

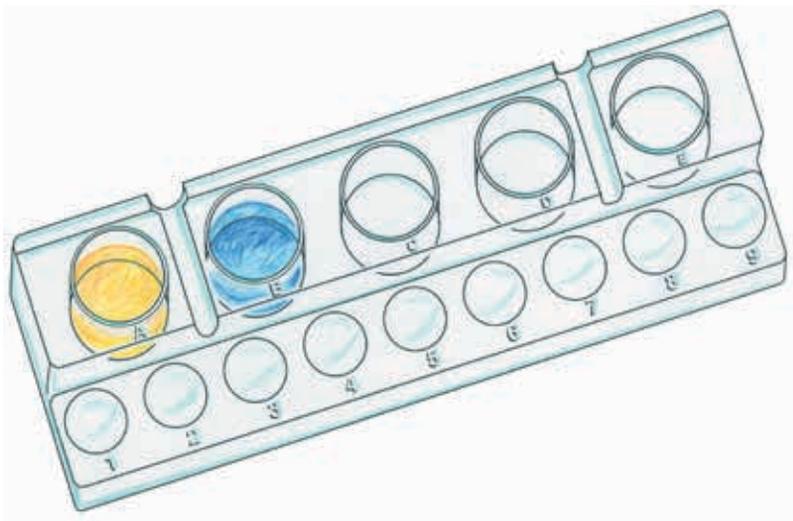
10

Gas Exchange

LABORATORY

IN THE LAST activity, you observed the effects of exercise on your circulatory and respiratory systems. With every breath you take, you inhale oxygen and exhale carbon dioxide. The cells in your body need oxygen so they can break down food and release energy. Without oxygen, your cells cannot get the energy they need to live. When your cells break down food, they produce wastes. One of the wastes is carbon dioxide. The function of the respiratory system is to exchange gases, removing carbon dioxide wastes and taking in oxygen.

Indicators are chemicals that change their appearance in different types of solutions. You will work with the indicator bromothymol blue, also known as BTB. BTB can be either blue or yellow. When added to a solution containing carbon dioxide, BTB is yellow.



Both solutions contain the indicator BTB. Which cup has a solution containing carbon dioxide?

GUIDING QUESTION

How much carbon dioxide is in your exhaled breath before and after you exercise?

MATERIALS

For each group of four students

- 1 dropper bottle of bromothymol blue (BTB) indicator
- 5 plastic cups
- supply of water

For each pair students

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

For each student

- 2 plastic bags (1-gallon)
- 2 straws
- 1 stir stick
- 1 pair of chemical splash goggles
- access to a wall clock or watch that displays seconds
- 1 Student Sheet 10.1, "Anticipation Guide: Gas Exchange"

SAFETY

In this activity, you will be blowing through a straw into chemicals. Do not inhale through the straw! Breathe in through your nose and exhale through your mouth. If you accidentally swallow liquid, rinse your mouth thoroughly and drink plenty of water. Be sure to tell your teacher.

Wear chemical splash goggles while working with chemicals. Do not touch chemicals or bring them into contact with your nose or mouth. Wash your hands thoroughly after completing the activity.

PROCEDURE

Use Student Sheet 10.1, "Anticipation Guide: Gas Exchange," to prepare you for learning about the respiratory system.

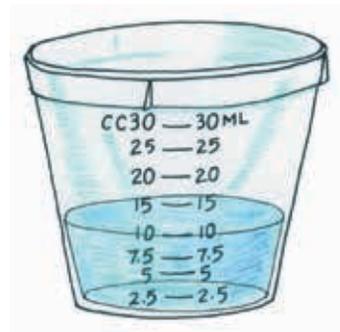
Part A: Testing for Carbon Dioxide

1. Work with your partner to add 5 mL of water to each of the five large cups (A–E) of your SEPUP tray. Use the 30-mL graduated cup to measure the water.
2. Add 2 drops of BTB to each cup and stir.

3. Create a data table to record the initial and final colors of the solutions in each cup. Record the initial colors now. Cup A will provide a control.
4. Use your dropper to bubble air into Cup B. Place the dropper into the solution, and press the air out of the bulb. Before releasing the bulb, remove the tip from the solution. This will prevent uptake of solution into the dropper. (If you accidentally get solution into the dropper, simply squirt it back into Cup B.) Repeat this for 15 s.
5. Record the final color of the solution in Cup B in your data table.
6. Add 3 drops of 0.05 M sodium hydroxide to Cup C. Record the final color in your data table.
7. Have one partner unwrap a straw and place one end in Cup D. That partner should take a deep breath, and then gently blow through the straw for 15 s. (Remember not to inhale through the straw!) Record the final color of the solution in Cup D in your data table.
8. Have the other partner blow through a clean straw into Cup E for 15 s. (Remind them not to inhale through the straw!) Record the final color in your data table.
9. Add 3 drops of sodium hydroxide to Cups D and E. In your science notebook, record any changes that you observe.
10. Work with your partner to complete Analysis items 1 and 2.

Part B: Measuring Carbon Dioxide in Exhaled Breath Before and After Exercise

11. Work with another pair of students to set up a control.
 - a. Measure 10 mL of water using the 30-mL graduated cup.
 - b. Add 5 drops of BTB to the graduated cup and stir.
 - c. Pour the BTB solution into a large plastic cup. This solution will be the control for every member of your group.



12. Have each person in your group set up their own bag of BTB solution.
 - a. Measure 10 mL of water using the 30-mL graduated cup.
 - b. Add 5 drops of BTB to the graduated cup and stir.
 - c. Pour the BTB solution into your own plastic bag.
13. Remove the air from your plastic bag by slowly flattening it. Be careful not to spill any of the BTB solution out of the bag. While keeping the air out of the bag, place a straw in the mouth of the bag. Make an airtight seal by holding the mouth of the bag tightly around the straw.



14. Be sure you are sitting down. Then fill the bag with air from your lungs by blowing through the straw until the bag is fully inflated. When you finish blowing, pull out the straw. As you pull out the straw, squeeze the bag tightly shut so no air escapes.



15. While holding the bag closed, shake it vigorously 25 times.
16. Pour the BTB solution from the bag into a clean, empty plastic cup.
17. How much carbon dioxide is in your exhaled breath? You can find out by counting how many drops of sodium hydroxide are needed to make your BTB solution the same color as the control.
 - a. Add 1 drop of sodium hydroxide to your plastic cup.
 - b. Gently stir the solution and wait at least 10 s.
 - c. Record in your science notebook that you added 1 drop.
 - d. Compare the color of your solution to the control. Is it the same color as the control for at least 30 s?
 - If your answer is no, repeat Steps 17a–d. Be sure to keep track of the total number of drops!
 - If your answer is yes, go on to Step 18.
18. In your science notebook, record the total number of drops it took to change your solution back to the same color as the control. Then record your total on the class data table.
19. Repeat Steps 12 and 13 to prepare your bag of BTB for the remaining steps.

20. As discussed in class, exercise for 5 minutes. After 5 minutes, stop exercising and sit down.

Hint: If you can have a normal conversation while exercising, you are not exercising hard enough. If you cannot talk at all, you are exercising too hard.

21. Repeat Steps 14–18.
22. Draw a bar graph with the class results before and after exercising. Remember to title your graph and label the axes.



EXTENSION

Asthma is a common medical condition that affects many people's breathing. With your partner or group, discuss what questions you have about asthma and how it affects the respiratory system. To research the answers to your questions, visit the *SEPUP Third Edition Body Systems* page of the SEPUP website at www.sepuplhs.org/middle/third-edition, and go the resources on asthma.

ANALYSIS

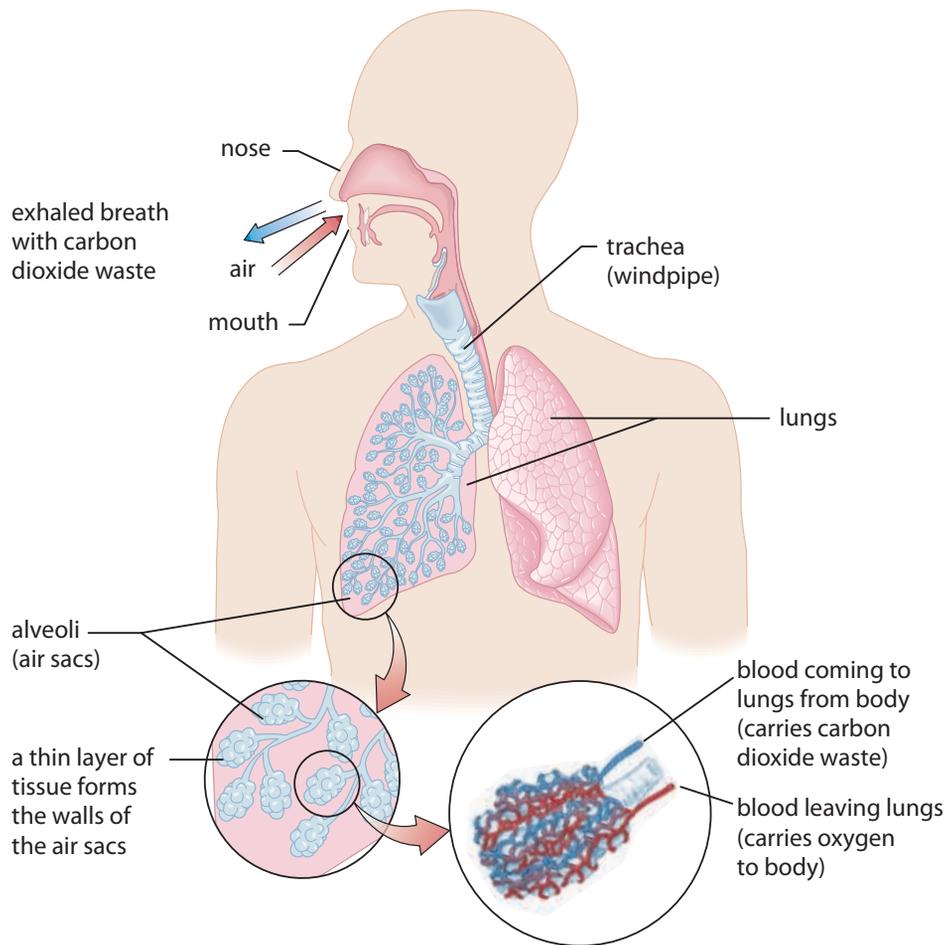
1. What was the purpose of the solution in Cup A?
2. Review your results.
 - a. Which of the solutions in Part A contained carbon dioxide? Support your answer with evidence from your experimental results.
 - b. What does this tell you about the exhaled breath of human beings?
 - c. Look at the table below. Compare the composition of air you breathe in to that of air you breathe out. Describe the differences.

Composition of Breath

COMPONENTS OF EARTH'S ATMOSPHERE	COMPOSITION OF AIR BREATHED IN (%)	COMPOSITION OF AIR BREATHED OUT (%)
Nitrogen	78	75
Oxygen	21	16
Argon	0.93	0.93
Carbon dioxide	0.036	4.0
Water vapor	0.4	4.0

3. Based on the results of this activity, describe the function of the respiratory system.
4. Look at the diagram below of the human respiratory system. Considering the function of the respiratory system that you described for Analysis item 3, why do you think the inside of the lung is structured the way it is?

Human Respiratory System



5. Complete Student Sheet 10.1. Be sure to explain how the activity provided evidence for your initial ideas or caused you to change your thinking.
6. **Reflection:** Many respiratory diseases limit a person's ability to exchange oxygen. One of these diseases is pneumonia, which causes the lungs to fill up with fluid. Another is pleurisy, which is an inflammation of the lining of the lung, making it painful to inhale and exhale. If you had one of these diseases, how do you think it would affect your body's function?

STUDENT SHEET 10.1

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 from 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 are meant to go down the same passageway. |
| _____ | _____ | 8. The walls of your lungs are filled with many tiny blood vessels. |