

Here are some variations that also demonstrate the Stroop Effect:

- Write the name of a shape inside the outline of a different shape (i.e. write "square" inside a circle, or "circle" inside a triangle).
- Prepare a color test like the one you did, but turn the whole chart upside down. Does that improve your time?
- Try writing colored words that don't represent colors, such as "dog" or "house."

There is some evidence that the anterior cingulate area of the brain is active during the Stroop Effect. The Stroop test has become widely used in clinical practice and brain investigation to measure mental processing ability. For example, if you try it when you are under stress or very tired, you might get different results than when you are well rested.

Describe your results and your experience with this lab.



MRI showing the location of the anterior cingulate cortex of the brain. (Image credit: Geoff B Hall)

Activity F. The Possible Future of Brain Science

Let's do a little time travel now!

Watch the TED talk by Sam Rodriques:

What we'll learn about the brain in the next century

This is an interesting and creative discussion about the technology that is needed to study the brain, and where we are falling short right now. Rodriques "envisions strange (and sometimes frightening) innovations that may be the key to understanding and treating brain disease, like lasers that drill tiny holes in our skulls and allow probes to study the electrical activity of our neurons." While you are watching, notice that the ideas are flowing fast. You might want to stop and repeat some sections to take it all in.

When you are done, write at least a one-page summary of your experience with this TED talk. Rather than summarizing this talk, give your reaction to the material. Include some of the following (incorporate them into your narrative):

- Does this technology that Rodriques is imagining seem possible to you in the next century?
- What about the fact that Rodriques was a physicist who switched over to neuroscience when he saw a need? Thinking about your own future, comment on the possibilities of taking an inquisitive mind and completely shifting careers, while still using your skills as a thinker.
- TED stands for "Technology, Entertainment, Design." The motto of TED is "ideas worth spreading." How well does this talk fit into those concepts? Comment on how well Rodriques took what could be a very dry subject and made an effort to engage people by making it fun.
- Why, in science, do we say that no idea is too wild and "out there" to consider? Why should we spread these ideas? How can the world (both inside and outside the science world) benefit? Give a couple of potential examples.

Lab: The Primary Sensory Cortex

As you have learned, your sense of touch is triggered partially by mechanoreceptors in your skin, and the neurons send the signal to the brain for analysis, in the same fashion that the photoreceptors in your eye detect light and send the signal to your brain. Only one signal at a time can be detected by each neuron, so if there are two points touching the same neuron, it will only send one signal to the brain.

Think about where in your body the neurons might be closer together, and where this is not needed. In what parts of your body is having a sensitive touch more or less important? Consider your shoulder, your fingertips, your back. Where might there be an advantage to having more neurons?

Look at figure 4.2 on page 831 of your textbook. There you can see the primary sensory cortex, also known as the somatosensory cortex. The amount of brain space allocated to receiving touch information from different parts of the body varies with the number of neurons that monitor that area, as you will see in this lab.

This lab involves recording how your brain perceives the sense of touch from different areas of your body. (This lab is adapted from "A Nervous Experiment," written by Brittany Sanner.)

Hypothesis

Create a hypothesis, explaining which part of your body—your upper arm, back, or fingertip—will be more sensitive to touch, and why.

Materials

- a partner
- one paper clip
- metric ruler
- paper and pencil

Procedure

1. Set up a data table. The left column should include distances between the paper clip ends ranging from 0 cm (ends touching) to 4 cm, in 0.5 cm increments. You will be testing the sensitivity on the upper arm, fingertip, and back. Set up the remaining columns accordingly.
2. Open the paper clip so the ends are exactly 4 cm apart. Have your partner close their eyes, and gently touch both ends at the same time to the fingertip (when the ends are spread this wide, one end will be down the finger and not quite at the tip). Record whether your partner feels one end or both ends of the paper clip . Write "1" or "2" in the appropriate place on the data table.
3. Repeat this on your upper arm and back, aligning the ends of the paper clip vertically, recording your results in the data table.
4. Push the ends of the paper clip together so they are only 3.5 cm apart. Repeat steps 2 and 3 for each of the three locations.
5. Continue doing this for each distance increment.
6. On the upper arm and back, try the test one more time, using the paper clip spread to 4 cm. This time, hold the paper clip so the ends are horizontal rather than vertical. Record these results so you can compare the vertical and horizontal alignment.

Analysis and Conclusion

Write up an analysis of your experiment. Include the following in your narrative. These should not be answered in list form, but rather incorporated into the narrative in which you analyze your results and develop a conclusion.

- What are the dependent and independent variables in this investigation?
- Was your hypothesis supported? Why or why not? Use your data to explain your answer.
- Did you see any patterns in your data?
- What parts of the body were least sensitive, and what parts were most sensitive? Explain why this is, based on your knowledge of the nervous system.
- What is the adaptive value of having more neurons and brain space devoted to certain areas of the body? In other words, why do you think we evolved in this way?
- What additional questions does this investigation raise that could be tested with further experimentation?

FOR ENROLLED STUDENTS

Please share the following work from lesson 3 with your Oak Meadow teacher.

- Neuron drawing (both original and final version)
- Answers to comprehension questions
- Answers to critical thinking questions
- Responses to all six activities:
    - Activity A. Endocrine System Quiz
    - Activity B. The Teenage Brain and Hormones
    - Activity C. Brain Science Exploration
    - Activity D. Quick Lab: The Blind Spot Test
    - Activity E. Quick Lab: The Stroop Effect
    - Activity F. The Possible Future of Brain Science
- Complete lab (lab hypothesis, data table, and analysis and conclusion)

Lesson

4 Respiration and Circulation

Imagine trying to run up ten flights of stairs and then trying to thread a needle immediately upon reaching the top. Sound challenging? There is one type of athlete that essentially does this. These are biathletes, and the sport is biathlon. Biathlon is a combination of cross-country skiing and target shooting. Biathletes are probably more tuned in to heart rate and breathing than any other athlete. Cross-country skiing is one of the most aerobically demanding sports there is. Biathletes will be skiing with a heart rate somewhere around 185 beats per minute. They then stop for 30 seconds to shoot their rifle at a target five times. It takes incredible concentration to be able to do this. At first it was thought that athletes consciously reduce their heart rate. But that takes too much time. What is actually happening is that the skiers are very aware of their heart rate and breathing. After each breath, there is an ever so slight lull before the next breath, and they take their shot at that point. On top of that, they do have to quiet their mind, relax other muscles (that are all screaming for oxygen), and try to focus, sometimes amid the roar of the crowd.

Magdalena Neuner represents Germany in a biathlon in 2012. (Image credit: Günter Hentschel)

ASSIGNMENT SUMMARY

- ☐ Read chapter 30.
- ☐ Explore the "Cardiovascular System" and the "Respiratory System" on Innerbody .com.
- ☐ Answer comprehension questions.
- ☐ Answer critical thinking questions.
- ☐ Activity A. Molecular Journey Story
- ☐ Activity B. Choice Activity
  - Option 1: Performance Enhancing Drugs
  - Option 2: Blood Doping Documentary
  - Option 3: Make a Spirometer
- ☐ Lab A: Determining Blood Type
- ☐ Lab B: Exploring Homeostasis and Exercise

In this lesson we will explore two very important organ systems: the ***respiratory*** and ***circulatory*** systems. Together they work to bring oxygen to our muscles, remove wastes from our tissues, and much more. We need to know about circulation to understand all the other body systems.

(You can expect to spend about 2½ weeks on this lesson.)

Learning Objectives

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

- Describe the structures and functions of the components of the respiratory and circulatory systems.
- Combine science and creativity in a description of the pathways of the cardiovascular system.
- Relate the physiology of these body systems to chemistry and physics concepts.
- Use modeling to understand blood types.

Before You Begin

Try this fun activity! Locate your voice box, or larynx, by placing your fingertips on the front of your throat while humming. You should feel the vibrations caused by air passing over the vocal cords in the larynx.

Now keep your fingertips there and swallow. Do you feel the larynx moving up and down? This movement causes the epiglottis to cover the opening of the trachea, preventing food from entering the trachea.

Next, hum a note, and while humming, press gently on the larynx with your fingertips. Did you notice that the pitch went down? By pressing, you were shortening the vocal cords, which changes the pitch.

Reading and Viewing

Read chapter 30, "Respiratory and Circulatory Systems," in your textbook.

Read and explore the "Cardiovascular System" and the "Respiratory System" on the Innerbody .com website. Be sure to read the text section below the images. There is a lot of good detail if you click around.

There are six Crash Course videos available about the circulatory system and two about the respiratory system. Watching them will help improve your understanding of these vital systems.

Try this quiz (you can access the link at oakmeadow.com/curriculum-links/):

"Label the Heart" quiz

Can you reduce your time with practice?

Comprehension

1. What is the mechanism by which gas exchange occurs across the capillary walls in the alveoli?
2. The left ventricle is the largest chamber of the heart. Relate the size to its function.
3. Describe the pulmonary and systemic circulation pathways. Why is it an advantage to have these two separate pathways?
4. Describe how the structure of arteries, capillaries, and veins relates to the function of each.
5. There are four main components of blood. Name each and briefly describe its function in the body.
6. Summarize the roles of the lymphatic system, explaining why it is part of both the circulatory system and the immune system.
7. Why is movement essential for the lymphatic system to function optimally?

Critical Thinking

1. Consider this connection between biology and physics: It may seem that when you take a breath, the breathing action starts in your mouth and nose. As you learned in this reading, this is not true. The brain receives input about the high CO2 concentration in the blood, and sends the message by way of the nervous and endocrine systems to the muscles of the diaphragm and rib cage to step up the pace. Review figure 1.2 and the explanation on page 854. Relate the process of breathing, in terms of air pressure changes, to what happens when a person is on a mechanical ventilator or is receiving CPR (cardiopulmonary resuscitation). During inhalation with mechanical breathing, air is forced into the lungs under pressure, and during exhalation, the pressure drops and air is released. How is this different than natural breathing? How is it similar?
2. When a body is found in a lake or river, forensic scientists need to find out if the person drowned or was killed in another way and then thrown into the water. How would examining the lungs of the person give clues to help solve the mystery?
3. Here's another physics connection: Have you ever held a hose, and put your thumb over the end of it to get a stronger spray of water? Using this or a similar analogy, explain why the narrowing of the arteries decreases blood flow but increases blood pressure.
4. Consider this chemistry connection: Iron oxide is the reddish compound known as rust. It forms when iron is exposed to moisture and binds to oxygen from the air. How is this similar to what is happening in blood? What makes blood red?
5. What would happen if a person with type A Rh- blood received a blood transfusion with type A Rh+ blood?

Blood Transfusions: Saving Lives

Charles Richard Drew was an African American surgeon who pioneered a method for preserving blood to be stored for transfusions. Drew separated out blood plasma, which was dehydrated and reconstituted as the blood components were needed. In World War II, Drew directed the blood plasma programs in the United States and Great Britain. He initiated the use of bloodmobiles, mobile units that allowed many more people to donate blood for those who need it. Drew organized donations of blood to be shipped overseas for soldiers. However, when the U.S. military insisted that the blood be segregated according to the donor's race, Drew became outraged and resigned from his post with the American Red Cross. He argued, rightfully, that blood has no race. He was an amazing man who received many awards for his accomplishments, both during his life and posthumously.

Activities

Complete Activity A and one of the options for Activity B.

- Activity A. Molecular Journey Story
- Activity B. Choice Activity
  - Option 1: Performance Enhancing Drugs
  - Option 2: Blood Doping Documentary
  - Option 3: Make a Spirometer

Activity A. Molecular Journey Story

Imagine that you are small enough to take a ride on an oxygen molecule on its journey through the human body. Write a story in which you describe your journey, beginning with your release from a plant in photosynthesis and being inhaled by a human. **Name and describe in detail all the parts of both the respiratory and circulatory system through which you pass.** Stay with your oxygen molecule as it gets used by the cells and they release it as carbon dioxide, and continue the journey back out of the body. Have fun with this; it is a combination of creative writing and science. Make your story as interesting, fanciful, and elaborate as you wish, but be sure to include all the structures and blood vessels through which you pass. This is the only assignment in this lesson where you are being asked about the pathway through the cardiovascular system—show what you know!

Activity B. Choice Activity

Read each option before deciding which one to complete.

- Option 1: Performance Enhancing Drugs

- Option 2: Blood Doping Documentary
- Option 3: Make a Spirometer

Option 1: Performance Enhancing Drugs

Performance enhancing drugs is an extremely hot topic among endurance athletes these days. The goal of these drugs is to increase the amount of hemoglobin in the blood so it can hold more oxygen. There are three main types of performance enhancing drugs that have this role: blood transfusions, erythropoietin (EPOs, or the newer generation of EOS, CERA), and synthetic oxygen carriers. Do some research about blood doping. Describe each of these types of drugs and give details about how they each work. Also describe the available test for each one.

Option 2: Blood Doping Documentary

With parents, siblings, or friends, watch the 2017 Netflix documentary *Icarus*. When he set out to make this 2017 documentary, filmmaker Bryan Fogel's goal was to determine how easy it was to evade drug testing and get away with doping. He wanted to find out how someone like cyclist Lance Armstrong could get away with it for so many years. He decided to try doping himself as an amateur cyclist in order to expose the doping issue, and enlisted the help of a Russian doctor who was the head of Moscow's anti-doping agency at the time. What transpired was an amazing and unpredicted series of events that revealed the entire Russian doping scandal, which Fogel found himself in the middle of while creating the film.

After you are done watching it, write a summary of your understanding of the prevalence of taking performance enhancing drugs and trying to evade the drug testers. Comment on the situation in Russia, the business of doping, and the political climate that encouraged doping. What did you think of the documentary? Did you find it interesting how the plot created itself during the filming?

Option 3: Make a Spirometer

In this activity, you will break down the different parts and types of breathing and relate them to the various aspects of lung capacity. Why does this information matter? Lung function can be compromised by many things such as asthma, COPD (chronic obstructive pulmonary disease), air pollution, aging, and much more. Having a baseline of average information is a starting place from which a doctor can get a sense of a person's lung capacity. Understanding the different parts of a breath and whether you have trouble taking a deep breath, exhaling fully, etc., can also give clues about lung health.

(Image credit: BruceBlaus)

If you have asthma, which is very common, you might have used a spirometer in a doctor's office. If you've had surgery or pneumonia, a spirometer might be used to test lung function to track your healing.

First, some background information you need to know. There are several methods and subcategories used to quantify lung volume and capacity.

Tidal volume (TV) is the volume of air that is inhaled and exhaled during one normal, relaxed breathing cycle. It is about 0.5 liters in both males and females.

Inspiratory Reserve Volume (IRV) is the amount of air that can be forcibly inhaled beyond the normal tidal inhalation.

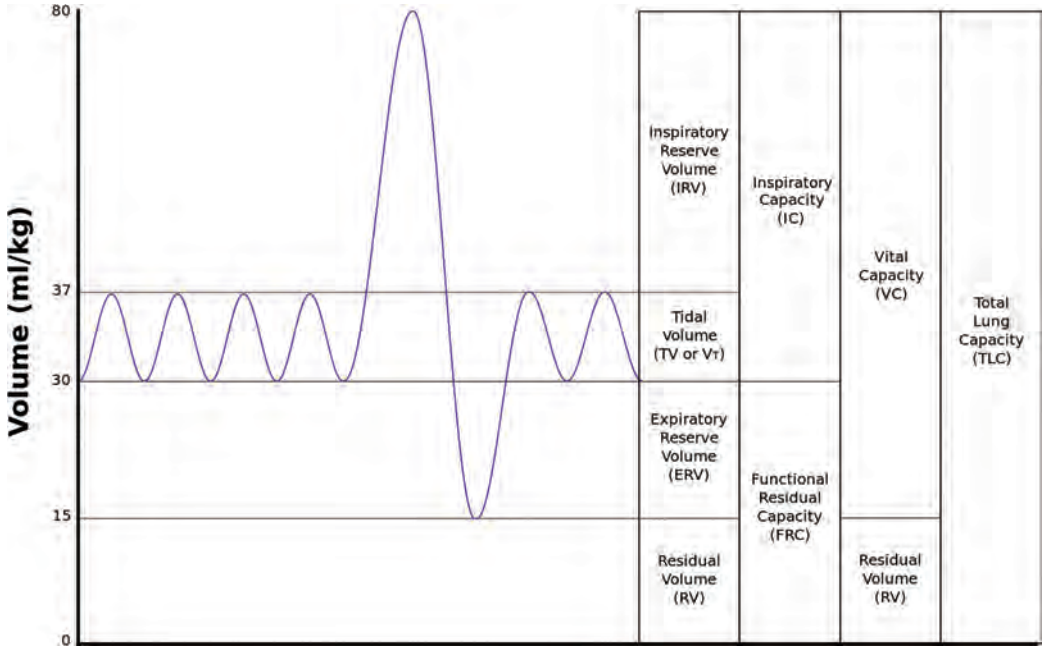
Expiratory Reserve Volume (ERV) is the amount of air that can be forcibly exhaled beyond the normal tidal exhalation.

Residual Volume (RV) is the amount of air that remains in your lungs even after you've exhaled as much as you can (there has to be air in there or your lungs would collapse!).

Vital Capacity (VC) is the greatest amount of air you can exhale after taking the deepest possible breath.

Total Lung Capacity (TLC) is the total amount of air in your lungs after taking the deepest inhalation you can. TLC = RV + VC

Here is a graph to help you understand all this:



Lung volumes (Image credit: Kapwatt)

In the medical world, all of these volumes and capacities (and more) are used, as well as different ratios of them, to help diagnose and monitor lung conditions. For example, in COPD, patients often can't exhale thoroughly (reduced ERV), so the residual volume (RV) increases. This causes its own additional problems, such as hyperinflated lungs.

In this lab, first you will make a simple spirometer. Then you will test the lung capacity of several people and analyze the data you collect. You will be measuring tidal volume and vital capacity to get a sense of how a spirometer is used.

Materials

- five people, including yourself, of different ages and genders
- large plastic bottle, 4 liters or a gallon (You might need a second bottle if anyone has a very high lung capacity. This second bottle can be a one liter bottle.)
- a length of flexible plastic tubing, 2–3 feet (0.6–0.9 meter) with a relatively large diameter that will still fit into the opening of the bottle
- masking or painters tape
- waterproof marker
- washtub or basin
- funnel
- measuring cup with metric scale or 250 mL beaker
- alcohol wipes (or paper towel and isopropyl alcohol)
- pencil and paper

Procedure

1. Create a data table. It should have a row for each person, and the following columns: name, age, gender, height, tidal volume, vital capacity, and notes.
2. Assemble your spirometer by following the procedure in the YouTube video "How to Measure Your Lung Capacity" from HooplaKidzLab, or "Lung Capacity—A BodyWorks On Tour science experiment" from the Glasgow Science Centre.

   A few notes: You are using plastic tubing rather than garden hose as it is more flexible. Garden hose will work as well; just be careful handling it. You will likely need a second person helping you invert the bottle or hold it upright.
3. First, take a normal "at rest" inhalation, and breathe into the tube, without forcing any extra air out—just a normal breath. Read the volume of air that you exhaled. Write down that volume. Repeat this once or twice more (you don't have to refill the bottle). With each repetition, you will

need to subtract the previous volume(s) so that you have the number just for that trial. Calculate the average of these trials, and record this average on your data table. This is your tidal volume.

4. Fill the bottle to the top again, and prepare for your second trial. This time, take a deep breath in, and force as much air into the tube as possible. When you are done, calculate the volume of water displacement in the same way as before. Record this on your data table. This is your vital capacity. If you want to try again, you will need to fill the bottle for your second try, and you can average the numbers.

   If your vital capacity is greater than the bottle's capacity, you will need to stop exhaling and switch the tubing over to your second bottle (which was prepared the same way) and continue. Then add the two volumes together.

5. Clean the end of the hose with an alcohol wipe before the next person uses it.
6. Repeat steps 3–5 with your other four people, recording the data in the data table.
7. The "notes" column of the data table is where you will put any other relevant information, such as "has asthma," "cross-country runner," "smokes," etc. Feel free to change the names if you are adding confidential information.

Analysis and Conclusions

1. Graph your data on a bar graph, organizing the people by age or height. Use different colors for male and female.
2. Describe your results. Do you see any patterns? Anything unexpected? Draw a conclusion about what you learned during this exercise.

You may be interested in seeing what you can do to increase your lung capacity. Doctors use incentive spirometers to measure healing after surgery, or increased lung volume with physical exercise. What do you think would increase your lung capacity? Do some research and find out.

Labs

Complete both of the following labs.

- Lab A: Determining Blood Type
- Lab B: Exploring Homeostasis and Exercise

Lab A: Determining Blood Type

When a patient receives a blood transfusion, it is very important that the blood received is the same blood type as the patient's or compatible with it. Review the description of the ABO blood groups on page 869. A person with type A blood has a type A protein marker, also known as an antigen. Type A blood also contains anti-B antibodies. If that person is given type B blood in a transfusion, the anti-B antibodies in their blood will attack the foreign blood cells, causing them to clump, with disastrous

results. Clumping is also known as *agglutination*. Here is a chart to help you understand what blood types have each antigen and antibody.

Antigens and Antibodies in Different Blood Types

ABO Blood Type	Antigen A	Antigen B	Antibody anti-A	Antibody anti-B
A	Yes	No	No	Yes
B	No	Yes	Yes	No
O	No	No	Yes	Yes
AB	Yes	Yes	No	No

You might wonder why type O blood is a universal donor, when it contains both antibodies. In fact, the antibodies in the donor's blood, if present, are sufficiently diluted in the recipient's blood so they don't cause a problem. **Any rejection of donated blood is dependent on the antibodies that are in the recipient's blood, and the antigens in the donor's blood.**

It is easy to determine blood type in a person. A few drops of blood are taken. Part of that blood is mixed with a serum containing anti-A antibodies, and part is mixed with a serum with anti-B antibodies. Whether or not clumping occurs indicates the blood type.

Before you begin, test your understanding:

1. Why doesn't type A blood have anti-A antibodies?
2. What will be the results if:
   a. a person with type B blood is given type B blood (which contains anti-A antibodies)? Explain.
   b. a person with type O blood is given type B blood? Explain.

In this lab, you are going to determine the blood type of simulated blood samples by mixing them with simulated antibody sera and looking for clumping in the mixtures.

The Question

What are the blood types of unknown blood samples?

Materials

- vinegar
- water
- milk
- oil
- 6 disposable plastic pipettes, 1 mL graduated

- 8 small glasses or beakers (or fewer if you wash them between trials)
- toothpicks

Procedure

You will be mixing each of your "blood samples" once with anti-A antibody serum, and once with anti-B antibody serum, and looking for a positive or negative reaction. In a positive reaction, clumping occurs to mimic the way red blood cells clump in the presence of antibodies. You will see small shreds of material or the mixture simply won't mix smoothly. In a negative reaction there is no clumping, and the sample and serum will mix smoothly.

You have one pipette for each sample and each serum. Be sure not to mix them up! Keep each pipette next to the substance you are using it for.

1. First, prepare your "blood sample" materials:

   Label each of the liquids with a sample number, as follows. You can put a number on a piece of paper in front of the container of liquid.

   - Sample 1 = vinegar
   - Sample 2 = water
   - Sample 3 = milk
   - Sample 4 = oil

   If you want, you can put about 3 mL of each in a small glass, and add red food coloring to the first three samples (so they look more like blood). Red food coloring won't mix with oil, so you need to use your imagination for that one!

2. Now, set aside your antibody sera in separate small containers. You will need about 3 mL of each:

   - anti-A antibody serum = vinegar
   - anti-B antibody serum = milk

Now you are ready to begin your test.

1. Carefully place 1 mL of Sample 1 into a small glass.
2. Slowly add 1 mL of anti-A antibody serum to Sample 1. Mix gently with a toothpick.
3. Examine the mixture to see if you have a positive or negative reaction. Record in the proper place in the data table: P for positive, N for negative.
4. Place 1 mL of Sample 1 into a clean glass.
5. Slowly add 1 mL of anti-B antibody serum to Sample 1. Mix gently with a clean toothpick.
6. Examine the mixture to see if you have a positive or negative reaction. Record in the proper place in the data table, as above.

7. Repeat these steps for Samples 2 through 4.
8. When you are done, clean up all your lab materials.

Data Table: Reactions between samples and antibody sera

	Sample 1	Sample 2	Sample 3	Sample 4
Anti-A antibody serum				
Anti-B antibody serum				

Analyze and Conclude

1. Based on the reaction to the antibody sera, what is the blood type of each of the samples?
2. Why is it important to mix each of the blood samples with both anti-A and anti-B antibody sera?
3. Which type of blood is most in demand by blood banks?
4. In this lab, it was very important that you keep careful track of your equipment, and label everything properly. What would be the consequences if you are a scientist and you are just a little bit careless with how you handle your equipment and data? On the other hand, explain how sometimes, being just a little bit sloppy can contribute to scientific knowledge.

Lab B: Exploring Homeostasis and Exercise

In this lab, which you will design, you will work with a partner and explore the effect of exercise on heart rate, respiration, and perspiration. You are well aware of what the effect is, but do you know *how much* your heart rate and breathing level increases with exercise? Do you know how quickly it slows down after exercise? Have you ever quantified the information?

You will be designing the investigation, and after you complete it, you will be guided through the negative feedback mechanism involved.

The Question

Come up with a question related to the above paragraph.

Hypothesis

Write a hypothesis with your expected results.

Materials

What materials will you need? Make a list.

Procedure

Write your procedure for the experiment. Identify your dependent and independent variables. Here are some things to consider:

- You will need one or two partners to help you with this. One person will be doing the exercise. Somebody needs to be in control of timing, and somebody needs to measure heart rate and breathing.
- Plan for the exercise to be a "cardio" workout, using the whole body, not just strength exercises.
- Exercise should be sustained for several measurements, with brief stops to measure pulse and breathing.
- How might you quantify perspiration? This is more of a qualitative observation, but try to figure out a scale to use.
- To measure heart rate, place the second and third finger on the wrist just below the fleshy base of the thumb. Count for 15 seconds and multiply by 4 to get beats per minute.
- To measure breathing rate, count the number of breaths in 15 seconds, and multiply by 4 to get number of breaths per minute. Note: one breath includes both the inhalation and exhalation.

After you come up with your procedure, create a data table before you carry out the lab. (If you aren't completely confident with your experimental plan, run it by your teacher or tutor.)

Analyze and Conclude

1. Graph your data. Include an informative title and specific unit measures. What type of graph will you use? Will you use one graph or more than one? Explain your choice.
2. Summarize your results. Do the results support your hypothesis?

Lab Extension: Making Connections

Review page 806 of your textbook to understand how a negative feedback loop works with breathing rate when the breath is held. Also review figure 2.2 as well as the paragraph below, which incorporates heart rate into the scenario. As you noticed, your breathing and heart rate fluctuate together!

When you exercise, the muscles use more oxygen and produce excess carbon dioxide. The same sensors in the circulatory and respiratory systems alert the brain stem of the increase in CO_2 and decrease in O_2. The brain sends the message to the appropriate muscles. Breathing rate increases so that more oxygen can enter through the lungs and more CO_2 can be expelled through the lungs. Heart rate increases so that more blood travels to the lungs to pick up O_2 and release CO_2.

What do you think happens when you stop exercise? Draw a negative feedback loop that illustrates the entire process that is going on here with exercise, breathing, and heart rate. Remember, a negative feedback loop is exactly that—a loop. Include this with your lab report.

FOR ENROLLED STUDENTS

Please share the following work from lesson 4 with your Oak Meadow teacher.

- Answers to comprehension questions
- Answers to critical thinking questions
- Responses to Activity A and your choice of Activity B
- All work from Lab A
- All work from Lab B (including Lab B Extension negative feedback loop drawing)