Body cells require an abundant and continuous supply of oxygen to carry out their activities. As cells use oxygen, they release carbon dioxide, a waste product that must be eliminated from the body. The circulatory and respiratory systems are intimately involved in obtaining and delivering oxygen to body cells and in eliminating carbon dioxide from the body. The respiratory system is responsible for gas exchange between the pulmonary blood and the external environment (that is, external respiration). The respiratory system also plays an important role in maintaining the acid-base balance of the blood.

Questions and activities in this chapter consider both the anatomy and physiology of the respiratory system structures.

**FUNCTIONAL ANATOMY**

1. The following questions refer to the primary bronchi. In the spaces provided, insert the letter R to indicate the right primary bronchus and the letter L to indicate the left primary bronchus.

   1. Which of the primary bronchi is larger in diameter? __________ Right bronchus

   2. Which of the primary bronchi is more horizontal? __________ Right bronchus

   3. Which of the primary bronchi is the most common site for lodging of a foreign object that has entered the respiratory passageways? __________ Right bronchus
2. Complete the following statements by inserting your answers in the answer blanks.

1. external nares
2. nasal septum
3. warm
4. moisten
5. clean / filter
6. sinuses
7. speech
8. oropharynx
9. larynx
10. tonsils
11. (hyaline) cartilaginous
12. pressure
13. anteriorly
14. thyroid
15. vocal cords
16. speak

Air enters the nasal cavity of the respiratory system through the (1) . The nasal cavity is divided by the midline (2) . The nasal cavity mucosa has several functions. Its major functions are to (3) , (4) , and (5) the incoming air. Mucous membrane-lined cavities called (6) are found in several bones surrounding the nasal cavities. They make the skull less heavy and probably act as resonance chambers for (7) . The passageway common to the digestive and respiratory systems, the (8) , is often referred to as the throat; it connects the nasal cavity with the (9) below. Clusters of lymphatic tissue, (10) , are part of the defensive system of the body. Reinforcement of the trachea with (11) rings prevents its collapse during (12) changes that occur during breathing. The fact that the rings are incomplete posteriorly allows a food bolus to bulge (13) during its transport to the stomach. The larynx or voice box is built from many cartilages, but the largest is the (14) cartilage. Within the larynx are the (15) , which vibrate with exhaled air and allow an individual to (16) .

3. Circle the term that does not belong in each of the following groupings.

1. Sphenoidal Maxillary Mandibular Ethmoid Frontal
2. Nasal cavity Trachea Alveolus Larynx Bronchus
3. Apex Base Hilus Larynx Pleura
4. Sinusitis Peritonitis Pleurisy Tonsillitis Laryngitis
5. Laryngopharynx Oropharynx Transports air and food Nasopharynx
6. Alveoli Respiratory zone Alveolar sac Primary bronchus
Figure 13-1 is a sagittal view of the upper respiratory structures. First, correctly identify all structures provided with leader lines on the figure. Then select different colors for the structures listed below and use them to color in the coding circles and the corresponding structures on the figure.

- Nasal cavity
- Pharynx
- Trachea
- Larynx
- Paranasal sinuses

Frontal sinus
Nasal cavity conchae
Sphenoid sinus
Opening of auditory tube
Hard palate
Oral cavity
Soft palate
Lingual tonsil
Epiglottis
Hyoid bone
Trachea
Pharyngeal tonsil
Internal nares
Nasopharynx
Palatine tonsil
Laryngopharynx
Vocal fold
Esophagus
5. Using the key choices, select the terms identified in the following descriptions by inserting the appropriate term or letter in the answer blanks.

**Key Choices**

A. Alveoli  
B. Bronchioles  
C. Conchae  
D. Epiglottis  
E. Esophagus  
F. Glottis  
G. Palate  
H. Parietal pleura  
I. Phrenic nerve  
J. Primary bronchi  
K. Trachea  
L. Visceral pleura

1. Smallest conducting respiratory passageways  
2. Separates the oral and nasal cavities  
3. Major nerve, stimulating the diaphragm  
4. Food passageway posterior to the trachea  
5. Closes off the larynx during swallowing  
6. Windpipe  
7. Actual site of gas exchanges  
8. Pleural layer covering the thorax walls  
9. Pleural layer covering the lungs  
10. Lumen of larynx  
11. Fleshy lobes in the nasal cavity which increase its surface area

6. Complete the following paragraph concerning the alveolar cells and their roles by writing the missing terms in the answer blanks.

**elastic connective tissue**  
(exchanging)  
(primaty)  
(surfactant)  
(decrease the)  
(surface tension)

1. With the exception of the stroma of the lungs, which is **(1)** tissue, the lungs are mostly air spaces, of which the alveoli comprise the greatest part. The bulk of the alveolar walls are made up of squamous epithelial cells, which are well suited for their **(2)** function. Much less numerous cuboidal cells produce a fluid that coats the air-exposed surface of the alveolus and contains a lipid-based molecule called **(3)** that functions to **(4)** of the alveolar fluid.
7. Figure 13–2 is a diagram of the larynx and associated structures. On the figure, identify each of the structures listed below. Select a different color for each and use it to color in the coding circles and the corresponding structures on the figure. Then answer the questions following the diagram.

- Hyoid bone
- Tracheal cartilages
- Circoid cartilage
- Thyroid cartilage
- Epiglottis

**Figure 13–2**

1. What are three functions of the larynx? **Routes air into the lungs and food into the esophagus. It also contains vocal cords responsible for speech.**

2. What type of cartilage forms the epiglottis? **Elastic cartilage**

3. What type of cartilage forms the other eight laryngeal cartilages? **Hyaline cartilage**

4. Explain this difference. **Hyaline cartilage is rigid, keeping the trachea open and larynx open. The elastic cartilage in the epiglottis allows it to be flexible.**

5. What is the common name for the thyroid cartilage? **Adam's apple**
8. Figure 13–3 illustrates the gross anatomy of the lower respiratory system. Intact structures are shown on the left; respiratory passages are shown on the right. Select a different color for each of the structures listed below and use it to color in the coding circles and the corresponding structures on the figure. Then complete the figure by labeling the areas/structures that are provided with leader lines on the figure. Be sure to include the following: pleural space, mediastinum, apex of right lung, diaphragm, clavicle, and the base of the right lung.

- Trachea
- Larynx
- Intact lung
- Primary bronchi
- Secondary bronchi
- Visceral pleura
- Parietal pleura

---

Figure 13–3
9. Figure 13–4 illustrates the microscopic structure of the respiratory unit of lung tissue. The external anatomy is shown in Figure 13–4A. Color the intact alveoli yellow, the pulmonary capillaries red, and the respiratory bronchioles green.

A cross section through an alveolus is shown on Figure 13–4B and a blow-up of the respiratory membrane is shown in Figure 13–4C. On these illustrations color the alveolar epithelium yellow, the capillary endothelium pink, and the red blood cells in the capillary red. Also, label the alveolar chamber and color it pale blue. Finally, in Figure 13–4C label the region of the fused basement membranes; add the symbols for oxygen gas (O₂) and carbon dioxide gas (CO₂) in the sites where they would be in higher concentration and arrows correctly showing their direction of movement through the respiratory membrane.

![Figure 13–4](image-url)
10. Using the key choices, select the terms identified in the following descriptions by inserting the appropriate term or letter in the answer blanks.

**Key Choices**

A. Atmospheric pressure
B. Intrapulmonary pressure
C. Intrapleural pressure

1. In healthy lungs, it is always lower than atmospheric pressure (that is, it is negative pressure)

2. Pressure of air outside the body

3. As it decreases, air flows into the passageways of the lungs

4. As it increases over atmospheric pressure, air flows out of the lungs

5. If this pressure becomes equal to the atmospheric pressure, the lungs collapse

6. Rises well over atmospheric pressure during a forceful cough

11. Many changes occur within the lungs as the diaphragm (and external intercostal muscles) contract and then relax. These changes lead to the flow of air into and out of the lungs. The activity of the diaphragm is given in the left column of the following table. Several changes in condition are listed in the column heads to the right. Complete the table by checking (√) the appropriate column to correctly identify the change that would be occurring relative to the diaphragm's activity in each case.

<table>
<thead>
<tr>
<th>Activity of diaphragm</th>
<th>Changes in Internal volume of thorax</th>
<th>Internal pressure in thorax</th>
<th>Size of lungs</th>
<th>Direction of air flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>(∧ = increased)</td>
<td>∧</td>
<td>∧</td>
<td>↑</td>
<td>Into lung</td>
</tr>
<tr>
<td>(]]= decreased)</td>
<td>↓</td>
<td>↓</td>
<td>↑</td>
<td>Out of lung</td>
</tr>
<tr>
<td>Contracted, moves downward</td>
<td>√</td>
<td></td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>Relaxed, moves superiorly</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td></td>
</tr>
</tbody>
</table>
12. Use the key choices to respond to the following descriptions. Insert the correct term or letter in the answer blanks.

**Key Choices**

A. External respiration  
B.Expiration  
C. Inspiration  
D. Internal respiration  
E. Ventilation (breathing)

1. Period of breathing when air enters the lungs
2. Exchange of gases between the systemic capillary blood and body cells
3. Alternate flushing of air into and out of the lungs
4. Exchange of gases between alveolar air and pulmonary capillary blood

13. Although normal quiet expiration is largely passive due to lung recoil, when expiration must be more forceful (or the lungs are diseased), muscles that increase the abdominal pressure or depress the rib cage are enlisted.

1. Provide two examples of muscles that cause abdominal pressure to rise.  
   ___________ diaphragm and ___________ abdominal muscles

2. Provide two examples of muscles that depress the rib cage.  
   ___________ internal intercostals and ___________ abdominal muscles

14. Four nonrespiratory movements are described here. Identify each by inserting your answers in the spaces provided.

1. Sudden inspiration, resulting from spasms of the diaphragm. ___________ hiccups

2. A deep breath is taken, the glottis is closed, and air is forced out of the lungs against the glottis; clears the lower respiratory passageways. ___________ coughing

3. As just described, but clears the upper respiratory passageways. ___________ sneezing

4. Increases ventilation of the lungs; may be initiated by a need to increase oxygen levels in the blood. ___________ yawning
15. The following section concerns respiratory volume measurements. Using key choices, select the terms identified in the following descriptions by inserting the appropriate term or letter in the answer blanks.

**Key Choices**

A. Dead space volume  
B. Expiratory reserve volume (ERV)  
C. Inspiratory reserve volume (IRV)  
D. Residual volume (RV)  
E. Tidal volume (TV)  
F. Vital capacity (VC)

1. Respiratory volume inhaled or exhaled during normal breathing
2. Air in respiratory passages that does not contribute to gas exchange
3. Total amount of exchangeable air
4. Gas volume that allows gas exchange to go on continuously
5. Amount of air that can still be exhaled (forcibly) after a normal exhalation

16. Figure 13–5 is a diagram showing respiratory volumes. Complete the figure by making the following additions.

1. Bracket the volume representing the vital capacity and color the area yellow; label it VC.
2. Add green stripes to the area representing the inspiratory reserve volume and label it IRV.
3. Add red stripes to the area representing the expiratory reserve volume and label it ERV.
4. Identify and label the respiratory volume, which is *now just yellow*. Color the residual volume (RV) blue and label it appropriately on the figure.
5. Bracket and label the inspiratory capacity (IC).

*Figure 13–5*
17. Use the key choices to correctly complete the following statements, which refer to gas exchanges in the body. Insert the correct letter response in the answer blanks.

Key Choices
A. Active transport
B. Air of alveoli to capillary blood
C. Carbon dioxide-poor and oxygen-rich
D. Capillary blood to alveolar air
E. Capillary blood to tissue cells
F. Diffusion
G. Higher concentration
H. Lower concentration
I. Oxygen-poor and carbon dioxide-rich
J. Tissue cells to capillary blood

1. All gas exchanges are made by (1). When substances pass in this manner, they move from areas of their (2) to areas of their (3). Thus oxygen continually passes from the (4) and then from the (5). Conversely, carbon dioxide moves from the (6) and from (7). From there it passes out of the body during expiration. As a result of such exchanges, arterial blood tends to be (8) while venous blood is (9).

18. Complete the following statements by inserting your answers in the answer blanks.

**hemoglobin** 1. Most oxygen is transported bound to (1) inside the red blood cells. Conversely, *most* carbon dioxide is carried in the form of (2) in the (3). Carbon monoxide poisoning is lethal because carbon monoxide competes with (4) for binding sites.

**bicarbonate ion** 2. 

**blood plasma** 3. 

**oxygen (O₂)** 4. 

19. Circle the term that does not belong in each of the following groupings.

1. ↑ Respiratory rate  ↓ In blood CO₂  Alkalosis  □ Acidosis
2. Acidosis  ↑ Carbonic acid  ↓ pH  □ ↑ pH
3. Acidosis  □ Hyperventilation  Hypoventilation  CO₂ buildup
4. Apnea  Cyanosis  ↓ Oxygen  □ ↑ Oxygen
5. ↑ Respiratory rate  ↑ Exercise  Anger  □ ↑ CO₂ in blood
6. High altitude  ↓ PO₂  ↑ PCO₂  □ ↓ Atmospheric pressure
20. There are several levels of breathing control. Match the structures given in Column B to the appropriate descriptions provided in Column A. Place the correct term or letter response in the answer blanks provided.

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>A. Chemoreceptors in the aortic and carotid bodies</td>
</tr>
<tr>
<td>C</td>
<td>B. Intercostal</td>
</tr>
<tr>
<td>F</td>
<td>C. Inspiratory center</td>
</tr>
<tr>
<td>A</td>
<td>D. Phrenic</td>
</tr>
<tr>
<td>D,</td>
<td>E. Pons centers</td>
</tr>
<tr>
<td></td>
<td>F. Stretch receptors in the lungs</td>
</tr>
</tbody>
</table>

5. Nerves that carry activating impulses to the muscles of inspiration

21. Match the terms in Column B with the pathologic conditions described in Column A.

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>A. Apnea</td>
</tr>
<tr>
<td>F</td>
<td>B. Asthma</td>
</tr>
<tr>
<td>D</td>
<td>C. Chronic bronchitis</td>
</tr>
<tr>
<td>G</td>
<td>D. Dyspnea</td>
</tr>
<tr>
<td>E</td>
<td>E. Emphysema</td>
</tr>
<tr>
<td>C</td>
<td>F. Eupnea</td>
</tr>
<tr>
<td></td>
<td>G. Hypoxia</td>
</tr>
<tr>
<td></td>
<td>H. Lung cancer</td>
</tr>
<tr>
<td></td>
<td>I. Tuberculosis</td>
</tr>
<tr>
<td>C, E, D</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
</tr>
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<td></td>
<td></td>
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<td></td>
<td></td>
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</tr>
</tbody>
</table>

7. Respiratory passageways narrowed by bronchiolar spasms

8. Together called COPD

9. Incidence strongly associated with cigarette smoking; outlook is poor

10. Infection spread by airborne bacteria; a recent alarming increase in drug users and AIDS victims
DEVELOPMENTAL ASPECTS
OF THE RESPIRATORY SYSTEM

22. Mrs. Jones gave birth prematurely to her first child. At birth, the baby weighed 2 lb 8 oz. Within a few hours, the baby had developed severe dyspnea and was becoming cyanotic. Therapy with a positive pressure ventilator was prescribed. Answer the following questions related to the situation just described. Place your responses in the answer blanks.

1. The infant’s condition is referred to as ____________ Infant Respiratory Distress Syndrome (IRDS) ____________

2. It occurs because of a relative lack of ____________ surfactant ____________

3. The function of the deficient substance is to ____________ lowers surface tension of luminal alveolar water, preventing alveolar collapse ____________

4. Explain what the positive pressure apparatus accomplishes. ____________ The ____________ pressure keeps the alveoli from collapsing during expiration ____________

23. Complete the following statements by inserting your answers in the answer blanks.

40–80 1. The respiratory rate of a newborn baby is approximately ____________ (1) ____________ respirations per minute. In a healthy adult, the respiratory range is ____________ (2) ____________ respirations per minute. Most problems that interfere with the operation of the respiratory system fall into one of the following categories: infections such as pneumonia, obstructive conditions such as ____________ (3) ____________ and ____________ (4) ____________, and/or conditions that destroy lung tissue, such as ____________ (5) ____________. With age, the lungs lose their ____________ (6) ____________, and the ____________ (7) ____________ of the lungs decreases. Protective mechanisms also become less efficient, causing elderly individuals to be more susceptible to ____________ (8) ____________.
24. Where necessary, complete statements by inserting the missing word(s)
in the answer blanks.

1. Your journey through the respiratory system is to be on foot. To begin, you simply will walk into your host's external nares. You are miniaturized, and your host is sedated lightly to prevent sneezing during your initial observations in the nasal cavity and subsequent descent.

2. You begin your exploration of the nasal cavity in the right nostril. One of the first things you notice is that the chamber is very warm and humid. High above, you see three large, round lobes, the ____, which provide a large mucosal surface area for warming and moistening the entering air. As you walk toward the rear of this chamber, you see a large lumpy mass of lymphatic tissue, the ____ in the ____, or first portion of the pharynx. As you peer down the pharynx, you realize that it will be next to impossible to maintain your footing during the next part of your journey. It is nearly straight down, and the ____ secretions are like grease. You sit down and dig your heels in to get started. After a quick slide, you land abruptly on one of a pair of flat, sheetlike structures that begin to vibrate rapidly, bouncing you up and down helplessly. You are also conscious of a rhythmic hum during this jostling, and you realize that you have landed on a _____. You pick yourself up and look over the superior edge of the ____, down into the seemingly endless esophagus behind. You chastise yourself for not remembering that the ____ and respiratory pathways separate at this point. Hanging directly over your head is the leaflike ____ cartilage.

Normally, you would not have been able to get this far because it would have closed off this portion of the respiratory tract. With your host sedated, however, that protective reflex does not work.

You carefully begin to pick your way down, using the cartilages as steps. When you reach the next respiratory organ, the ____, your descent becomes much easier, because the structure's C-shaped cartilages form a ladderlike supporting structure. As you climb down the cartilages, your face is stroked rhythmically by soft cellular extensions, or ____. You remember that their function is to move mucus laden with bacteria or dust and other debris toward the ____.

You finally reach a point where the descending passageway splits into two ____, and since you want to control your progress (rather than slide downward), you choose the more horizontal ____.
branclh. If you remain in the superior portion of the lungs, your return trip will be less difficult because the passageways will be more horizontal than steeply vertical. The passageways get smaller and smaller, slowing your progress. As you are squeezing into one of the smallest of the respiratory passageways, a (14), you see a bright spherical chamber ahead. You scramble into this (15), pick yourself up, and survey the area. Scattered here and there are lumps of a substance that looks suspiciously like coal, reminding you that your host is a smoker. As you stand there, a soft rustling wind seems to flow in and out of the chamber. You press your face against the transparent chamber wall and see disc-like cells, (16), passing by in the capillaries on the other side. As you watch, they change from a somewhat bluish color to a bright (17) color as they pick up (18) and unload (19).

You record your observations and then contact headquarters to let them know you are ready to begin your ascent. You begin your return trek, slipping and sliding as you travel. By the time you reach the inferior end of the trachea, you are ready for a short break. As you rest on the mucosa, you begin to notice that the air is becoming close and very heavy. You pick yourself up quickly and begin to scramble up the trachea. Suddenly and without warning, you are hit by a huge wad of mucus and catapulted upward and out onto your host’s freshly pressed handkerchief! Your host has assisted your exit with a (20).

AT THE CLINIC

25. After a long bout of bronchitis, Ms. Dupee complains of a stabbing pain in her side with each breath. What is her probable condition?

Pleurisy (inflammation of the pleura)

26. The Kozloski family is taking a long auto trip. Michael, who has been riding in the back of the station wagon, complains of a throbbing headache. A little later, he seems confused and his face is flushed. What is your diagnosis of Michael’s problem?

There's an exhaust leak into the back of the wagon. Michael has carbon monoxide poisoning.

27. A new mother checks on her sleeping infant, only to find that it has stopped breathing and is turning blue. The mother quickly picks up the baby and pats its back until it starts to breathe. What tragedy has been averted?

This was likely sudden infant death syndrome (SIDS).
28. Joanne Willis, a long-time smoker, is complaining that she has developed a persistent cough. What is your first guess as to her condition? What has happened to her bronchial cilia?

First guess is bronchitis, but as a smoker, her bronchial cilia have been destroyed, and no longer brush mucus into the pharynx.

29. Barbara is rushed to the emergency room after an auto accident. The 8th through 10th ribs on her left side have been fractured and have punctured the lung. What term is used to indicate lung collapse? Will both lungs collapse? Why or why not?

Could be called atelectasis or pneumothorax (specifically) Both lungs will not collapse as the pleura are not connected between the left and right lungs.

30. A young boy is diagnosed with cystic fibrosis. What effect will this have on his respiratory system?

Thick, excessive mucus production will lead to dyspnea. Increased incidence of respiratory infections is likely.

31. Mr. and Ms. Rao took their sick 5-year-old daughter to the doctor. The girl was breathing entirely through her mouth, her voice sounded odd and whiny, and a puslike fluid was dripping from her nose. Which one of the sets of tonsils was most likely infected in this child?

Sounds like the pharyngeal tonsils, AKA adenoid tonsils

32. Assume that you are a second-year nursing student. As your assignment you are asked to explain how each of the following might interfere with a patient’s gas exchange.

1. Iron deficiency that causes a decrease in the number of red blood cells.

   Low RBC count would lead to hypoxia, lethargy, cyanosis.

2. Cystic fibrosis in which the surfaces of the alveoli become coated with thick, sticky mucus.

   Thick mucus hinders O₂ and CO₂ diffusion, Patient suffers dyspnea.

3. The patient is a heavy smoker.

   Cilia in the trachea are destroyed, so patient has chronic cough. Likelihood of developing bronchitis, emphysema, and/or lung cancer is increased.