Human Anatomy and Physiology

Oak Meadow Teacher Manual

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Introduction

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

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

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

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

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

In this teacher manual, you will find the full text for all assignments and activities. Teacher manual answers are seen in **color**. 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 manual 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 manual word for word, a discussion about plagiarism and the importance of doing original work is necessary. While students in high school are expected to be well aware of academic honesty, any discussion about it should be approached as a learning opportunity. Make sure your student is familiar with when and how to properly attribute sources (there's an extensive section on this in the appendix of the student's coursebook).

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.

Lesson

Getting Started with Anatomy and Physiology

Learning Objectives

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

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

Viewing

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

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

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

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.

Before You Begin

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

Students will complete this activity as explained.

Biology Quiz

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

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

1. What is a cell?

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

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

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

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

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

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

   DNA

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

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

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

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

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

8. What is an enzyme?

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

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

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

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

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

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

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

12. What is osmosis?

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

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

    Cellular respiration

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

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

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

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

Assignments

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

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

2. After reviewing chapters 1–4, correct any of your quiz answers that need adjustment, using a different color 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.

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

Reading

Review the following chapters in the textbook:

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

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

Lesson

Human Body Systems

Learning Objectives

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

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

Before You Begin

Time for some science trivia!

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

Students will include this with their work for this lesson.

Reading

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

Read chapter 28, "Human Systems and Homeostasis."

Comprehension

1. What is a zygote?

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

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

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?

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

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

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

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

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

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

   In type 1 diabetes, no insulin is made by the body. A person with type 1 diabetes depends on synthetic insulin. If insulin is not monitored carefully, a whole chain of negative effects can occur, including altered pH of the blood, disrupted metabolism, heart disease, blindness, and more.

Critical Thinking

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

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

2. Answer the following:

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

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

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

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

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

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

Activities

Complete all three of the following activities.

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

Activity A. Quick Lab

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

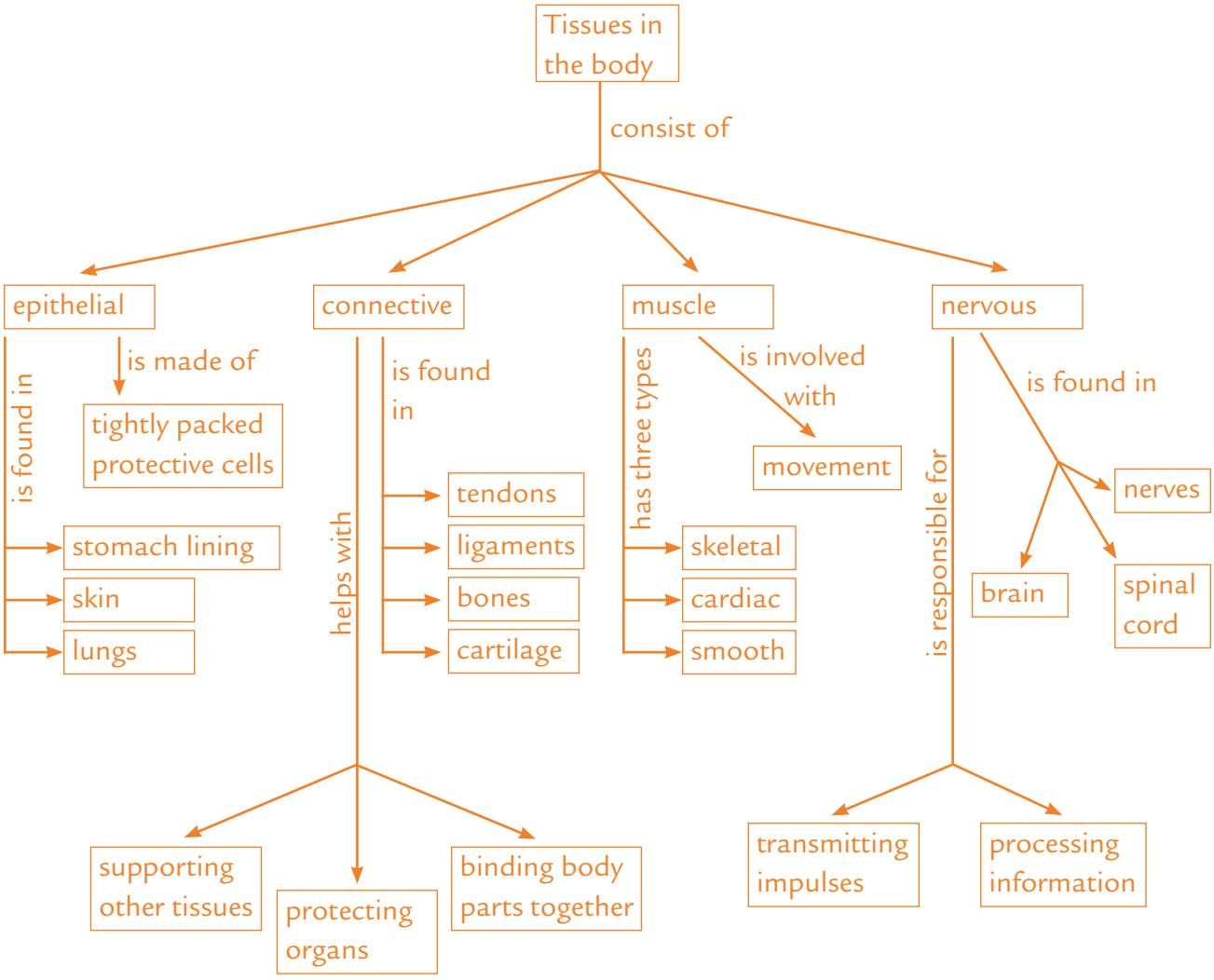
Sensors in the scalp detected changes in the book's position, and sent messages to the muscles to make adjustments. With eyes closed, students lost sensory information about body position in relation to the surroundings. This likely (but not necessarily) made the balancing task more difficult.

Activity B. Tissues Concept Map

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

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

Here is a sample concept map:



Activity C. Drawing a Neuron

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

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

(See student coursebook for the description.)

When you are done, draw arrows to represent the direction the electrical signal moves through the neuron.

Students will draw a neuron based on the description in the coursebook.

Lab: Are You Vitruvian?

See the student coursebook for the full instructions.

The Question

Write the question that you will be investigating.

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

Procedure

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

Analyze and Conclude

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

   Students will describe their data, addressing the questions above.

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

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

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

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

   Write at least one paragraph.

   Students should write a narrative paragraph addressing the points mentioned (as opposed to listing their answers in order). This information could be very useful in any

art involving the human body, such as drawing or sculpting. It might be useful to help clothing designers as well. Other questions might include whether body proportions run in families, what some other proportional relationships are (Vitruvius had many more), how they change from babies to adulthood, etc.

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

Lesson

The Nervous and Endocrine Systems

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.

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

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

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.

   The nervous system sends signals through its own specialized tissues, works quickly, and controls immediate processes. The endocrine system sends its signals through the bloodstream, works slowly, and controls processes that occur over long periods of time.

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?

      The charge is negative.

   b. What causes an area of the inner membrane to become positively charged? How does this happen?

      When a stimulus reaches the inner membrane, it becomes positively charged. The Na^+ (sodium) channels open, allowing Na^+ to rush into the cell.

   c. How does the impulse (area of positive charge) move down the axon?

      The Na^+ channels open along the axon, allowing more Na^+ ions to rush in, and the area of positive charge moves down the axon.

   d. How is the negative charge of the axon's inner membrane restored?

      K^+ (potassium) channels open, causing K^+ to move out of the cell, restoring the negative charge.

   e. What is the role of neurotransmitters in nerve transmission?

      Neurotransmitters are released from the axon terminal when the nerve impulse reaches that point. They carry the signal across the synapse to the next neuron and bind to receptors there. Na^+ channels open, and the impulse moves into the next neuron.

   f. Extra credit question: By what process are neurotransmitters released from the presynaptic neuron? (Hint: review chapter 3).

      Exocytosis

3. In what part of the eye is light transmitted to an electrical impulse?

   The retina (Students might say rod and cone cells in the retina.)

4. Suggest a possible defect of the retina that would cause color blindness, a condition in which a person cannot distinguish between certain colors.

   Cone cells enable color vision. Any damage to the cone cells, or missing cone cells, could result in colorblindness.

5. To which senses do mechanoreceptors contribute?

   Mechanoreceptors contribute to hearing, balance, and touch.

6. Why does a human brain have so many folds?

   There is not a lot of room inside the skull, and the many folds increase the surface area of the brain greatly. The surface area is large enough to hold more than 10 billion neurons—that's quite a bit of brain capacity!

7. Why is a reflex arc more rapid than a voluntary movement?

   A reflex arc only goes to the spinal cord, not to the brain for processing.

8. Compare and contrast the autonomic and somatic nervous systems. Include the two divisions of the autonomic nervous system.

   Both systems are part of the PNS that links the CNS to the rest of the body. The somatic nervous system controls muscles that are under voluntary control. The autonomic (be sure students don't spell it "automatic") nervous system regulates internal organs that are under involuntary control.

9. Describe three important neurotransmitters in the brain.

   Students will describe three of the following:

   Acetylcholine: involved in learning and memory

   Dopamine: influences emotions, stress, and muscle function

   Serotonin: influences mood, hunger, and muscle function

   Glutamate: involved in learning, memory, and brain development

   GABA: prevents the neuron from generating an impulse

10. How do releasing hormones of the hypothalamus connect the nervous and endocrine systems?

    The hypothalamus is part of the CNS. It receives impulses from the nervous system, and conveys the message chemically to other glands, mainly the pituitary gland, through hormones called releasing hormones. Many of the body's processes are regulated in this way.

Critical Thinking

1. Why is it beneficial for neurons to have many dendrites?

   Having many dendrites enables a neuron to receive signals from multiple neurons.

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.

   Taste and smell both involve chemoreceptors. Both of them sense molecules, but taste buds detect molecules that are dissolved in liquid, and olfactory receptors detect molecules in air. Invertebrates in the water only are surrounded by one medium—water—so there is no need to detect substances in air. This likely evolved when species moved onto land and became air breathers.

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.

   The sensors in the nervous system are the sensory neurons, which are part of the PNS. The information then goes to the interneurons, which are in the brain and spinal cord that make up the CNS. The communication system in this process involves electrical nerve impulses and chemical neurotransmitters. The motor neurons, also part of the PNS, communicate the message to the target muscles or organs.

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?

   The orientation of the semicircular canals in three directions allows the body to receive information about the position of the body in all three dimensions. This is necessary information for balance.

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?

   Cocaine works by inhibiting the "re-uptake" of neurotransmitters by the axon terminal. Therefore, the synapse is flooded with too many neurotransmitters. The next neuron responds by reducing the number of receptors for the neurotransmitters to respond to, in an effort to restore equilibrium. This is desensitization. Now, with fewer receptors

available, higher doses of the drug are needed to elicit a reaction in the postsynaptic neuron. The body becomes dependent on cocaine to function normally.

6. Review the "Correlation or Causation" data analysis practice activity on page 839. Answer the two questions.

   1. There is correlation between mitral valve prolapse and panic attacks. According to the graph, 50% of people with mitral valve prolapse have panic attacks, whereas only 10% of the general population does. If there was no correlation, both populations would have equal rates of panic attacks.

   2. No, there is no information that indicates that mitral valve prolapse causes panic attacks. There could be other causes; additional research is needed before causation can be proven.

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.

      Students should refer back to chapter 3 in the textbook, or remember from their review in lesson 1. Answers should include terms such as receptors, transport proteins, or protein channels.

   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.)

      Steroid hormones are made of cholesterol, which is a lipid. The phospholipid bilayer of the cell membrane lets steroids through easily because they are nonpolar and fat-soluble.

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.

The student's corrected drawing should be similar to the drawing in the textbook (not in terms of artistic ability, but in terms of being correctly shaped and labeled). Both the original and final versions should be included.

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

See the student coursebook for the full text of each activity.

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 **adrenal glands: epinephrine**
2. responsible for blood sugar regulation **pancreas: insulin, glucagon**
3. causes facial hair and deeper voice to develop in males **testes: testosterone**
4. causes white blood cells to mature **thymus: thymosin**
5. regulates the release of other hormones, is part of the CNS, and is now considered the master gland **hypothalamus: releasing hormones**
6. controls cell growth, and regulates water concentration in the blood **pituitary: growth hormone, antidiuretic hormone**
7. controls egg production and menstrual cycle in females **ovaries: estrogen, progesterone**
8. regulates metabolism **thyroid: thyroxin, calcitonin**

Activity B. The Teenage Brain and Hormones

Read the following article (you can access the link at oakmeadow.com/curriculum-links/):

"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!)

Students are encouraged to think about this, and express their personal thoughts on it. If they are feeling some of the mood changes that occur in teens, this might help them understand that it is perfectly normal. Encourage any discussion about the science involved. Student responses should address the questions above.

Activity C. Brain Science Exploration

Visit the website BrainFacts.org. 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.

This exercise will hopefully spark some interest in the fascinating field of brain science. Students will review two articles, and then comment on what aspects of brain science are most interesting.

Activity D. Quick Lab: The Blind Spot Test

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

Students will perform the blind spot tests, and comment on their experience.

Activity E. Quick Lab: The Stroop Effect

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?

Describe your results and your experience with this lab.

Students will do the tests and share their results. The one with conflicting information should take much longer to complete; the brain should be confused!

Activity F. The Possible Future of Brain Science

Watch the TED talk by Sam Rodriques:

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

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.

Students will write a summary of their takeaways from this inspiring TED talk, addressing some of the points mentioned. Rodriques presents some rather radical ideas, along with criticism about why our current research on brain science is inadequate. It's going to take a whole new kind of thinking to study our own sophisticated brains. There are no ideas too crazy; on the other hand, creative and radical thinking is needed for new science discoveries to be made.

The fact that Rodriques was a physicist before he switched to neuroscience allows him to bring a whole new perspective to the field of neuroscience, and not be stuck in the same patterns of thinking that he might have been if he started out studying neuroscience. This could be seen as a value of shifting careers. He knew that the root of the problem with advancement in brain study is how to access and measure electrical currents in the neurons of the brain, so he applied his knowledge of physics and came up with ideas.

Another point that might be brought up is that we currently don't have ways of safely studying healthy brains; we tend to use our more invasive methods only on sick brains, for medical purposes rather than research purposes. Rodriques's ideas could allow safe brain research in healthy and willing participants. His main point is that "we're not going to make any progress . . . until we figure out how to get at the electrical activity of neurons in healthy humans." He weaves medical knowledge and ideas for new research methodology together in an intriguing way that allows much more precise medical treatments in the future.

Lab: The Primary Sensory Cortex

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.

Hypotheses will vary.

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?

Students will write up the results of their lab, addressing all the questions answered. The hypothesis may or may not have been supported. The fingertip should receive more sensory information. The results should be more accurate for the fingertip than the forearm. The fingertip has more space devoted to it in the primary sensory cortex because the fingers are what we use to feel things. There is survival value in the brain devoting more space to the fingers, to get a more accurate sense of our environment. This ability was likely selected for over time.

The independent variables are the distance between the ends of the paper clip, the location of the test on the body (fingertip, upper arm, back), and the alignment of the paper clip on the back. The dependent variable is the number of points that are felt with each trial (the results). Students might need to review dependent and independent variables in Chapter 1 or page R11 of the textbook.

The report should conclude with additional questions. Some examples include the following:

- **What will the results be on other parts of the body?**
- **Does more or less body hair make a difference in the results?**
- **Is there a difference with age?**
- **How will this work if you use a different kind of stimulus, such as heat or cold?**

Lesson

Respiration and Circulation

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.

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?

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

Comprehension

1. What is the mechanism by which gas exchange occurs across the capillary walls in the alveoli?

   The mechanism is diffusion. The oxygen and carbon dioxide diffuse across the capillary walls in the alveoli according to their concentration gradient.

2. The left ventricle is the largest chamber of the heart. Relate the size to its function.

   The left ventricle pumps blood to the whole body. The larger volume and more muscle tissue there help exert more force to accomplish this.

3. Describe the pulmonary and systemic circulation pathways. Why is it an advantage to have these two separate pathways?

   Pulmonary circulation occurs between the heart and lungs, while systemic circulation occurs between the heart and the rest of the body. Separating these pathways keeps the oxygen-rich and oxygen-poor blood separate, enabling the whole system to be more efficient.

4. Describe how the structure of arteries, capillaries, and veins relates to the function of each.

   Arteries have thick, flexible walls, allowing them to withstand changes in pressure. Capillary walls are very thin, allowing materials to diffuse into and out of the blood easily. Veins have thin walls and larger diameters. Because the blood isn't under as much pressure in veins, they don't need a thick flexible wall, but they do need valves to keep the blood from flowing backward.

5. There are four main components of blood. Name each and briefly describe its function in the body.

   Plasma makes up most of the volume of blood. It is 90% water. It dissolves many substances that are transported in blood.

   Red blood cells transport oxygen and carbon dioxide in the blood.

   White blood cells defend the body against infection, and remove foreign material and dead cells from the blood. (They are considered part of the immune system.)

   Platelets are cell fragments that are important for blood clotting.

6. Summarize the roles of the lymphatic system, explaining why it is part of both the circulatory system and the immune system.

   The lymphatic system collects excess fluid that leaks out of the blood capillaries. It filters the fluid (called lymph) in vessels called lymph nodes. These nodes trap harmful microorganisms and dead cell fragments; they contain specialized immune cells that destroy these substances. This is the immune system function. There are also other immune system organs (the thymus and spleen) that are part of the lymphatic system.

After filtering, the lymph is then returned to the blood. This helps maintain blood volume and composition.

7. Why is movement essential for the lymphatic system to function optimally?

   The lymphatic system has no pump of its own. It requires muscle contraction to circulate the lymph.

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 CO_2 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?

   The pressure changes with artificial ventilation have different sources than those of natural breathing. During inhalation, the machine creates positive pressure to force air into the lungs. In natural breathing, the chest expands, lowering the pressure in the lungs so that air moves in. During exhalation in mechanical breathing, the machine stops, and the lower pressure on the outside causes air to flow out of the lungs. In natural breathing, the chest relaxes, which increases pressure in the lungs, and air flows out. In both cases, it is pressure difference that causes the air movement. What differs is the cause of the pressure difference.

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?

   If a person drowns, there is always water in the lungs. A person will hold their breath as long as they can, and eventually inhale water. If the person was killed in another way and then thrown into the water, there may or may not be water in the lungs. It can be concluded that if there is not water in the lungs, the person did not drown.

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.

   A narrow artery decreases the amount of blood that can pass through the artery, just as covering the end of the hose does. With a narrow opening, more force is needed to push

the blood through to meet the demands of the body, resulting in higher blood pressure. In the hose analogy, the pressure increases because the same amount of water needs to pass through the opening, just like in a blood vessel. (Students may have done experiments with this type of thing in previous physical science courses.)

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?

   Blood is red because of the hemoglobin in red blood cells. It is an iron-rich protein that binds with oxygen. Iron, when it is oxidized, becomes red.

5. What would happen if a person with type A Rh– blood received a blood transfusion with type A Rh+ blood?

   Because the Rh– person does not have the Rh factor protein, the Rh+ blood will be rejected. The immune system will create proteins that cause the Rh+ blood cells to swell and burst. The type A blood is a good match, but the recipient must receive A– blood.

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

See the student coursebook for full descriptions of the activities.

Activity A. Molecular Journey Story

Students need to pay close attention to the pathways through the respiratory and circulatory system to be thorough with this. Look for all the parts of each system to be mentioned, including the chambers of the heart and the different blood vessels. Reward creativity as well.

Activity B. Choice Activity

Option 1: Performance Enhancing Drugs

Students will research the ever-changing topic of performance enhancing drugs. Reports should include properly cited sources.

Option 2: Blood Doping Documentary

Students will watch the documentary and in their summary, address the questions mentioned. The political climate that encouraged this to happen should be discussed. Also, it is interesting what happened when the filmmaker found himself in the middle of the political scandal. It added an unexpected twist that made the documentary much more interesting. Students might also comment on how important the methods of evading the drug testing became, and how everyone up to the top of the political ladder was involved in the scandal.

Option 3: Make a Spirometer

The student should read the entire lab and view the videos first. The instructions will be followed, and results recorded in the data table. This is a fun project that moves along quickly once the materials are gathered. It can really help a student understand the concept of lung capacity. Students might have used a spirometer in a doctor's office.

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.

   Be sure the graph has both axes labeled, and a title.

2. Describe your results. Do you see any patterns? Anything unexpected? Draw a conclusion about what you learned during this exercise.

   Students will describe the results, looking for patterns, and draw a conclusion about them. Any other comments to summarize the experience are welcome.

Lab A: Determining Blood Type

Before you begin, test your understanding:

1. Why doesn't type A blood have anti-A antibodies?

   If type A blood had anti-A antibodies, a person's blood would destroy itself.

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.

      This is a compatible mix, and the type B blood would be well accepted by the person.

   b. a person with type O blood is given type B blood? Explain.

      A person with type O blood has both anti-A and anti-B antibodies, and therefore cannot accept any blood other than type O. If given type B blood, agglutination would occur.

Analyze and Conclude

Students will carry out the lab, carefully keeping the materials and data organized. The data table should look like this:

Data Table: Reactions between samples and antibody sera

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

1. Based on the reaction to the antibody sera, what is the blood type of each of the samples?

   Sample 1 = blood type B

   Sample 2 = blood type O

   Sample 3 = blood type A

   Sample 4 = blood type AB

   Students will often get all of these blood types backward. The key information they are missing in this case is the paragraph below the blood type table in the lab in the coursebook that includes the sentence in bold print. It requires careful and logical thinking.

2. Why is it important to mix each of the blood samples with both anti-A and anti-B antibody sera?

   The reaction (positive or negative) to each antibody type must be known. This is evident by looking at the data table. For example, a sample that shows a negative reaction to anti-B antibody serum could be either type A or O, and a sample that shows a negative reaction to anti-A serum could be B or O.

3. Which type of blood is most in demand by blood banks?

   Type O blood is most in demand. It is known as the "universal donor," and can be donated to someone of any blood type.

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.

   Students should discuss the importance of being organized in scientific research. In this lab, mistakes can lead to incorrect data. In real life, the consequences could be deadly.

Conversely, being sloppy has often led to new scientific discoveries. Ideally this would happen with no harm done, but that is not always the case.

Note: Students might notice that Rh factor is not considered in this lab, and it is every bit as important in determining blood type compatibility. This was done for simplicity. The concept is the same; Rh factor adds another variable to the situation. If students have the ability to do some real blood typing, that would be an excellent substitute for this lab.

Lab B: Exploring Homeostasis and Exercise

The Question

Come up with a question related to the above paragraph.

Students will come up with a question similar to this: How does exercise affect heart rate, breathing rate, and perspiration?

Hypothesis

Write a hypothesis with your expected results.

Sample hypothesis: Heart rate, breathing rate, and perspiration will all increase during exercise, and decrease soon after exercise is stopped.

Procedure

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

Students will come up with their own procedure, using the guidelines given. The independent variables are time and the type of exercise. The dependent variables are the variables being measured. Students should include readings before exercise starts, and also after exercise stops.

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.

   Students will prepare a graph. Heart rate and breathing rate can be on the same graph, in which case the graph will be a *double y-axis line graph*. Heart and breathing rates should not use the same y-axis, as it is important not to have different units using the same numbers on the axis (beats per minute versus breaths per minute). If perspiration is measured and quantified, it is likely another graph will be needed. This could be a bar graph.

2. Summarize your results. Do the results support your hypothesis?

   Students will write a conclusion, summarizing their results and describing if the hypothesis is supported.

Lab Extension: Making Connections

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.

Negative feedback flowcharts should look something like this: