

Section Preview of the Teacher's Edition for
Body Works, Issues and Life Science, 2nd Edition
Activities 17-19

Suggested student responses and answer keys have been blocked out so that web-savvy students do not find this page and have access to answers.

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2
40- to 50-minute sessions



ACTIVITY OVERVIEW

This activity explores the role of the respiratory system in the regulation of gases in the blood. Students investigate how to quantitatively measure the amount of carbon dioxide in their exhaled breath by using an indicator to perform a titration.

KEY CONCEPTS AND PROCESS SKILLS

(with correlation to NSE 5–8 Content Standards)

1. Scientists create models to communicate scientific information. (INQUIRY: 1)
2. Living systems, such as the respiratory system, demonstrate the complementary nature of structure and function. (LIFE SCIENCE: 1)
3. Organisms must be able to maintain stable internal conditions while living in a constantly changing environment. (LIFE SCIENCE: 3)

KEY VOCABULARY

control
indicator
function
organ
qualitative/quantitative data
range
respiratory system
structure

MATERIALS AND ADVANCE PREPARATION



For the teacher

- 1 Transparency 2, “Science Skills, Using a Dropper Bottle”
- 1 Color Transparency, “Systems to Cells 1”
- * 1 large sheet of chart paper (or overhead transparency)
- * 1 overhead projector
- * 1 large sponge
- * 1 large bottle of carbonated water (optional)
- 1 Scoring Guide: ORGANIZING DATA (OD)



For each group of four students

- 1 dropper bottle of bromthymol blue indicator
- 5 plastic cups
- * supply of water (may require distilled water—see below)



For each pair of students

- 1 dropper bottle of 0.05 M sodium hydroxide
- 1 SEPUP tray
- 1 dropper
- 1 30-mL graduated cup



For each student

- 1 1-gallon plastic bag
- 1 straw
- 1 stir stick
- 1 pair of safety goggles
- * access to a wall clock or watch with a second hand
- 1 Student Sheet 17.1, “Anticipation Guide: Gas Exchange”
- 1 Scoring Guide: ORGANIZING DATA (OD) (optional)

**Not supplied in kit*

In areas with extremely soft water (in which the addition of the bromthymol blue results in a yellow-green color rather than a blue color), mix one drop of 0.05M sodium hydroxide with 1 drop of water in a cup of a SEPUP tray. Add 1-2 drops of the dilute sodium hydroxide to the BTB solution until it turns blue. You may also use distilled water instead of tap water. If the distilled water turns yellow-green with the addition of BTB, use 1-2 drops of dilute sodium hydroxide until the solution turns blue.

Prepare a large sheet of chart paper (or an overhead transparency) for students to post their results in Part A. Construct two columns, as shown below.

Name	Number of Drops of Sodium Hydroxide



SAFETY NOTE

Wear safety goggles while working with chemicals. Do not touch the chemicals or bring them into contact with your eyes or mouth. Wash your hands after completing the activity.

TEACHING SUMMARY

Getting Started

1. (LITERACY) Use Student Sheet 17.1, “Anticipation Guide: Gas Exchange,” to explore students’ understanding of the respiratory system.
2. Read the introduction, and prepare students for the activity.

Doing the Activity

3. Student pairs test solutions for carbon dioxide using BTB (Part A).
4. Students work in groups to measure the carbon dioxide in their own exhaled breath (Part B).

Follow-Up

5. Discuss the role of the respiratory system.
6. (LITERACY) Revisit students’ ideas after they complete Student Sheet 17.1, “Anticipation Guide: Gas Exchange.”

Extension 1

Students repeat Part B of the Procedure, holding their breaths before exhaling.

Extension 2

Students can research more about how the lungs work and the effect asthma has on the lungs by visiting the *Issues and Life Science* page of the SEPUP website.

Extension 3

Students design and conduct an investigation to determine how the body gets more oxygen during exercise.

Extension 4

Students collect quantitative data on the amounts of carbon dioxide in their breath. Data can be further analyzed to determine the mean, median, and mode, as well as the significance of those values.



BACKGROUND INFORMATION

Indicators

Bromthymol blue (BTB) is a chemical indicator that is yellow in acidic solution and blue in basic solution. Its equivalence point is at $\text{pH} = 6.7$; consequently, it is blue in a neutral solution ($\text{pH} = 7$). As a solution of BTB gradually changes color, it appears to go through an intermediate green stage. The green color results from some of the BTB molecules being in the blue state and some in the yellow state. Since carbon dioxide in solution produces carbonic acid, BTB is yellow in the presence of sufficient carbon dioxide. Addition of a base (such as sodium hydroxide) to a yellow BTB solution eventually turns the solution blue, as the sodium hydroxide neutralizes the acidity and then turns the overall solution basic.

Respiration

Cellular respiration is the complex series of chemical reactions by which cells use oxygen to burn glucose for energy, producing waste carbon dioxide. (Respiration at the cellular level is addressed in the Micro-Life unit of Science and Life Issues.) Respiration by the respiratory system is better described as “breathing and gas exchange.”

The internal structure of each lung shows several stages of branching, from the bronchi (tubes from the trachea into each lung) to the 300 million or so tiny alveoli, or air sacs. This incredibly high surface-to-volume ratio allows for rapid diffusion of oxygen and carbon dioxide across the alveolar membranes, in the direction of high to low concentration. Since the blood that enters the lungs has been partially depleted of its oxygen supply and is laden with waste carbon dioxide, oxygen flows into the capillaries while carbon dioxide flows out. As a result, over a quarter of the oxygen inhaled is transferred to the bloodstream, while the exhaled air acquires a concentration of carbon dioxide 100 times that of the inhaled air (see Transparency 17.2, “Composition of Breath”).

During exercise, the primary way in which the body meets the need for increased oxygen is by increasing the number of breaths per minute. This increases the average oxygen concentration in the air inside the lungs, so there is increased oxygen diffusion across the lung surfaces. Meanwhile, oxygen delivery increases due to an increased rate of blood flow to the exercising muscles. Oxygen extraction by the muscles also increases, since they are using more oxygen in cellular respiration. This results in the venous blood carrying less oxygen than at rest, which in turn increases the rate of oxygen diffusion across the lung surfaces. However, the concentration of oxygen in the arterial blood shows no change during exercise.

TEACHING SUGGESTIONS

■ GETTING STARTED

1. (LITERACY) Use Student Sheet 17.1, “Anticipation Guide: Gas Exchange,” to explore students’ understanding of the respiratory system.



Student Sheet 17.1, “Anticipation Guide: Gas Exchange,” provides a preview of important ideas in the activity and is also an opportunity for students to explore their existing ideas. Students often think that the air they breathe in is entirely or at least mostly made up of oxygen. Likewise, they think the air they exhale is entirely made up of carbon dioxide. This idea is addressed through discussion, the table that follows Part A in the Student Book, and the review of the Anticipation Guide.

Hand out Student Sheet 17.1. You may want to read the statements aloud and clarify any questions students might have about their meaning. Instruct each student to record whether they agree or disagree with each statement by placing a “+” or “-” in the “Before” column. Explain that they will have a chance to revisit these statements after the activity to see if their ideas have changed or remained the same.

2. Read the introduction, and prepare students for the activity.

Have students read the introduction to the activity, either individually or as a class. Students will be collecting evidence about this gas exchange by using an indicator to test for the presence of carbon dioxide in their exhaled breath. Be sure to discuss the second paragraph, which introduces indicators. In this activity, students will be using bromthymol blue (BTB) as an indicator for carbon dioxide.

Use Transparency 2, “Science Skills, Using a Dropper Bottle,” to review how to hold SEPUP dropper bottles correctly. When used this way, the bottles produce consistent drops, allowing for quantification.

■ DOING THE ACTIVITY

3. Student pairs test solutions for carbon dioxide using BTB (Part A).

Discuss the important Safety Note in the Student Book before students begin. In Part A of the Procedure, students observe that the presence of dissolved carbon dioxide causes a change in the color of bromthymol blue (BTB). Note that they are required to create their own data table in Step 3. You may wish to use the ORGANIZING DATA (OD) variable to score the organization and completeness of students’ data tables. Their tables may look something like Table 1, in which the expected results have been entered.

As student pairs complete Part A, they can go on to work on Analysis Questions 1 and 2. Depending on your student population, it may be necessary to discuss the responses to these questions before moving on to Part B.

Table 1: Testing for Carbon Dioxide (Part A)

Table 1: Testing for Carbon Dioxide			
Cup	Initial BTB Color	Final BTB Color	After Adding NaOH
A (control)			
B (air)			
C (sodium hydroxide)			
D (exhaled breath)			
E (partner's exhaled breath)			

Sample responses removed for preview

If students are having difficulty understanding the use of BTB as an indicator for carbon dioxide, discuss the presence of dissolved carbon dioxide in carbonated beverages, such as soft drinks. Have students read the label from a bottle of carbonated water (such as seltzer water) and test the water for the presence of carbon dioxide. Use the results of the test to reinforce the idea that BTB turns yellow in a solution containing large amounts of carbon dioxide.

■ **Teacher’s Note:** After completing Part A, some students may ask why the sodium hydroxide made the yellow BTB solution turn back to blue. This is due to the fact that BTB is an acid-base indicator (as described in the Background Information) and not simply an indicator for the presence of carbon dioxide. Decide whether you want to introduce the role of acid-base chemistry in these reactions.

4. Students work in groups to measure the carbon dioxide in their own exhaled breath (Part B).

In Part B of the activity, each student exhales into a plastic bag containing BTB solution. They then titrate with sodium hydroxide solution to find the relative amount of carbon dioxide in their exhaled breath. When the color of the BTB returns to that of the control solution shared within each group, enough sodium hydroxide has been added. The amount of sodium hydroxide needed is proportional to the amount of carbon dioxide in the exhaled breath.

■ **Teacher’s Note:** You may wish to set up a control with a bag containing BTB solution left open to the air and then shaken. If so, use Procedure Steps 12 and 15 as a guide to preparing this control, but omit steps 13 and 14. This will provide additional evidence that the yellow color obtained by the students is due to their exhaled breath.

Before students begin Part B, be sure to review Step 17, which explains how to perform the titration. After adding each drop of sodium hydroxide solution, it is important that students wait at least 10 seconds to compare the resulting color to the color of the control (the unchanged cup of BTB solution shared within each student group). If students are not sure whether another drop is needed, advise them to add the drop and simply not include it in the final count if it is clear that the drop was unnecessary. Students may be interested in knowing that using an indicator and another chemical (such as sodium hydroxide) to determine the amount of another substance (like carbon dioxide) is known as titration, a procedure used frequently by chemists.

Students may notice that yellow BTB solution left open to the air gradually returns to the color of the control. This is not a neutralization effect: the carbon dioxide dissolved in the solution gradually returns to the surrounding air. (A more dramatic example of this occurs when carbonated beverages are allowed to go “flat.”)

■ FOLLOW-UP

5. Discuss the role of the respiratory system.

After students have completed the activity, discuss and review their results. In Analysis Question 3, you may want to calculate the class average and compare it to the range of results illustrated by the bar graphs students constructed in Step 19.

Ask students, *How does the body obtain energy?* Students should know that food provides energy. Ask, *What happens to the food as it goes through the body?* Reinforce the idea that food breaks down into nutrients. Inform students that the human body uses a gas dissolved in the blood to help break down the food chemically. Encourage them to consider a burning candle as an analogy. The human body burns food just as a candle flame burns wax. People even give off heat like a candle does! *What gas is required to keep a candle burning?* Many students will know that it is oxygen; fewer students may be aware that, just like a candle, humans give off waste carbon dioxide.

Analysis Question 4, which elicits students’ thoughts about the relationship between structure and function, is more challenging, and is intended to be discussed as a class. Direct students’ attention to the Student Book diagram, “Human Respiratory System” which shows the organs of the respiratory system and the internal structure of the lungs.

Point out the other organs of the respiratory system and then focus attention on the lungs. Students often have the mistaken idea that the lungs are like two empty balloons in the chest. Hold up a large sponge. Point out that the sponge is filled with numerous spaces for holding water, yet the sponge is a solid object. Human lungs are solid organs, containing millions of air spaces. The tissue of the lungs forms

the walls of these spaces. These air spaces branch through the lungs, similar to the branches of a tree. In fact, if plastic resin is injected into the spaces of a human lung and the tissue removed from around it, the plastic mold looks like a small, upside-down tree, as shown in the Student Book. When a person inhales, air flows into these smallest spaces, known as alveoli (or air sacs). This is where the exchange of oxygen and carbon dioxide between the air and the bloodstream occurs. Use Color Transparency, “Systems to Cells 1,” to review the relationship of cells, tissue, organs and organ system within the respiratory system.

Use the table in the Student Book, “Composition of Breath,” to review with the class that neither inhaled breath nor exhaled breath is composed entirely of a single gas, and that exhaled breath (as corroborated by this activity) contains about 100 times as much carbon dioxide as inhaled air. Emphasize the interaction between the human body and the environment. The body uses oxygen, so oxygen flows in through the lungs; it produces carbon dioxide as waste, so carbon dioxide flows out.

6. (LITERACY) Revisit students’ ideas after they complete Student Sheet 17.1, “Anticipation Guide: Gas Exchange.”

✓ After finishing the activity, have students complete Student Sheet 17.1 by agreeing or disagreeing with the same statements in the “After” column. Students are then expected to explain how the activity gave evidence to support or change their ideas. Be sure to discuss students’ responses and review the accuracy of each statement. This can be used as a Quick Check of students’ understanding of the respiratory system.

■ **EXTENSION 1**


Students repeat Part B of the Procedure, holding their breaths before exhaling.


■ **EXTENSION 3**

Students design and conduct an investigation to determine how the body gets more oxygen during exercise.

Two hypotheses are offered in the Student Book: that one breathes faster, or that more oxygen is absorbed from the air with each breath.

SUGGESTED ANSWERS TO QUESTIONS


1.  *What was the purpose of the solution in Cup A?*


2. a.  *Which of the solutions in Part A contained carbon dioxide? Support your answer with evidence from your experimental results.*

- b. *What does this tell you about the exhaled breath of human beings?*

- c. *Look at the table below. Compare the composition of air you breathe in to that of air you breathe out. Describe the differences.*

Part B: Using BTB to Measure Carbon Dioxide in Exhaled Breath

3.  Review the class data table. What was the range of carbon dioxide in exhaled breath (as measured by drops of sodium hydroxide?)

4.  Look again at the diagram of the human respiratory system. Considering all the oxygen that has to get into your blood and all the carbon dioxide that has to escape from your blood why do you think the inside of the lung is structured the way it is?

6. a. Look carefully at the diagram of the human respiratory system. What are some of the important structures in the respiratory system?

b. Explain where gases are exchanged within the respiratory system.

5. a. Were the data collected in Part A qualitative or quantitative? Explain.

b. Were the data collected in Part B qualitative or quantitative? Explain.

Sample responses removed for preview



Complete Student Sheet 17.1. Be sure to explain how the activity provided evidence for your initial ideas or caused you to change your thinking.

✓ Final Responses to Student Sheet 17.1, “Anticipation Guide: Gas Exchange”

1. Carbon dioxide is produced when your body chemically breaks down substances in food.

2. All of the air that you exhale is carbon dioxide.

3. Your body needs oxygen to get energy from food.

4. The amount of carbon dioxide that you exhale is different than the amount exhaled by other people.

5. The air you breathe in is pure oxygen.

6. Your lungs are sacs with smooth walls, similar to the walls of a balloon.

7. Air and food go down the same passage-way.
8. The walls of your lungs are filled with many tiny blood vessels.

Statements 1 and 2 are referred to in the introduction.

Statement 3 is a common misconception and is referred to in the Student Book in Part A of the Analysis Questions.

Statement 4 requires students to make deductions from the activity.

Statement 5 is referred to in Transparency 17.2, “Composition of Breath.”

Statement 6 is a common misconception that is addressed by Figure 1, “Human Respiratory System,” in the Student Book.

Statement 7 is addressed by Figure 1, “Human Respiratory System,” and by comparing it to Student Sheet 14.1, “Digestive System.”

Statement 8 is correct, as demonstrated in Figure 1 in the Student Book.

8. **Reflection:** *Many respiratory diseases limit a person’s capacity to exchange oxygen. One of these diseases is pneumonia, which causes the alveoli to fill up with fluid. Another is pleurisy, which is an inflammation of the lining of the lungs, making it painful to inhale and exhale. If you had one of these diseases, how would you feel?*

Anticipation Guide: Gas Exchange

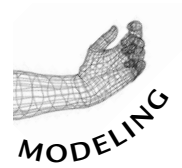
Before starting the activity, mark whether you agree (+) or disagree (–) with each statement below.

After completing the activity, mark whether you agree (+) or disagree (–) with each statement below. Under each statement, explain how the activity gave evidence to support or change your ideas.

Before **After**

- | | | |
|-------|-------|--|
| _____ | _____ | 1. Carbon dioxide is produced when your body chemically breaks down substances in food. |
| _____ | _____ | 2. All of the air that you exhale is carbon dioxide. |
| _____ | _____ | 3. Your body needs oxygen to get energy from food. |
| _____ | _____ | 4. The amount of carbon dioxide that you exhale is different than the amount exhaled by other people. |
| _____ | _____ | 5. The air we breathe is pure oxygen. |
| _____ | _____ | 6. Your lungs are sacs with smooth walls, similar to the walls of a balloon. |
| _____ | _____ | 7. Air and food go down the same passageway. |
| _____ | _____ | 8. The walls of your lungs are filled with many tiny blood vessels. |

1-2
40- to 50-minute sessions



ACTIVITY OVERVIEW

As a class, students model the path of blood as it travels through the human cardiovascular system. The activity emphasizes the transport function of blood, particularly the transport of gases, nutrients, and wastes.

KEY CONCEPTS AND PROCESS SKILLS

(with correlation to NSE 5–8 Content Standards)

1. Scientists create models to communicate scientific information. (INQUIRY: 2)
2. Humans have systems for digestion, respiration, reproduction, circulation, excretion, movement, control, and coordination, and organs comprise these systems. (LIFE SCIENCE: 1)
3. Living systems, such as the cardiovascular system, demonstrate the complementary nature of structure and function. (LIFE SCIENCE: 1)
4. Organisms must be able to maintain stable internal conditions while living in a constantly changing environment. For example, nutrient, oxygen, and waste exchange must be kept in balance within the human body for a person to survive. (LIFE SCIENCE: 3)

KEY VOCABULARY

absorption
cardiovascular system
function
model
nutrient
organ
structure
toxin
tissue

MATERIALS AND ADVANCE PREPARATION



For the teacher

- sidewalk chalk, assorted colors (or masking tape)
- 1 Transparency 18.1, "Diagram of Blood Flow"
- 1 Transparency 18.2, "Rules of The Circulation Game"
- * 1 overhead projector
- * 2 overhead transparency pens, one blue and one red
- * road map (optional)
- * 1 transparency of Student Sheet 12.1, "Functions of Human Body Systems"
- * 1 transparency of Student Sheet 12.2, "Human Body Systems"
- 1 Scoring Guide: ORGANIZING SCIENTIFIC INFORMATION (SI)



For the class

- 40 oxygen cards
- 32 carbon dioxide cards
- 40 nutrient cards
- 24 waste cards
- * small drum (optional)



For each student

- 1 Role Card
- * paper clip, safety pin, string, or transparent tape
- 1 Student Sheet 18.1, "KWL: The Cardiovascular System"
- 1 Scoring Guide: ORGANIZING SCIENTIFIC INFORMATION (SI) (optional)

**Not supplied in kit*

This activity works best with a large number of students. If you have fewer than 32 students in a class period, consider combining classes with another teacher. Or you can reduce the number of roles so that an adequate number of students (at least half the class) play the role of blood. Note, however, that reducing the number of roles does not work as well as increasing the number of participating students. You can reduce roles by: (1) eliminating Roles 13 and 14 (the heart); (2) letting students play more than one role card e.g., one student could perform Roles 1 and 2 (the brain); and (3) eliminating Role 8 (one of the liver roles). Note that 18 copies of Role Card 15 (blood) are provided.

If possible, do Activity 18, "The Circulation Game," outdoors. Use the sidewalk chalk to draw a diagram of the cardiovascular system identical to "Diagram of Blood Flow" in the Student Book or Transparency 18.1 on a large open area of concrete or blacktop. You can also use spray paint to create the diagram on a large area of grass. This diagram will be the template on which students will travel, so be sure to make the diagram large enough for students to walk along. Students will also be stationed at each of the organ sites. Provide enough space for at least two students to stand within each organ site as another student walks by. Use pink or red chalk to draw in the path of oxygenated blood and blue chalk to draw the path of de-oxygenated blood.

If no outside area is available, use masking tape and paper signs to re-create the template indoors, either in a large classroom or in a gym. (Note that, in some cases, masking tape can be difficult to remove.)

Mark five nutrient cards with the word “toxin” in fairly large letters. The student representing Role Card 8 (liver) will be removing those cards from circulation.

During the simulation, students will need to identify the roles of other students. In addition, students may need to refer to their Role Cards if they forget or become confused. Students can tape the Role Cards to themselves or use string to wear it around their necks (the cards have been provided with two punched holes).

TEACHING SUMMARY

Getting Started

1. (LITERACY) Elicit students’ ideas about the cardiovascular system.
2. Introduce the cardiovascular system and blood as the transport system for the human body.

Doing the Activity

3. Students explore the cardiovascular system (Part A).
4. The class discusses Part A.
5. Explain the circulation model (Part B).
6. Conduct the model (Play the Circulation Game.) (Part B).

Follow-Up

7. (SI ASSESSMENT) The class evaluates the model.

Extension

You may wish to have students simulate a blocked artery after playing the “Circulation Game.” Place a chair or some other object over an artery so blood cannot move through it. Have the class play the game again and observe what happens to the organ that was supplied with oxygen and nutrients by that artery.

BACKGROUND INFORMATION

The Cardiovascular System

An average adult has about 10.5 pints (6 liters) of blood. This entire blood supply is pumped around the body about once a minute at rest. Thus, the heart of an average adult pumps about 2,000 gallons a day. Blood is pumped out of the heart through large vessels called arteries; these branch progressively until they become capillaries, which can be as narrow as a single red blood cell. The tiny capillaries pervade the body, allowing for a maximally efficient exchange of dissolved substances with the tissues. The capillaries converge again until they become veins, carrying blood back to the heart.

The mammalian cardiovascular system is really two cardiovascular systems in one. The pulmonary circulation pumps blood from the right ventricle to the capillaries in the lungs and back to the left atrium. With the exception of right lung vs. left lung, there are no alternative pathways. The systemic circulation pumps blood to the rest of the body, including back to the heart itself via the coronary arteries. After blood leaves the left ventricle through the aorta (the largest artery in the body), it can travel to the brain or through any of several parallel pathways through the rest of the body. Blood becomes oxygenated as it passes through the lungs and is gradually deoxygenated during its longer voyage around the body, as oxygen diffuses passively into energy-using tissues. However, oxygenated/deoxygenated are relative terms; deoxygenated blood may still contain some oxygen.

In the lungs, blood acquires oxygen from inhaled air. The oxygen dissolves across the lining of the alveoli into the capillaries. At the same time, waste carbon dioxide diffuses out of the blood and is then exhaled. Oxygen enables the cells to accomplish the complete oxidation (breakdown) of sugars through cellular respiration. Carbon dioxide is produced as a waste by the cellular respiration process: it carries carbon in a low-energy form back to the atmosphere where it is reincorporated into sugars by photosynthetic organisms such as plants and algae. Other wastes produced by cells as they use up nutrients include urea (which is produced in the liver by the breakdown of amino acids) and the breakdown products of various toxins. These wastes are filtered out by the kidneys, whose capillaries filter the liquid component of the blood and pool the resulting urine into the bladder. Nutrients, such as sugars, fatty acids, and amino acids, enter the bloodstream through the small intestine, where they cross the surfaces of the villi and enter the underlying capillaries.

REFERENCES


This activity is modified from an activity developed by Debra Jockisch, formerly of the Science Department, Orinda Intermediate School, Orinda, CA (October 1998).

TEACHING SUGGESTIONS

■ GETTING STARTED

1. (LITERACY) Elicit students' ideas about the cardiovascular system.

This activity provides students a Directed Activity Related to Text (DART) strategy known as a “KWL,” which is on Student Sheet 18.1, “KWL: The Cardiovascular System.” These letters refer to the three questions that are a part of this strategy: What do I Know? What do I Want to know? What did I Learn? DARTs, such as KWL, allow students to process and manipulate the information that they encounter in a reading. For more information on this strategy or on literacy strategies in general, refer to the Literacy section of Teacher Resources II: Diverse Learners.



Hand out Student Sheet 18.1, “KWL: The Cardiovascular System,” and have students fill out the first two columns: what they know and what they want to know about the cardiovascular system. Encourage students to work together to brainstorm ideas and questions. They will revisit the KWL throughout the remaining activities in the unit.

2. Introduce the cardiovascular system and blood as the transport system for the human body.

■ **Teacher's Note:** Activity 18, “The Circulation Game,” has two parts. In Part A: Blood Flow, students work in their groups to discuss a simplified diagram of blood flow. In Part B: Modeling Circulation, the class works together to physically model the process of blood flowing through the human body. Depending on student ability level, students may require from 15 minutes to an entire class period to complete Part A. Part B will require an entire class period. In addition, Part B requires the class to work cooperatively. The success of the model will initially depend on students' ability to carry out their individual roles. Before beginning the model, anticipate spending approximately 20 minutes reviewing material related to the model and discussing individual roles.

The goal of this activity is to provide students with a

solid understanding of the transport function of the blood. The model will help lay the groundwork for future investigations in this unit. In addition, the class will be asked to identify the limitations of the model. This provides an opportunity to address any misconceptions and to further discuss the use of modeling in science.

You may wish to use the Group Interaction (GI) variable to score the class or individual students during this activity.

Begin the activity by reviewing the ideas in the introduction to the activity. Define the cardiovascular system as the heart and blood vessels that transport to every organ in the body. You can read the introduction, briefly present the information, or ask the class questions to elicit this information.

■ DOING THE ACTIVITY

3. Students explore the cardiovascular system (Part A).

Display Transparency 18.1, “Diagram of Blood Flow.” Explain that this is a schematic diagram of the cardiovascular system, meaning that it represents the flow of blood around the body but is not identical to the way blood actually flows, since it is not anatomically correct. Point out that the left side of the heart is represented on the right side of the diagram. Provide students with another example of a schematic diagram, such as a road map. If available, show a road map and discuss ways in which it is and is not like the real environment represented by the map.

■ **Teacher's Note:** Students will learn much more about the heart's structure and function in Activities 19–29. For now, point out that the heart has two sides. The arrows on the blood flow diagram show the direction of blood flow through each part of the heart.

Ask, *What organs are missing from this diagram?* Missing organs include the pancreas, spleen, reproductive organs, and bladder. In addition, blood flow to the arms and other tissues of the body is not represented. Point out that this figure simply models certain aspects of the cardiovascular system.

Activity 18 • The Circulation Game

Ask, *Why do you think this diagram has been simplified? Why not include all of the organs and structures that blood travels to in the human body?* Encourage students to think of the diagram as a way to focus on certain aspects of the cardiovascular system; including all of the organs would make the diagram extremely complicated. Inform the class, In this activity, we will find out what a simplified model can tell us about the cardiovascular system.

Instruct students to complete Part A of Activity 18. Students will need to work both individually (in Steps 1–3) and in small groups (in Steps 4–6). Do not require students to write responses to the questions in Step 4; they are intended to guide a group discussion. If accountability is an issue for your student population, consider having each group present to the entire class a response to one of the questions.

4. The class discusses Part A.

Discuss student responses to the questions in Step 4. On Transparency 18.1, follow the path of the blood to demonstrate how the blood can travel through the body after it leaves the heart. Emphasize that blood can travel to organs in the upper or lower parts of the body. For example, blood traveling through the lower half of the body can circulate to the liver, stomach and intestines, kidneys, or leg muscles. As blood passes through an organ, it will head back to the heart, from which it will be pumped through the lungs. Different students will have traced different paths through different

organs, but each complete path takes the blood through the heart twice and lungs once. Summarize the functions of these organs by discussing responses to Table 1 (shown below). Students can write and complete the table in their science notebooks or fill in a photocopied table individually or as a group, or complete the table on the board or an overhead transparency as a class activity.

Review with students what happens as the blood passes through the lungs. Discuss an important function of blood: the transport of oxygen and carbon dioxide. Ask, *Which side of the diagram carries blood containing oxygen?* The right side of the diagram, which represents the left side of the heart of a person facing out from the page, carries blood that has just left the lungs. Use the red overhead pen to trace along these lines. Ask, *What happens to the oxygen as it reaches the other parts of the body?* Students may know that the body uses oxygen and releases carbon dioxide as waste. Ask, *Does the blood on the other side of the diagram contain more or less oxygen?* Students should be able to deduce that it has much less oxygen. In fact, it does not contain enough oxygen to supply any to the organs. Emphasize that, while the level of oxygen in the blood on the left side of the diagram is reduced, the level of carbon dioxide has increased. Use the blue overhead pen to trace the path of the deoxygenated blood. Point out that the blood has another important function: to carry nutrients and remove wastes from different parts of the body. (Be sure that students know that the term “nutrients” is used because pieces of food are not traveling through the blood. The food has been broken down and absorbed by the digestive system and it is the nutrients that are being carried to various parts of the body.) Point out that nutrients are required by all parts of the body, not just the stomach. The blood acts as the transport vehicle after the stomach has digested food, producing nutrients for all parts of the body.

■ **Teacher’s Note:** The use of nutrients and oxygen by cells is discussed in the Cell Biology and Disease unit of *Issues and Life Science*.

Function	Organ(s)
Pumps blood	Sample responses removed for preview
Brings oxygen into the body	
Carries carbon dioxide out of the body	
Absorbs nutrients	
Removes wastes	

5. Explain the circulation model (Part B).

Explain that students will now model, on a larger version of Transparency 18.1, the roles of the blood and organs as blood travels through the body. Students representing blood will travel along the pathways to model the flow of blood. They may not realize that they do not always have to follow the same path through repeated cycles around the body. Students role playing blood will have to choose a path to follow. You may want to point out that blood does not actually “make a choice,” and that this is one limitation of the model. The circulation path forks in many directions and leads through different organs. Each time students circulate through the body, they can choose different paths and thereby pass through different organs.

Students role playing blood will begin with one *oxygen* and one *nutrient* card. During the modeling activity, they will acquire and give away all four kinds of cards. However, at no time should they be without at least one *oxygen* or *carbon dioxide* card.

Review the other roles (Roles 1–14) that will be performed during the first round of the activity and point out the place on the diagram where these roles will be located. *Do not mention Roles 16–19 at this time.* Those students situated at the various organs will either take away oxygen and replace it with carbon dioxide (in the Brain, Stomach, Liver, Kidneys, and Leg Muscles); take away nutrients and replace them with wastes (in the Brain, Liver, and Leg Muscles); provide oxygen (in the Lungs); provide nutrients (in the Stomach); remove wastes (in the Kidneys); or pump blood (in the Heart). Emphasize that *all* parts of the body require nutrients and oxygen, and *all* parts of the body produce carbon dioxide and other wastes.

The two students located in the heart set the pace of the activity. All of the students representing blood should be moving at the same pace. To increase or decrease the movement of the blood, have the students in the heart shout heartbeats aloud (e.g., “thump, thump, thump...”) at faster or slower speeds while *gently* pushing the blood through the heart at the same pace as the beats. Or use a small drum to set the pace of students’ movement.

At this point, review with the class the rules on Transparency 18.2, “Rules of The Circulation Game.” Then distribute the Role Cards to individual students. *Do not hand out Role Cards 16–19 at this time.* The first 14 students should receive one of the first 14 Role Cards. The rest of the students should be assigned Role 15 (blood). Have students read their Role Cards carefully, and collect the appropriate number of nutrient, waste, carbon dioxide, and oxygen cards. Before starting the game, have students fasten their role cards onto their clothing.

6. Conduct the model (Play the Circulation Game) (Part B).

Move outside to the template. Have one student who is playing the role of blood walk completely around one of the possible circulation paths (beginning and ending on the oxygenated side of the body) to demonstrate how the blood “should move and exchange nutrients and wastes. The other students should watch. Then have all students take their places around the body and WALK around one of the circulation paths. Be sure that all of the students representing blood begin on the oxygenated side of the body.

Begin the second run by having the blood move to a beat. The students playing the role of the heart may wish to clap their hands or you may have a student beat on a drum to simulate the rhythm of the heart beating. The students playing the blood should only step forward on the beat.

After a short time, some students representing the organs will run out of *nutrient*, *oxygen*, *waste*, and *carbon dioxide* cards, while others will accumulate these Substance Cards. Gather students together and discuss why this happened. Ask, ***How do additional nutrients come into the body? How does the body absorb more oxygen and release carbon dioxide? How are liquid wastes eliminated?*** Lead students to suggest macroscopic interactions with the environment (such as breathing in, breathing out, eating, and urinating). Based on these answers, give four students who are role playing blood new Role Cards: Role 16 (eating), Role 17 (breathing in), Role 18 (breathing out), and Role 19 (urination). These students will move about the periphery of the

Activity 18 • The Circulation Game

template to re-distribute the Substance Cards, being careful not to interfere with the flow of blood.

Have students re-organize the cards so that they have their initial number of cards. Then begin the third run of the model with every role covered. Tell the students to move through slowly at first, but to gradually increase the rate of movement of blood through the body. The model should now run relatively smoothly.

Have students re-organize the cards so that they have their initial number of cards. Then have students switch roles, so that those students who represented blood are now at organ sites and vice versa. Run the model for a fourth time.

■ EXTENSION

Simulate a blocked artery. Place a chair or some other object over an artery so blood cannot move through it. Have the class play the game again and observe what happens to the organ that was supplied with oxygen and nutrients by that artery.

■ FOLLOW-UP

7. (SI ASSESSMENT) The class evaluates the model.

Use Analysis Question 1 to discuss the Circulation Game as a model. Reinforce the idea that models often simplify complex processes in order to promote understanding of a single point—in this case the transport function of the blood. If your students are beginning to master the concept of modeling, you may wish to have them answer Question 1 individually. Regardless of your approach, be sure to emphasize the use of models to enhance understanding of what happens within the human body. Encourage students to evaluate the strengths and weaknesses of the model.

Analysis Question 2 is intended to be discussed by student groups. To prepare students for the assessment, it is important that you review the idea that every organ takes up oxygen and nutrients and releases wastes (both carbon dioxide and other wastes). Use Transparency 18.1 to record which organs received oxygen and nutrients in the model. Then record which organs produced carbon dioxide

and other wastes. Ask, **Do any other organs need oxygen and nutrients?** Record the fact that all of the structures on the diagram require these, and emphasize the idea that despite the limitations of the model, the heart (as well as organs not represented in the model) does as well. Ask, **Which organs produce carbon dioxide and other wastes?** Record the fact that all organs in the body, whether represented on the diagram or not, produce wastes.

Ask, **How would the human body be affected if blood flow to the heart became blocked?** Use this question to emphasize that just like any other organ, the heart must receive oxygen. This oxygen is not provided by the blood circulating through the heart's chambers—if it were, the entire left side of the heart would not receive oxygen! Even the right side would not receive enough oxygen, due to a lack of enough surface area. Instead, oxygen must be provided by oxygenated blood flowing through capillary networks throughout the heart muscle. Point out that this was not modeled in the Circulation Game. Ask, **How could you model this in the Circulation Game?** This could be modeled by adding a path for the blood to go to the heart (pumped by the heart, right back to its own tissues) and by having students role play the heart using oxygen and nutrients while producing carbon dioxide and waste.

Analysis Questions 3–5 can be used for individual student review and can be completed as a homework assignment. Be sure to review student responses. Questions 4 and 5 address the main concepts of this activity, while Question 3 provides a link to Activity 13, “Living with Your Liver.” Responses to Question 5b can be assessed using the COMMUNICATING SCIENTIFIC INFORMATION (SI) variable.


The cardiovascular system is the fourth system to be discussed in depth in this unit. Review the concept of systems as groups of organs contributing to the same overall function by displaying transparency 12.1 and 12.2


system (cardiovascular system) • organs (e.g. heart)

tissues (e.g., blood, muscle).


Then have students help you to prepare similar flow charts of other body systems. Have students review the questions they wrote on Student Sheet 18.1, “KWL: The Cardiovascular System.” If any of their questions were answered, or they learned something relating to one of their questions, have them fill in the “What did I learn?” column.


SUGGESTED ANSWERS TO QUESTIONS

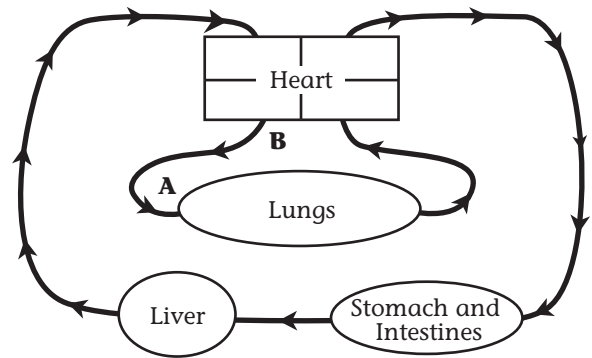
1.  Compare the circulation model to the human body. How well did the Circulation Game represent what really happens inside your body?

2.  Do all parts of the human body use oxygen and nutrients? Explain your answer.

3. Why does blood flow from the stomach and intestines directly to the liver? Hint: Review your notes from Activity 13, “Living with Your Liver,” and Activity 15, “Digestion—An Absorbing Tale,” for help.

4.  What are the functions of the blood as it travels around the human body? Be specific.

5.  Look at the diagram below.



a. Use your finger to trace the path between Point A and Point B, making sure to follow the direction of the arrows. List the organs in the order in which you passed through them.

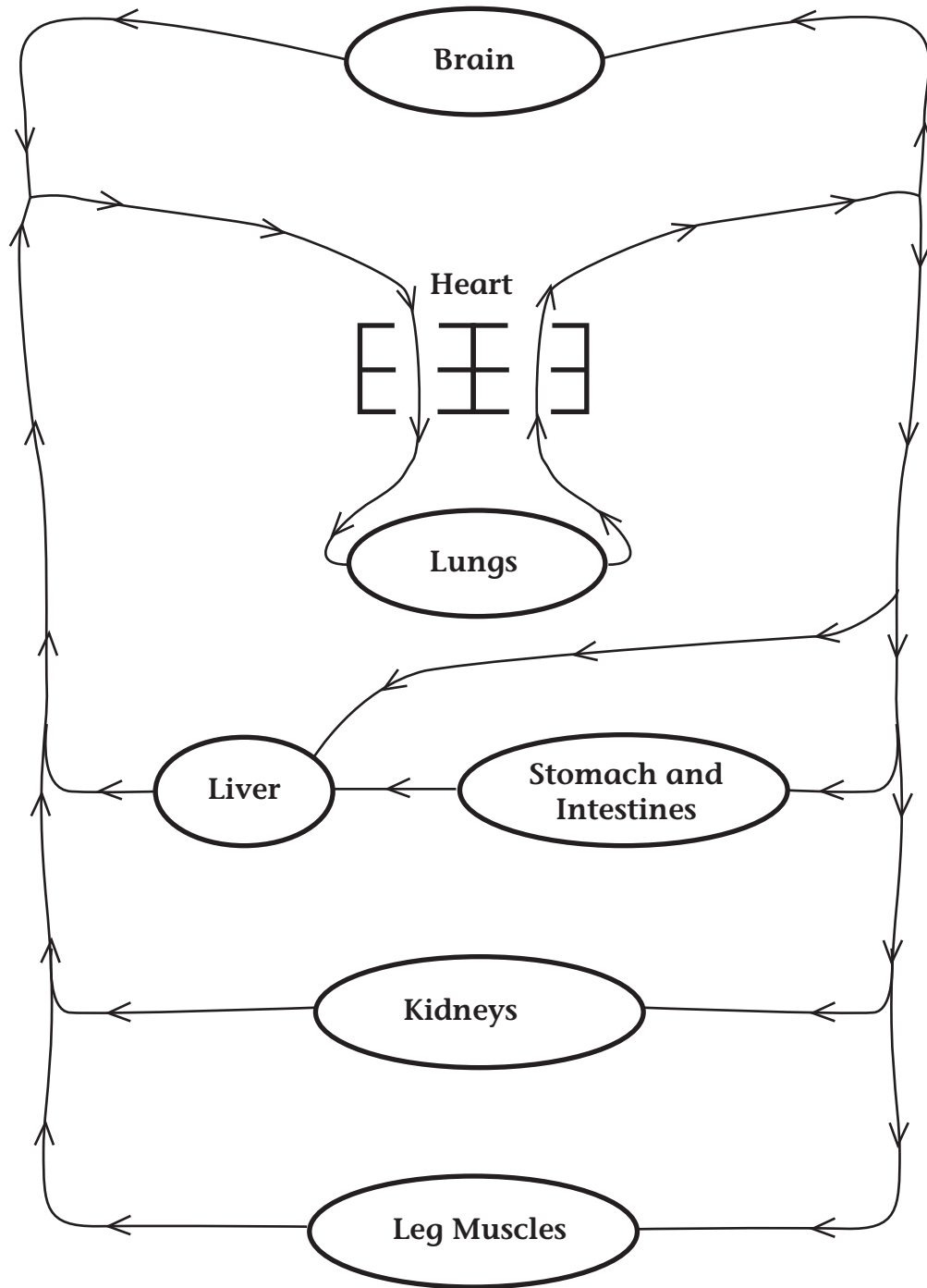
Activity 18 • The Circulation Game

- b. *(SI ASSESSMENT) Imagine blood carrying only carbon dioxide and nutrients at Point A. Describe what happens to the blood as it flows from Point A to Point B.*

Level 3 Response

6. *Complete as much as you can of the third column of Student Sheet 18.1 “KWL: The Cardiovascular System.”*

Diagram of Blood Flow



Rules of the Circulation Game

- Blood moves around the body as it follows the path of blood flow.
- Blood must get to all the different parts of the body. If you are role playing blood, you should not go to the same organ twice in a row. Go to other organs instead. Try to avoid organs where there is already too much blood.
- Blood does not have to give its oxygen and nutrients to the first organ it comes to. If blood is going to travel to other organs it may save the oxygen and nutrients. However, it must exchange oxygen and nutrients for carbon dioxide and wastes before returning to the heart.
- Organs must stay in the same location in the body and not move.
- The heart should push the blood gently on its way.
- Toxins may only be removed by the liver.

KWL: The Cardiovascular System

Complete the first two columns before doing Activity 18. Complete the last column after finishing Activity 18 and again as instructed by your teacher throughout the rest of the unit.

BEFORE the Activities		AFTER the Activities
What I know about the cardiovascular system	What I want to know about the cardiovascular system	What I learned about the cardiovascular system

1
40- to 50-minute sessions



ACTIVITY OVERVIEW

Students collect data on their heart rates by measuring their pulses before and after moderate-impact exercises. They then measure the recovery time of their heart rate as an indicator of their physical fitness. As an extension, students can measure the effect on recovery time of regular exercise performed over a month-long period.

KEY CONCEPTS AND PROCESS SKILLS

(with correlation to NSE 5–8 Content Standards)

1. Graphs can reveal patterns that are not immediately apparent from data tables. (INQUIRY: 1)
2. Humans have systems for digestion, respiration, reproduction, circulation, excretion, movement, control, and coordination. (LIFE SCIENCE: 1)
3. Living systems, such as the cardiovascular system, demonstrate the complementary nature of structure and function. (LIFE SCIENCE: 1)
4. Organisms must be able to maintain stable internal conditions while living in a constantly changing environment. For example, heart rate changes to keep blood oxygen levels in the range needed for survival. (LIFE SCIENCE: 3)
5. People make important personal decisions about their health based on their perceptions of benefits and risks. (PERSPECTIVES: 4)

KEY VOCABULARY

pulse
quantitative data
range
regulate/regulation
variable

MATERIALS AND ADVANCE PREPARATION



For the teacher

- * 1 overhead projector
- * 1 overhead transparency
- 1 Scoring Guide: ANALYZING DATA (AD)
- 1 Scoring Guide: ORGANIZING DATA (OD)



For the class

- * access to a wall clock or watch with a second hand

For each pair of students

- * 1 calculator

For each student

- 1 Student Sheet 19.1, “Pulse Data”
- 1 Scoring Guide: ANALYZING DATA (AD) (optional)
- 1 Scoring Guide: ORGANIZING DATA (OD) (optional)
- 1 Science Skills Student Sheet 4, “Scatterplot and Line Graphing Checklist” (optional)
- Student Sheet 18.1, “KWL: The Cardiovascular System,” from Activity 18

**Not supplied in kit*

Masters for all Scoring Guides are in Teacher Resources III: Assessment.

Consult with a physical education teacher about what types of exercises might be most appropriate for your student population (see Step 2 of the Teaching Suggestions). If possible, conduct Part B of the Student Procedure outdoors.

Inform students in advance that they will be exercising in class. Encourage them to wear appropriate attire and to be prepared to perspire.

TEACHING SUMMARY

Getting Started

1. Students predict their resting and exercising pulses.

Doing the Activity

2. The class agrees on an exercise.
3. Students complete the Procedure.

Follow-Up

4. (AD, OD ASSESSMENT) The class discusses results.

Extension

Students develop individual exercise plans to improve their recovery time.

Extension 2

This activity offers numerous opportunities to teach or review graphing skills. For example, students can use their predictions of exercising pulse rates to create a scatterplot to determine the range of responses as well as the most common response(s) (the mode). They can construct a histogram or scatterplot to analyze average resting pulse rates. They can also calculate the average, or mean, resting pulse of 12-year-olds. Then you can use this to reinforce the concept of sample size.

BACKGROUND INFORMATION

Recovery Time

Recovery time is a measure of physical fitness. It is the time it takes for your pulse to return to within 20% of your resting heart rate. The more physically fit a person is, the more efficiently oxygen and nutrients can be transported to the muscles and waste products can be removed from the muscles. Therefore, a faster recovery time indicates better physical fitness.

TEACHING SUGGESTIONS

■ GETTING STARTED

1. Students predict their resting and exercising pulses.

■ **Teacher’s Note:** This activity has two parts to the Procedure. In Part A: Resting Pulse, students measure their pulse at rest and calculate their average resting pulse per minute. In Part B: Recovery Time, students exercise and then measure their pulse over time in order to determine their recovery time (see Background Information).

Begin the activity by asking, *What is a pulse? How can you measure your pulse?* Emphasize that the pulse tells us the number of contractions of the heart in a specified time, usually a minute. Relate this to the function of the heart as a pump. Review the idea that the heart beats in order to move blood around the body. The blood can then transport oxygen and nutrients to the muscles and other tissues and carry away waste products.

Procedure Step 1 has students respond to the following questions in their science notebooks:

a. When you are at rest, how many times do you think your heart beats (as measured by your pulse) in 1 minute?

b. After you have done some moderate exercise, how many times do you think your heart beats (as measured by your pulse) in 1 minute?

Determine how you will chart students’ responses. You might develop a histogram on the board or overhead and have students record their own responses, or you might have students call out responses as you chart them. State the range of students’ responses, and have students record this in their science notebooks. It is likely that student predictions for resting pulse will vary from accurate (normally 60–80 beats per minute) to extremely high (e.g., 175 beats per minute) to extremely low (e.g., 2 beats per minute). In most cases, students will predict the exercising pulse to be higher than the resting pulse, regardless of numerical value.

■ DOING THE ACTIVITY

2. The class agrees on an exercise.

In Part B of the Student Procedure, students are expected to complete an aerobic activity in order to measure their pulse after exercise. Inform the class that they will be doing an exercise to raise their heart rate. Have students brainstorm possible variables, either as a class or in their groups of four. You may wish to refer to Science Skills Student Sheet 5, “Elements of Experimental Design,” in Teacher Resources II: Diverse Learners.

As a class, design the aerobic activity(ies) students will perform. Reach consensus on how to keep all of the variables the same for every student. Some options are jogging in place, a step exercise, jumping jacks, squats, or running between two points.

■ **Teacher’s Note:** Many students may not exercise strenuously enough, which can make measuring recovery time impossible. Therefore, choose an exercise in which students will fully participate. For example, running between two points may force students to be more active than jogging in place.

After the class has decided on an exercise, ask, *What variable are we investigating?* (Heart rate.) *What other variables can we keep the same?* The most obvious variable is time, or how long to exercise (the procedure prescribes a period of 5 minutes). Intensity, or how hard students exercise, is another variable. Ask students to offer ways to quantify exercise intensity. Discuss their suggestions and include their ideas in how the activity is conducted. With jumping jacks, for example, the entire class could perform them together in unison as you set the pace by counting jumping jacks aloud.

3. Students complete the Procedure.

Review how to measure resting pulse. Some students may have difficulty finding their pulse and require some assistance. A description, including a photo, is found below Step 1 of the Student Procedure. Students can also refer to Steps 1 and 2 of the Procedure for guidance. Move around the room observing students taking their pulse, and assisting

as necessary. When you are reasonably confident that your students know how to take their pulse, pass out Student Sheet 19.1, “Pulse Data,” and have them complete Activity 19.

After students have completed Procedure Step 13, have them compile all data on a scatterplot. The graph could be drawn on an overhead transparency, a piece of chart paper, a chart board, or a SMART Board.

As students complete the activity, they can work on Analysis Question 1 in their groups.

■ FOLLOW-UP

4. (AD, OD ASSESSMENT) The class discusses results.

Begin by reviewing Analysis Question 1, which provides a link to concepts introduced in Activity 17, “Gas Exchange.” Analysis Question 2 can then be used to discuss how the body’s regulatory mechanisms keep systems in balance. As you discuss the questions, emphasize how breathing and heart rate are regulated to maintain oxygen levels in the body.

Ask, *Why was it important to take your resting pulse more than one time?* Discuss how averaging values eliminated obvious errors in technique and ensured greater accuracy. Ask, *What was your average resting pulse? How did your average resting pulse compare with what you had predicted?* On an overhead transparency, record the resting pulses among students in the class.

■ **Teacher’s Note:** If you have concerns about students sharing this information, go around the room as students answer Analysis Questions 3 and 4 and record this information anonymously.

Ask, *What is the range of resting pulse rates among students in this class?* Compare the range and the average of resting pulse rates to students’ earlier predictions of resting pulse. Though resting pulse can vary widely, the normal range for adults is 60–80 beats per minute, which is considered healthy. It is likely that most students will fall within the 60–80 beats per minute range, though some may have a slightly lower or higher resting pulse. People with a

resting pulse above 80 beats per minute are considered to have a high heart rate. Such a pulse might indicate the need for additional testing to determine the cause of the higher than normal rate. People with a resting pulse below 60 beats per minute have a lower than normal pulse. In many instances, this is a result of better than average health as a result of physical conditioning. However, it may also be a warning sign for certain health problems. The establishment of a healthy range does not preclude being healthy outside of that range; it simply establishes parameters that generally allow a quick check of overall health. Encourage students with any concerns to share the information on their pulses with their parents or guardians.

After students have had a chance to complete Analysis Questions 3 and 4, ask, *Was your recovery time what you expected?* Students may want to know how their recovery time relates to their physical fitness level. Assuming that students raised their heart rates during exercise, a steeper curve on Graph 1 indicates a faster recovery time and a higher level of physical fitness. As described in the Extension, discuss how students could possibly improve their level of fitness, as measured by recovery time. You may wish to use the ANALYZING DATA (AD) variable to score students’ responses to Analysis Question 3b.

Encourage students to find out more about careers in physical fitness. They can interview a physical education teacher, a coach or exercise instructor, a physical trainer, or chiropractor. Invite them to share what they find out with the class.

Summarize the activity by reviewing the role of heart rate and respiratory rate in maintaining internal levels of oxygen and carbon dioxide within the range appropriate for life. Activities 17, 18, and 19 can be used to provide an introduction to the important biological concept of homeostasis.

■ EXTENSION

Students develop an individual exercise plan to improve their recovery time.


Students can carry out a one-month investigation of the effect of regular exercise on recovery time, as


Activity 19 • Heart-ily Fit


described on page B-51 in the Student Book. Each student can choose an exercise, record it in his or her science notebook, and practice it at least three times a week for at least 20 minutes each time. Be sure to remind students to exercise each week. Set aside a time one month later to discuss the outcomes when you can have each student report any changes in his or her recovery time. In order for students to measure this value, they should re-measure and average their individual resting pulse (Part A of the Procedure). They should then re-calculate the 20% range for their resting pulse (1.2 times the resting pulse).

Ask students to suggest a way to record the changes so that data can be compared and discussed. Ideally, students may suggest creating one or more kinds of graphs to display the data. The graphs could be used to interpret the range of class performance as well as the most common changes that have occurred. Point out the improvement in recovery time for students who followed a regular plan of exercise for at least 20 minutes a session, three times a week. Some students may show little or no change. This could be due to a variety of factors ranging from not doing the exercise properly to being in excellent physical condition and having an initial low recovery time. An interesting comparison is the amount of change found by students in regular training programs for athletic competition compared with those not involved in such programs.

SUGGESTED ANSWERS TO QUESTIONS

-  *What happened to your breathing rate during exercise? Discuss what was happening inside your body that caused this to happen.*

-  *What caused the difference between your resting pulse and your pulse after exercise? In other words, what was happening inside your body that caused your pulse to change?*


-  *a. Recovery time is the time it takes for your pulse to return to within 20% of your resting pulse. In order to measure your recovery time, you must first know when you are within 20% of your resting pulse. Calculate this value by multiplying your resting pulse by 1.2.*

$$\text{Resting pulse} \times 1.2 = \underline{\hspace{2cm}} \text{ beats/min}$$

- b. (AD ASSESSMENT) Look at your 60-second pulse values in section III, "Recovery Time," of Student Sheet 19.1. How many minutes after you stopped exercising did it take you to return to within 20% of your resting pulse? (This is your recovery time.)*

Be sure students understand that their individual recovery time is the number of minutes it took to return to within 20% of their resting pulse after stopping the exercise. For example, if their calculated value for Question 3a was 84 beats/min, how many minutes did it take for their resting pulse to be equal to or less than 84 beats/min? This is the recovery time.



Level 3 Response

4.  (OD ASSESSMENT) Prepare a line graph of your pulse during the time of the recovery period.

You may want to provide Science Skills Student Sheet 4, “Scatterplot and Line Graphing Checklist,” to help students construct their graphs. You may assess students on their graphing ability using the ORGANIZING DATA (OD) Scoring Guide. If you are planning to assess their work, be sure to review with them your expectations (criteria) for a Level 3 response. You may tell them, for example, that you expect them to title their graph and to label each axis. A Level 3 response is shown below.

5. *If you improved your level of physical fitness, would you expect your resting pulse to increase or decrease? Explain.*

6. *What do you predict would happen to your recovery time if you exercised at least three times a week for a month?*

7.   Complete the third column of Student Sheet 18.1, “KWL: The Cardiovascular System.”

Have students review the questions they wrote on Student Sheet 18.1, “KWL: The Cardiovascular System.” If any of their questions were answered, or they learned something relating to one of their questions, have them fill in the “What did I learn?” column.

Pulse Data

I. Calculating My Resting Pulse

	15-Second Pulse		x 4 =	60-Second Pulse
Trial 1	_____			_____
Trial 2	_____			_____
Trial 3	_____			_____

II. My Average Resting Pulse: _____ beats per minute

- a. Add the 3 numbers in the column titled "60-Second Pulse": _____
- b. Divide the total from (a) by 3: _____
This number is your average resting pulse per minute.

III. Recovery Time

	15-Second Pulse		x 4 =	60-Second Pulse
Immediately	_____			_____
After 30 seconds	_____			_____
After 1 minute	_____			_____
After 30 more seconds	_____			_____
After 2 minutes	_____			_____
After 30 more seconds	_____			_____
After 3 minutes	_____			_____
After 30 more seconds	_____			_____
After 4 minutes	_____			_____
After 30 more seconds	_____			_____
After 5 minutes	_____			_____