CHAPTER

13 The Respiratory System

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? _____

2. Which of the primary bronchi is more horizontal? _____

3. Which of the primary bronchi is the most common site for lodging of a foreign object that has entered the respiratory passageways? _____

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

_____ 1.
_____ 2.
_____ 3.
_____ 4.
_____ 5.
_____ 6.
_____ 7.
_____ 8.
_____ 9.
_____ 10.
_____ 11.
_____ 12.
_____ 13.
_____ 14.
_____ 15.
_____ 16.

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

4. 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
- ◯ Larynx
- ◯ Pharynx
- ◯ Paranasal sinuses
- ◯ Trachea

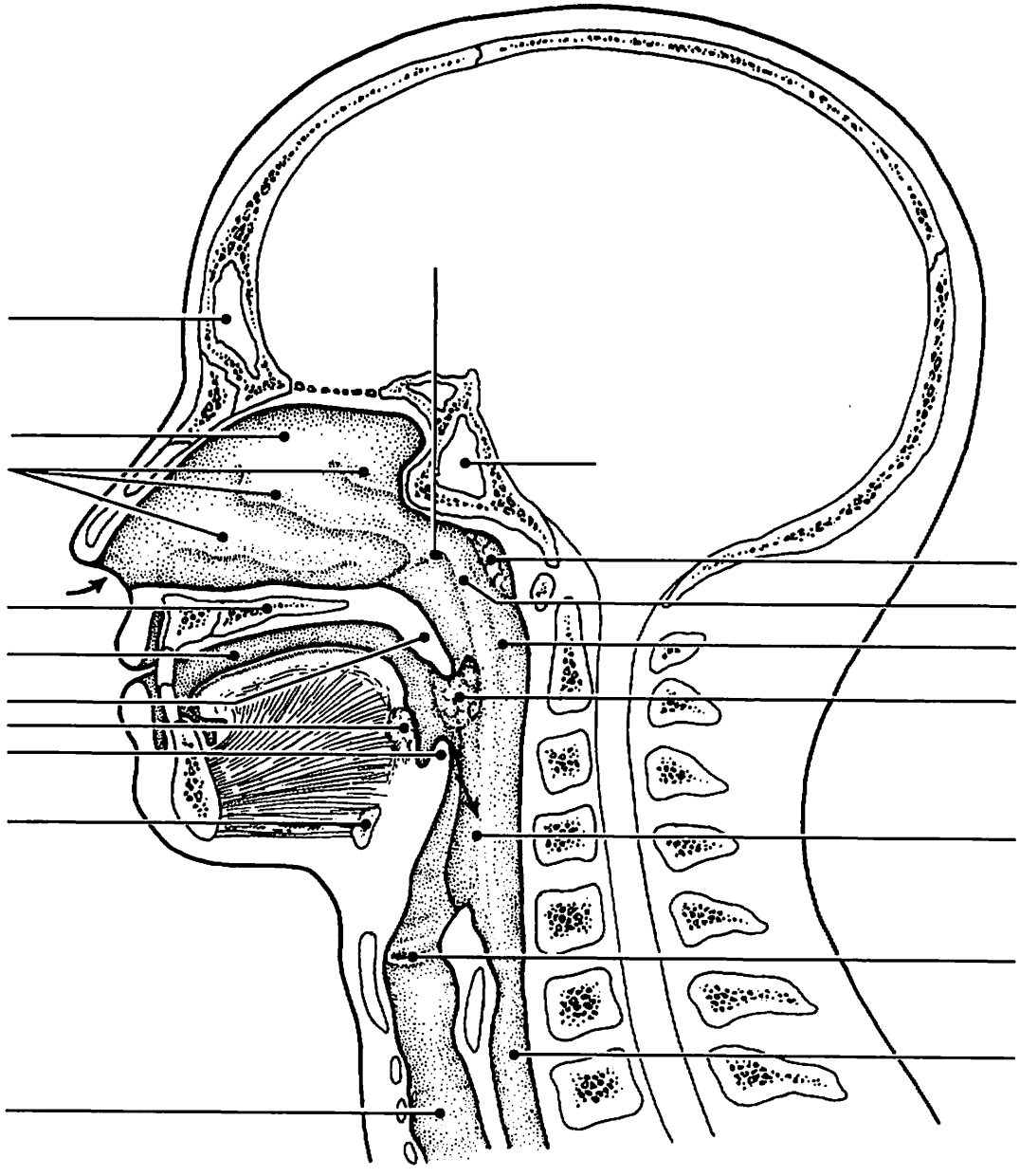


Figure 13–1

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

_____ 1.
_____ 2.
_____ 3.
_____ 4.

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

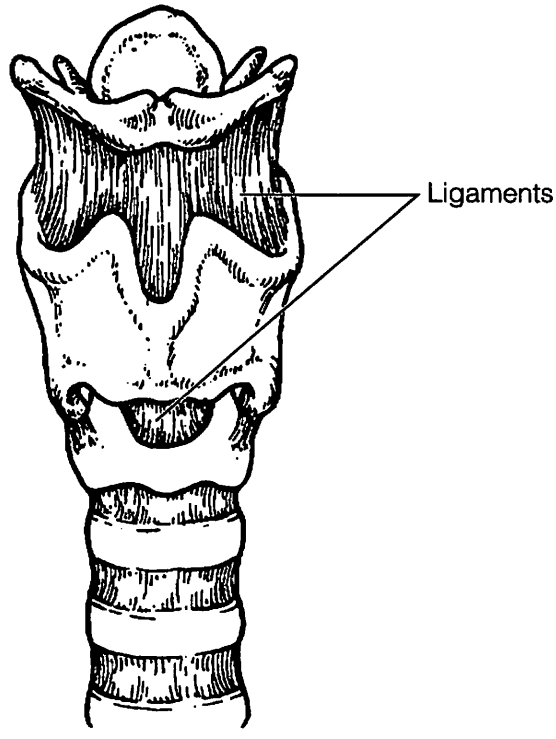


Figure 13–2

1. What are three functions of the larynx? _____

_____

_____

2. What type of cartilage forms the epiglottis? _____

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

4. Explain this difference. _____

_____

_____

5. What is the common name for the thyroid cartilage? _____

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

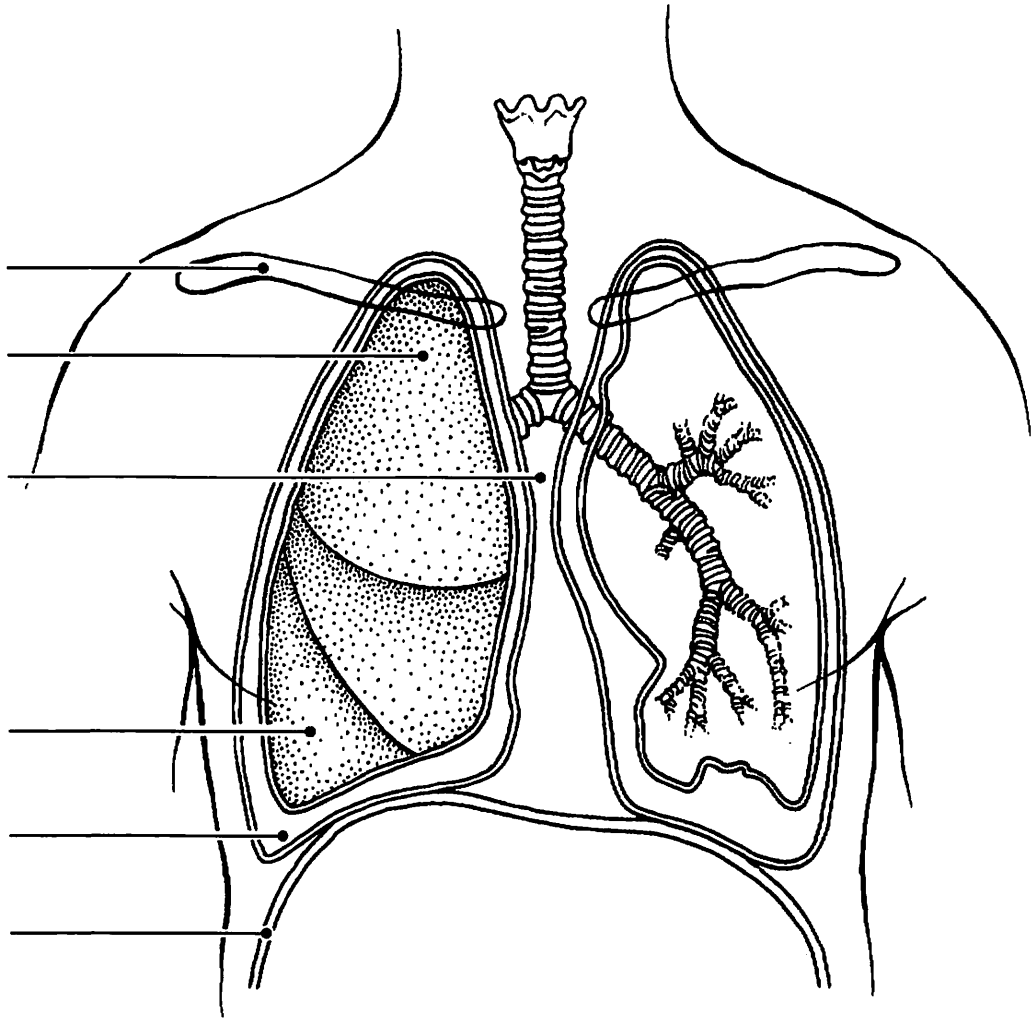
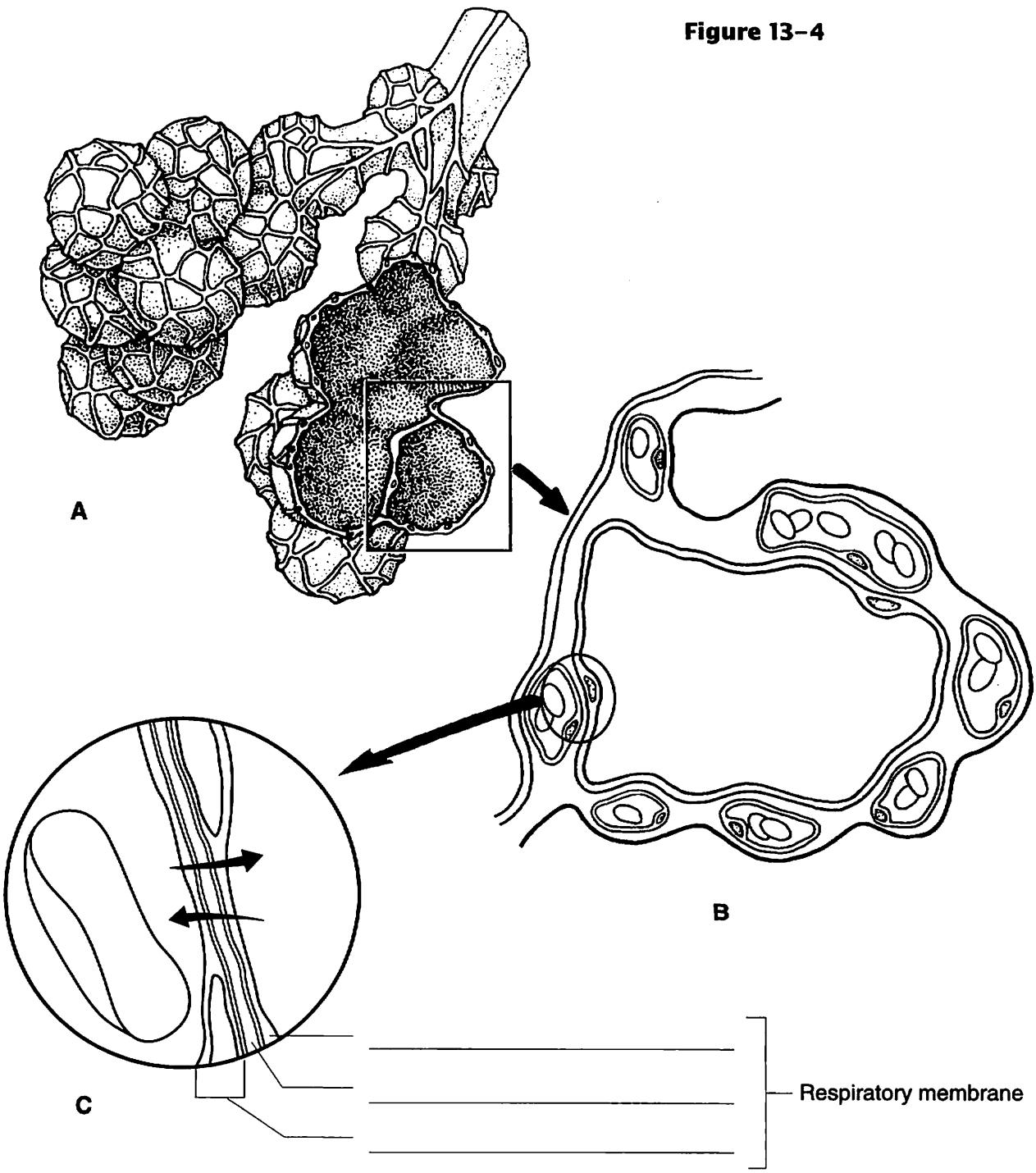


Figure 13–3

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 (O_2) and carbon dioxide gas (CO_2) 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



RESPIRATORY PHYSIOLOGY

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.

Activity of diaphragm	**Changes in**							
	Internal volume of thorax		**Internal pressure in thorax**		**Size of lungs**		**Direction of air flow**	
(↑ = increased) (↓ = decreased)	↑	↓	↑	↓	↑	↓	Into lung	Out of lung
Contracted, moves downward								
Relaxed, moves superiorly								

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.

_____ and _____

2. Provide two examples of muscles that depress the rib cage.

_____ and _____

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. _____
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. _____
3. As just described, but clears the upper respiratory passageways. _____
4. Increases ventilation of the lungs; may be initiated by a need to increase oxygen levels in the blood. _____

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).

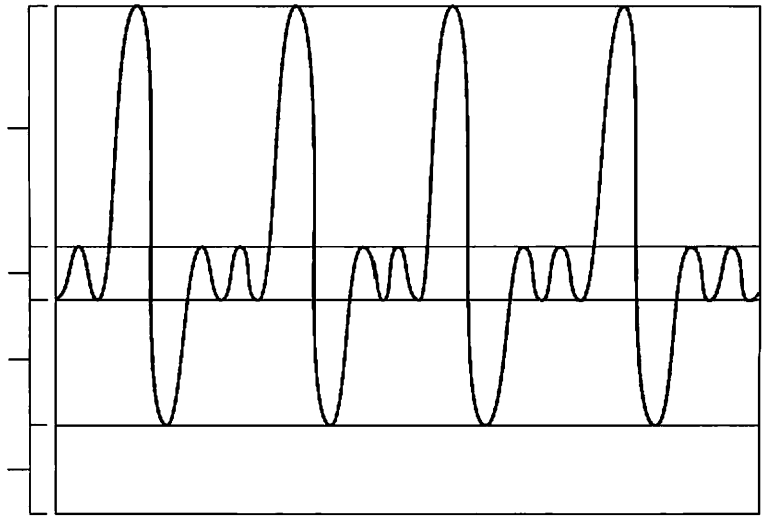


Figure 13–5

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. _____ 2. _____ 3. _____ 4. _____ 5. _____ 6. _____ 7. _____ 8. _____ 9.

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.

_____ 1. _____ 2. _____ 3. _____ 4.

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.

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

1. ↑ Respiratory rate ↓ In blood CO_2 Alkalosis Acidosis
2. Acidosis ↑ Carbonic acid ↓ pH ↑ pH
3. Acidosis Hyperventilation Hypoventilation CO_2 buildup
4. Apnea Cyanosis ↑ Oxygen ↓ Oxygen
5. ↑ Respiratory rate ↑ Exercise Anger ↑ CO_2 in blood
6. High altitude ↓ PO_2 ↑ PCO_2 ↓ 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.

Column A	Column B
_____ 1. Smooth out the basic rhythm of breathing set by the medulla	A. Chemoreceptors in the aortic and carotid bodies
_____ 2. Respiratory control center in the medulla	B. Intercostal
_____ 3. Respond to overinflation of the lungs	C. Inspiratory center
_____ 4. Respond to decreased oxygen levels in the blood	D. Phrenic
_____, _____ 5. Nerves that carry activating impulses to the muscles of inspiration	E. Pons centers
	F. Stretch receptors in the lungs

RESPIRATORY DISORDERS

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

Column A	Column B
_____ 1. Lack or cessation of breathing	A. Apnea
_____ 2. Normal breathing in terms of rate and depth	B. Asthma
_____ 3. Labored breathing, or "air hunger"	C. Chronic bronchitis
_____ 4. Chronic oxygen deficiency	D. Dyspnea
_____ 5. Condition characterized by fibrosis of the lungs and an increase in size of the alveolar chambers	E. Emphysema
_____ 6. Condition characterized by increased mucus production, which clogs respiratory passageways and promotes coughing	F. Eupnea
_____ 7. Respiratory passageways narrowed by bronchiolar spasms	G. Hypoxia
_____ 8. Together called COPD	H. Lung cancer
_____ 9. Incidence strongly associated with cigarette smoking; outlook is poor	I. Tuberculosis
_____ 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 _____

_____

2. It occurs because of a relative lack of _____

3. The function of the deficient substance is to _____

_____

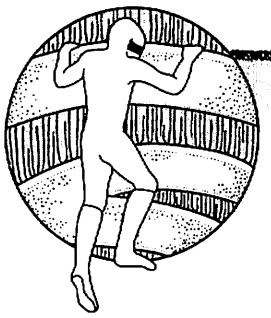
4. Explain what the positive pressure apparatus accomplishes. _____

_____

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

_____ 1.
_____ 2.
_____ 3.
_____ 4.
_____ 5.
_____ 6.
_____ 7.
_____ 8.

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)__.



INCREDIBLE JOURNEY

A Visualization Exercise for the Respiratory System

You carefully begin to pick your way down, using cartilages as steps.

24. Where necessary, complete statements by inserting the missing word(s) in the answer blanks.

_____ 1.
_____ 2.
_____ 3.
_____ 4.
_____ 5.
_____ 6.
_____ 7.
_____ 8.
_____ 9.
_____ 10.
_____ 11.
_____ 12.
_____ 13.

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.

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 __(1)__, 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 __(2)__ in the __(3)__, 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 __(4)__ 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 __(5)__. You pick yourself up and look over the superior edge of the __(6)__, down into the seemingly endless esophagus behind. You chastize yourself for not remembering that the __(7)__ and respiratory pathways separate at this point. Hanging directly over your head is the leaflike __(8)__ 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 __(9)__, 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 __(10)__. You remember that their function is to move mucus laden with bacteria or dust and other debris toward the __(11)__.

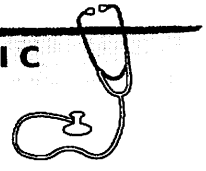
You finally reach a point where the descending passageway splits into two __(12)__, and since you want to control your progress (rather than slide downward), you choose the more horizontal __(13)__

_____ 14.
_____ 15.
_____ 16.
_____ 17.
_____ 18.
_____ 19.
_____ 20.

branch. 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 edge 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?

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?

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?

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?

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?

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

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?

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.

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

3. The patient is a heavy smoker.