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 respiratory 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."

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.”

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

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

“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."

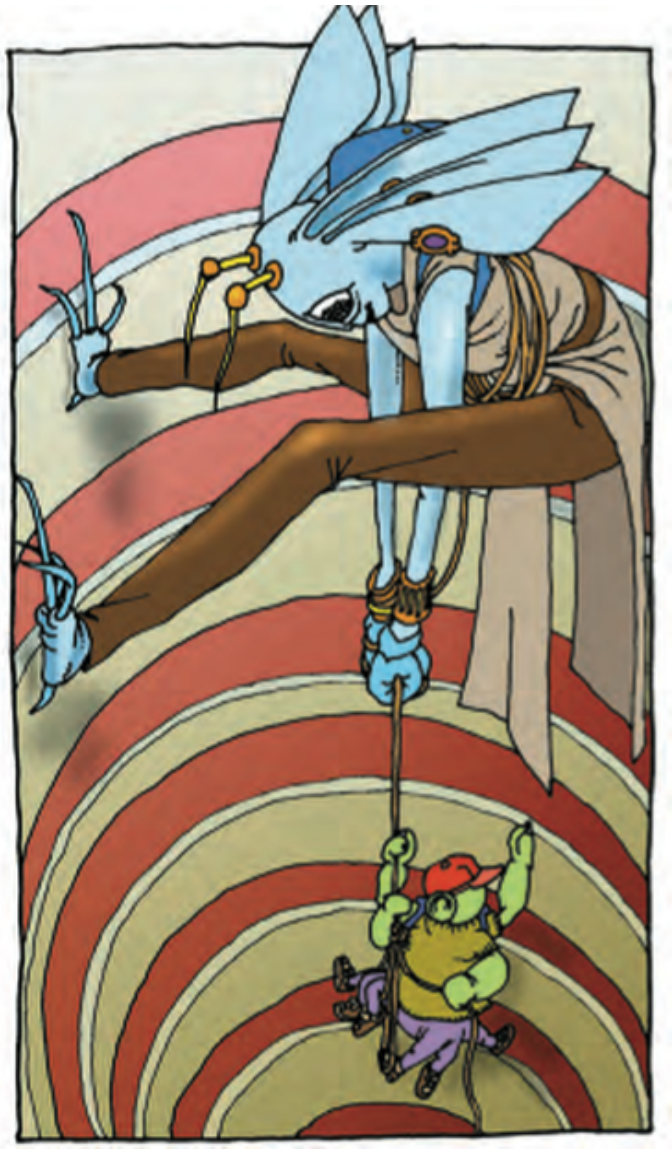
"The vocal cords?" says Bollo, after sneaking a peek in Peppi's book.

"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 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.



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

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. 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.

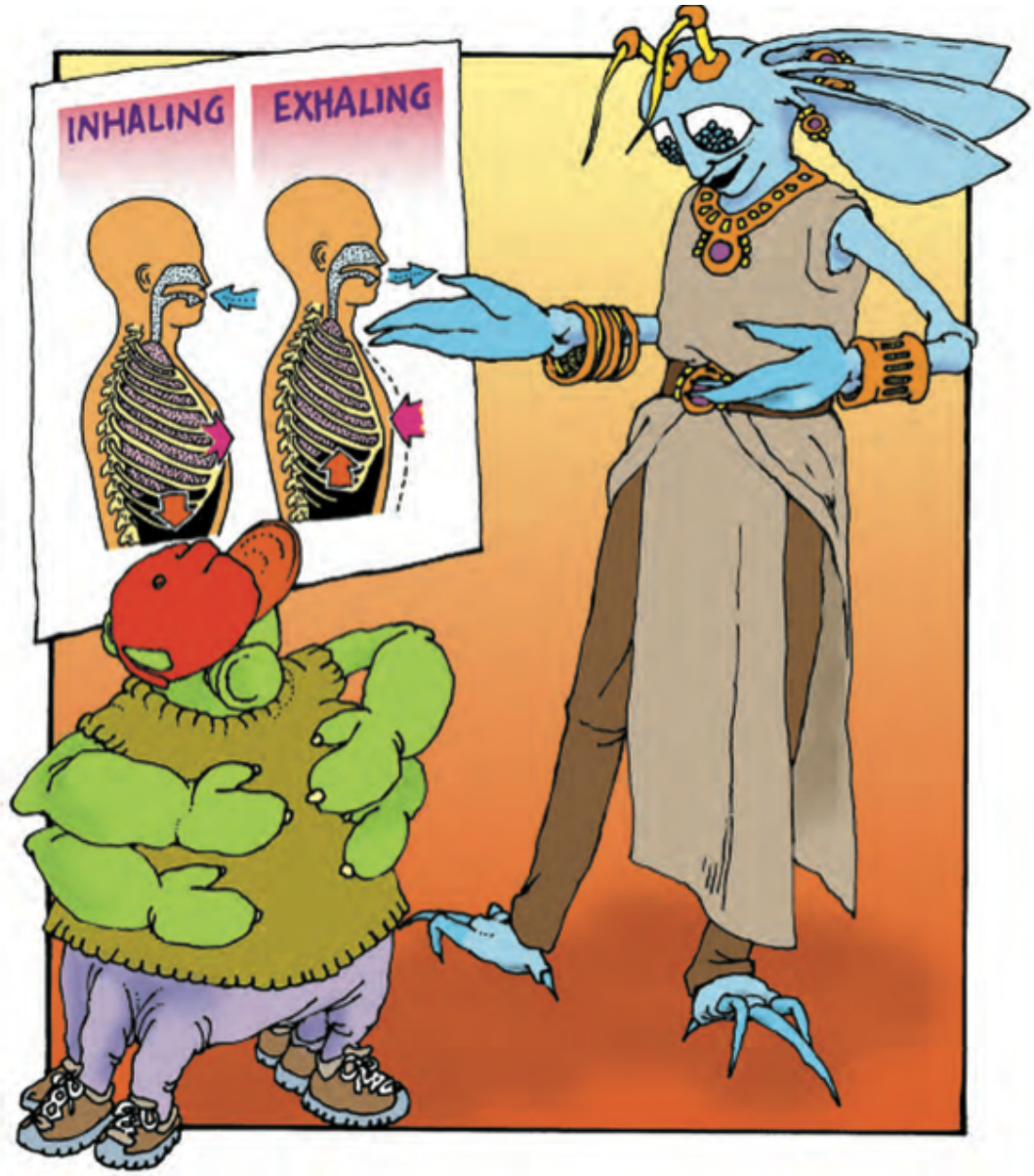
“Right. That’s what happens when humans inhale. The ribs go up and out, causing the lungs to expand. As the volume inside the lungs increases, air pressure inside drops, and new air rushes in. Now wait a minute.”

“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.



Peppi reviews the breathing process.