

Assessing Breathing Models



CORBIS / JEAN-YVES RUSZKIEWSKI; TEMPOSPORT

Breath control is essential for swimmers, especially those who compete in meets.

INTRODUCTION

In the first part of this module, you explored how your body digests food and how nutrients are absorbed into the bloodstream. Food is one of the main ingredients your body needs to function. Another one is oxygen. How does your body take in oxygen? And then what happens?

To answer these questions, you need to know about the structure of a second human body system—the respiratory system. You also need to know how the process of breathing works.

You will begin this lesson by discussing what you already know about breathing. You'll examine a model that is often used to simulate how air enters and leaves the lungs. Then you will design and construct your own model of the breathing process. On the basis of what you know about breathing and the structure of the human respiratory system, you will discuss the strengths and limitations of each model.

OBJECTIVES FOR THIS LESSON

Review what you already know about the breathing process.

Observe a demonstration of the bell jar model of breathing.

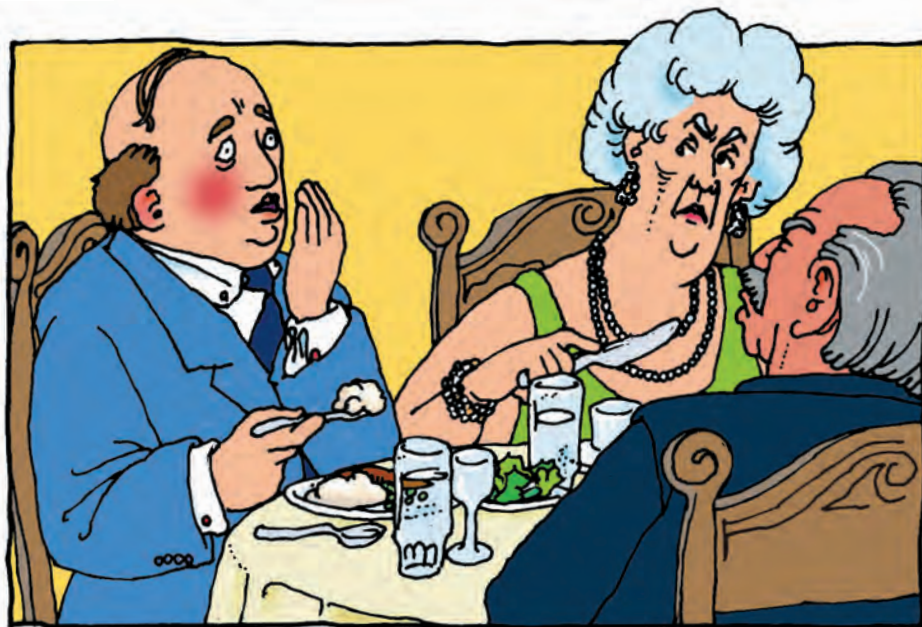
Design, construct, and operate a model that simulates the breathing process.

Assess the strengths and limitations of two breathing models.

Recognize that all models have limitations.

Become familiar with the basic structure and functioning of the human respiratory system.

EXCUSE ME, PLEASE!



Sometimes you can't help it. You do something that your parents and teachers have told you isn't polite. You burp. Or you get the hiccups. Embarrassing!

What causes burps and hiccups? Let's take a look.

Burps: Doing Away With Extra Air

A burp is your body's way of getting rid of swallowed air. That air gets into your stomach by way of the esophagus, just as food does. But food is supposed to be in the stomach; air belongs in the lungs, right?

If you "swallow" too much air while you're eating, you'll start to feel uncomfortable. It's especially likely to happen if you're eating fast.

Once you've swallowed too much air, you'll get an unpleasant sense of fullness that is caused by the pressure of the air. Burping gets rid of the extra air and relieves the uncomfortable feeling.

When you drink a soda, you swallow carbon dioxide bubbles. That can lead to burping. Or maybe you've "burped" your baby brother or sister. Burping babies is necessary because they swallow air when they are

MATERIALS FOR LESSON 10

For you

- 1 copy of Student Sheet 10.1: Assessing the Syringe Model of Breathing

For your group

- 1 plastic box
- 2 syringes
- 2 balloons
- 2 400-mL beakers
- Water (or access to a sink)



being fed. If they get too much gas, their stomachs expand. That hurts, and the baby usually starts to cry. By placing your baby sister on your shoulder and patting her gently on the back, you can help the air come back up.

Although burping is frowned on in our society, it's a compliment to the host in some other cultures. It's kind of like saying, "Thank you for an excellent meal. I enjoyed it!"

Hiccups: Things Get Out of Synch

Hiccups can be worse than burps. Once you get them, you think they'll never end!

Hiccups are a sign that your breathing is out of synch. To understand why hiccups happen, you have to know something about how the respiratory system works.

Respiration involves two main types of muscles—the rib, or intercostal, muscles and the diaphragm, which lies at the base of your lungs.

Normally, these two muscle groups work together like a well-synchronized machine. When you inhale, the intercostal muscles contract, and your rib cage moves up and out. The diaphragm moves down and flattens. This makes room for air in your lungs. A moment later, when you exhale, the diaphragm and intercostal muscles relax, forcing air out of the lungs.

Hiccups happen when the diaphragm contracts and pushes down at the wrong time, forcing air to move quickly past the vocal cords. Your brain says, "Wait a minute!" It sends a message to the tongue and the back of your throat to stop that air.

When air is forced across the vocal cords in the back of your mouth, the cords snap shut. You make a funny sound, called a hiccup.

People try many things to stop the hiccups. Some people eat a spoonful of sugar. Some breathe into a bag. Others believe the cure is to hold their breath and drink water.

The best thing to do is just to relax and try to breathe regularly. Soon things will get back in synch and the "hic-hic-hic" will stop.



Getting Started

1. Listen as student volunteers read “Excuse Me, Please,” about burps and hiccups, in this lesson. Your teacher will use this reading selection to introduce you to the respiratory system, which is shown in Figure 10.1.

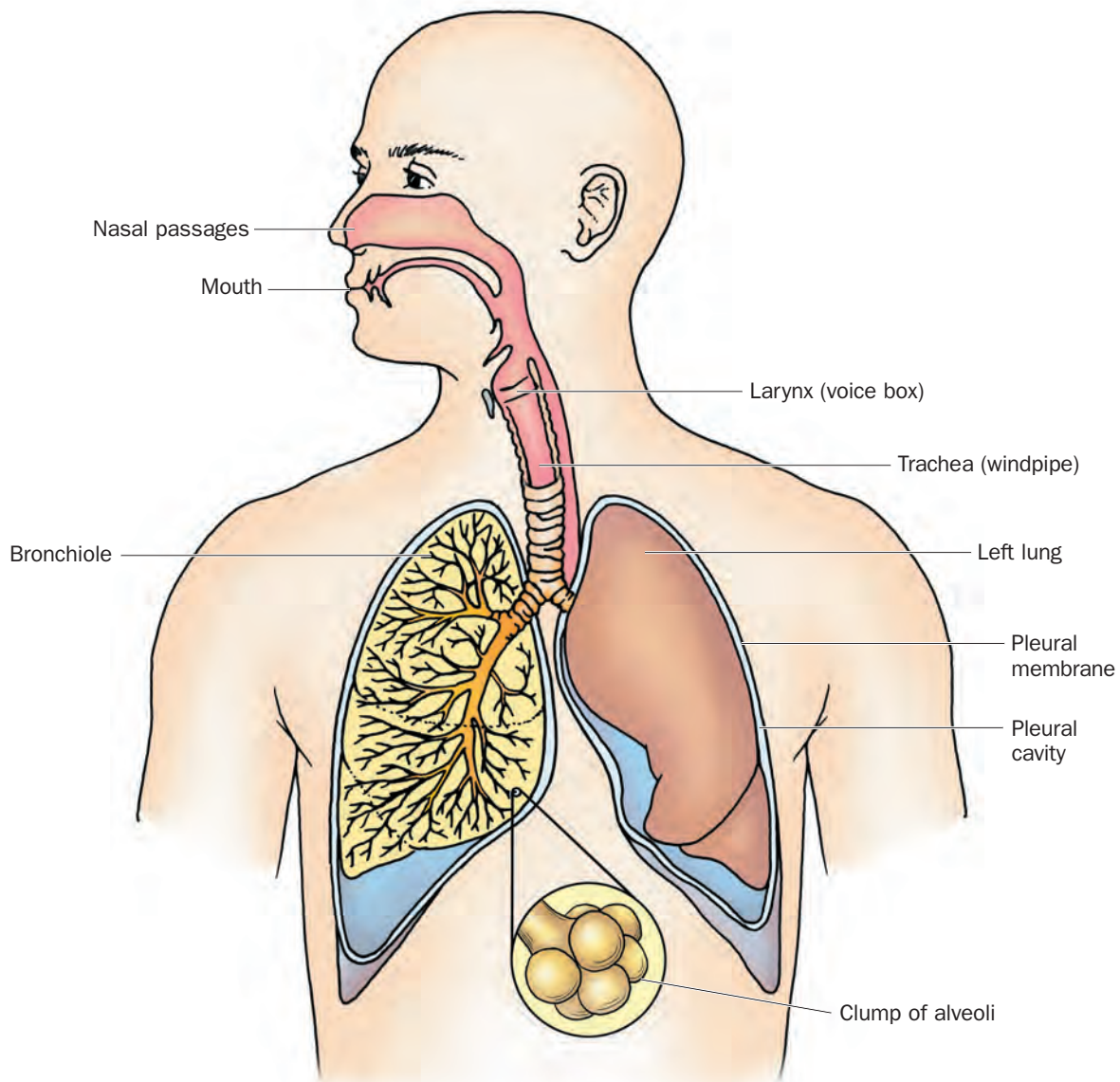


Figure 10.1 *The respiratory system*

2. Now it is time to focus on what happens when you breathe. Have one member of your group stand up, take a deep breath, and let it out slowly. Have the person repeat the procedure a few more times. In your science notebook, record everything you see happening.
3. Share your list with the class.
4. Listen as your teacher explains the breathing process and how gases are exchanged in the lungs. These actions are illustrated in Figures 10.2 and 10.3.

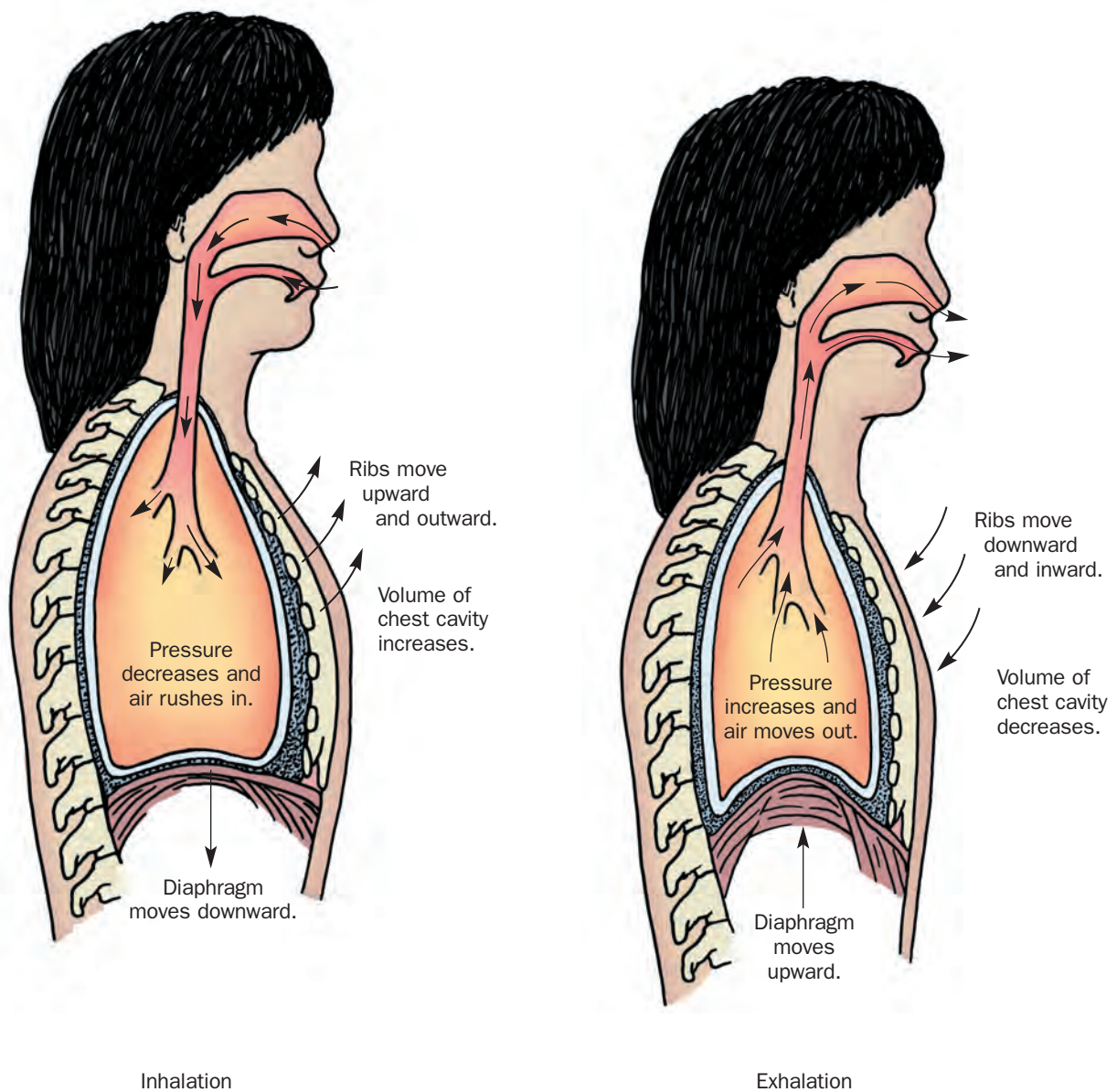


Figure 10.2 *The breathing process*

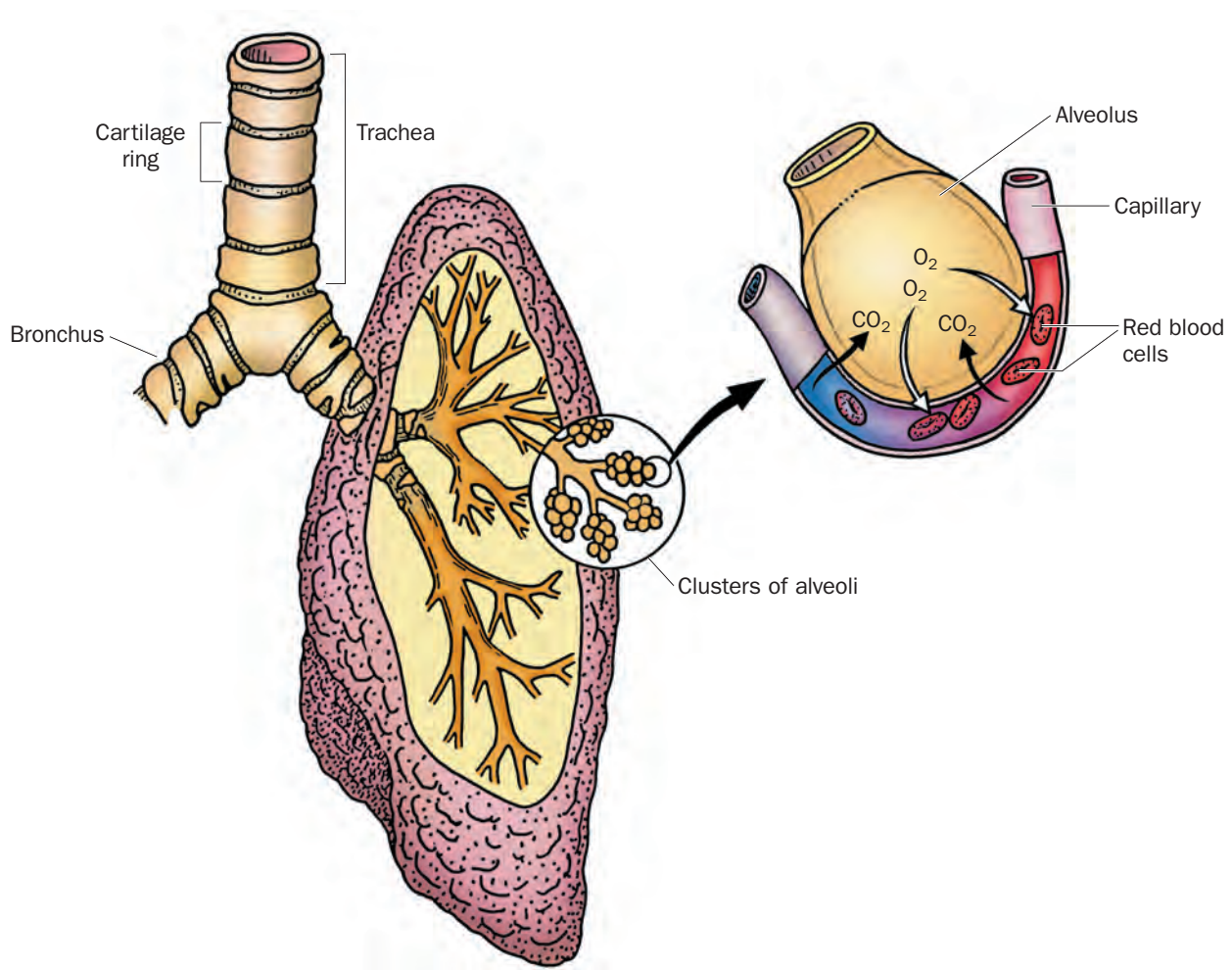


Figure 10.3 Gas exchange in the lungs

5. Now watch as your teacher demonstrates the bell jar model, which is often used to simulate the breathing process. The model is shown in Figure 10.4.
6. Turn to a blank page in your science notebook. At the top, write the words “The Bell Jar Model of Breathing.” Draw a vertical line down the middle of the page. Label the left column “Strengths” and the right column “Limitations.” On the basis

of what you understand about the breathing process, make a list in each column. “Strengths” are features in the model that accurately show what happens when humans breathe. “Limitations” are characteristics of the model that fail to show (or do not show accurately) what actually happens during breathing.

7. Share your list with your class.

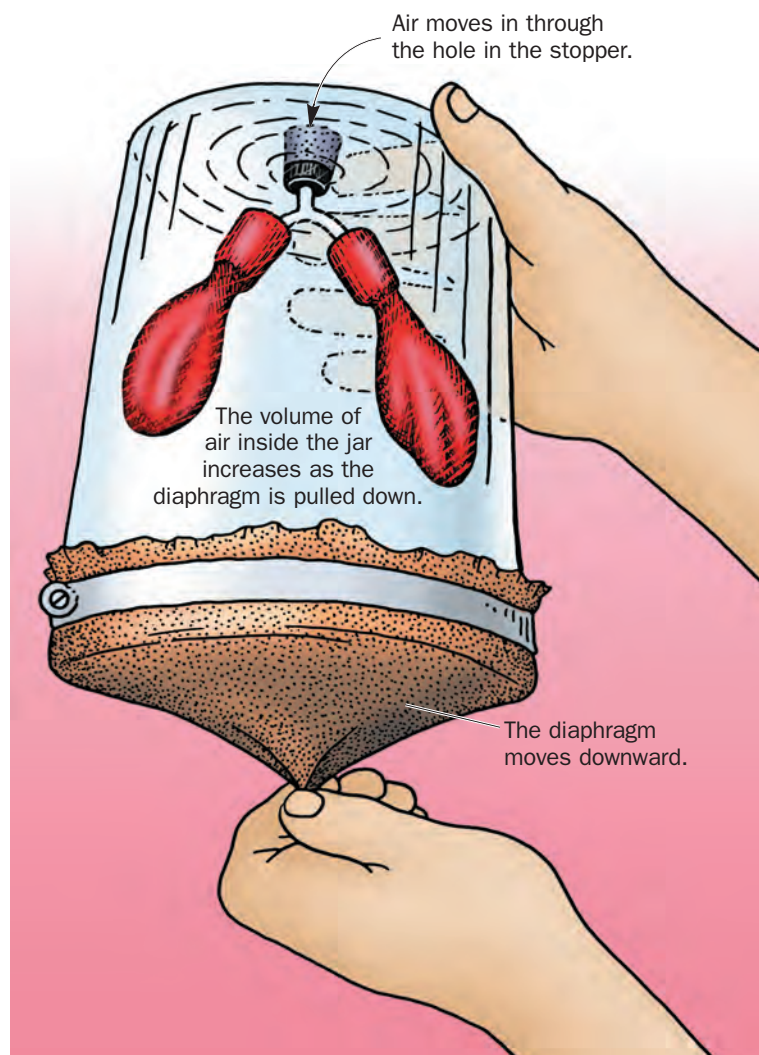


Figure 10.4 The bell jar model of breathing

Inquiry 10.1

Assessing the Syringe Model of Breathing

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Figure 10.5 Assembling the syringe model

PROCEDURE

- 1.** Have someone pick up your group's materials. Then watch as your teacher demonstrates how to operate the syringe.
- 2.** You will work in pairs for this inquiry. Your challenge is to design and build a breathing model using a syringe, a balloon, and water (see Figure 10.5). Before you begin to construct your model, think about the following questions and answer them in your science notebook:
 - A. What part of the syringe can be compared with the diaphragm? The mouth? The chest cavity?*
 - B. Why is water, rather than air, used in this model?*
- 3.** With your partner, plan how to build your model. Diagram your method in your notebook. When you have finished, show your proposal to your teacher, who will decide whether you are ready to begin constructing your model.
- 4.** Using the syringe, balloon, and water, construct and operate your breathing model. Discuss the following questions with your partner:
 - A. Does your model work as planned?*
 - B. If not, what could you do to improve it?*
- 5.** If necessary, try again to construct your breathing model.
- 6.** After you have operated your breathing model, return your materials to the distribution center.
- 7.** Now complete the table on Student Sheet 10.1.

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Jazz trumpeter Dizzy Gillespie had great breath control. But it was his lungs and diaphragm, not those puffed-up cheeks, that really did the work!

REFLECTING ON WHAT YOU'VE DONE

1. Using Student Sheet 10.1, discuss the strengths and limitations of the syringe model of breathing.
2. In your science notebook, make a table similar in format to the one on Student Sheet 10.1. Title it “Using Models.” Label the left column “Strengths” and the right column “Limitations.” Reflecting on what you know about models in general, complete the table. Discuss your ideas with the class.
3. Using the information you read in the episode of “Spies” in this lesson, explain why it is better to breathe through your nose than through your mouth.
4. Take another look at the list you recorded in your science notebook at the start of the lesson. Revise it as necessary.



THE SECOND JOURNEY BEGINS

Having recuperated from his trip through the digestive system, Bollo is ready for a new adventure.

"Where are we going today?" he asks, looking at the human body map.

"We're going to explore the respira-

tory system—the system that humans use to breathe. Our map says that the departure point for this trip is just north of the mouth. It's the nose. Are you ready?"

"Let's go," Bollo replies.



The spies prepare to depart for a trip through the respiratory system. Starting point? The nose!

Pairs

"We already have a choice. Humans have just one mouth, but two nostrils. Do we go left or right?"

"It doesn't matter, because they both lead to the same place," says Peppi. "But now that you've mentioned it, this is something I want you to think about. In many cases, the human body is designed in pairs: two nostrils, two eyes, two ears, and so forth. Why do you think that is?"

"To make people look better?" says Bollo. "I've seen pictures of those one-eyed monsters."

"That's one explanation. Pairs *do* provide balance. Keep the idea of pairs in mind as our travels continue. Maybe you'll think of another reason."

Into the Nose

A whoosh of air draws Peppi and Bollo into the left nostril. They find themselves in a moist, dark, warm place.

"This is the nasal cavity," says Peppi. "It plays sort of the same role for the respiratory

system that the mouth does for the digestive system. But here, we're dealing with air, not food."

Achoo!

Bollo and Peppi find themselves flying out of the nose.

"Wow! What happened?" says Bollo. "I nearly lost my cap."

"Joanne sneezed!" replies Peppi. "Air has tiny particles in it—dust, pollen, germs, and other things. One job of the human nose is to filter out those particles and to get rid of the ones that are irritating. When something really irritates the delicate lining of the nose, humans sneeze."

"Sneezes are caused by a sudden contraction of the muscles of respiration. When that happens, air bursts from the lungs. Sneezes can be powerful—I once clocked a sneeze at 100 miles per hour! Coughs are similar to sneezes, but they originate lower in the respiratory tract. They offer humans a second way of getting rid of those germs and dust."



Watch out, Bollo! Don't get trapped in the nasal hairs!

The Nose Knows

"The air looked fine to me," Bollo insists. "How does the nose detect dust?"

The two spies sail back up into the nostril for a second try. "Look around," says Peppi. "See those hairs waving back and forth? They catch the particles that are in the air that humans inhale.

"If the hairs don't catch everything, the body has a second line of defense. It's the mucous membrane, which is the lining of the nose. The membrane is covered by a thick substance called

mucus. Feel it."

"Warm and slimy," says Bollo.

"That's right. Both these properties help the mucous membrane do its job. It traps particles that have sneaked by the nasal hairs. It also helps warm the air. Otherwise, the lungs would get a cold blast when humans are outside in winter."

"So the nose is the watchdog," says Bollo. "It's one of the body's lines of defense against dirt, germs, and other unwanted characters."

"Right," says Peppi. "But the nose has

another role, too. See that patch just over our heads? It's the olfactory membrane. The membrane is covered with cells that react to certain chemicals. When they meet up with a chemical, these cells send a message to the brain by way of the olfactory nerve. The brain decodes the message. And it becomes . . ."

"What?"

"A smell! All odors—from the fragrance of a fine perfume to the smell of a skunk—start when chemicals react with the receptor cells in the area of the nose. Smelling and breathing are related," says Peppi. "For example, when humans get a cold and their noses get stuffed up, they can temporarily lose their sense of smell."

In the Pipeline

Peppi and Bollo head downward toward a narrow tube. More hairs and mucus. ("More chances to get caught if the body thinks you might cause trouble," thinks Bollo.)

"Is that our old friend the esophagus below us?" asks Bollo.

"Yes. And remember the epiglottis? The 'safety valve' that keeps food and air going in the right direction? Look out ahead. It's important at this point, too."

"Yes, when we were investigating the digestive system, the epiglottis snapped shut, and we continued on our way to the stomach. This time, it's opening!" says Bollo.

The spies enter through the glottis, which is the opening to the windpipe. "This is the larynx. It's also called the voice box," says Peppi. "The larynx is firm and stiff. Inside, stretching from the top to the bottom, are two pairs of thick bands."

"The vocal cords?" says Bollo, after sneaking a peek in Peppi's book.

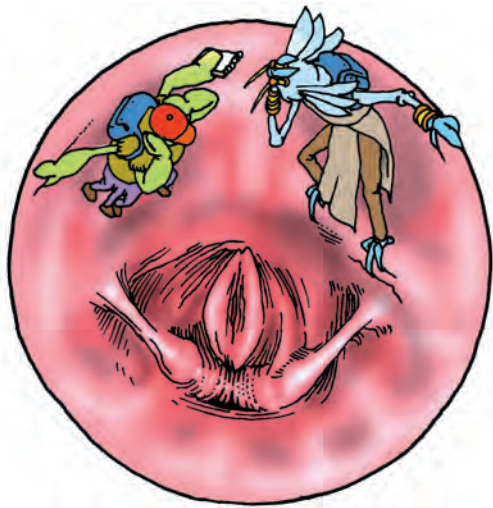
"Absolutely right. There are two pairs. The first pair is the false vocal cords. They're not important, as far as speech is concerned. The pair below do the work.

They are the true vocal cords.

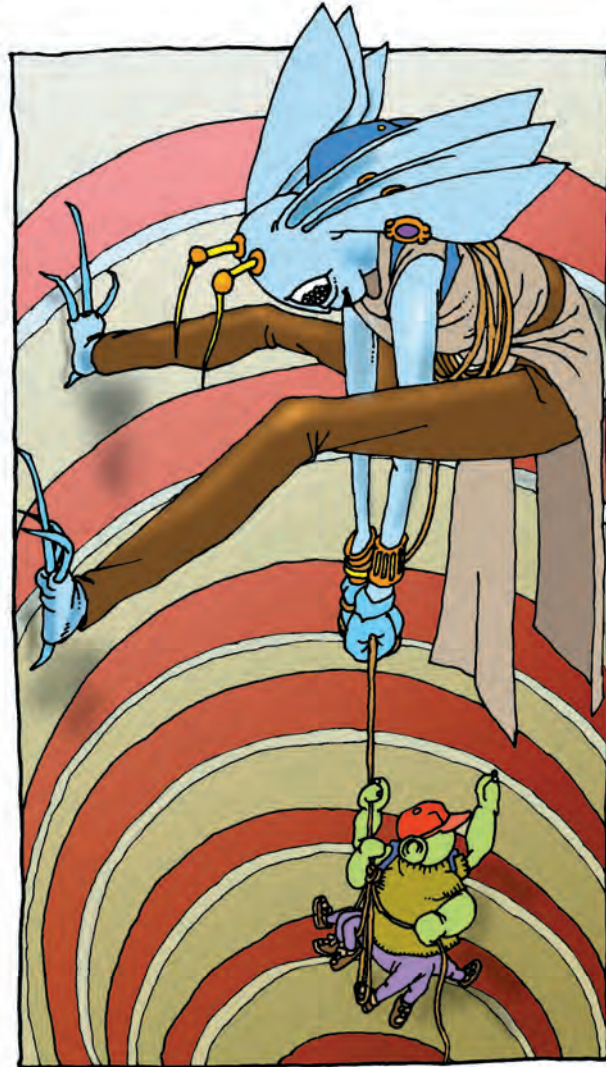
“Human sound starts when air is pushed up from the lungs through the larynx. When the muscles of the larynx relax or contract, they make the vocal cords get longer or shorter. The more tension on the cords,

the higher the pitch of the sound. As far as making specific sounds—saying ‘cat’ instead of ‘that,’ or ‘dog’ instead of ‘log’—that’s up to the mouth, lips, and tongue. They shape sound into words.”

Bollo lands on one of the cords and jumps up and down a



Look how the vocal cords open and close, lengthen and shorten, to help Joanne make different sounds!



Bollo uses the cartilage rings that make up the windpipe as a make-shift ladder as he journeys down to the bronchi.

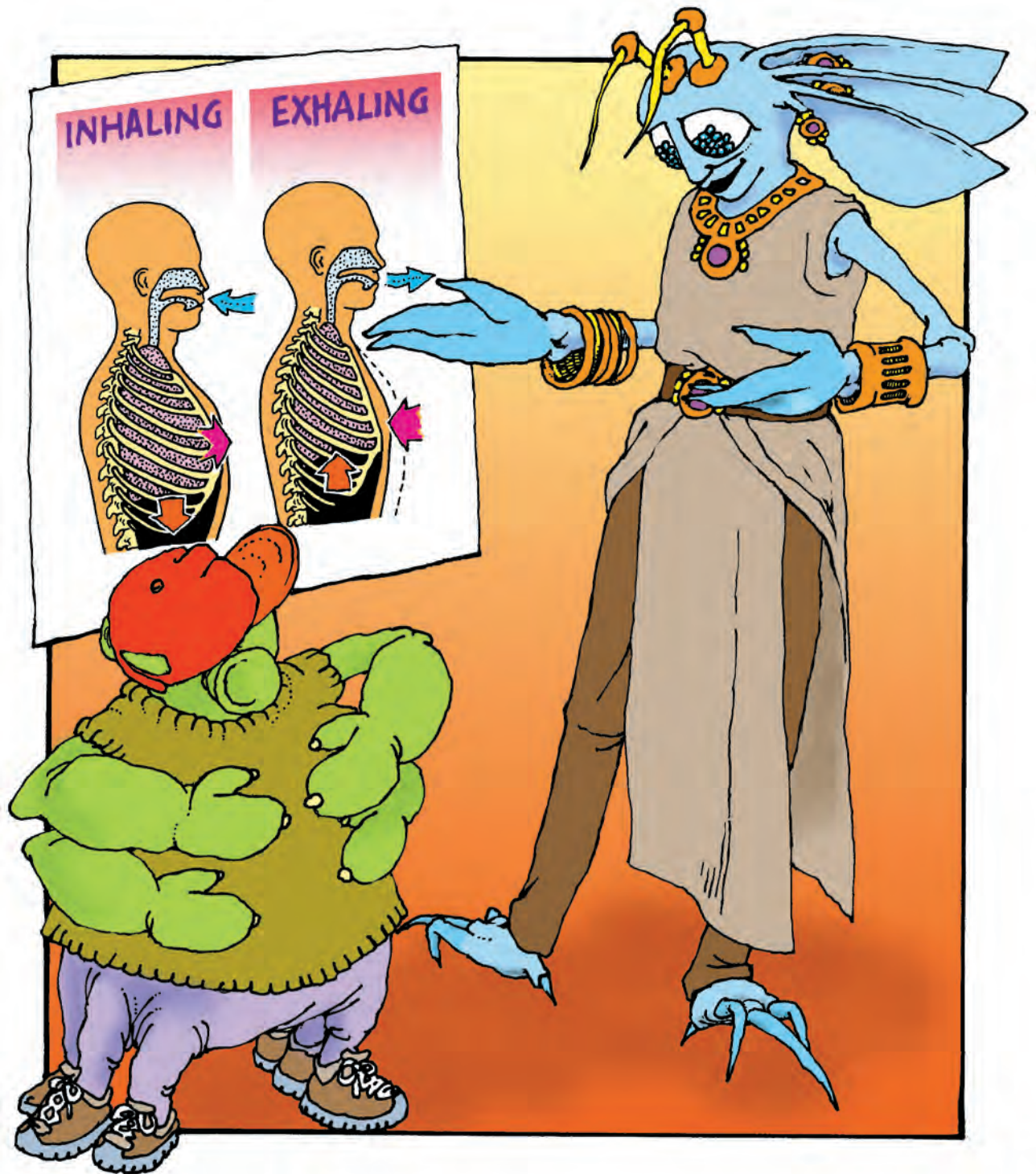
few times. “Springy—sort of like a trampoline. I can see that they’d be able to stretch. But what makes sound loud or soft?”

“That depends on how much air passes through. If there is a lot of air, the sound is loud. Whispering needs just a tiny bit of air,” replies Peppi.

A New Kind of Tree

“There’s a lot more to the respiratory system than just moving air in and out. It has a role in the sense of smell and in speech. But let’s get moving. I want to get to the center of the action—the lungs,” says Bollo.

Peppi and Bollo continue down the windpipe, or trachea.



Peppi reviews the breathing process.

Just ahead, the road branches in two directions.

“We’re approaching the lungs,” says Peppi. “Each lung is served by a bronchus. (The plural of “bronchus,” which is a Latin word, is “bronchi.”) In humans, the bronchi are the beginning of something called the bronchial tree. Why do you think it got that name?”

“That’s a no-brainer,” says Bollo. “It is like an upside-down tree. The bronchus is like the trunk. It keeps branching out. Look at the tiny branches at the end!”

“Those are the bronchioles. The smallest ones are thinner than the finest hairs. At the end of each tiny branch are clusters of air sacs, or alveoli. It is through the membranes of these sacs that gas exchange takes place. And what gases are we talking about?”

“Oxygen and carbon dioxide,” replies Bollo promptly.

“Right you are,” Peppi says with a smile.

Time for Review

“Now before we go any farther, let’s take time to review. Why do humans breathe in the first place?”

“Well, I know that humans breathe because they need oxygen,” says Bollo. “And oxygen enters the body through the respiratory system. Humans also need to get rid of that carbon dioxide.”

“Right. Now one of the remarkable things about this system is that it’s all on ‘automatic.’ Nobody has to think about breathing, because it is controlled in a special location in the brain, called the medulla. When humans start to use more oxygen, for example, when they’re working or playing hard and build up carbon dioxide, the muscle cells send a message to the respiratory center. ‘Help! This carbon dioxide is killing us! We need more oxygen,’ they cry. The brain tells the breathing muscles to speed up.”

“So the lungs are muscles?” says Bollo.

“I can see how you might think so, but the lungs aren’t that tough. The tough guys are the respiratory muscles, and there are two kinds.

“See those bands between the ribs? They’re the intercostal, or rib, muscles. And that large, arched muscle directly below—the one looks like a sheet? That’s the diaphragm.

Those muscles work as a team. Watch and tell me what you see.”

Bollo looks around. “The diaphragm is flattening out and the intercostal muscles are contracting and pulling the ribs upward and outward,” he says.

“Right. That’s what happens when humans inhale. The ribs go up and out, causing the lungs to expand. As the volume inside the lungs increases, air pressure inside drops, and new air rushes in. Now wait a minute.”

“The diaphragm just moved up, and the intercostal muscles relaxed and fell in,” says Bollo. “That

must mean that air is being exhaled.”

“You’ve got the picture,” says Peppi. “Humans normally breathe about between 10 and 14 times a minute. They breathe more often at times when they are using a lot of energy. The lungs hold about 6 liters of air.

“So now that we’ve taken a look at the big picture, let’s concentrate on what happens when the air reaches the alveoli.”

“Give me 15 minutes for a quick nap and I’ll be ready for a close-up view of respiration,” Bollo replies. □