

CHAPTER 7

The Respiratory System

Chapter Concepts

7.1 Structures of the Respiratory System

- The upper respiratory tract filters, warms, and moistens oxygen-containing air, and channels it into the lungs.
- The lower respiratory tract is made up of specialized structures that exchange oxygen for carbon dioxide in the bloodstream.

7.2 Breathing and Respiration

- Humans ventilate their lungs by the mechanism of breathing, which involves inspiration and expiration.
- The volume of air that is taken into the lungs can increase if the need for oxygen increases, such as during exercise.
- External respiration takes place in the lungs, between the air in the alveoli and the blood in the capillaries.
- Internal respiration takes place between the blood in the capillaries and tissue cells.
- Gas exchange occurs through the processes of simple diffusion and facilitated diffusion.

7.3 Respiratory Health

- Some disorders are specific to the respiratory system. Technologies are available to treat respiratory disorders, but they may not be able to restore the respiratory system to optimal health.
- Smoking causes respiratory diseases. Technologies can help some symptoms of smoking, but many symptoms are untreatable.



Mount Everest is the highest mountain on Earth. Each year, hundreds of people brave the extreme conditions of Mount Everest in an attempt to climb it. At 8850 m above sea level, the summit of Mount Everest poses a particular challenge to those who reach it—breathing! While oxygen and other gases are present in the same proportions as at lower elevations, the air pressure is much lower. As a result, gas particles are spread much farther apart and climbers cannot draw enough oxygen into their lungs when they breathe. By wearing oxygen masks, climbers can get enough oxygen to stay alive as they near the summit. Without this technology, climbers would become confused and soon lose consciousness. Oxygen is so important to life that even minutes without it can lead to brain damage and death.

Launch Lab

Modelling Your Lungs

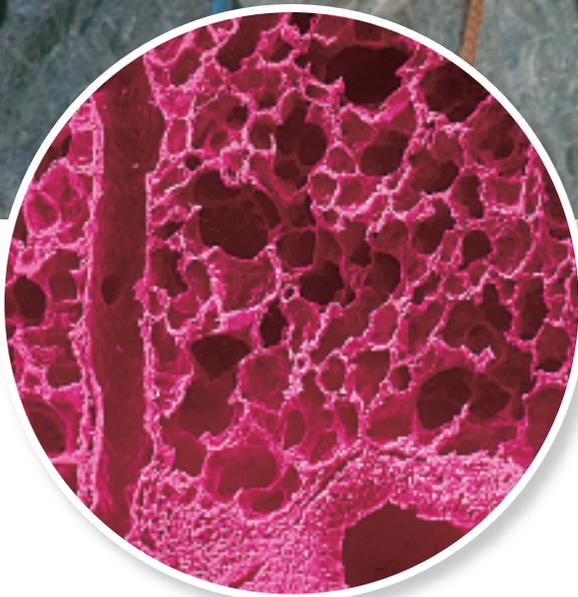
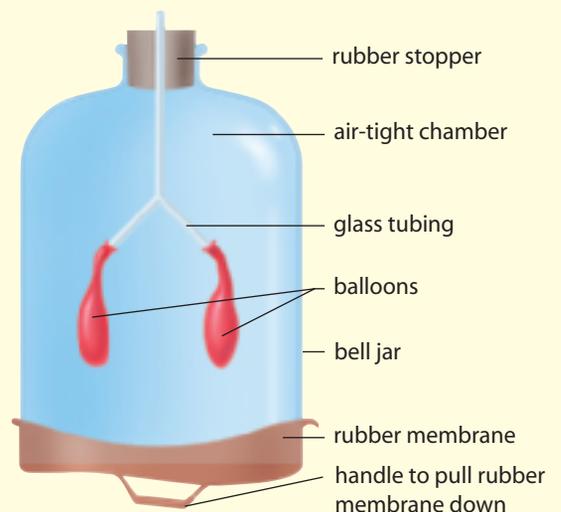
Your lungs work like a balloon. They expand and deflate with air, just like a balloon does. There is one difference, however, between how your lungs and a balloon work—a balloon fills with air when air is pushed in from the outside. If your lungs were like this, you would need an outside pump to push the air in. So, how do your lungs fill with air?

Procedure

1. Examine the model of human lungs shown in the diagram. With a partner or in a small group, share your ideas about how this model could work to cause the balloons to inflate.
2. If possible, obtain materials to build this model, or a similar model of human lungs, to test your ideas.

Analysis

1. Describe what happens to the balloons as the volume of air inside the container changes.
2. Would the model work (that is, would the balloons inflate) if the system were not airtight? Justify your answer.
3. Sketch a flowchart to show how air moves in and out of the balloons. Begin with the rubber membrane expanding.



Magnification: 280 ×

The respiratory system delivers oxygen in the air you breathe to these delicate-looking tissues of the lungs. Why is oxygen essential to life?

SECTION 7.1

Structures of the Respiratory System

Section Outcomes

- In this section, you will
- **identify** the principal structures of the respiratory system
 - **identify** the principal functions of the respiratory system
 - **observe** and **identify** the major respiratory structures

Key Terms

respiratory system
nasal passages
pharynx
epiglottis
glottis
larynx
trachea
bronchi
bronchioles
alveoli
pleural membrane

BiologyFile

Try This

Cellular respiration is not the same as breathing, and yet the term respiration is used to describe the process that includes breathing. How can you distinguish clearly between cellular respiration and respiration to avoid possible confusion or misconceptions? (**Hint:** Do all organisms have respiratory systems?)



Figure 7.1 When the warm air from your lungs meets the cold air outside your body, water droplets in your breath condense and form a visible cloud.

As you move about on Earth's surface, you wade through a colourless mixture of nitrogen, oxygen, carbon dioxide, and other gases. If you are like most people, you probably tend not to notice the air surrounding you because you cannot usually see any physical evidence that it exists. Figure 7.1 shows one situation in which you can see evidence of the invisible ocean of air that envelopes Earth.

The oxygen in air is vital to survival because it is needed to carry out cellular respiration, the process that produces the energy used to fuel all cell functions. Cellular respiration also produces carbon dioxide, and each cell must rid itself of this waste gas. The main function of the human **respiratory system**, therefore, is to ensure that oxygen is brought to each cell in the body and that carbon dioxide can leave each cell and be removed from the body. Respiration is the general term that is used to describe this overall process.

There are two main requirements for respiration. First, the surface area, or respiratory surface, must be large enough for the exchange of oxygen and carbon dioxide to occur at fast enough rates to

meet the body's needs. Second, respiration must take place in a moist environment, so that the oxygen and carbon dioxide are dissolved in water. As summarized below, there are several stages in human respiration, and each stage has specialized structures to facilitate it. You will explore these stages in greater detail over the course of this chapter.

Stages in Respiration

- *Breathing* involves two basic processes: inspiration (breathing in, or inhaling) and expiration (breathing out, or exhaling). Inspiration moves air from the external environment to the lungs inside the body. Expiration moves air from the lungs back to the external environment.
- *External respiration* is the exchange of oxygen and carbon dioxide between the air and the blood.
- *Internal respiration* is the exchange of oxygen and carbon dioxide between the body's tissue cells and the blood.
- *Cellular respiration*, as you know from Chapter 5, is the series of energy-releasing chemical reactions that take place inside the cells. Cellular respiration is the final stage in

respiration. It is the sole means of providing energy for all cellular activities, and it helps the body maintain homeostasis.

- 1 What is the main function of the human respiratory system?
- 2 How is external respiration different from internal respiration?

The Respiratory Tract

The lungs are the principal organs of respiration. The lungs are located deep within the body, where they are protected by the bone and muscular structure of the thoracic (chest) cavity. (The word “thoracic” comes from a Greek word meaning “chest plate,” thus referring to the protective covering that warriors used in battle.) Because the lungs are located deep within the body, a suitable passageway is necessary for air to move from the external environment to the respiratory surface inside the body. This passageway is called the respiratory tract. As you can see in Figure 7.2, the

respiratory tract consists of several structures and extends from the nose to the lungs. Air moves through the passageways of the upper and lower respiratory tract on its journey toward external respiration.

The Upper Respiratory Tract

Air begins its journey into the respiratory system by passing into the nose through the paired nostrils. Air can also enter through the mouth, especially if breathing is rapid, as it is during exercise. The **nasal passages** in the upper respiratory tract serve to warm, moisten, and clean the incoming air. They are lined with ciliated cells, like those shown in Figure 7.3. Other cells secrete mucus, which cleans the air by trapping foreign particles, such as dust and bacteria. The action of the ciliated cells moves the foreign particles back up into the nose and throat. The foreign particles can then be expelled by coughing or sneezing.

Very thin bones, called **turbinate bones**, project into the nasal cavity. These bones serve an important function by increasing the surface area of the nasal passages. They are covered in cilia, which

BiologyFile

Try This

Gently touch your throat with your fingertips. Find your larynx at the top of your throat. You may need to swallow so that you can feel your larynx move out of the way of your esophagus. Softly say a few words, and note the vibration caused by air moving between your vocal cords. Locate your trachea by feeling for the cartilaginous rings that give it support and protect it from damage.

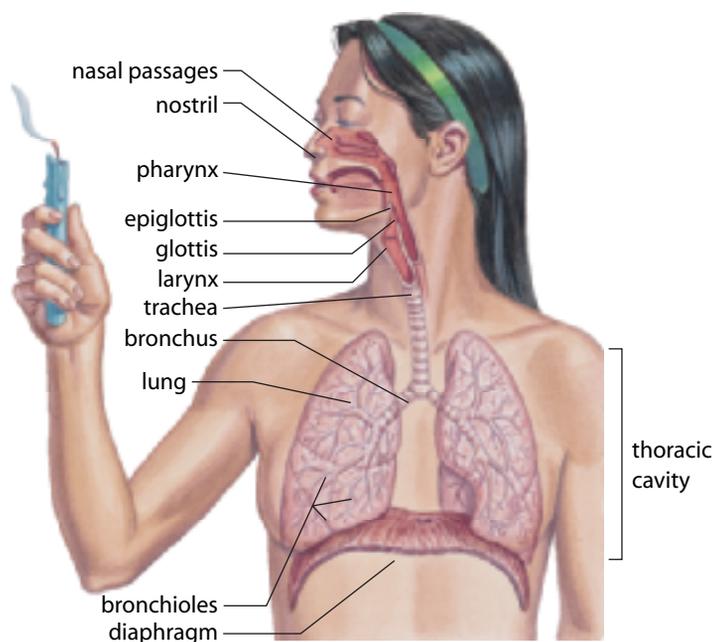


Figure 7.2 The structures of the respiratory tract provide a passageway for air to move from the external environment to deep within the lungs, where external respiration (gas exchange) occurs.

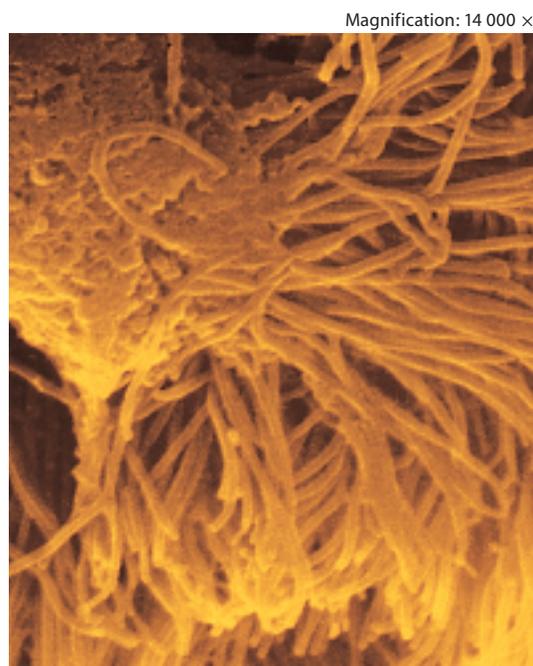


Figure 7.3 Ciliated cells, like the ones shown here, line the interior of the nasal passages and upper respiratory tract.

BiologyFile

FYI

The curved shape of the turbinate bones causes the air that enters the nasal passages to churn and circulate before it moves into the throat (pharynx). The name of these bones comes from the Latin word *turbinatus*, which means “like a spinning top.” The English word “turbine” also comes from this Latin word.

catch and remove particles in the air. The turbinate bones, and the rest of the lining of the nasal passages, are covered with a thin membrane that secretes mucus and is well-supplied with blood vessels. The heat from the blood warms the air as it passes through, and the mucus moistens the air. Both the warming and the moistening of the air are necessary to protect the delicate structures that are found in the lower respiratory tract.

The **pharynx**, commonly known as the throat, is the passageway for air into the respiratory system, as well as the passageway for food and water into the digestive system. The **epiglottis** is a flap of cartilage that lies behind the tongue and in front of the larynx. The epiglottis closes over the opening to the trachea, the **glottis**, when a person swallows. This prevents food and drink from entering the trachea and passing into the bronchi of the lungs. When the epiglottis is at rest, it is upright and allows air to pass unobstructed into the lower respiratory tract.

The **larynx**, or voice box, is made from cartilage and contains the vocal cords. (Cartilage is a tough and firm connective tissue.) When you breathe normally, there is a large gap between the vocal cords. When you speak, however, the muscles around the larynx contract and the vocal cords are drawn together. Air passes through this narrower space, causing the vocal cords to vibrate and make a sound. The pitch (highness or lowness) of the sound changes, depending on how long the vocal cords are. Longer cords create a lower sound, and shorter cords create a higher sound. Because men generally have longer vocal cords than women, men tend to have lower-pitched voices and women tend to have higher-pitched voices. During puberty, the larynx and vocal cords grow very quickly in males. This can cause their voices to “break” (fluctuate in pitch) occasionally, until the cords finish growing.

After passing through the larynx, air moves down the flexible tube of the

trachea, also known as the windpipe. The trachea is strengthened by semicircular, cartilaginous arches that prevent it from collapsing. The open part of the semicircle faces the esophagus and allows the esophagus to expand when food is being swallowed.

3 Identify the structures that make up the upper respiratory tract.

4 Describe the roles of mucus and cilia in the upper respiratory tract.

The Lower Respiratory Tract

The trachea branches into two smaller passageways, called **bronchi** (singular: bronchus), that enter the right and left lungs. Each bronchus subdivides many times to create a branching network of smaller and finer tubes, called **bronchioles**, within each lung. The bronchi contain C-shaped cartilaginous rings that surround and are part of the bronchus wall. They are stacked one on the next, running the length of the bronchus and providing support. Bronchioles do not have C rings. Both the bronchi and bronchioles are lined with cilia and mucus-producing cells, just as in the upper respiratory tract. The mucus captures foreign particles, such as microscopic pollutants and pathogens. The cilia move the foreign particles up into the upper respiratory tract. From there, the foreign particles can be ejected from the body by coughing or sneezing, or they can be swallowed.

Each lung is divided into distinct regions called lobes. The right lung has three lobes, and the left lung has only two, leaving space for the heart. Each lobe is made up of many lobules that extend from each bronchiole.

Each lung is surrounded by a thin, double-layered membrane called the **pleural membrane**. The outer layer of this membrane attaches to the inside of the chest wall. The inner layer of

BiologyFile

Web Link

Respiration is studied in biological science, but the mechanics of breathing are governed by the laws of physical science. What are these laws? What other phenomena do they describe in the natural world and in technology?

www.albertabiology.ca
WWW

the membrane attaches to the lung. Fluid fills the space between these two membrane layers so that they adhere to each other in the same way that a film of water can cause two plates to stick together. The pleural membrane layers serve as a means for connecting the lungs to the thoracic cavity, enabling them to expand and contract with the movement of the chest.

Each bronchiole ends in a cluster of tiny sacs called **alveoli** (singular: alveolus). It is within these alveoli that the actual exchange of gases takes place during external respiration. Each alveolus is enclosed by a membrane called the alveolar wall. The alveolar wall is one cell thick and is surrounded by a network of tiny capillaries, as shown in Figure 7.4.

Capillaries are tiny blood vessels—their walls are also one-cell thick—that link the arteries with the veins. (Arteries carry oxygen-rich blood from the heart to the body tissues. Veins carry oxygen-poor blood from the body tissues back to the heart.) Where capillaries surround the alveoli, carbon dioxide dissolved in the blood is exchanged for oxygen. You

will learn more about this important relationship between the alveoli of the respiratory system and the capillaries of the blood circulation system in the next section.

The arrangement of the bronchioles and alveoli is kept in a relatively permanent position by elastic connective tissue that fills the space between them. As well, the alveoli are lined with a lubricating film that helps to keep them from collapsing and prevents their sides from sticking together and closing.

5 Some biologists refer to the system of bronchi and bronchioles as the “bronchial tree.” Why is this a suitable metaphor?

BiologyFile

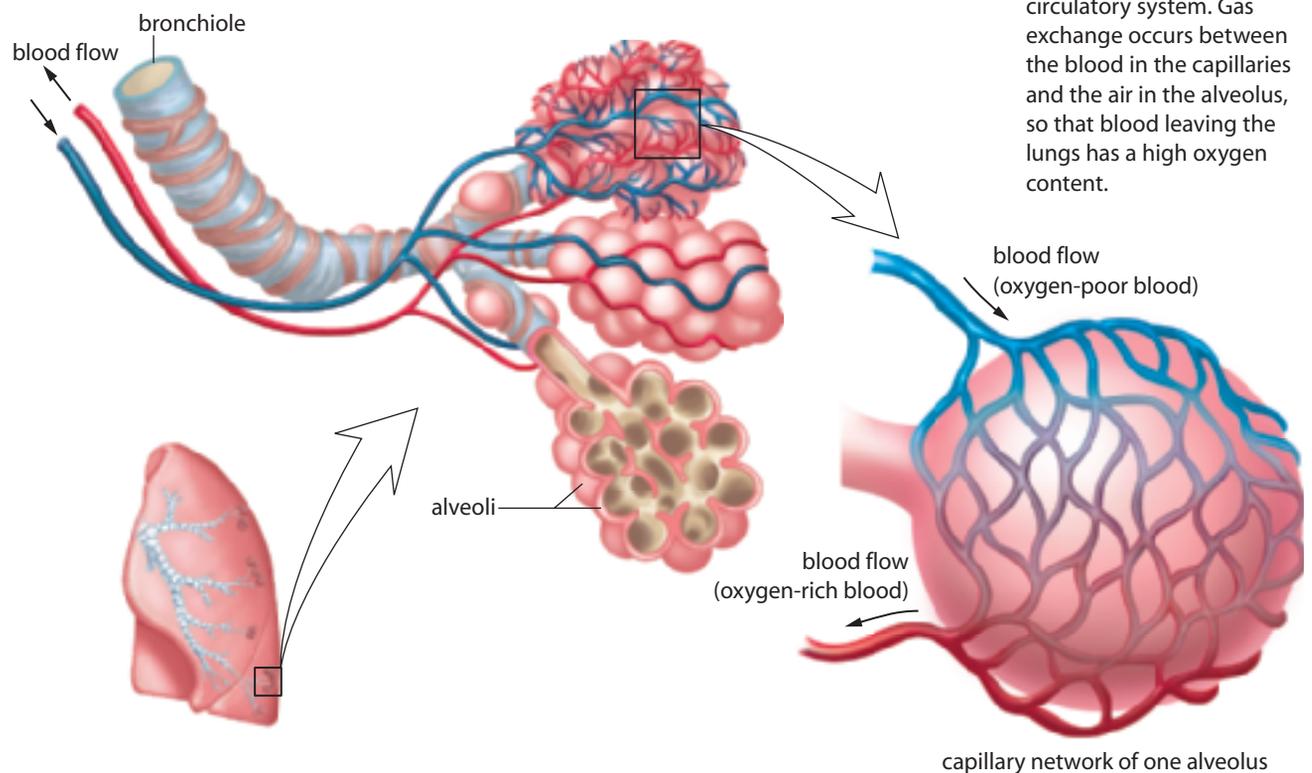
FYI

The branching network that leads into and makes up the lungs is quite staggering to imagine. The 2 bronchi branch into 4 bronchioles, and then into 8, 16, 32, and so on, up to 60 000 bronchioles. The bronchioles themselves branch off into about 500 000 even smaller branches. *These* branches lead to approximately 8 million clusters of alveoli, containing a total of about 300 million alveoli in one pair of lungs.

Section 7.1 Summary

- The respiratory tract extends from the nose to the lungs. It is a passageway for air to move from the outside environment into the lungs, where gas exchange occurs. It is lined with mucus-producing cells and ciliated

Figure 7.4 Each bronchiole ends in several clusters of alveoli. Surrounding each alveolus is a fine network of capillaries from the circulatory system. Gas exchange occurs between the blood in the capillaries and the air in the alveolus, so that blood leaving the lungs has a high oxygen content.



cells that work together to capture foreign particles and move them out of the respiratory system.

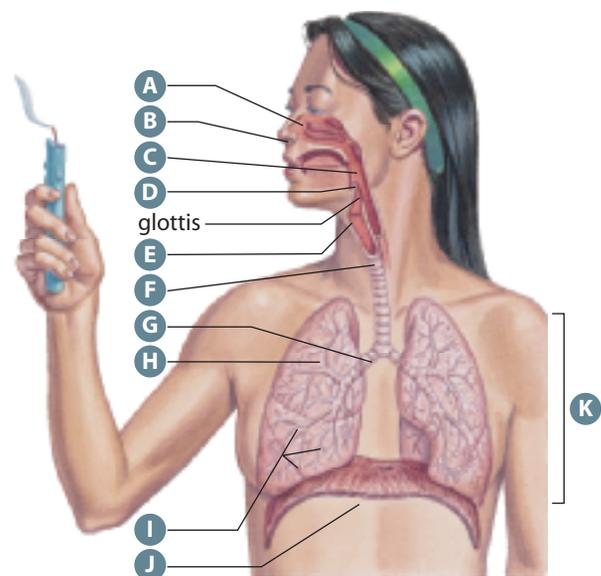
- Respiration is the overall process that provides oxygen to tissue cells and removes carbon dioxide from the body. It is made up of four distinct stages: breathing, external respiration, internal respiration, and cellular respiration.

- The upper respiratory tract contains the nasal passages, pharynx, glottis, epiglottis, larynx, and trachea. It warms, moistens, and cleans the incoming air.
- The lower respiratory tract contains the bronchi, bronchioles, and alveoli that make up the lungs. The lungs are covered by a two-layer pleural membrane.

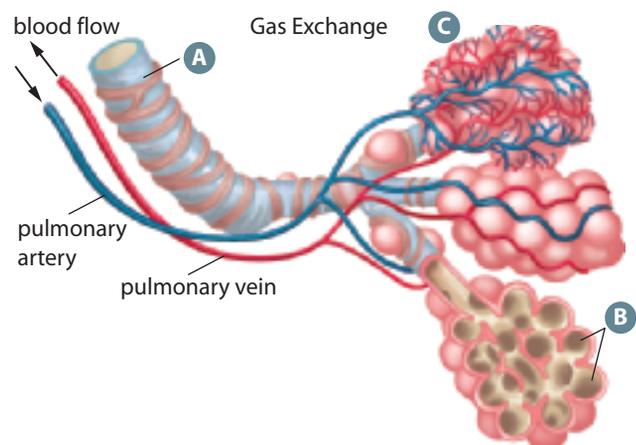
Section 7.1 Review

1. Summarize the functions of the respiratory system.
2. Identify the two main requirements for respiration.
3. Define or describe the following stages in respiration:
 - a) breathing
 - b) external respiration
 - c) internal respiration
 - d) cellular respiration
4. Outline, in a chart or table, the different structures in the upper respiratory tract that alter the properties of air in preparation for gas exchange in the lungs. Explain how each structure modifies the air.
5. Explain the purpose of the epiglottis. Describe what would happen if the epiglottis did not function properly.
6. Some cough medicines work by inhibiting the production of mucus in the upper respiratory tract. Infer possible side effects of these medications.
7. Winter air can be very cold and dry. How would the air entering your lungs be different if you breathed through your mouth instead of your nose while walking on a cold winter day?
8. Illustrate, using a flowchart, the path that air would take from the nose to the alveoli.
9. In a medical emergency, a physician may insert a tube down a person's trachea to help the person breathe. Infer why the person would be unable to talk during this procedure.
10. Describe the pleural membranes and explain their function.
11. Explain why the trachea and bronchioles contain cartilaginous arches.

12. Sketch the following diagram into your notebook. Identify the structures indicated by the letters A to K on this diagram.



13. Sketch the following diagram into your notebook. Label the diagram and identify where gas exchange occurs.



14. Identify two characteristics of the alveoli that facilitate gas exchange and infer their significance for this process.

Section Outcomes

In this section, you will

- **explain** the mechanics of breathing
- **explain** how gases are exchanged between the human respiratory system and the external environment
- **perform** an experiment to determine your respiratory volume
- **perform** an experiment to examine factors that affect the rate of respiration

Key Terms

diaphragm
rib muscles
inhalation
exhalation
spiograph
tidal volume
inspiratory reserve volume
expiratory reserve volume
vital capacity
residual volume
external respiration
internal respiration

The respiratory system is an elegant and specialized system that provides a passageway for air to move from the external environment to the interior of the body, where gas exchange occurs. Air does not just flow into and out of the lungs on its own, however. Two muscular structures—the diaphragm and the rib muscles—control the air pressure inside the lungs, causing air to move into and out of the lungs. The **diaphragm** is a dome-shaped layer of muscle that separates the region of the lungs (thoracic cavity) from the region of the stomach and liver (abdominal cavity). The **rib muscles**, or intercostal muscles, are found between the ribs and along the ventral (inside) surface of the ribs. The rib muscles extend down to the diaphragm.

The Mechanics of Breathing

The diaphragm and the rib muscles work simultaneously to move air into and out of the lungs, as shown in Figure 7.5. The air pressure within the lungs is under the control of these two structures.

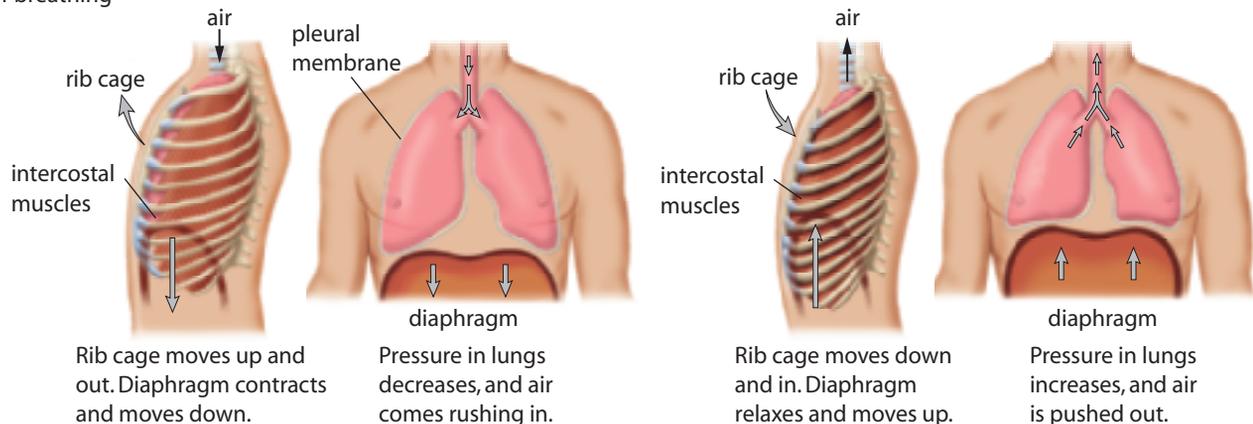
Inhalation begins when the external rib muscles and the diaphragm contract. This action expands the rib cage upward and outward, and the floor of the chest cavity downward. Since the thoracic

cavity is airtight, its volume increases. The increase in volume means that the same amount of air is contained in a larger space. When the molecules of a gas are farther apart, as they are when the volume of the thoracic cavity increases, they exert less outward pressure. As a result, the air pressure in the thoracic cavity decreases.

The lungs are suspended in the thoracic cavity and are sensitive to changes in the air pressure of the cavity. As the air pressure in the cavity decreases, the walls of the lungs are drawn outward into the thoracic cavity and the lungs expand. This expansion causes the air pressure in the lungs to be lower than the air pressure in the external environment. Since air moves from regions of higher pressure to regions of lower pressure, air rushes into the lungs from the external environment.

The opposite muscle movements expel air from the lungs. **Exhalation** begins when the diaphragm and the rib muscles relax, reducing the volume of the thoracic cavity. As a result, the volume of the lungs decreases, the air pressure inside the lungs increases, and air moves from the lungs to the lower-pressure environment outside the body.

Figure 7.5 The mechanics of breathing



A Inhalation The intercostal muscles contract, lifting the rib cage up and out. At the same time, the diaphragm contracts and pulls downward. As the lungs expand, air moves in.

B Exhalation The intercostal muscles relax, allowing the rib cage to return to its normal position. The diaphragm also moves upward, resuming its domed shape. As the lungs contract, air moves out.

BiologyFile

Try This

Normally, the pressure inside the lungs is greater than the pressure outside the lungs, or inside the pleura. This difference in pressure allows the lungs to inflate. If air collects between the two layers of the pleura because of an injury, the pressure outside the lung increases and causes the lung to “collapse.” This condition is called a pneumothorax. Experiment with the lung model you made in the Launch Lab to see what happens if air enters the airtight apparatus that represents the thoracic cavity. Why would physicians insert a tube into the chest to “reinflate” the lung?

In other words, a change in air pressure causes air to move from an area of high pressure (the lungs) to an area of lower pressure (the external environment).

6 Outline briefly, in the form of a paragraph or diagram, the processes of inhalation and exhalation.

Respiratory Volume

Take a deep breath. How does this feel different from your normal breathing? Think about your breathing rate after you have physically exerted yourself in some way. It is probably faster than your normal breathing rate. Under normal circumstances, your regular breathing does not use the full capacity of your lungs. When your body needs more oxygen, however, the volume of air that is drawn into your lungs can increase. The graph in Figure 7.6, called a **spiograph**, represents the amount of air that moves into and out of the lungs with each breath. The terms that are used in a spiograph are described below.

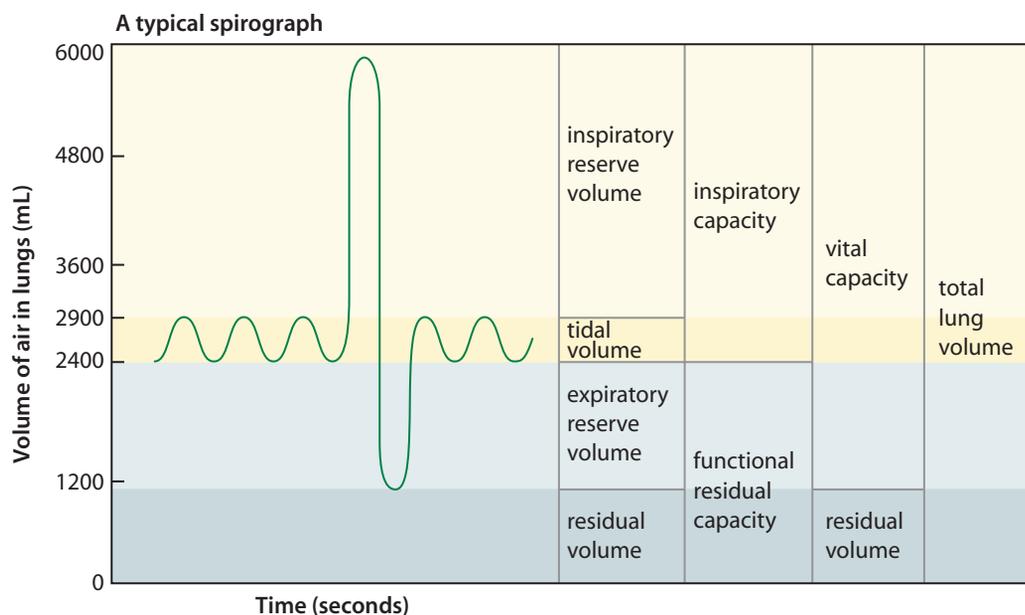
- **Tidal volume** is the volume of air that is inhaled and exhaled in a normal breathing movement when the body is at rest.

- **Inspiratory reserve volume** is the additional volume of air that can be taken into the lungs, beyond a regular, or tidal, inhalation.
- **Expiratory reserve volume** is the additional volume of air that can be forced out of the lungs, beyond a regular, or tidal, exhalation.
- **Vital capacity**, or total lung volume capacity, is the total volume of gas that can be moved into or out of the lungs. It can be calculated as tidal volume + inspiratory reserve volume + expiratory reserve volume.
- **Residual volume** is the amount of gas that remains in the lungs and the passageways of the respiratory system even after a full exhalation. This gas never leaves the respiratory system; if it did, the lungs and respiratory passageways would collapse. The residual volume has little value for gas exchange because it is not exchanged with air from the external environment.

Gas Exchange and External Respiration

Respiration is a combination of two separate processes: external respiration and internal respiration. **External respiration** takes place in the lungs. During external respiration, gases are exchanged between the alveoli and the

Figure 7.6 This graph shows typical values for human vital capacity: the maximum volume of air that can be moved into and out of the lungs during a single breath. The pattern of this graph is called a spiograph.



Performing, recording, analyzing, and drawing conclusions based on data obtained by measuring respiratory volumes

Assessing the validity of the data

Measuring Respiratory Volumes

In this investigation, you will measure your respiratory volume using a device called a spirometer.

Question

How can you use a spirometer, which measures air as it is exhaled, to determine the volume of air you inhale in a normal breath and a deep breath?

Prediction

Predict what percentage of your vital capacity is represented by your tidal volume.

Safety Precautions

Do not inhale or exhale to the point of faintness.

Materials

- materials for recording data
- spirometer with disposable mouthpieces
- nose plug (optional)

Procedure

1. Set the spirometer gauge to zero, and insert a clean mouthpiece. If you are using a nose plug, put it on.
2. Begin by taking a few relaxed breaths. Then inhale normally, put the mouthpiece into your mouth, and exhale normally into the spirometer. Record the value as your *tidal volume*.
3. Reset the spirometer. Inhale and exhale normally. At the end of the normal exhalation, put the spirometer mouthpiece into your mouth and exhale as much as you can. Make sure you do this all in one breath. Record the value as your *expiratory reserve volume*.
4. Reset the spirometer. Inhale as deeply as you can, and then exhale normally into the spirometer. **Do not force the exhalation.** Record the value as your *inspiratory capacity*.
5. Calculate your *inspiratory reserve volume* by subtracting your tidal volume from your inspiratory capacity. Record your inspiratory reserve volume.
6. Calculate your *vital capacity* by adding your inspiratory reserve volume, expiratory reserve volume, and tidal volume. Record the value as your *calculated vital capacity*.

7. Reset the spirometer. Inhale as deeply as you can, and then exhale deeply into the spirometer, forcing out as much air as you can. Do this all in one breath. Record the value as your *recorded vital capacity*.

Analysis

1. Compare your calculated vital capacity with your recorded vital capacity. Explain any difference.
2. Compare your inspiratory reserve volume with your expiratory reserve volume. Explain any difference.

Conclusions

3. Can you use the spirometer to measure your total lung capacity? Explain.
4. How might an athlete use information about his or her vital capacity? Predict how respiratory volumes relate to athletic performance.

Extension

5. Compare your respiratory volumes with those of other students by creating a class data table. How much variation do you see? Are there patterns in this variation, such as differences between males and females, or differences based on height? What factors could contribute to differences in respiratory volumes? Design an experiment to test the effects of two of these factors.

Application

6. Vital capacity can be used to determine fitness, because it shows the extent to which individuals can ventilate their lung surface. Do research to determine how vital capacity is affected in two different respiratory disorders. Prepare a brief report about how these disorders affect the respiratory system and how they can be treated. **ICT**
7. A ventilator is a piece of medical equipment that maintains respiratory movements in a person who is unable to breathe. Consider a young, otherwise healthy person who is paralyzed as a result of a car crash. Would it be a good idea to adjust a ventilator to maximize the volume of air inhaled and exhaled? Explain.

blood in the capillaries. The walls of the alveoli and the capillaries are each one cell thick, which allows gases to diffuse through their cell membranes (see Figure 7.7). Recall that diffusion is the movement of molecules from a region of high concentration to a region of lower concentration. The air that enters the alveoli after inhalation has a higher concentration of oxygen than the blood in the capillaries next to the lungs. (The blood in the capillaries has had oxygen diffuse out of it into the tissue cells and has had carbon dioxide diffuse into it from the tissue cells.) As a result, oxygen diffuses out of the alveoli into the blood in the capillaries. Diffusion alone, however, is not always enough to transfer the necessary amount of oxygen to the blood. Approximately 30% of the oxygen transfer happens by facilitated diffusion. In facilitated diffusion, protein-based molecules in the wall of the alveoli facilitate diffusion by “carrying” oxygen across the cell membranes. This process does not require extra energy because the oxygen is still moving along the concentration gradient from an area of high concentration to an area of low concentration. Facilitated diffusion simply speeds up the gas exchange.

The blood in the capillaries has a higher concentration of carbon dioxide than the alveoli because it is returning from the body tissues. Thus, the carbon dioxide diffuses into the alveoli from the capillaries. The carbon dioxide is then, as you know, exhaled into the air.

Once oxygen and carbon dioxide have been exchanged between the capillaries and alveoli, the blood in the capillaries begins its journey back to the heart and

then on to the tissue cells. There, it undergoes **internal respiration** and exchanges the oxygen for carbon dioxide once again.

In blood, oxygen and carbon dioxide are transported in different ways. Approximately 99 percent of the oxygen that reaches cells is carried by an oxygen-transporting molecule called hemoglobin, which is only in red blood cells. The rest is dissolved in the blood plasma.

Slightly less than one-quarter (23 percent) of carbon dioxide is carried in the blood by hemoglobin. Approximately 7 percent is carried in the plasma, and approximately 70 percent is dissolved and carried in the blood as bicarbonate ion (HCO_3^-). Carbonic acid (H_2CO_3) is formed in the blood when a carbon dioxide molecule (CO_2) reacts with a water molecule (H_2O). The carbonic acid quickly dissociates (breaks down) into a hydrogen ion (H^+) and a bicarbonate ion. This reaction occurs in the red blood cells. The H^+ then combines with hemoglobin, and the bicarbonate ions diffuse out of the red blood cells into the plasma, which is carried to the lungs. When the blood reaches the lungs, the whole process reverses to re-form carbon dioxide and water. The carbon dioxide then diffuses into the air in the alveoli and is exhaled.

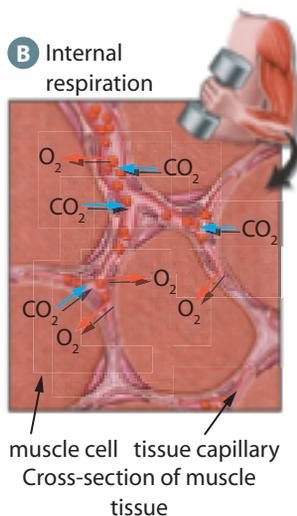
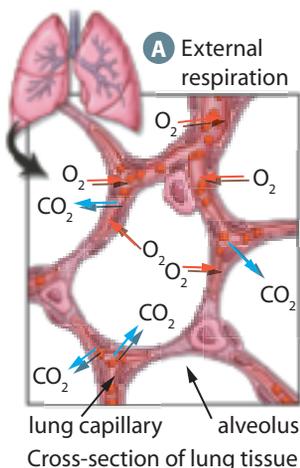


Figure 7.7 External respiration (A) occurs between alveoli and the capillaries next to them. As blood moves away from the body tissues, it is oxygen-poor and carbon dioxide-rich. As it moves through the lung capillaries, oxygen from the air in the alveoli diffuses into the capillaries and carbon dioxide diffuses out of the blood. Internal respiration (B) occurs between the capillaries and the body tissues. Oxygen diffuses from the blood into the oxygen-poor tissues while carbon dioxide diffuses from the tissues into the blood.

7 What occurs during external respiration?

8 Briefly describe the process of gas exchange and the structures involved.

Target Skills

Conducting investigations into relationships between and among observable variables with respect to the rate of respiration

Collecting, communicating, and assessing the validity of results, using appropriate terminology

Carbon Dioxide and the Rate of Respiration

When you exercise, the increase in your body activity triggers an increase in your rate of respiration. You might think your rate of respiration increases because your muscles are working hard and need more oxygen. Scientists have determined experimentally that the concentration of oxygen in the body is not the primary stimulus that affects the rate of respiration. Could the concentration of carbon dioxide, the other gas exchanged during respiration, be the primary stimulus? How could you test this idea?

Question

How can the level of carbon dioxide in the body be altered?

Prediction

Predict what will happen if the level of carbon dioxide in the body is increased.

Safety Precautions

- Students with respiratory and heart disorders should not be subjects in this experiment.
- Do not hold your breath or hyperventilate long enough to cause faintness. At the first sign of faintness or dizziness, stop the experiment and resume normal breathing.
- Do not substitute a plastic bag for the paper bag in this investigation. Do not breathe into a paper bag for any longer than 15 seconds, because carbon dioxide can build up very quickly in the bloodstream. At the first sign of distress, remove the paper bag immediately and take several calm, natural breaths.

Materials

- paper bag
- stopwatch
- materials for recording data

Procedure

1. Prepare a data table like the one shown below.

Condition	Resting	After holding breath	After hyperventilating	While breathing into paper bag
Rate of respiration (in breaths per minute)				

2. Work with a partner. Count the number of breaths your partner takes while resting in a sitting position for 3 min. Divide the number of breaths by 3 to calculate the number of breaths per minute. Record this value under “Resting” in your data table.
3. Have your partner hold her or his breath for about 45 s. Then count the number of breaths that she or he takes in the next 3 min. Divide the number of breaths by 3, and record this value under “After holding breath” in your data table.
4. Ask your partner to take 10 fast, deep breaths. Then count the number of breaths she or he takes in the next 3 min. Divide the number of breaths by 3, and record this value under “After hyperventilating.”
5. Ask your partner to place a large paper bag over her or his mouth. Then count the number of breaths she or he takes in the next 15 s. Multiply the number of breaths by 4, and record this value under “While breathing into a paper bag” in your data table.
6. Switch roles, and repeat steps 2 to 5.

Analysis

1. What effect did each condition—holding your breath, hyperventilating, and breathing into a paper bag—have on the level of oxygen and carbon dioxide in your body? Explain your results, with reference to the concentration of respiratory gases.

Conclusion

2. Based on your observations, describe the role of carbon dioxide in breathing.

Extension

3. Compare your results with the results of other students. What similarities and differences can you identify? Provide a hypothesis to account for the differences. Write a procedure to test your hypothesis.

Section 7.2 Summary

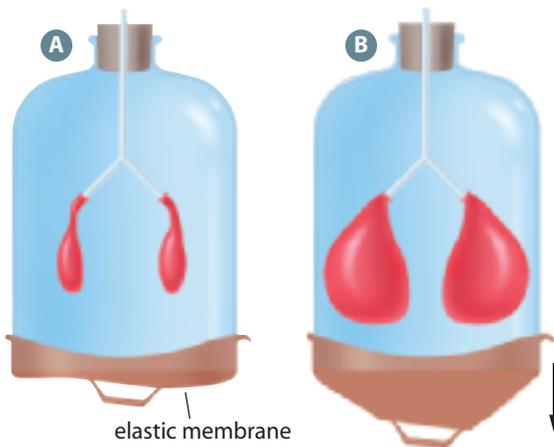
- Two muscular structures, the diaphragm and the rib muscles, work together to move air into and out of the lungs.
- The volume of air in your lungs can change depending on how much oxygen you need and your level of activity.
- External respiration takes place in the lungs. Internal respiration occurs in the tissues. Oxygen and carbon dioxide are

exchanged between the alveoli and the capillaries by the processes of passive and facilitated diffusion. Oxygen (O_2) diffuses into the blood from the alveoli, and carbon dioxide (CO_2) diffuses out of the blood into the alveoli.

- Oxygen is carried in the blood bound to hemoglobin in red blood cells. Most carbon dioxide is carried as bicarbonate dissolved in blood plasma.

Section 7.2 Review

1. Explain how the two basic requirements for gas exchange identified in Section 7.1 are met by the structure of the lungs.
2. Describe the role of the diaphragm in inhalation and exhalation.
3. Use the following diagram to explain the mechanics of breathing.



4. a) Describe the purpose of a spirometer.
b) Sketch an example of a spirometer. Include the following terms: tidal volume, inspiratory reserve volume, expiratory reserve volume, vital capacity, and residual volume.
c) Describe or define all of the volumes of air that you represented on your sketch.
5. a) Identify the three “volumes” of air that make up an individual’s vital capacity.
b) Explain the purpose of the residual volume of air in the lungs.
6. Sketch two diagrams in your notebook that compare external respiration with internal respiration. Describe these two processes and discuss the role of diffusion and facilitated transport in gas exchange.

7. Describe the role of hemoglobin and bicarbonate ions in gas exchange.
8. In an automobile accident, the diaphragm of a passenger is punctured. How would this affect the person’s ability to breathe?

Use the following information to answer the next two questions.

Pneumothorax

A pneumothorax is commonly known as a collapsed lung. Normally, the outer surface of the lung sits next to the inner surface of the chest wall. The lung and the chest wall are covered by thin membranes called pleura. A collapsed lung occurs when air escapes from the lungs or leaks through the chest wall and enters the space between the two membranes (pleural cavity). As air builds up, it causes the nearby lung to collapse. A collapsed lung can result from blunt force trauma, rib fractures, or a foreign object entering through the thoracic cavity and into the lung.

9. Explain how a pneumothorax would impair gas exchange in the collapsed lung.

Use the additional information to answer the next question.

When this is the case in larger mammals, the lung will sometimes reinflate after the air is evacuated by inserting a needle or a chest tube into the thoracic cavity.

10. Why would removing the air from the thoracic cavity help the lung to reinflate?
11. You may have experienced a situation when a toddler gets upset and states emphatically that they are going to hold their breath until they get their way. Explain, in terms of the control of breathing, why most people can only hold their breath for less than a minute.

Traditional Healing in Modern Times

Humans have been treating ailments for millennia. Before universities and medical schools, a community's specialized knowledge about healing techniques and technologies was passed on orally and through apprenticeships with skilled healers. The teachings would include extensive knowledge about the most effective parts of local plants—leaves, flowers, or roots—and the best way to preserve materials and prepare and administer the treatments. Dried and ground roots or leaves, made into pastes and teas, are just two of the ways traditional medicines are prepared. Practitioners also need to know how to find and properly identify medicinal plants and, depending on the culture, offer appropriate prayers of thanks for them.

Examples of traditional remedies include:

- **white willow** (*salix species*) In use since Roman times, teas made from the bark of this tree contain salicin, which reduces fever. The synthetic form of salicin is called acetyl salicylic acid (brand name, Aspirin™).
- **boswellia** (*Boswellia serrata*) The sap of this tree has been used as an anti-inflammatory since ancient times in India. The active ingredients are boswellic acids, which are considered to be effective herbal alternatives to nonsteroidal anti-inflammatory drugs (NSAIDs) for the treatment of arthritis.
- **Seneca snakeroot** (*Polygala senega*) Snakeroot contains a milky liquid that the Seneca First Nations used to treat snakebite, which is the source of its common name. Aboriginal people across North America have used the dried root for centuries as a decongestant and to loosen mucus in the lungs.
- **Pleurisy root** (*Asclepias tuberosa*) First Nations people used this powerful remedy to treat chest and upper respiratory problems, including colds, coughs, bronchitis, pneumonia, and pleurisy.

Dr. Malcolm King of the University of Alberta is a descendant of a long line of traditional native healers in the Six Nations confederacy and is a member of the Mississaugas of New Credit First Nation. He is also a research scientist and professor in the pulmonary division of the University of Alberta's department of medicine. He studies the flow of mucus in the lungs and other organs and the treatment of asthma, bronchitis, and cystic fibrosis. Dr. King's special area of interest is the use of traditional aboriginal remedies to treat illnesses related to the respiratory system.

Dr. King and his students have examined the use of rat root (*Acorus calamus*) to improve the excretion of mucus in the lungs and found it could be helpful in clearing lung infection. They have also tested extracts of

licorice root (*Glycyrrhiza glabra*) in the lab, and Dr. King has used the extract to treat his own colds.

Dr. King's challenge is to find funding for his research. Natural products cannot be patented, and drug companies are therefore reluctant to invest in research. In addition, Dr. King feels that traditional native healers "would not be interested in sharing with drug companies."

...

1. Do you think traditional remedies are safer than the products manufactured by pharmaceutical companies? Explain your answer.
2. Should traditional remedies be scientifically tested and regulated the same way that manufactured drugs are? Why or why not?
3. Does anyone own traditional remedies? Do you think companies should be allowed to patent them? Give reasons to justify your opinion.



Cree elders boil the leaves of the Labrador tea plant (shown here) to make a drink loaded with vitamin C and helpful in the treatment of colds, sore throats, and insomnia. Too much of this remedy can be toxic, so the elder's knowledge of the correct dosage is vital to the health of the community.

Section Outcomes

In this section, you will

- **identify** specific diseases that are associated with the respiratory system
- **identify** technologies that may be used to treat these respiratory diseases
- **summarize** the physiological effects of smoking and the limitation of technologies to address these effects

Key Terms

tonsillitis
laryngitis
bronchitis
pneumonia
pleurisy
emphysema
cystic fibrosis
asthma
lung cancer
carcinoma
carcinogen

BiologyFile

Web Link

Infections of the respiratory tract often have similar symptoms. How can one infection be distinguished from the other? And, more importantly, what can be done to feel better and get better when an infection sets in?

www.albertabiology.ca
WWW

Like the digestive system, the respiratory system directly links the internal environment of the body with the external environment. The quality of both environments plays a key role in the health of the respiratory system. Changes in the external environment, as well as personal lifestyle choices, can have a significant impact on how well the respiratory system functions and, by extension, on how well the whole body functions.

Upper Respiratory Tract Infections

Infections of the upper respiratory tract are usually caused by viruses or bacteria. When the cause of an infection is bacterial, antibiotics are often used to treat it. How viral and bacterial infections develop, and how our bodies fight them, will be explored in the next chapter.

Tonsillitis

Tonsillitis is an infection of the tonsils, which are located in the pharynx. (Refer to Figure 7.2 for the location of the pharynx.) A viral infection, rather than a bacterial infection, is the more common cause of tonsillitis. The tonsils can be removed surgically if the infections are frequent and breathing is impaired. In the past, many children had their tonsils removed as a precaution, but this surgery is no longer as common. The tonsils help to prevent bacteria and other foreign pathogens from entering the body, so removing them can increase the number of infections later in life.

Laryngitis

Laryngitis is an inflammation of the larynx (see Figure 7.2). Recall that the larynx contains the vocal cords. The most common cause of laryngitis is a viral infection; allergies and overstraining of the voice can also lead to

laryngitis. When the larynx is inflamed, the vocal cords are not able to vibrate as they normally do. This reduces the ability to speak in a normal voice or even to speak at all. Symptoms of laryngitis include a sore throat and hoarseness.

9 Which pathogens, bacteria or viruses, are most likely to cause a case of tonsillitis or laryngitis?

Lower Respiratory Tract Disorders

More than three million Canadians, of all ages, experience serious respiratory disorders in the lower respiratory tract. The primary causes of these respiratory disorders are infections, obstructive pulmonary disorders (OPD), and lung cancer. Figure 7.8 on the next page highlights some of the more common lower respiratory tract disorders.

Bronchitis

Bronchitis is a disorder that causes the bronchi to become inflamed and filled with mucus, which is expelled by coughing. Acute bronchitis is a short-term disorder that is caused by a bacterial infection and can be treated with antibiotics. Chronic bronchitis is a long-term disorder that is caused by regular exposure to irritants and foreign bodies. Because exposure to the irritants has been over a long period of time, the cilia are destroyed, so their cleansing action no longer occurs. This means that the bronchi become even more inflamed and infection is even more likely. The most common cause of chronic bronchitis is one that is preventable—cigarette smoking. There is no cure for chronic bronchitis. Treatment is aimed at reducing the symptoms and complications with medication and regular exercise. Along with the treatment, it is important to

Pneumonia

Alveoli fill with thick fluid, making gas exchange difficult.

Bronchitis

Airways are inflamed due to infection (acute) or due to an irritant (chronic). Coughing brings up mucus.

Asthma

Airways are inflamed due to irritation, and bronchioles constrict due to muscle spasms.

Emphysema

Alveoli burst and fuse into enlarged air spaces. Surface area for gas exchange is reduced.

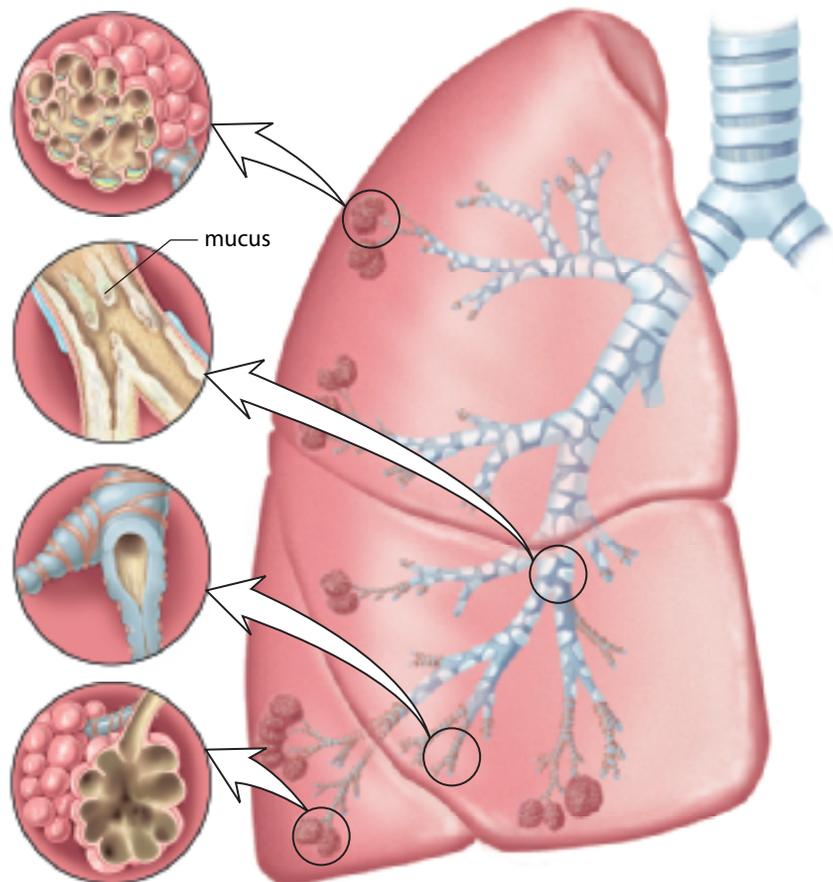


Figure 7.8 Several lower respiratory tract disorders are shown. Exposure to infectious pathogens and/or air pollutants, including cigarette and cigar smoke, often cause the disorders shown here.

avoid the causal irritant—which most often means quitting smoking.

Pneumonia

Pneumonia is a disease that occurs when the alveoli in the lungs become inflamed and fill with liquids. This interferes with gas exchange, and the body becomes starved for oxygen. There are two main types of pneumonia: lobular pneumonia and bronchial pneumonia. As shown in Figure 7.9, lobular pneumonia affects a lobe of the lung and bronchial pneumonia affects patches throughout both lungs.

There are several different causes of pneumonia. The main causes are bacterial infection and viral infection. Lobular pneumonia is caused by the bacterium *Streptococcus pneumoniae*. This bacterial infection can spread out of the lungs, via the bloodstream, and affect other tissues. There is a preventative vaccine, called the

pneumococcal vaccine, which provides long-term protection from the bacterium. You will learn more about vaccines and the immune system in Chapter 8.

Viral pneumonias are usually less severe than bacterial pneumonias, and they can be treated with anti-viral medications. Viral pneumonias may be followed, however, by a secondary bacterial infection, which must be treated separately with antibiotics or with preparations that have antibiotic properties. People who have AIDS often

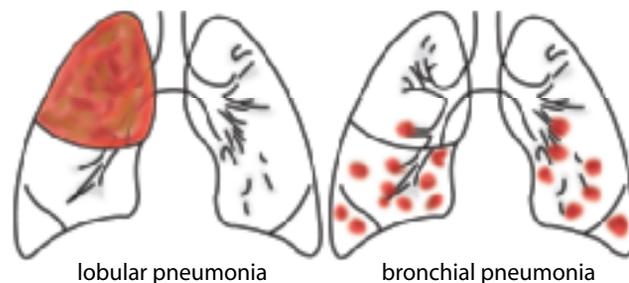


Figure 7.9 The two main types of pneumonia

BiologyFile

Web Link

Asthma is the only major respiratory ailment that is increasing in the population. Approximately 20 years ago, 2.3 percent of Canadians over the age of 15 were diagnosed with asthma. Today, this figure has increased to more than 8 percent. The United States has seen more than a 60 percent increase in the diagnosis of asthma. What hypotheses do medical experts have to explain these dramatic increases?



experience a rare type of bacterial pneumonia, which is hardly ever seen in people with strong immune systems.

Pleurisy

Pleurisy is a lung disorder that is caused by the swelling and irritation of the pleura, the membranes that surround the lungs. There are many different causes of pleurisy, including viral or bacterial infections, a blood clot in a lung, or cancer. The symptoms include a sharp stabbing pain in the chest, usually localized in one particular area. Treating pleurisy involves treating the cause of the swelling and irritation.

- 10 Why does bronchitis affect a person's ability to breathe properly?
- 11 Why does pneumonia affect a person's ability to breathe properly?

Emphysema

Emphysema is an obstructive respiratory disorder in which the walls of the alveoli break down and lose their elasticity. This reduces the surface area for gas exchange and causes oxygen shortages in the tissues. Exhaling becomes difficult because of the loss of elasticity, so breathing is laboured. Almost all cases of emphysema are caused by smoking. Emphysema is permanent and incurable, although medications that open up the bronchioles can help to improve breathing (Figure 7.10A). People who have emphysema often need to use a low-flow oxygen tank in order to breathe and acquire sufficient oxygen. A low-flow oxygen tank provides concentrations of oxygen that vary with the individual's rate of breathing. This type of supplemental oxygen system is called a variable performance system. A high-flow system, or fixed performance system, provides a constant concentration of oxygen that meets or exceeds the individual's needs.



Figure 7.10A This device, called an inhaler, delivers medicine in aerosol form to provide relief for people who have emphysema. People who have asthma also use inhalers.

Lung volume reduction surgery (LVRS) is an experimental surgery for the treatment of emphysema. Up to 30 percent of the most damaged tissue from each lung is removed. The goal is to have the healthy portions work more effectively once the damaged areas are removed, and thus become more efficient in their gas exchange. The effectiveness of LVRS is still uncertain.

Cystic Fibrosis

Cystic fibrosis is a serious genetic condition that affects the lungs. Cystic fibrosis is caused by an abnormal gene that disrupts the function of the cells lining the passageways of the lungs. When these cells do not function properly, the homeostatic balance of salt and water cannot be maintained, causing the thin mucus and liquid coating on the insides of the lungs to become very thick and sticky. The mucus in the lungs normally traps pathogens and then is expelled from the body by coughing. In people who have cystic fibrosis, the mucus is so thick that the pathogens are trapped but cannot be expelled. As a result, the lungs get repeated infections that reduce lung function, and the individual has trouble breathing.

Currently, cystic fibrosis is treated with medicines to thin the mucus and antibiotics to treat the lung infections. New treatments for cystic fibrosis are still being perfected. In one of these new treatments, gene therapy, an inhaler (Figure 7.10A) is used to spray healthy versions of the abnormal gene deep into the lungs. The healthy genes are able to correct the function of the cells lining the lungs and cause them to produce normal mucus.

Asthma

Asthma is a chronic obstructive lung disease that affects the bronchi and bronchioles, making breathing difficult or impossible because of reduced air flow. Asthma can develop at any age, and the effects vary from mild reactions to severe reactions that can cause death.

People with asthma have a constant inflammation in their airways and are extremely sensitive to some triggers, such as pollen, dust, cigarette smoke, and other air pollutants. These triggers can cause an asthma attack. During an asthma attack, the bronchi and bronchioles swell, the bronchial muscles tighten, and mucus production increases. These changes obstruct the airways and make breathing difficult or impossible.

Asthma can be managed but not cured. Most people with asthma use an inhaler, which is a hand-held device that delivers medication deep into the lungs. There are two main types of inhalers: metered dose inhalers and dry powder inhalers. Metered dose inhalers force the medicine out of the inhaler when the inhaler is compressed through the action of a chemical propellant. The person squeezes the inhaler canister to compress the inhaler and, at the same time, inhales the medicine deep into the lungs. Dry powder inhalers do not contain a chemical propellant, so the medicine does not come out as fast. Therefore, the person must inhale rapidly when the inhaler canister is compressed. Some people who have asthma, especially those who are very young or very ill, are unable to use an inhaler properly. Instead, they can use a nebulizer, which is a mask worn over the mouth and nose. The mask contains the medicine suspended in a mist.

Asthma medications work to reduce the inflammation in the airways and relax the bronchiole muscles, both of which open up the airways. Asthma attacks can be fatal, so some people with asthma use a device called a peak flow meter (see Figure 7.10B). The peak flow meter measures lung volume and can show when lung volume is decreasing compared with normal volumes. This is

12 Use a Venn diagram to compare and contrast emphysema with asthma.

an early warning that an attack is coming and medication is needed.

Lung Cancer

Lung cancer is the uncontrolled and invasive growth of abnormal cells in the lungs. It is the leading cause of cancer deaths for men and women in Canada. Figure 7.11 shows the difference between healthy lung tissue and cancerous lung tissue.

The abnormal cells multiply and form malignant tumours, or **carcinomas**. The tumours reduce the surface available for gas exchange and may stop air from entering the bronchioles. Growing tumours may damage tissue or produce toxins that are harmful to the lung cells. Most cases of lung cancer are caused by smoking, which makes this type of cancer preventable. Many substances in tobacco smoke are known **carcinogens**, or cancer-causing agents. These carcinogens have been linked to lung cancer in smokers as well as non-smokers exposed to second-hand smoke. Another cause of lung cancer is exposure to radon, a heavy gaseous radioactive element that is colourless and odourless. It is found in small quantities in rocks and soil, and it can gather in buildings, entering through cracks in the foundation. Radon can be measured using specially designed kits. Finally, exposure to asbestos, a fibrous mineral resistant to heat and fire, increases the risk of lung cancer.

BiologyFile

Web Link

Cancer is a devastating disease, with more than 14 000 new cases diagnosed in Alberta each year. Due to cancer's impact, extensive research has been done to try to understand cancer, its causes, and how it progresses. Use the following terms to build a story of how cancer develops: oncogene, malignant, tumour, and metastasis.



Figure 7.10B These different peak flow meters all work to measure lung volume. Changes in peak flow warn that an asthma attack might be coming.





Figure 7.11 (A) These normal lungs have healthy red tissue. (The heart is visible near the lower centre.) **(B)** These diseased lungs have black tissue caused by heavy smoking. The white areas are tumours, or carcinomas.

Technologies for Detecting and Treating Lung Disorders

Successfully treating lung disorders is challenging because these disorders are usually difficult to diagnose before they have progressed to an untreatable stage. For example, lung cancer can be detected using a specialized X ray, called a CT scan, that locates abnormalities in the lungs. A new type of scan, called a helical

low-dose CT scan, is able to detect lung cancer when the tumours are still very small. Unfortunately, even when a tumour is diagnosed with a helical low-dose scan, it has usually progressed past a stage where it can be treated and the cancer stopped. Figure 7.12 shows a lung tumour that has grown and started to spread. The spread of a tumour throughout the body is called metastasis,

Thought Lab 7.1 Smoking and the Respiratory System

Target Skills

Outlining and assessing the physiological effects of tobacco smoke

There are more than 4000 chemicals in tobacco smoke. At least 10 percent of these cause cancers of the mouth, lungs, and other body organs. In this activity, you will add to your understanding of body systems by conducting research to explore the effects of smoking on the respiratory and other body systems.

Note: For many Aboriginal peoples, tobacco is a sacred plant used as a key part of many traditional ceremonies. The focus of this activity is on the “common” use of tobacco in society, not its ceremonial use.

Procedure

Working alone or in small groups, plan a public-awareness product such as a poster, pamphlet, or multimedia presentation. Decide what audience your public-awareness product will address. Use your knowledge of the path of inhaled smoke through the respiratory system in your project. Make sure your research answers the following questions.

- By law, which chemicals in tobacco smoke must be listed on tobacco products? In what concentrations are they present, and what are their effects? (For example, ammonia is a chemical found in cigarette smoke in concentrations

ranging from 50 to 130 µg/cigarette. Ammonia is a fatal poison in large-enough amounts in the body.)

- What other chemicals are found in tobacco smoke? List at least five, and give their concentrations and effects.
- How can tobacco chemicals appear in other body organs such as the bladder, heart, and reproductive organs?
- What are examples of long-term and short-term effects of smoking?
- In what ways is tobacco smoke particularly harmful for women who are pregnant?
- What technologies are available to assist people who choose to quit smoking?

Analysis

1. List three harmful effects of smoking on the respiratory system and three harmful effects on other body systems.
2. Because smoking has clearly identified health risks, why do you think people smoke? Give at least two reasons.
3. Identify at least two technologies developed to assist people who choose to quit smoking.

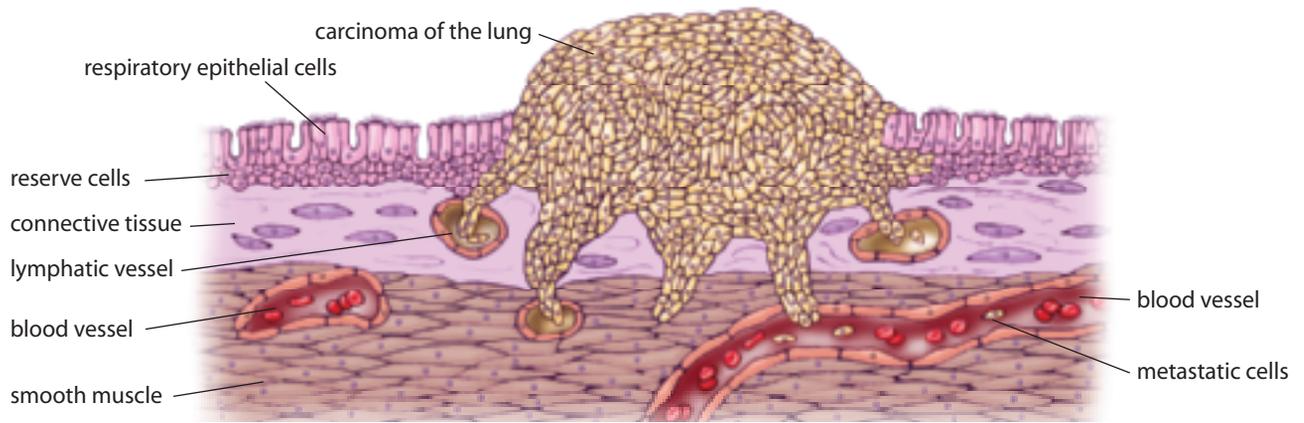


Figure 7.12 The large ball of cells in the centre of the image is a carcinoma that has developed from the interior surface cells of the human lung. The carcinoma continues to grow and invade surrounding tissues, including the lymphatic and blood vessels in the lung. The lymphatic and blood vessels circulate through the body and carry the cancerous cells, or metastatic cells, to new locations where they can grow and invade new tissues.

and the cancerous cells that spread are called metastatic cells.

Several new technologies are being developed to fight the development and spread of lung cancer. Researchers have recently developed a breakthrough technology that pinpoints the cells that are most likely to become cancerous. This technology uses DNA analysis to look for genetic changes that warn the cell may become cancerous. The focus of the research is to find a method to detect

lung cancer before the tumours have grown too large to treat.

Another recent technology uses liposomes, which are artificial microscopic vesicles that consist of a liquid centre surrounded by phospholipid layers. They are manufactured in a lab, filled with cancer-fighting drugs, and released into the bloodstream. Their tiny size allows them to follow the spread of the cancerous cells and attack the cells before the cells start their uncontrolled growth at a new location.

BiologyFile

FYI

While often touted as being a safer alternative to cigarettes, smokeless tobacco or chewing tobacco contains nicotine and several cancer-causing chemicals. Chewing tobacco has been linked to an increase in oral cancer and the precancerous condition called leukoplakia. Chewing tobacco also damages the teeth and gums.

Thought Lab 7.2 You Diagnose It

Target Skills

Inferring and **drawing** conclusions from evidence

Working cooperatively to collect, assess, and communicate results

Imagine that you have been working on a team at a medical clinic that specializes in helping people with respiratory problems. It is the summer, and there is smog in the hot humid air. Your team has collected the following information about two people who recently visited your clinic complaining of having trouble breathing.

Person A: Male, age 15, is a non-smoker. He is complaining of wheezing and trouble breathing. He started having episodes in which he had difficulty breathing last summer, but the problem seemed to go away in the winter.

Person B: Female, age 35, smokes 10 to 15 cigarettes per day. She has started having trouble exhaling and gets tired very easily. She is also coughing a lot and bringing up mucus when she coughs.

Procedure

1. Review the symptoms for these two people.
2. Working together, make a list all of the possible respiratory disorders that could be causing their symptoms.

Analysis

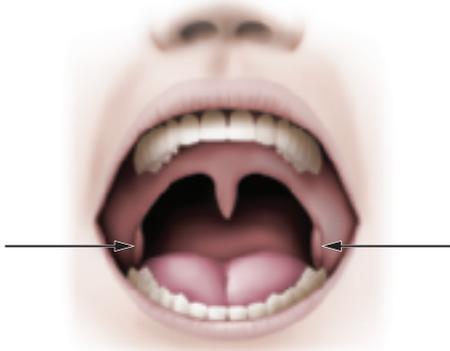
1. Create a table that lists the symptoms of the most common respiratory disorders. Is it clear, from your table, which respiratory disorders the people are suffering from? Is there more than one possible disorder, given the symptoms? Explain your answer.
2. What else would you need to know to make a complete diagnosis? Explain how you would collect the information.
3. Create an information sheet for each person, listing what they should do to reduce their symptoms. What behaviours should they change? How would these changes improve their respiratory health?

Section 7.3 Summary

- The respiratory tract is one of the main connections between the internal environment of the body and the external environment. It is exposed to many different irritants that can cause infection and disease.
- Many upper respiratory tract infections begin with a virus and are followed by a secondary bacterial infection.
- Lower respiratory tract disorders are usually caused by infections, obstructive pulmonary disorders, and lung cancer.
- Smoking is a serious health risk. Smoking causes diseases in the respiratory tract, and it affects the cardiovascular system and other organs.
- Technologies can treat, but not cure, most respiratory tract disorders.

Section 7.3 Review

1. Identify the structures indicated in the illustration below. Describe their function as well as an illness that is associated with these lymph nodes.



2. Describe the causes, symptoms, and breathing problems associated with bronchitis and pneumonia.
3. Describe emphysema and explain why a person with this disease is treated using a low-flow oxygen system.
4. Explain why a person with cystic fibrosis is prone to repeated respiratory system infections.
5. Describe the causes, symptoms, and breathing problems associated with asthma.

Use the following information to answer the next question.

Bronchial dilators

Bronchial dilators are the mainstay of asthma treatments. These can be given orally or by inhaled aerosol treatments. Usually, the inhaled route of administration is preferred because more of the medication gets to the lungs and there is less that gets to the rest of the body to cause side effects and unwanted problems.

6. Explain how bronchial dilators help reduce the symptoms associated with asthma.
7. Explain what lung cancer is. Describe how a carcinoma forms and how the cancer spreads throughout the body.

8. Identify two causes of lung cancer, and describe two ways that you can reduce your risks of getting this form of cancer.
9. Briefly describe how each of the following technologies could be used to detect or treat lung disorders.
- a) CT scan
 - b) liposomes

Use the following information to answer the next question.

Asbestosis

Asbestosis (Pulmonary Fibrosis) is a serious, chronic, non-cancerous respiratory disease. Inhaled asbestos fibres aggravate lung tissue, which causes them to scar (fibrosis). Scarred lung tissue does not expand and contract normally and cannot perform gas exchange. The severity of the disease depends upon the duration of exposure to asbestos and the amount inhaled.

Asbestos fibres were commonly used in construction before 1975. Asbestos exposure occurs in asbestos mining and milling industries, construction, fireproofing, and other industries. In families of asbestos workers, exposure can also occur from particles brought home on the worker's clothing.

10. Predict four symptoms that an individual with asbestosis would display, and explain why this individual would have each symptom. Focus your answers on the respiratory system only.
11. You have discovered that a friend has started smoking. What reasons might your friend give you to explain why he or she started smoking? What information could you give your friend to convince your friend to stop smoking?
12. An individual with lung cancer might display the following symptoms: a chronic cough; hoarseness; coughing up blood; shortness of breath; and repeated bouts of bronchitis or pneumonia. Explain why lung cancer would be associated with each of these symptoms.

Respiration enables the body to take oxygen from the external environment and process it for delivery to the cells and, at the same time, rid itself of carbon dioxide.

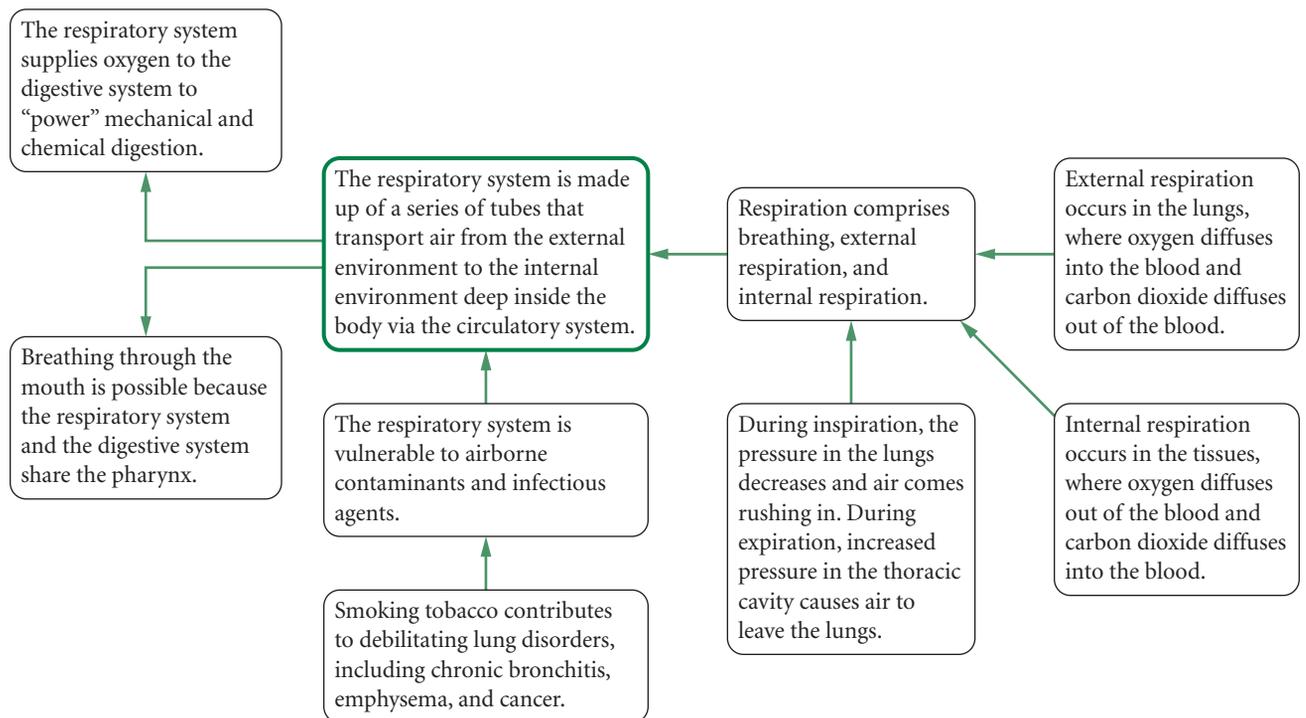
Oxygen is delivered to the cells and carbon dioxide is removed from the cells and the body in a number of exchanges. Inspiration (breathing in, inhaling) and expiration (breathing out, exhaling) exchange air between the environment and the lungs. External respiration exchanges oxygen and carbon dioxide between the air in the lungs and the blood. Internal respiration exchanges oxygen and carbon dioxide between the blood and the body's tissue cells. Cellular respiration is the final step, when the oxygen delivered to the cells is used to provide the energy for all cellular activities; carbon dioxide is the waste product of cellular respiration.

The respiratory tract is the passageway for air to move from the external environment into the lungs. The upper

respiratory tract begins at the nostrils and includes the nasal passages, pharynx, larynx, and trachea. These passageways all clean and warm the air as it passes through. The lower respiratory tract consists of two bronchi that each lead to a lung. Within the lungs are small, fine tubes called bronchioles, where the air continues to be cleaned and warmed. The exchange of gases takes place in a cluster of tiny sacs at the end of each bronchiole, called alveoli, where the oxygen diffuses through the membranes of the alveoli into the capillaries of the circulatory system.

A number of disorders of the respiratory tract can impair the delivery of oxygen to the cells, including bronchitis, pneumonia, pleurisy, emphysema, cystic fibrosis, asthma, and lung cancer. These are all disorders of the lower respiratory tract. Infections of the upper respiratory tract, such as tonsillitis and laryngitis are short term infections that do not obstruct breathing.

Chapter 7 Graphic Organizer



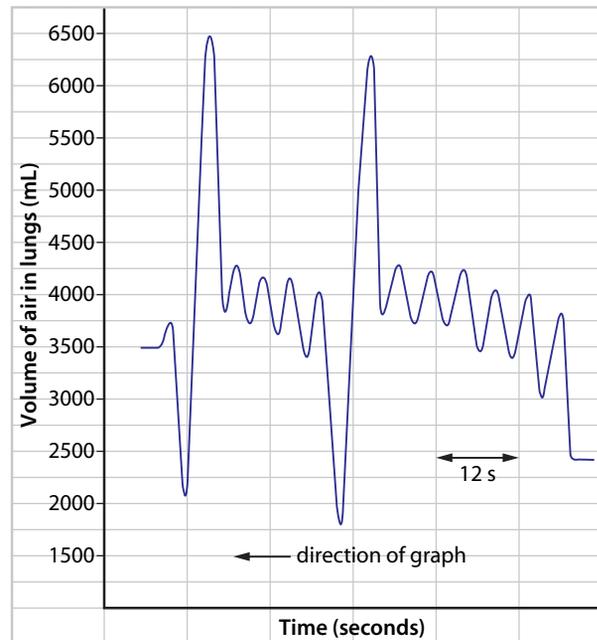
Understanding Concepts

- Arrange the following structures in the order that they would be encountered by air entering the human respiratory system: glottis, pharynx, alveoli, bronchiole, nasal cavity, larynx.
- Decide whether each of the following statements is true or false. If a statement is false, rewrite it to make it true.
 - Respiration can be divided into two processes: inspiration and expiration.
 - Carbon dioxide is one important factor in regulating the rate of respiration.
 - Air enters the human lungs because the air pressure inside the lungs is greater than the air pressure in the external environment.
 - The maximum volume of air that can be moved into and out of the lungs during a single breath is called the tidal volume.
- Identify the four stages of respiration, and briefly describe each stage.
- Identify the two basic requirements of a gas exchange system. Explain how these requirements are met in the human respiratory system.
- Describe three lower-tract respiratory system disorders, and explain why they make breathing difficult.
- Explain how lung cancer cells spread throughout the body.
- Use word processing software to create two flow charts that compare inspiration to expiration. **ICT**
- Identify two immediate benefits of quitting smoking. If someone has tried to quit smoking but has not been successful, what two aids might lead to success?
- Explain how these two processes are involved in gas exchange.
 - dissolving
 - diffusion

Applying Concepts

- The illustration shows the spirograph of a healthy, non-smoking, adult male. Use this illustration to answer the following questions.
 - Estimate the tidal volume and the vital capacity for this individual. Record your answer in millilitres.
 - Each vertical line on this graph represents a time interval of 12 seconds. Estimate the breathing rate of this individual. Record your answer in breaths/minute.

Spirograph of a healthy, non-smoking, adult male



- Compare the total lung capacity of this individual with the total lung capacity of an adult male who has been smoking for several years.
- Practitioners of some forms of exercise teach that special breathing techniques can help to relieve stress and improve physical (as well as emotional) well-being. One school of yoga, for example, recommends first inhaling normally and exhaling deeply, and then inhaling deeply and exhaling normally. Infer the effect on the body after a few minutes of this breathing exercise.
 - Explain how diffusion is involved in external respiration. Use graphics software to draw a diagram to support your answer. **ICT**
 - The Canadian Lung Association states, “Just because the air doesn’t stink, doesn’t mean the air doesn’t stink.” Explain what you think the CLA means by this statement. Use examples to support your answer.
 - Use word processing software to draw a flowchart that illustrates why you breathe faster during strenuous exercise. Write a caption for your flowchart, and include all the following terms in your caption: inspiratory reserve volume, waste product, oxygen concentration, rib muscles. **ICT**
 - Breathing is partially under voluntary control, which explains why you can hold your breath. When carbon dioxide levels in the blood reach too high a concentration, however, breathing is triggered involuntarily. Given this information, explain why some swimmers and divers breathe very quickly and hyperventilate before they dive.

Use the following information to answer the next question.

Heimlich Manoeuvre

You are having lunch at a restaurant when someone at the next table begins choking. A bystander rushes over, stands behind the person who is choking, and wraps her arms around him. Then, holding her hands together, just below the person's rib cage, she squeezes with a rapid, upward movement.

- 16. a)** What is this technique intended to accomplish? Explain how it works, with references to the structures and processes involved in respiration.
- b)** Another bystander suggests giving the choking person a glass of water. Would this be a good idea? Explain your answer.

Use this additional information to answer the next question.

The rescuer is successful in dislodging the obstruction that caused the choking. By this time, however, the person has stopped breathing. A medical team with resuscitation equipment arrives on the scene.

- c)** Although carbon dioxide levels stimulate the breathing centre in the brain, why would this individual receive high levels of oxygen gas on his way to the hospital?

Use the following information to answer the next question.

Smoker's Cough

When you inhale tobacco smoke, the respiratory system tries to protect itself by producing mucus and stimulating coughing. Normally, the cilia that line the trachea and bronchi beat outward to sweep harmful substances out of the lungs. Chemicals in smoke paralyze the sweeping action of the cilia. As a result, some of the toxins remain in the lungs and mucus remains in the airways. When you sleep, some cilia recover and start functioning again. On waking, you cough because your lungs are trying to get rid of the toxins from the previous day's smoking. Eventually, after long-term exposure to tobacco smoke, the cilia stop functioning completely.

- 17. a)** Explain why smokers usually wake up coughing in the morning.
- b)** What substances do you expect to be coughed up?
- c)** Identify a lower respiratory disease that could result from smoking, and explain how this disease is related to the long-term exposure to tobacco smoke.

Making Connections

- 18.** Explain how the environment can influence the respiratory system. Identify three respiratory system disorders that are directly related to the environment. Describe the steps that you could take to reduce the effects of the external environment on these disorders.

Use the following information to answer the next question.

Toxic Smoke

You are walking through town when you come to a construction site where waste material is being burned. You want to minimize the amount of smoke you inhale as you pass the site, but the distance is too far for you to simply hold your breath.

- 19.** Do you think the total amount of smoke you inhale will be greater if you take occasional deep breaths or more frequent shallow breaths? Will there be any difference? Explain your reasoning.

Use the following information to answer the next question.

Tracheostomy

Tracheotomy is a surgical procedure that is usually done in the operating room under general anesthesia. A *tracheotomy* is an incision into the trachea (windpipe) that forms a temporary or permanent opening, which is called a *tracheostomy*. Sometimes the terms "tracheotomy" and "tracheostomy" are used interchangeably. The opening, or hole, is called a *stoma*. The incision is usually vertical in children and runs from the second to the fourth tracheal ring.

- 20. a)** Identify the functions that are affected by this alternation to the respiratory system.
- b)** Describe some of the features that must be incorporated into the artificial tracheal cover in order to maintain the integrity of the respiratory system.

Use the following information to answer the next question.

Viral Pharyngitis

You have gone to see your doctor because you have a sore throat, runny nose, post-nasal drip, and a cough. Your doctor diagnoses your symptoms and tells you that you have a viral infection called pharyngitis.

- 21. a)** Identify the parts of the upper respiratory tract that are affected by this disease.
- b)** Explain the symptoms of the disease with respect to the protective mechanisms of the respiratory system.