Respiratory System

Chapter Concepts

9.1 Respiratory Tract

- Air passes through a series of tubes before gas exchange takes place across a very extensive moist surface. 166

9.2 Mechanism of Breathing

- Respiration comprises breathing, external and internal respiration, and cellular respiration. 170
- During inspiration, the pressure in the lungs decreases, and air comes rushing in. During expiration, increased pressure in the thoracic cavity causes air to leave the lungs. 172–73

9.3 Gas Exchanges in the Body

- External respiration occurs in the lungs where oxygen diffuses into the blood and carbon dioxide diffuses out of the blood. 174
- Internal respiration occurs in the tissues where oxygen diffuses out of the blood and carbon dioxide diffuses into the blood. 174
- The respiratory pigment hemoglobin transports oxygen from the lungs to the tissues and aids in the transport of carbon dioxide from the tissues to the lungs. 174

9.4 Respiration and Health

- The respiratory tract is especially subject to disease because it is exposed to infectious agents. 177
- Smoking tobacco contributes to three major lung disorders—chronic bronchitis, emphysema, and cancer. 179, 181

9.5 Homeostasis

- The respiratory system works with the other systems of the body to maintain homeostasis. 184

Respiratory System

Respiratory Tract :- Air passes through a series of tubes before gas exchange takes place across a very extensive moist surface.

The lung:- Soft cone shaped organ that occupy a large portion of the thoracic cavity: the function gas exchange .

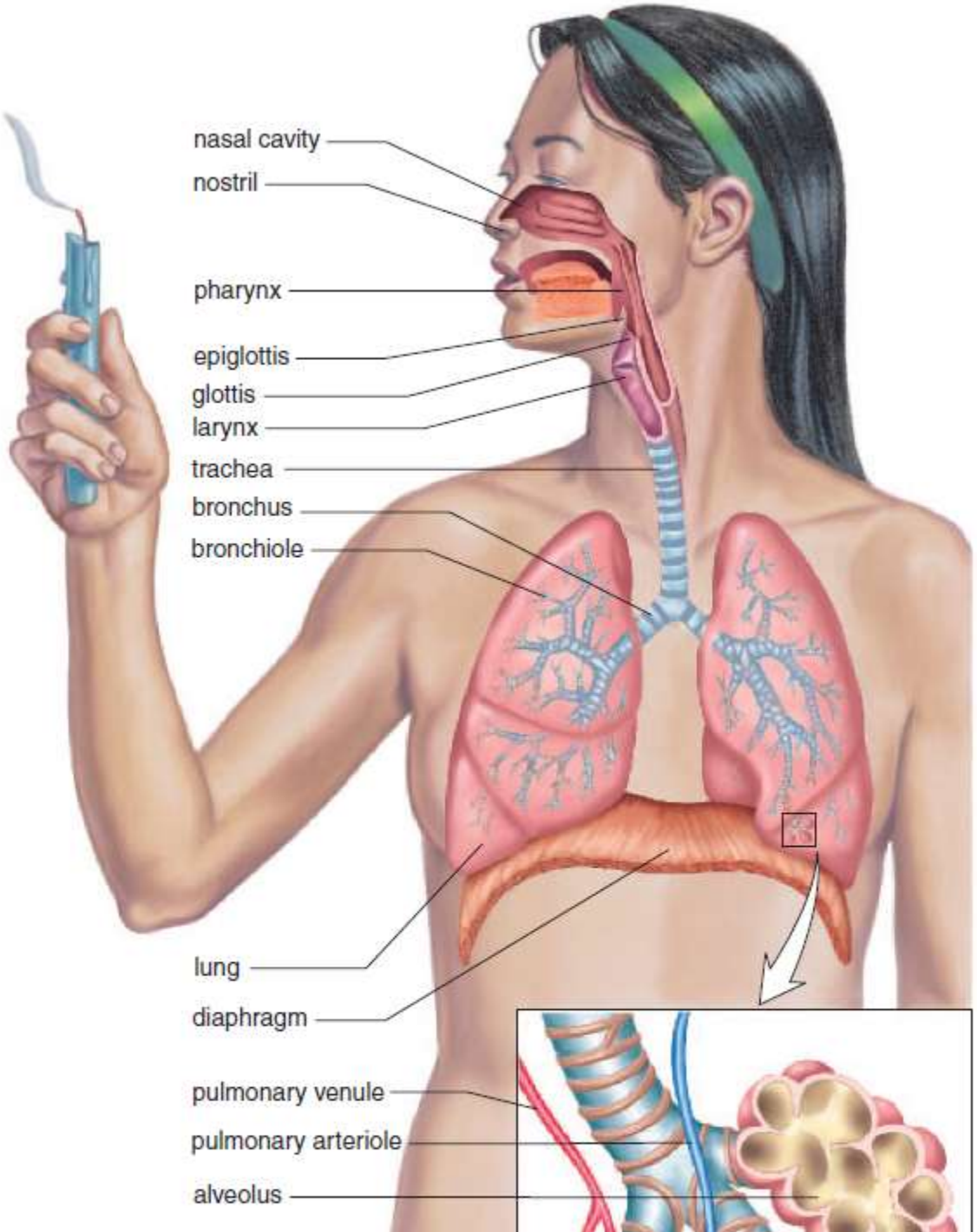

nasal cavity
nostril
pharynx
epiglottis
glottis
larynx
trachea
bronchus
bronchiole
lung
diaphragm
pulmonary venule
pulmonary arteriole
alveolus

Table 9.1 Path of Air

Structure	Description	Function
Nasal cavities	Hollow spaces in nose	Filter, warm, and moisten air
Pharynx	Chamber behind oral cavity and between nasal cavity and larynx	Connection to surrounding regions
Glottis	Opening into larynx	Passage of air into larynx
Larynx	Cartilaginous organ that contains vocal cords (voice box)	Sound production
Trachea	Flexible tube that connects larynx with bronchi (windpipe)	Passage of air to bronchi
Bronchi	Divisions of the trachea that enter lungs	Passage of air to lungs
Bronchioles	Branched tubes that lead from bronchi to the alveoli	Passage of air to each alveolus
Lungs	Soft, cone-shaped organs that occupy a large portion of the thoracic cavity	Gas exchange

Respiratory Trac

- During **inspiration** or inhalation (breathing in) and **expiration** or exhalation (breathing out),
- Air is conducted toward or away from the lungs by
- a series of cavities, tubes, and openings.
- traces the path of air from the nose to the lungs. As air moves in along the airways,
- it is filtered, warmed, and moistened. Filterin is accomplished by coarse hairs, cilia, and mucus in the region of the nostrils In the nose, the hairs and the cilia act as a screening device.
- In the trachea and other airways, the cilia beat upward, carrying mucus, dust, and occasional bits of food that “went down the wrong way” into the pharynx, where the accumulation can be swallowed or expectorated.
- The air is warmed by heat given off by the blood vessels lying close to the surface of the lining of the airways,
- and it is moistened by the wet surface of these passages.

Gas Exchanges in the Body

Mechanism of Breathing

Respiration **Consist** breathing, external and internal respiration, .

External respiration occurs in the lungs where oxygen diffuses into the blood and carbon dioxide diffuses out of the blood to air sac of alveoli .

During inspiration, the pressure in the lungs decreases, and air comes rushing in.

During expiration, increased pressure in the thoracic cavity causes air to leave the lungs.

Internal respiration(Cellular respiration). occurs in the tissues where oxygen diffuses out of the blood and carbon dioxide diffuses into the blood.

The respiratory pigment hemoglobin transports oxygen from the lungs to the tissues and aids in the transport of carbon dioxide from the tissues to the lungs

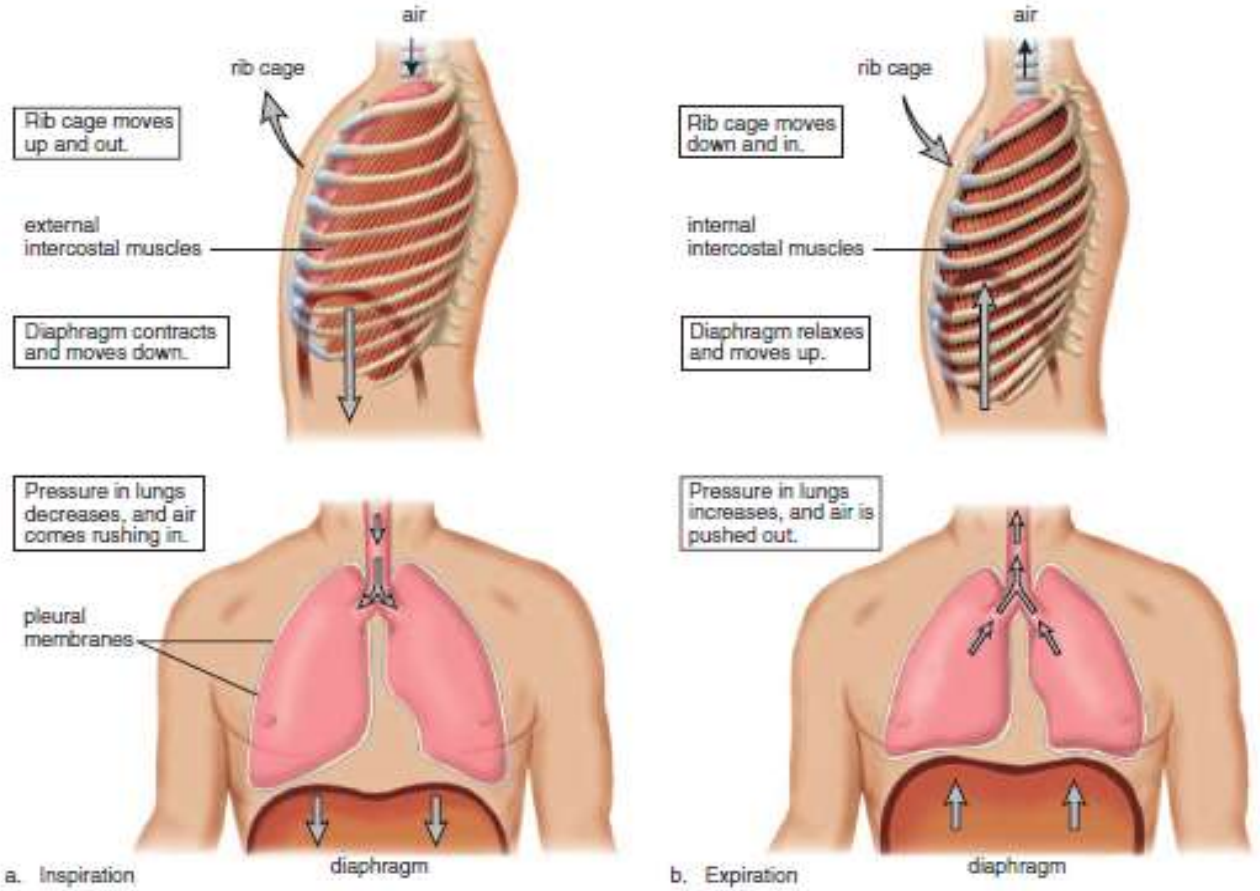


Figure 9.8 **Inspiration versus expiration.**
a. During inspiration, the thoracic cavity and lungs expand so that air is drawn in. **b.** During expiration, the thoracic cavity and lungs resume their original positions and pressures. Now, air is forced out.

The Bronchial Tree

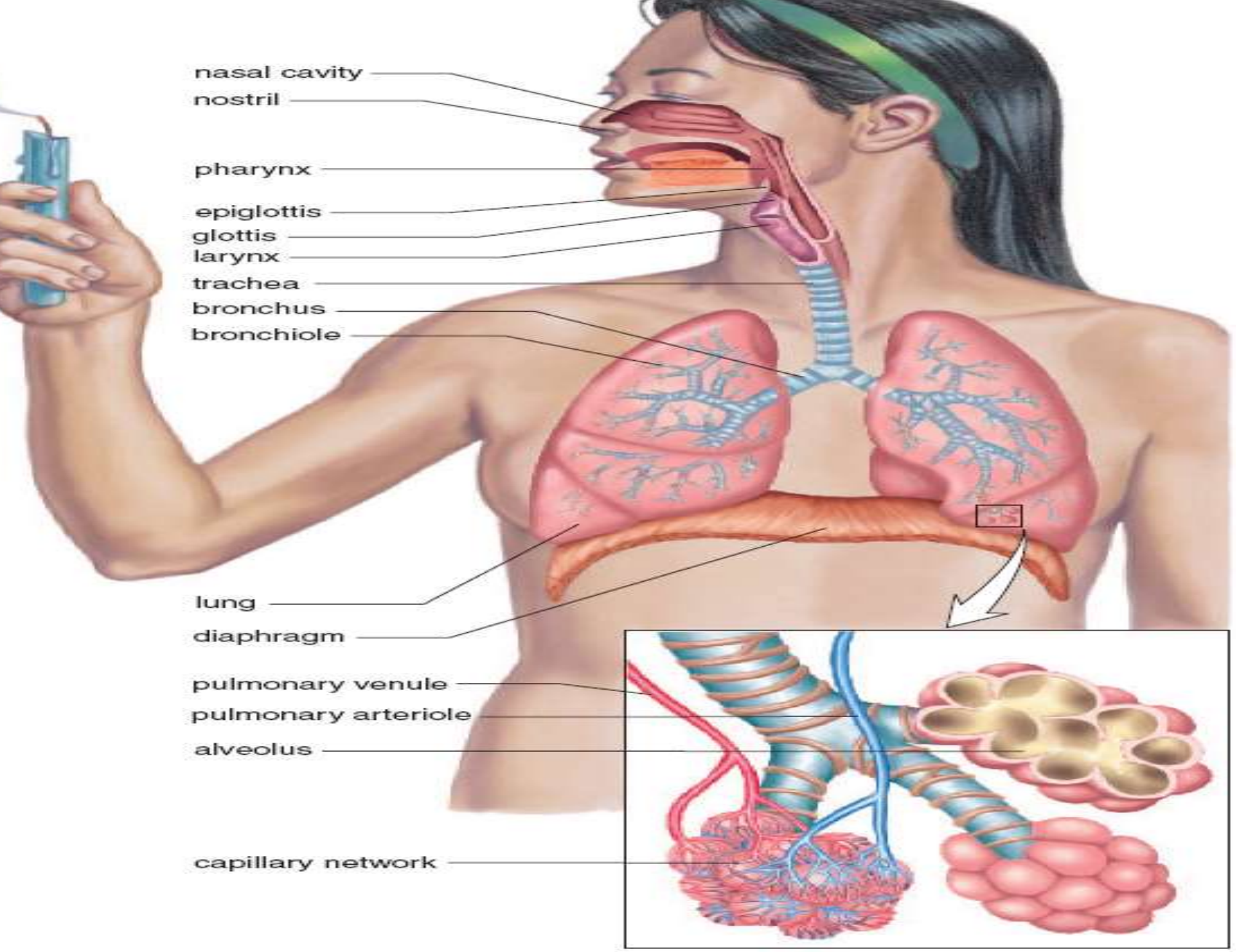
- The trachea divides into right and left primary bronchi (sing., **bronchus**), which lead into the right and left lungs
- The bronchi branch into a great number of secondary bronchi that eventually lead to **bronchioles.**
- The bronchi resemble the trachea in structure, but as the bronchial tubes divide and subdivide, their walls become thinner,and the small rings of cartilage are no longer present.
- During an asthma attack, the smooth muscle of the bronchioles contracts, causing bronchiolar constriction and characteristic wheezing.

The Lungs

- The **lungs** are paired, cone-shaped organs within the thoracic cavity. The right lung has three lobes,
- and the left lung has two lobes, allowing room for the heart,.
- The lungs lie on either side of the heart in the thoracic cavity. The base of each lung is broad and concave so that it fits the convex surface of the diaphragm.
- A lobe is further divided into lobules, and each lobule has a bronchiole serving many alveoli.

The Alveoli

- Each alveolar sac is made up of simple squamous epithelium surrounded by blood capillaries.
- Gas exchange occurs between air in the alveoli and blood in the capillaries ,Oxygen diffuses across the alveolar wall and enters the bloodstream, while carbon dioxide diffuses from the blood across the alveolar wall to enter the alveoli.
- The alveoli of human lungs are lined with a surfactant, a
- film of lipoprotein that lowers the surface tension and prevents them from closing..
- There are altogether about 300 million alveoli, with a total
- cross-sectional area of 50–70 m2. Because of their many air
- spaces, the lungs are very light; normally, a piece of lung tissue dropped in a glass of water floats.


nasal cavity
nostril
pharynx
epiglottis
glottis
larynx
trachea
bronchus
bronchiole
lung
diaphragm
pulmonary venule
pulmonary arteriole
alveolus
capillary network

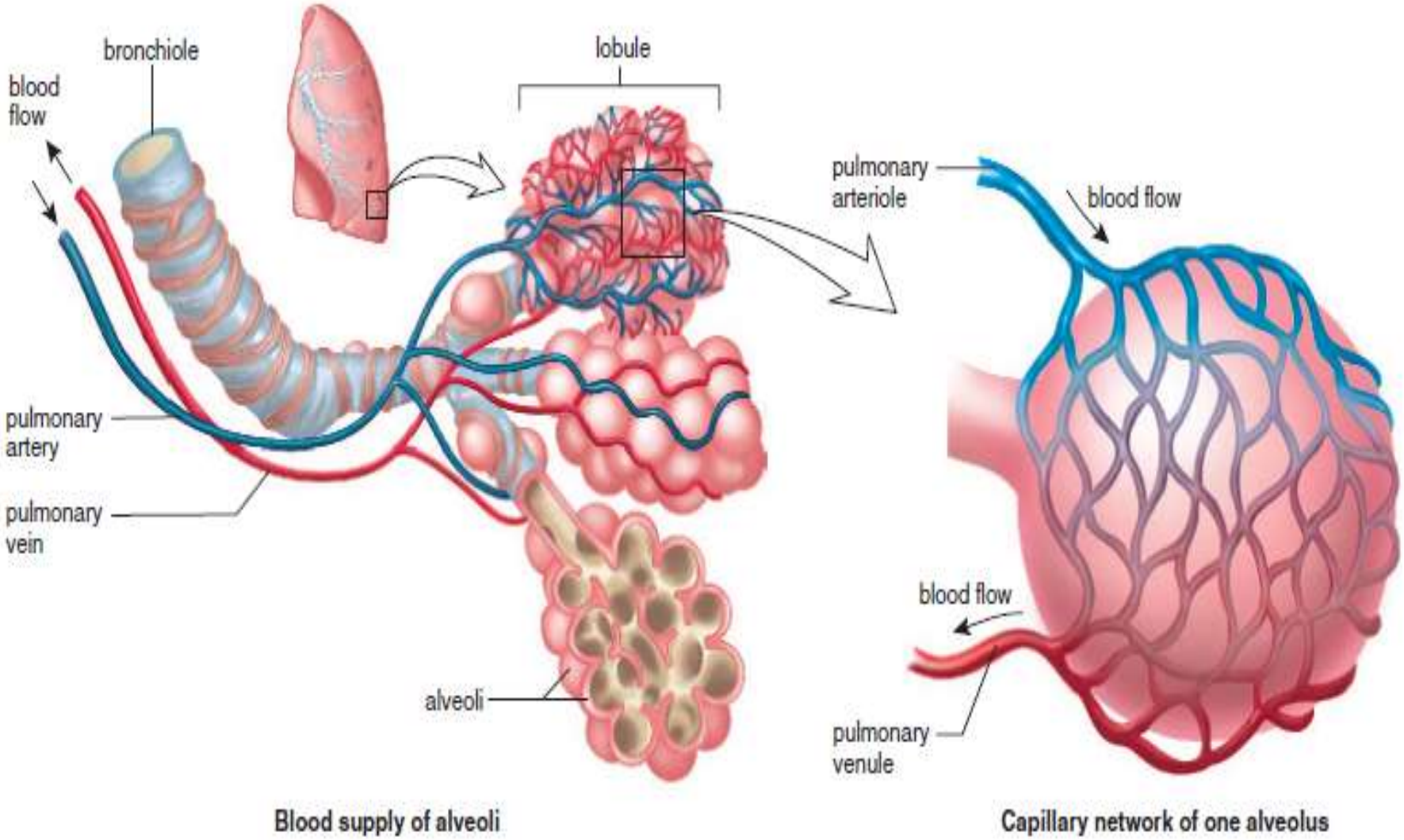


Figure 9.5 **Gas exchange in the lungs.**

The lungs consist of alveoli, surrounded by an extensive capillary network. Notice that the pulmonary arteriole carries O_2-poor blood (colored blue) and the pulmonary venule carries O_2-rich blood (colored red).

Respiratory Volumes

When we breathe, the normal amount of air moved in and out with each breath is called the **tidal volume.** The tidal volume is about 500 ml, but we can increase the amount inhaled and exhaled by deep breathing. The maximum volume of air that can be moved in and out during a single breath is called the **vital capacity** (Fig. 9.6).

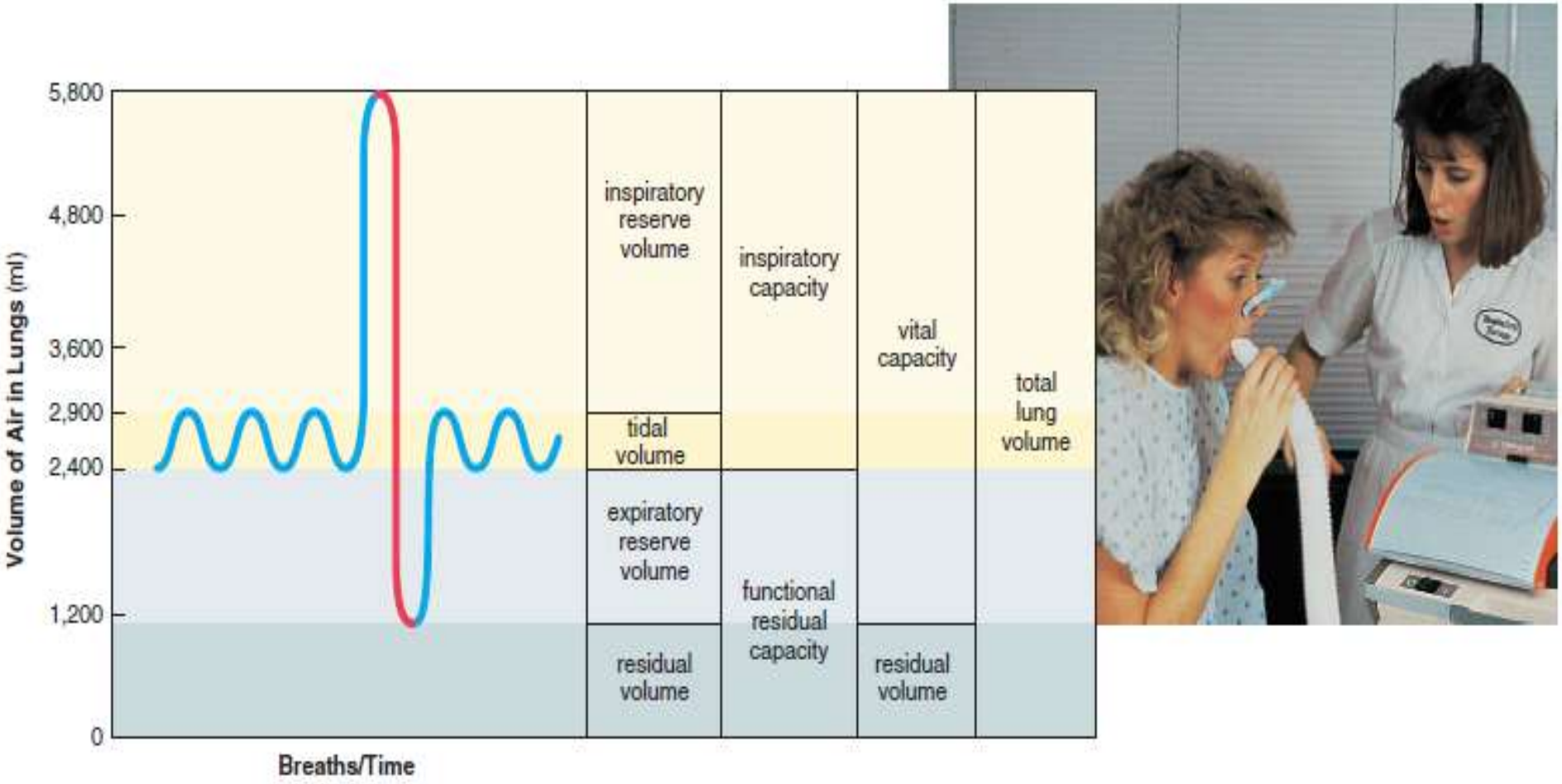


Figure 9.6 Vital capacity.
A spirometer measures the amount of air inhaled and exhaled with each breath. During inspiration, the pen moves up and during expiration, the pen moves down. Vital capacity (red) is the maximum amount of air a person can exhale after taking the deepest inhalation possible.

9.2 Mechanism of Breathing

The term respiration refers to the complete process of supplying oxygen to body cells for cellular respiration and the reverse process of ridding the body of carbon dioxide given off by cells. Respiration includes the following components:

1. Breathing: *inspiration* (entrance of air into the lungs) and *expiration* (exit of air from the lungs).
2. *External respiration:* exchange of the gases oxygen (O_2) and carbon dioxide (CO_2) between air and blood in the lungs.
3. *Internal respiration:* exchange of the gases O_2 and CO_2 between blood and tissue fluid.
4. *Cellular respiration:* production of ATP in cells.

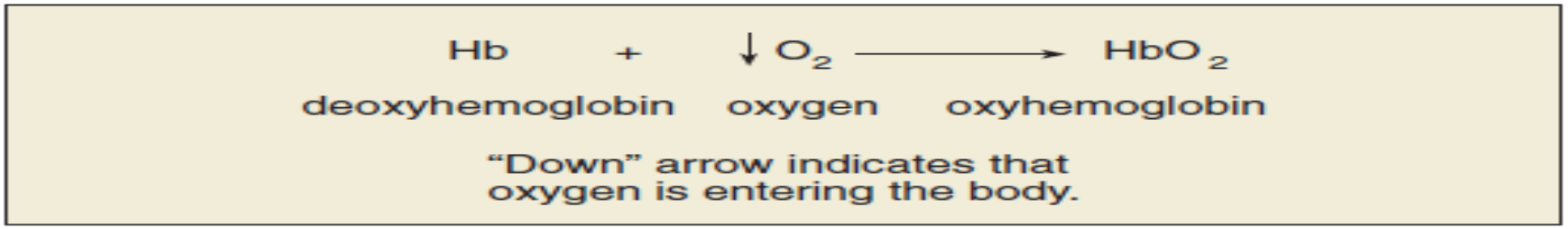
Gas Exchanges in the Body

External respiration occurs in the lungs where oxygen diffuses into the blood and carbon dioxide diffuses out of the blood.

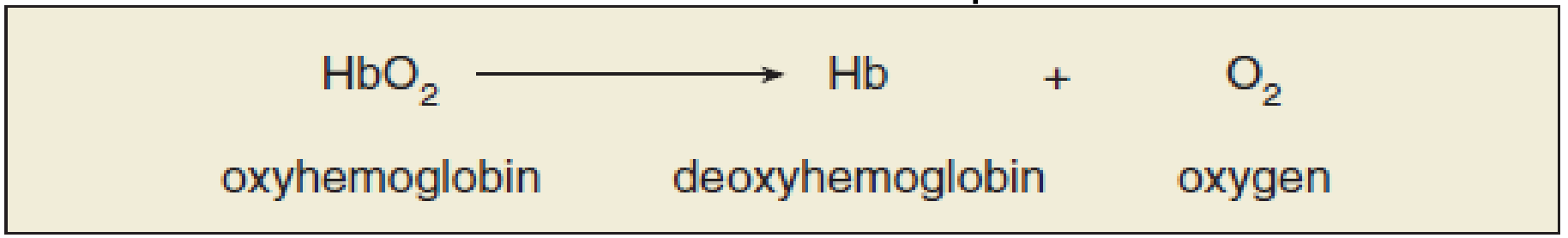
Internal respiration occurs in the tissues where oxygen diffuses out of the blood to tissues and carbon dioxide diffuses from tissues to the blood.

The respiratory pigment hemoglobin transports oxygen from the lungs to the tissues and aids in the transport of carbon dioxide from the tissues to the lungs

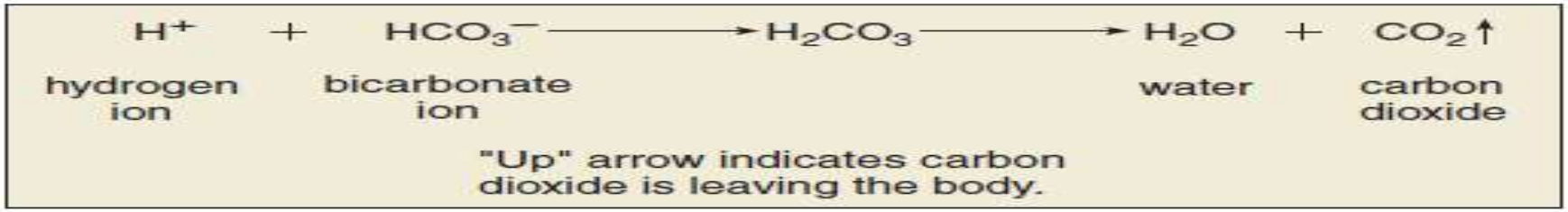
O2 in the air sac diffuse to the blood through the lung in external respiration



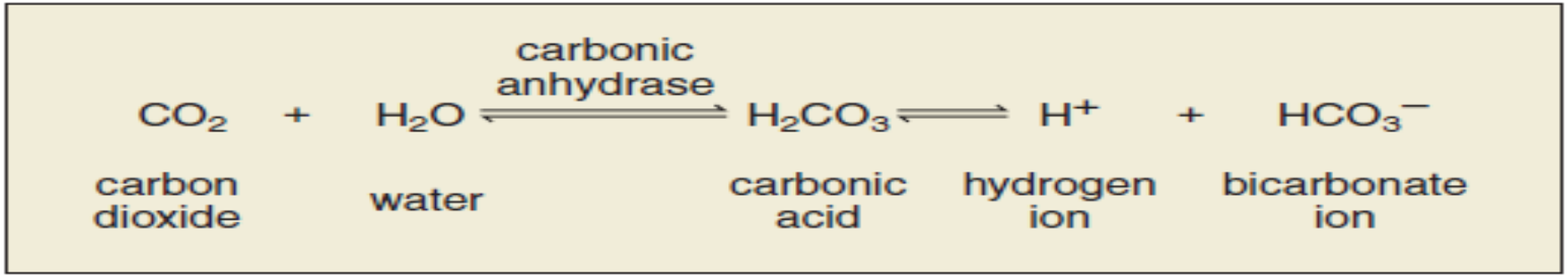
O2 in the blood diffuse to the tissue in internal respiration

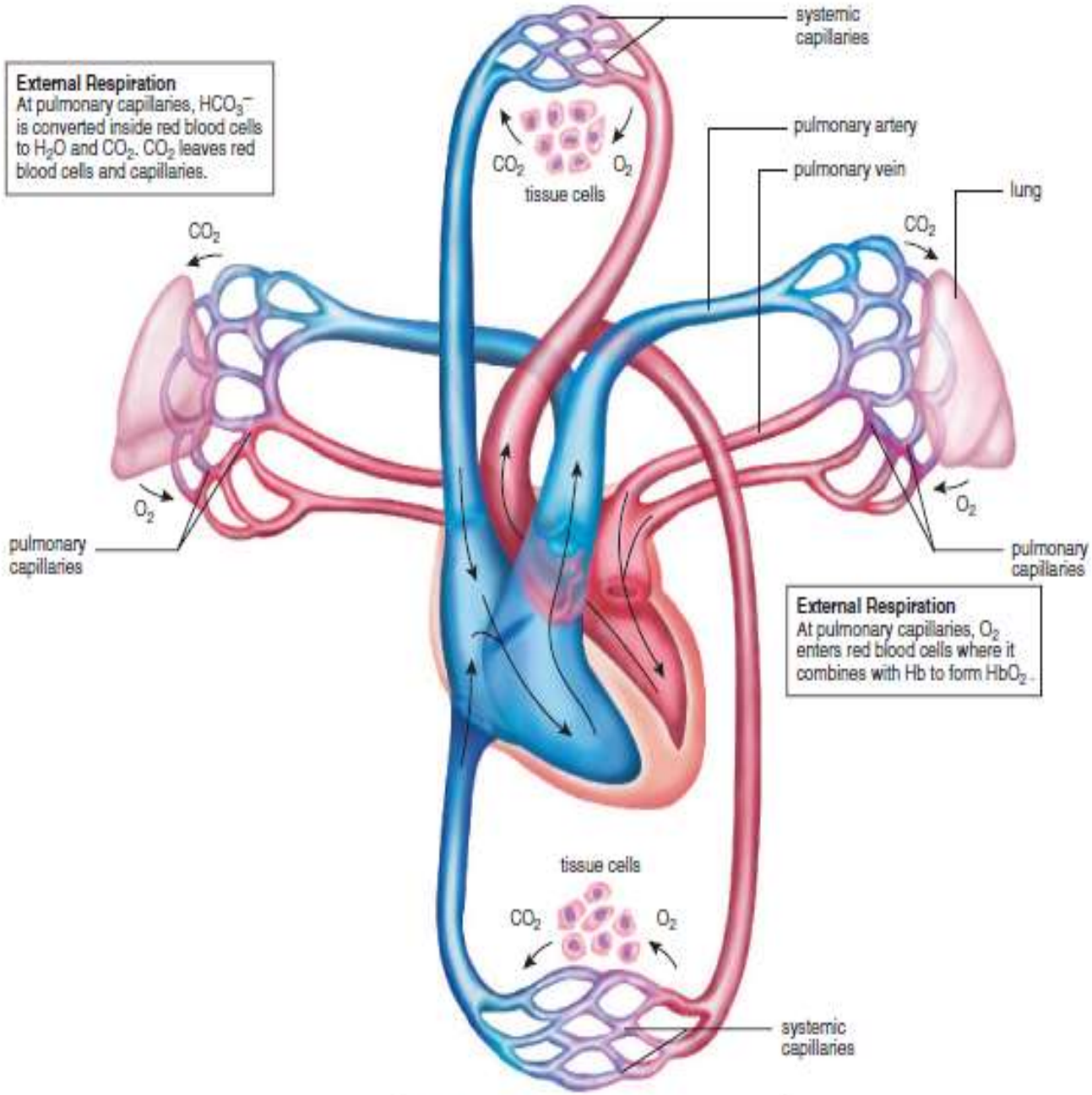


CO2 in the blood diffuse out to the air sac through the lung in external respiration



CO2 in the tissue fluid diffuse to the blood in internal respiration




External Respiration
At pulmonary capillaries, HCO_3^- is converted inside red blood cells to H_2O and CO_2. CO_2 leaves red blood cells and capillaries.
systemic capillaries
pulmonary artery
pulmonary vein
lung
CO_2
O_2
tissue cells
CO_2
O_2
pulmonary capillaries
pulmonary capillaries
External Respiration
At pulmonary capillaries, O_2 enters red blood cells where it combines with Hb to form HbO_2.
tissue cells
CO_2
O_2
systemic capillaries
Internal Respiration
At systemic capillaries, CO_2 enters red blood cells.

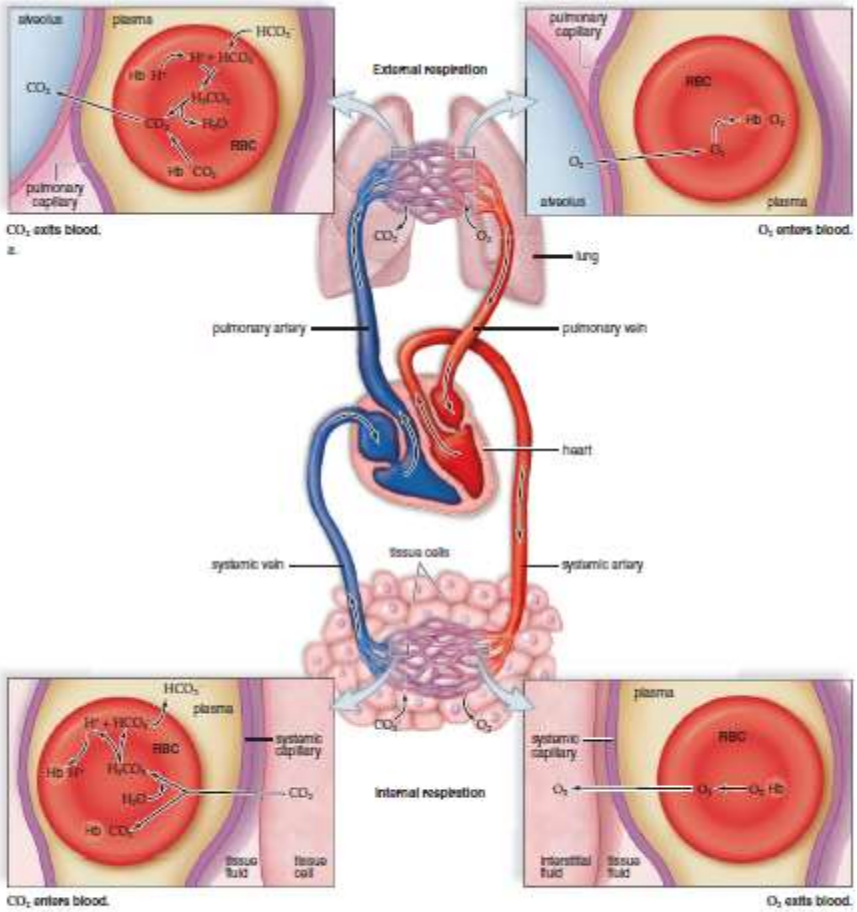


Figure 10.11 Movement of gases during external and internal respiration.
a. During external respiration in the lungs, HCO_3^- is converted to CO_2, which exits the blood. O_2 enters the blood and hemoglobin (Hb) carries O_2 to the tissues. **b.** During internal respiration in the tissues, O_2 exits the blood, and CO_2 enters the blood. Most of the CO_2 enters red blood cells, where it becomes the bicarbonate ion, carried in the plasma. Some hemoglobin combines with CO_2 and some combines with H^+.

9.3 Gas Exchanges in the Body

Gas exchange is critical to homeostasis. The act of breathing brings oxygen in air to the lungs and carbon dioxide from the lungs to outside the body. Respiration includes not only the exchange of gases in the lungs, but also the exchange of gases in the tissues (Fig. 9.9). The principles of diffusion alone govern whether O_2 or CO_2 enters or leaves the blood in the lungs and in the tissues.

External Respiration

External respiration refers to the exchange of gases between air in the alveoli and blood in the pulmonary capillaries. Gases exert pressure, and the amount of pressure each gas exerts is its partial pressure, symbolized as P_{O_2} and P_{CO_2}. Blood entering the pulmonary capillaries has a higher P_{CO_2} than atmospheric air. Therefore, *CO_2 diffuses out of the blood into the lungs*. Most of the CO_2 is carried as **bicarbonate ions** (HCO_3^-). As the little remaining free CO_2 begins to diffuse out, the following reaction is driven to the right:

$$H^+ + HCO_3^- \longrightarrow H_2CO_3 \longrightarrow H_2O + CO_2\uparrow$$

hydrogen ion; bicarbonate ion; water; carbon dioxide

"Up" arrow indicates carbon dioxide is leaving the body.

The enzyme **carbonic anhydrase,** present in red blood cells, speeds up the reaction. This reaction requires that the respiratory pigment **hemoglobin,** also present in red blood cells, gives up the hydrogen ions (H^+) it has been carrying; that is HHb becomes Hb. Hb is called deoxyhemoglobin.

The pressure pattern is the reverse for O_2. Blood entering the pulmonary capillaries is low in oxygen, and alveolar air contains a much higher partial pressure of oxygen. Therefore, *O_2 diffuses into plasma and then red blood cells in the lungs*. Hemoglobin takes up this oxygen and becomes **oxyhemoglobin** (HbO_2).

$$Hb + O_2 \longrightarrow HbO_2$$

Internal Respiration

Internal respiration refers to the exchange of gases between the blood in systemic capillaries and the tissue fluid. Blood that enters the systemic capillaries is a bright red color because red blood cells contain oxyhemoglobin. Oxyhemoglobin gives up O_2, which diffuses out of blood into the tissues.

$$HbO_2 \longrightarrow Hb + O_2$$

oxyhemoglobin; deoxyhemoglobin; oxygen

Oxygen diffuses out of the blood into the tissues because the P_{O_2} of tissue fluid is lower than that of blood. The lower P_{O_2} is due to cells continuously using up oxygen in cellular respiration. *Carbon dioxide diffuses into the blood from the tissues* because the P_{CO_2} of tissue fluid is higher than that of blood. Carbon dioxide, produced continuously by cells, collects in tissue fluid.

After CO_2 diffuses into the blood, it enters the red blood cells, where a small amount is taken up by hemoglobin, forming **carbaminohemoglobin.** Most of the CO_2 combines with water, forming carbonic acid (H_2CO_3), which dissociates to hydrogen ions (H^+) and bicarbonate ions (HCO_3^-). The increased concentration of CO_2 in the blood drives the reaction to the right.

$$CO_2 + H_2O \xrightleftharpoons{\text{carbonic anhydrase}} H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$$

carbon dioxide; water; carbonic acid; hydrogen ion; bicarbonate ion

The enzyme carbonic anhydrase, present in red blood cells, speeds up the reaction. Bicarbonate ions diffuse out of red blood cells and are carried in the plasma. The globin portion of hemoglobin combines with excess hydrogen ions produced by the overall reaction, and Hb becomes HHb, called **reduced hemoglobin.** In this way, the pH of blood remains fairly constant. Blood that leaves the capillaries is a dark maroon color because red blood cells contain reduced hemoglobin.

External and internal respiration are the movement