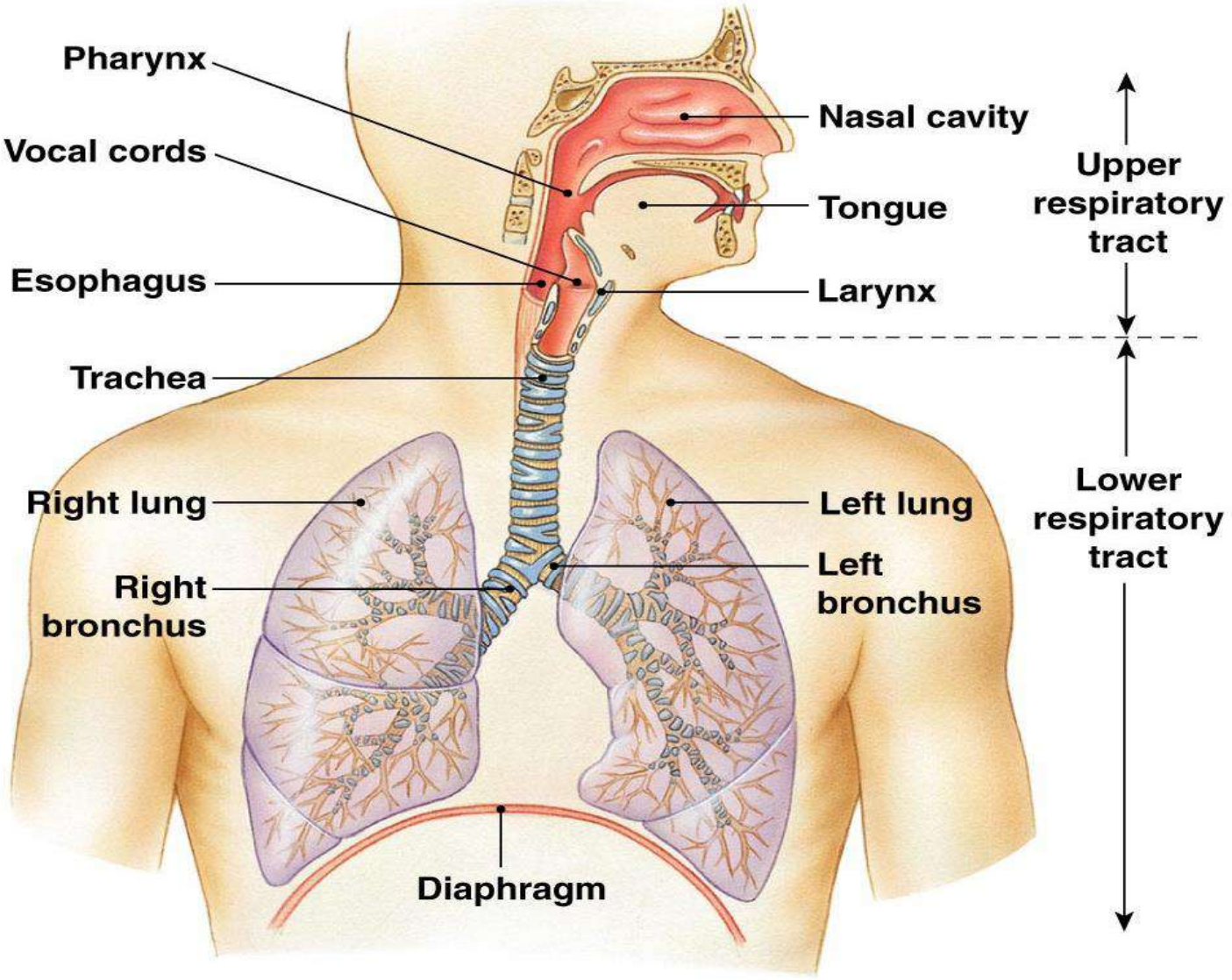
Respiratory System

Respiratory System

- Consists of the respiratory and conducting zones
- **Respiratory zone:**
  - Site of gas exchange
  - Consists of bronchioles, alveolar ducts, and alveoli
- **Conducting zone:**
  - Conduits for air to reach the sites of gas exchange
  - Includes all other respiratory structures (e.g., nose, nasal cavity, pharynx, trachea)
- **Respiratory muscles:**
- Diaphragm, Intercostals, Abdominal and other muscles that promote ventilation

Respiratory System



igure 22.1

Respiration – four distinct processes

- **Pulmonary ventilation** – moving air into and out of the lungs
- **Chemical Respiration**– gas exchange between the lungs and the blood
- **Transport** – transport of oxygen and carbon dioxide between the lungs and tissues
- **Internal respiration** – gas exchange between systemic blood vessels and tissues

Major Functions of the Respiratory System

- To supply the body with oxygen and dispose of carbon dioxide

- **WHAT ELSE?????**

Function of the Nose

- The only externally visible part of the respiratory system that functions by:
  - Providing an airway for respiration
  - Moistening and warming the entering air
  - Filtering inspired air and cleaning it of foreign matter
  - Serving as a resonating chamber for speech
  - Housing the olfactory receptors

Nasal Cavity

- **Vestibule** – nasal cavity superior to the nares
  - Vibrissae – hairs that filter coarse particles from inspired air
- **Olfactory mucosa**
  - Lines the superior nasal cavity
  - Contains smell receptors
- **Respiratory mucosa**
  - Lines the balance of the nasal cavity
  - Glands secrete mucus containing lysozyme and defensins to help destroy bacteria

Nasal Cavity

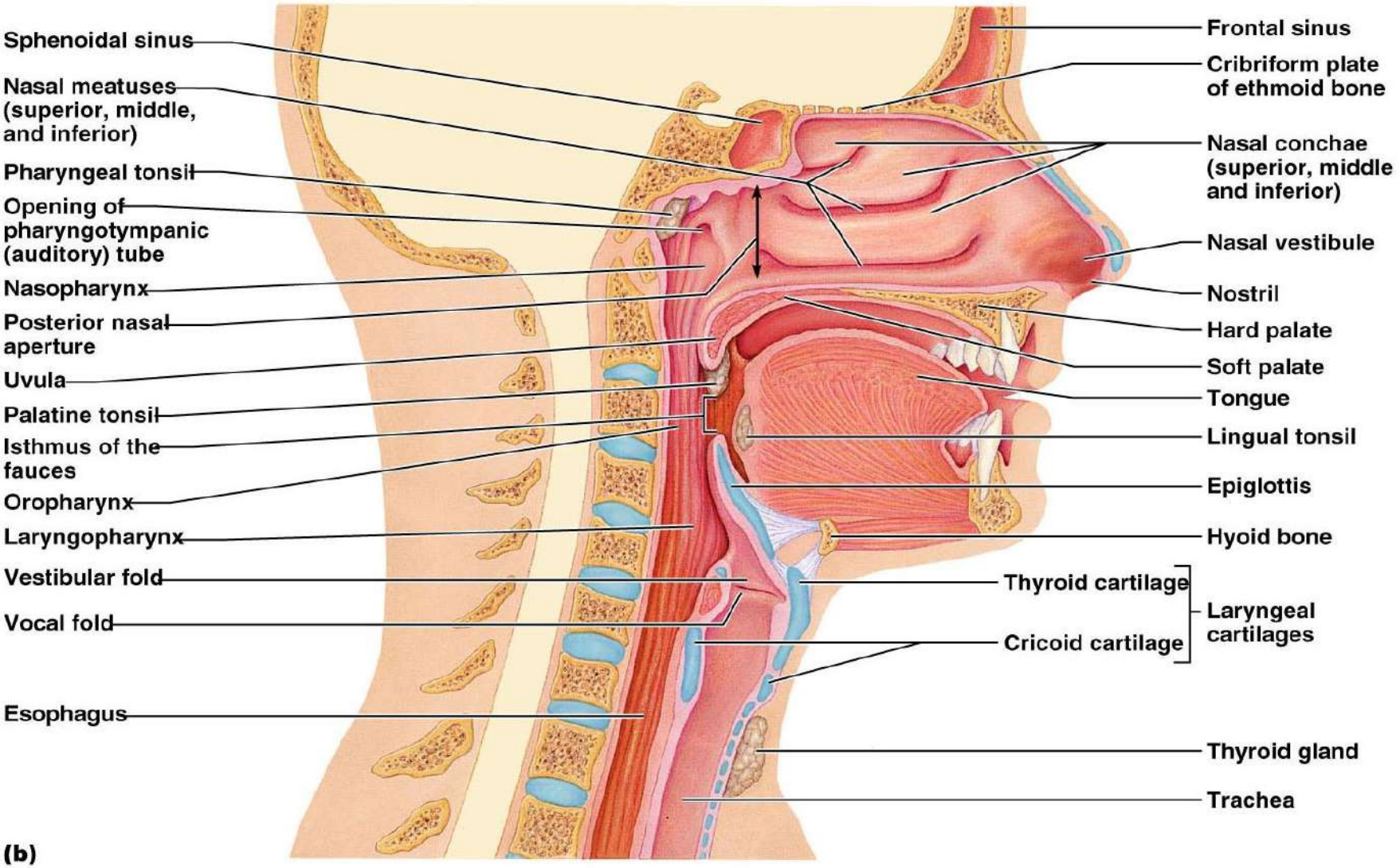


Figure 22.3b

Functions of the Nasal Mucosa

- During inhalation the conchae and nasal mucosa:
  - **Filter, heat, and moisten air**
- During exhalation these structures:
  - Reclaim heat and moisture
  - Minimize heat and moisture loss

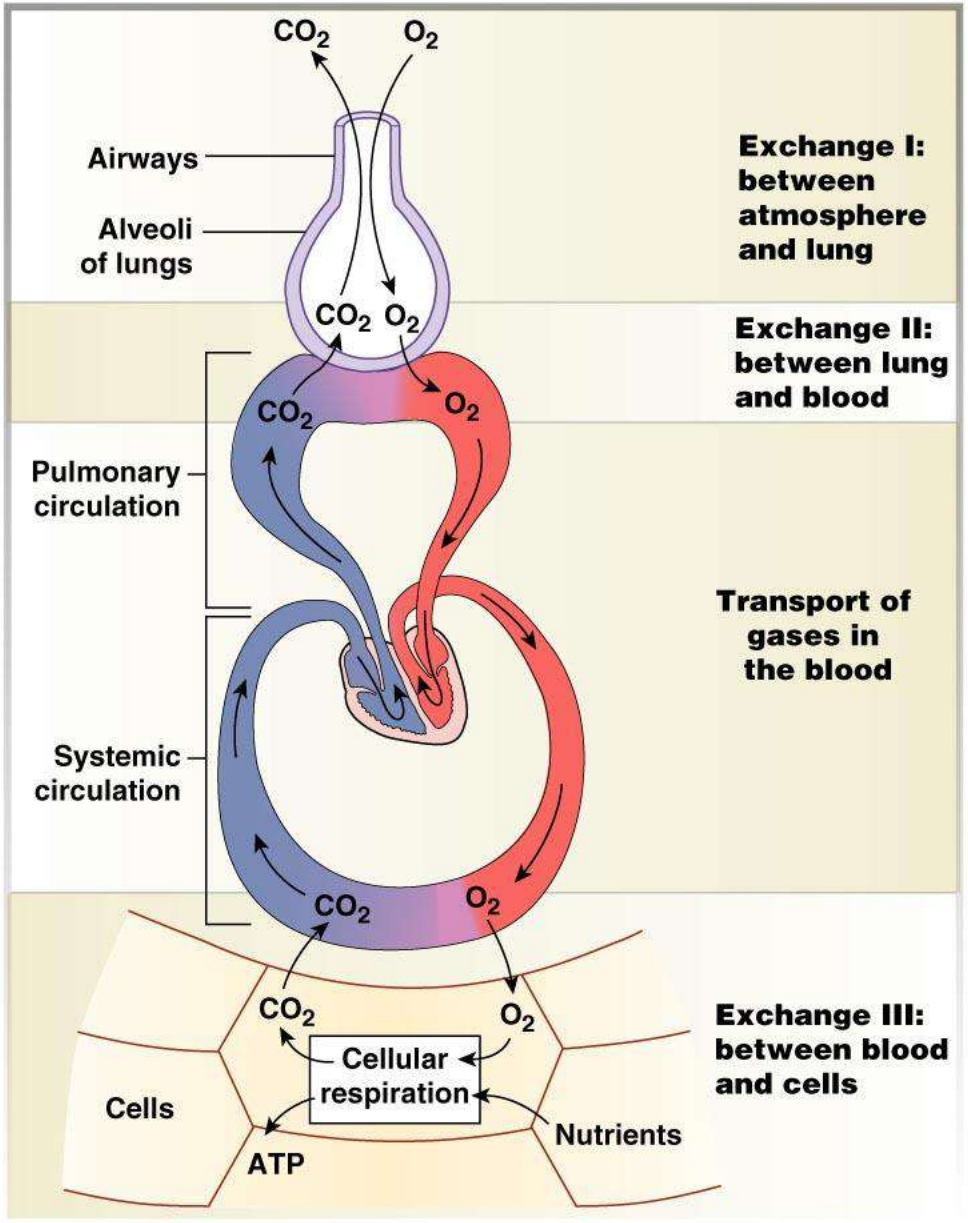


Figure 17-1

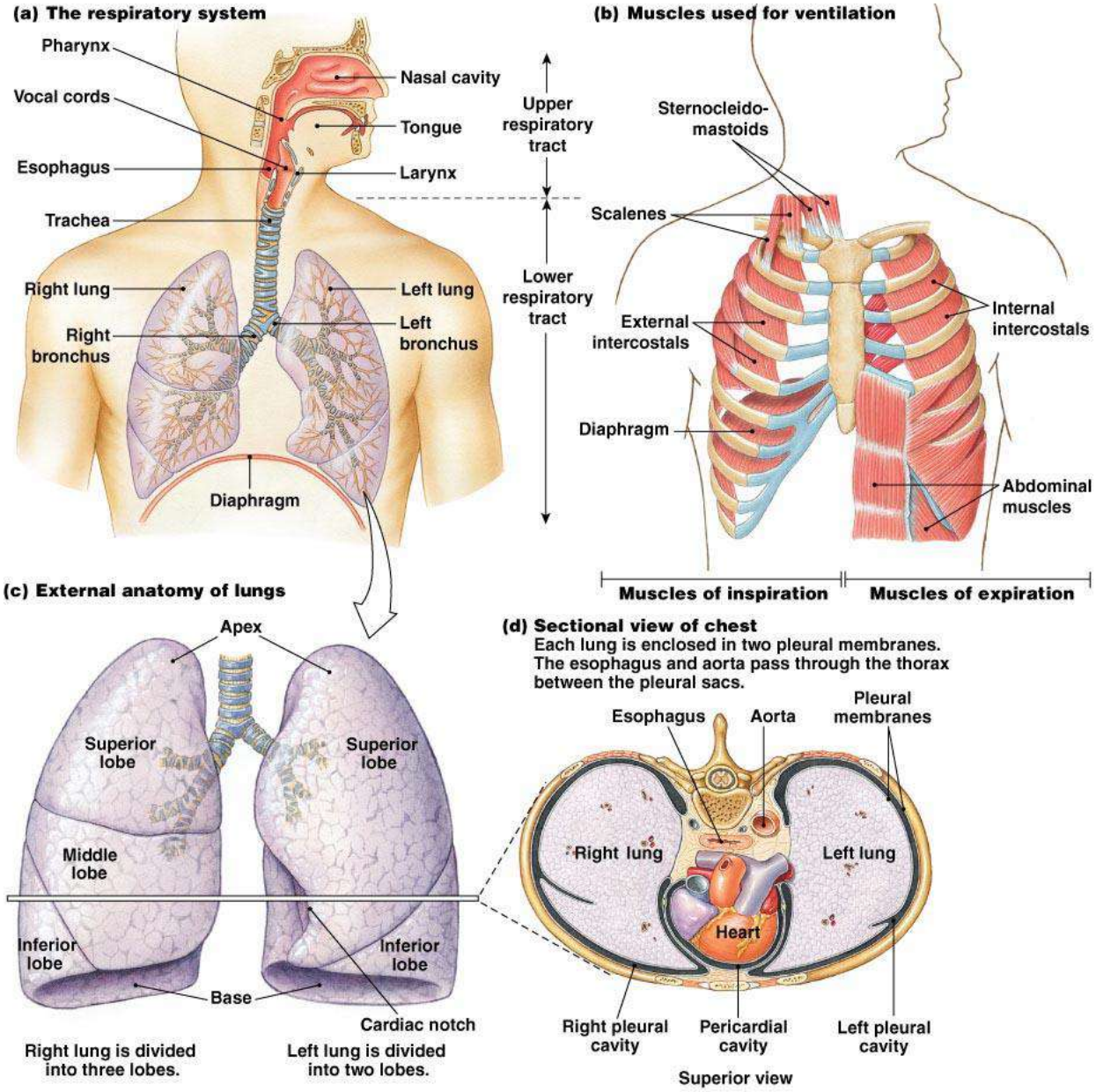


Figure 17-2 – Overview (1 of 2)

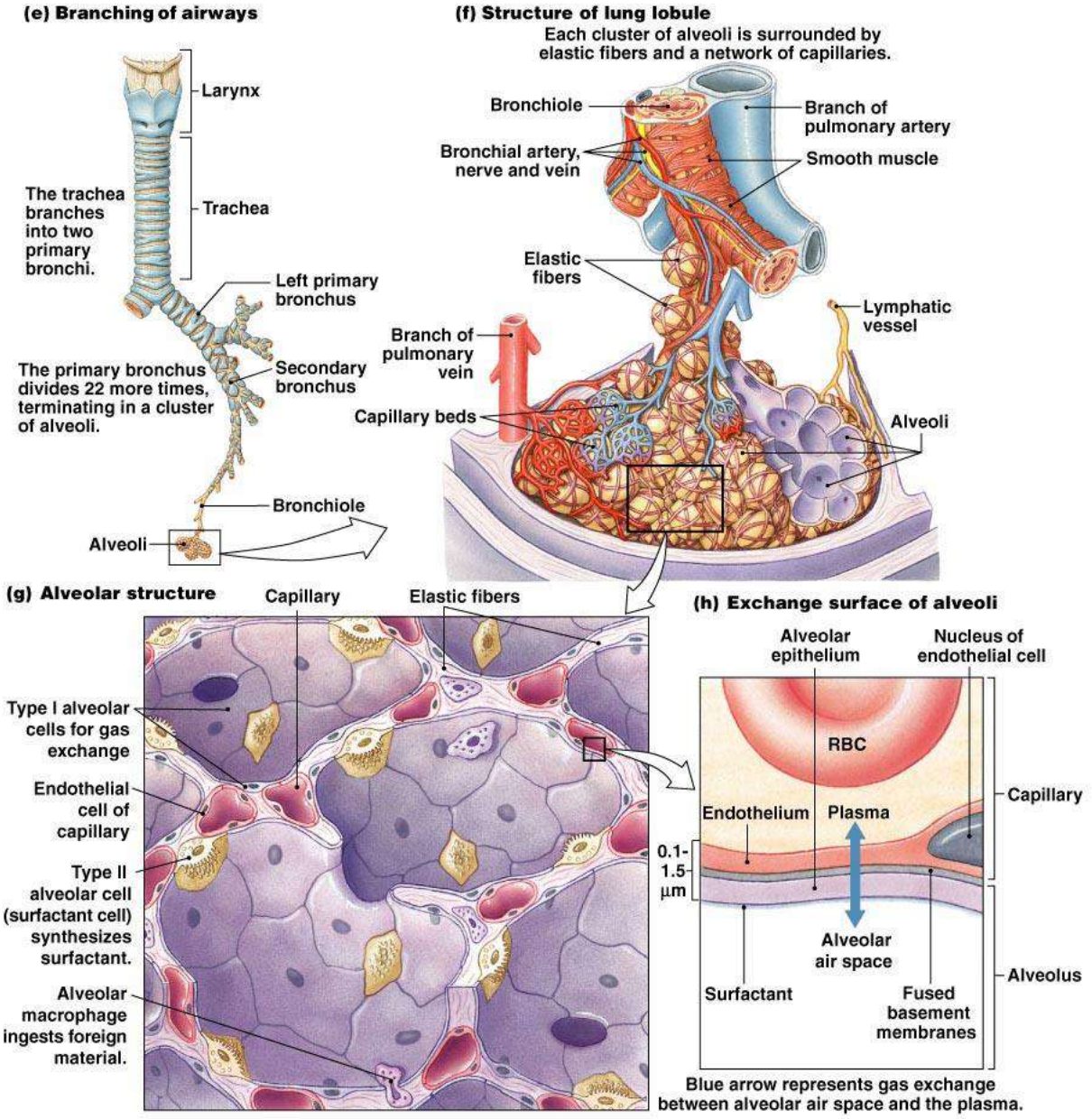


Figure 17-2 – Overview (2 of 2)

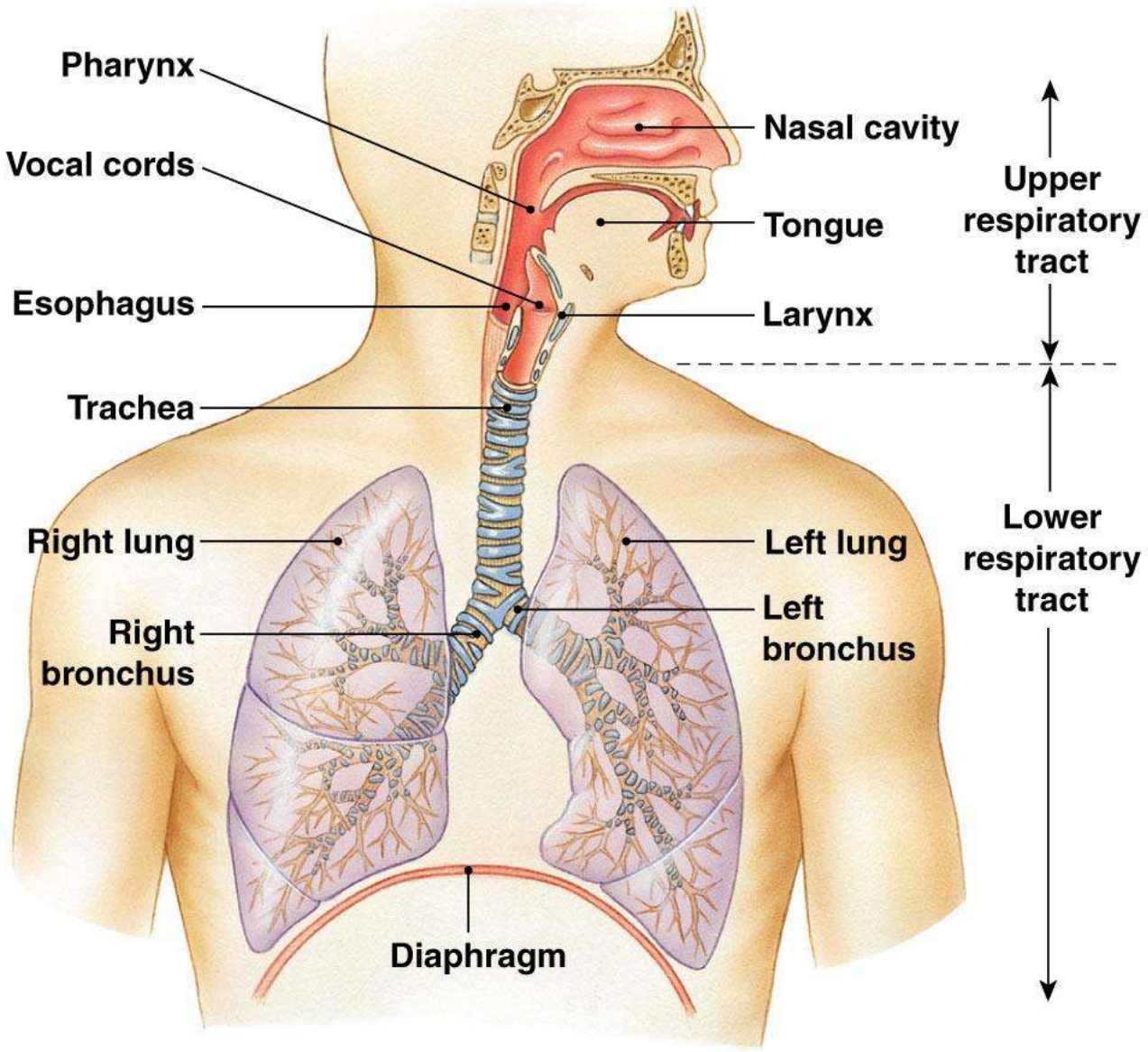


Figure 17-2a

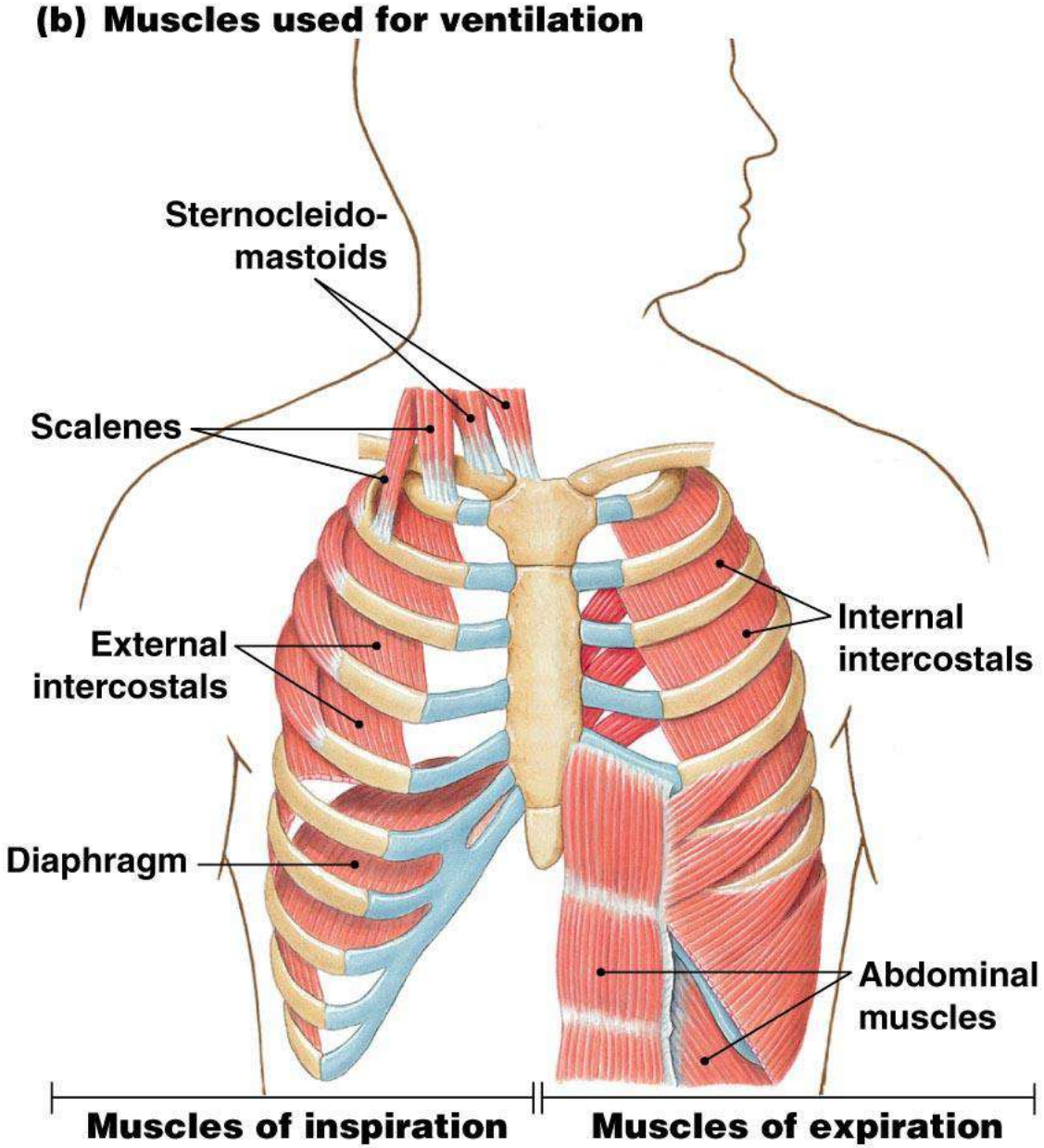
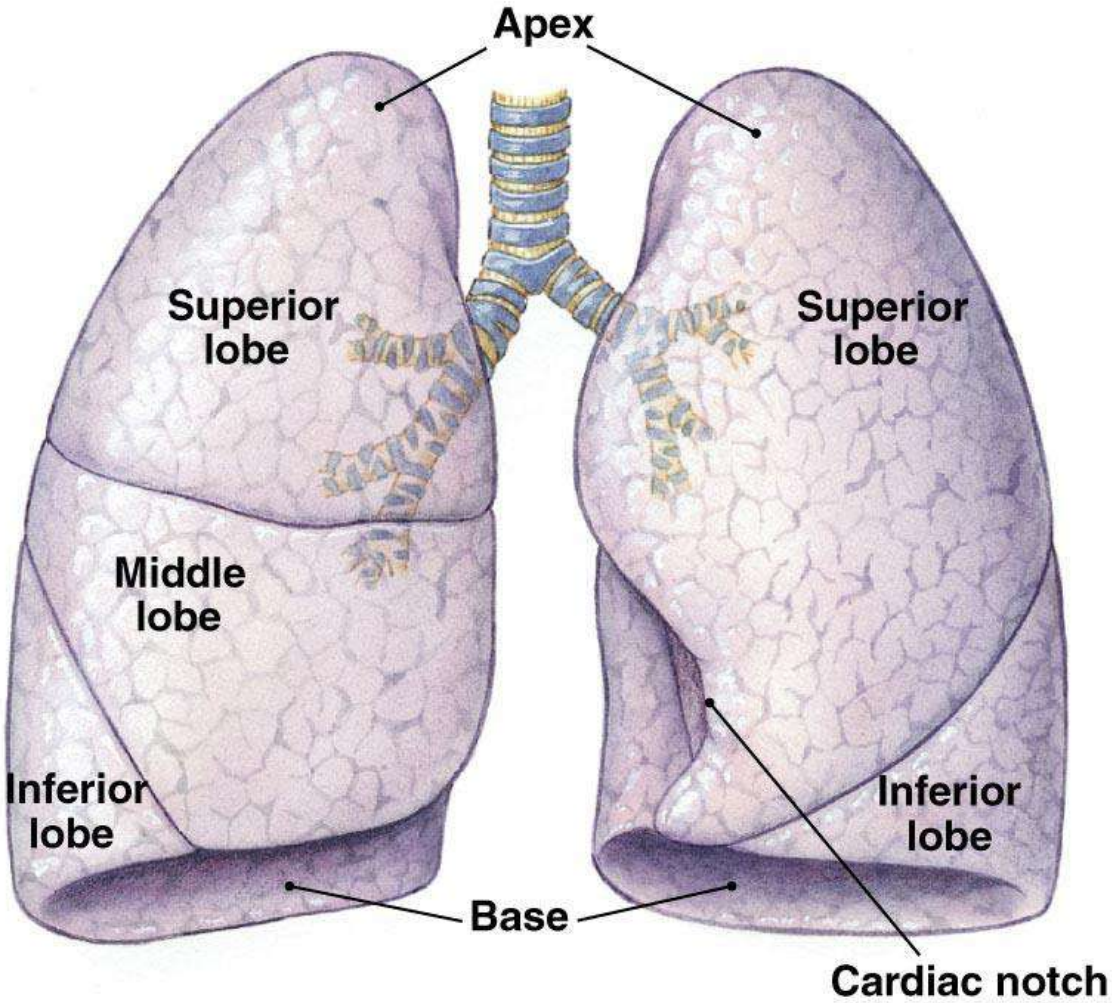


Figure 17-2b

(c) External anatomy of lungs

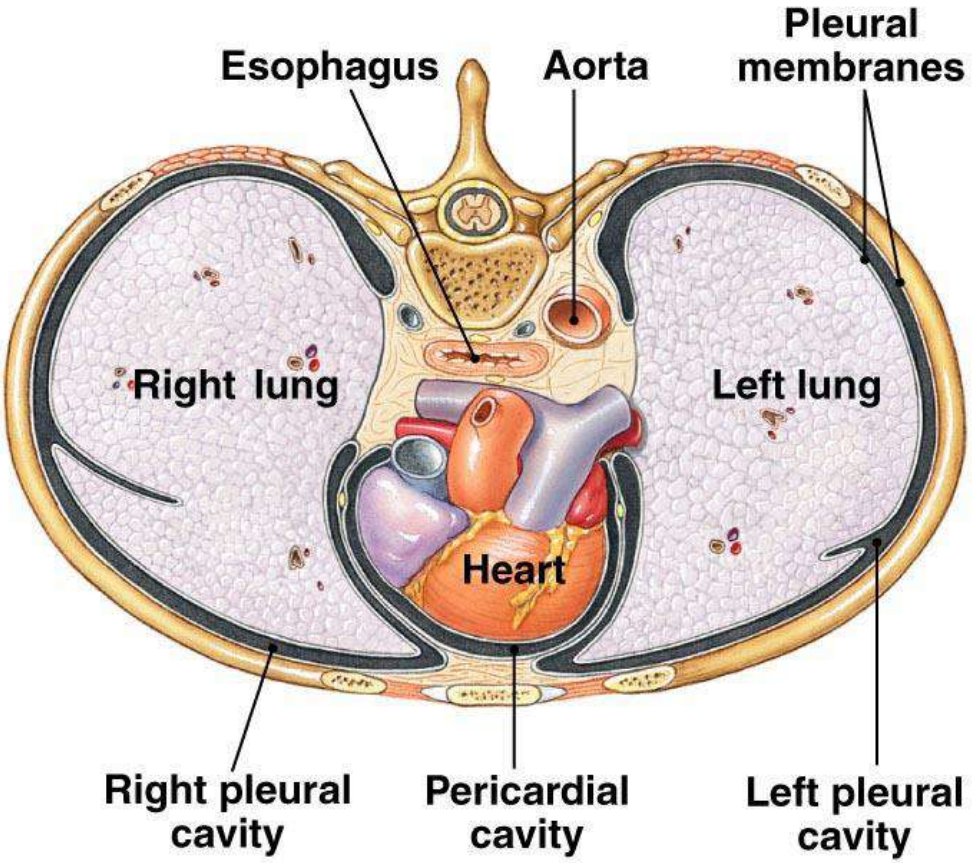


Right lung is divided into three lobes.

Left lung is divided into two lobes.

Figure 17-2c

(d) Sectional view of chest
Each lung is enclosed in two pleural membranes. The esophagus and aorta pass through the thorax between the pleural sacs.



Superior view

Figure 17-2d

Trachea

- Flexible and mobile tube extending from the larynx into the mediastinum
- Composed of three layers
  - **Mucosa** – made up of goblet cells and ciliated epithelium
  - **Submucosa** – connective tissue deep to the mucosa
  - **Adventitia** – outermost layer made of C-shaped rings of hyaline cartilage

(e) Branching of airways

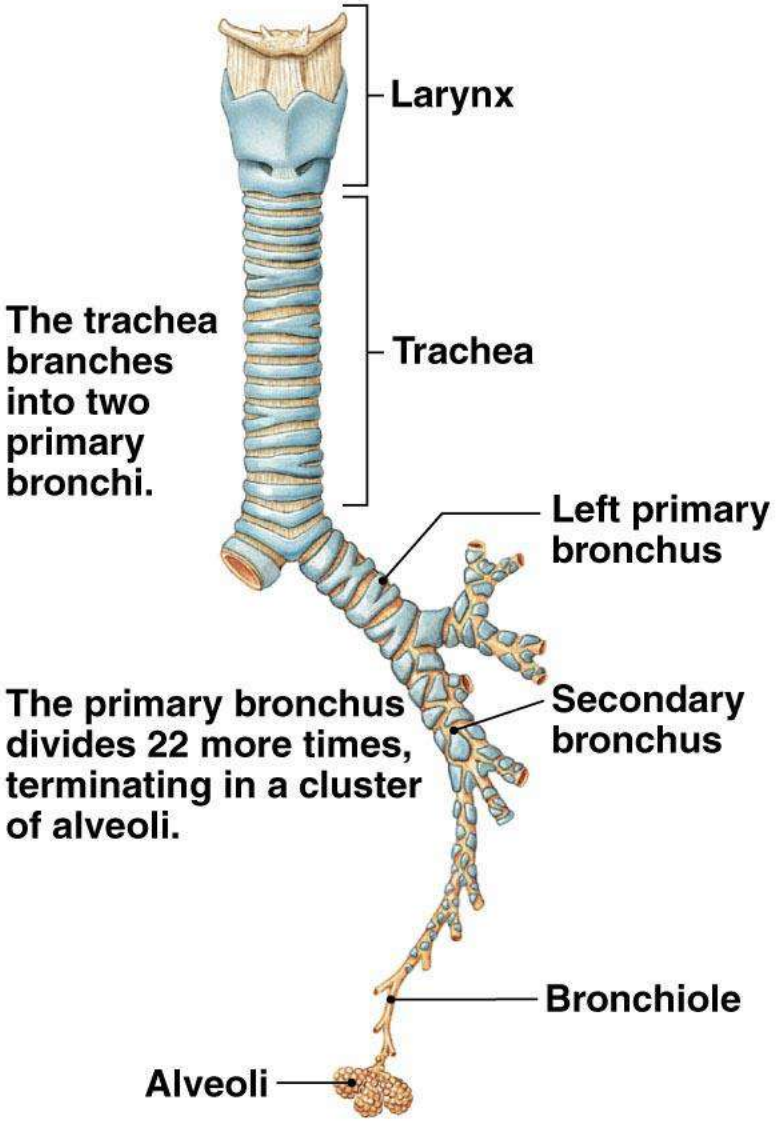


Figure 17-2e

Trachea

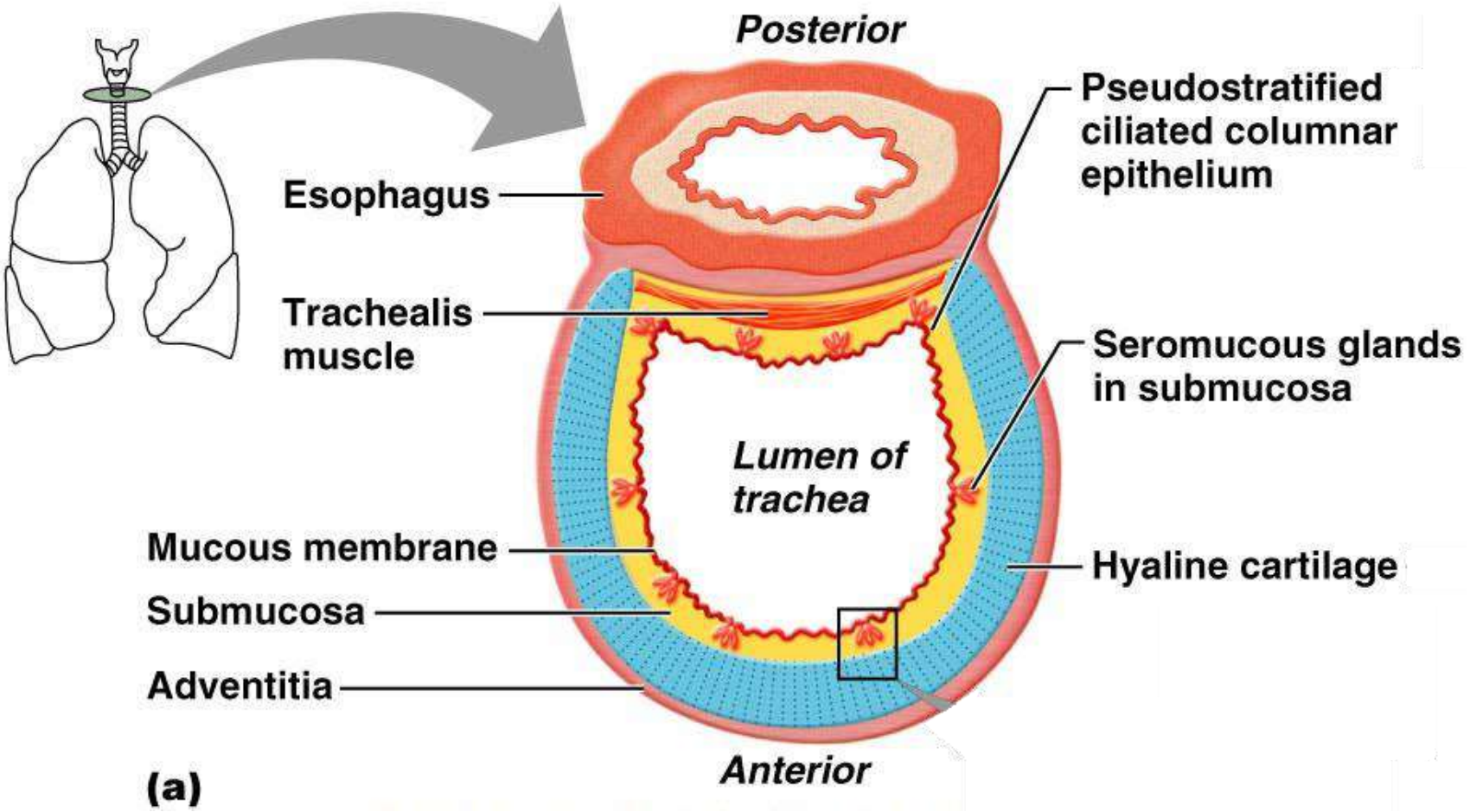


Figure 22.6a

Conducting Zone

- **Carina** of the last tracheal cartilage marks the end of the trachea and the beginning of the bronchi
- Air reaching the bronchi is:
  - Warm and cleansed of impurities
  - Saturated with water vapor
- Bronchi subdivide into secondary bronchi, each supplying a lobe of the lungs
- Air passages undergo 23 orders of branching

	Name	Division	Diameter (mm)	How many?	Cross-sectional area (cm^2)
Conducting system	Trachea	0	15–22	1	2.5
	Primary bronchi	1	10–15	2	↓
	Smaller bronchi	2	1–10	4	↓
		3		↓	
		4		↓	
		5		↓	
		6–11		1×10^4	↓
	Bronchioles	1–23	0.5–1	2×10^4 ↓ 8×10^7	100 ↓ 5×10^3
Exchange surface	Alveoli	24	0.3	$3–6 \times 10^8$	$>1 \times 10^6$

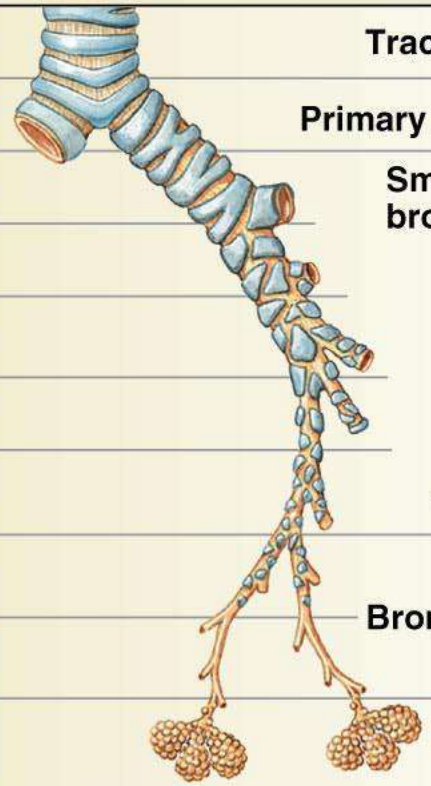


Figure 17-4

Conducting Zones

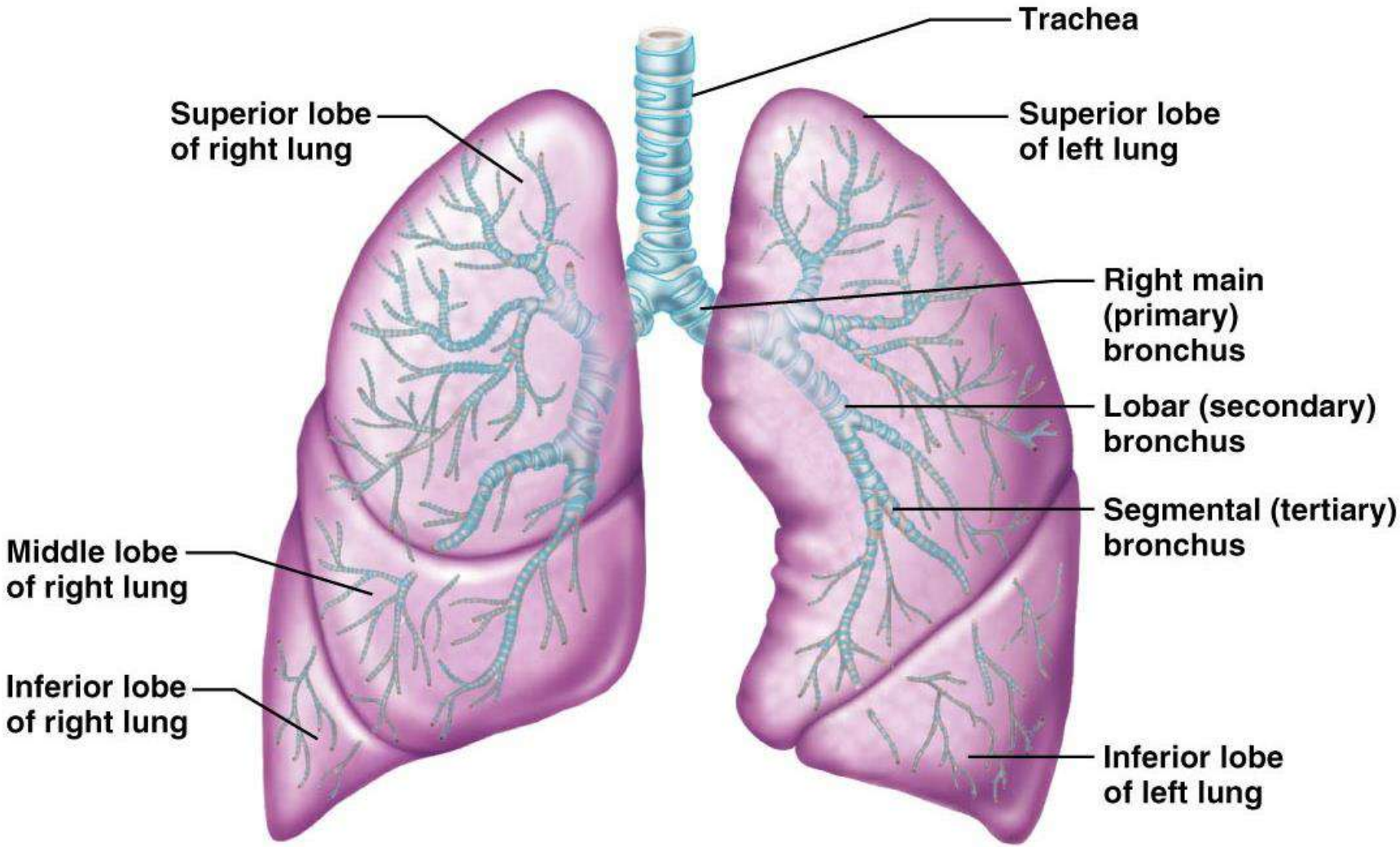


Figure 22.7

Dead Space

- **Anatomic**
- **Physiologic**

Respiratory Zone

- Defined by the presence of alveoli; begins as terminal bronchioles feed into respiratory bronchioles
- Respiratory bronchioles lead to alveolar ducts, then to terminal clusters of alveolar sacs composed of alveoli
- Approximately 300 million alveoli:
  - Account for most of the lungs' volume
  - Provide tremendous surface area for gas exchange

Respiratory Zone

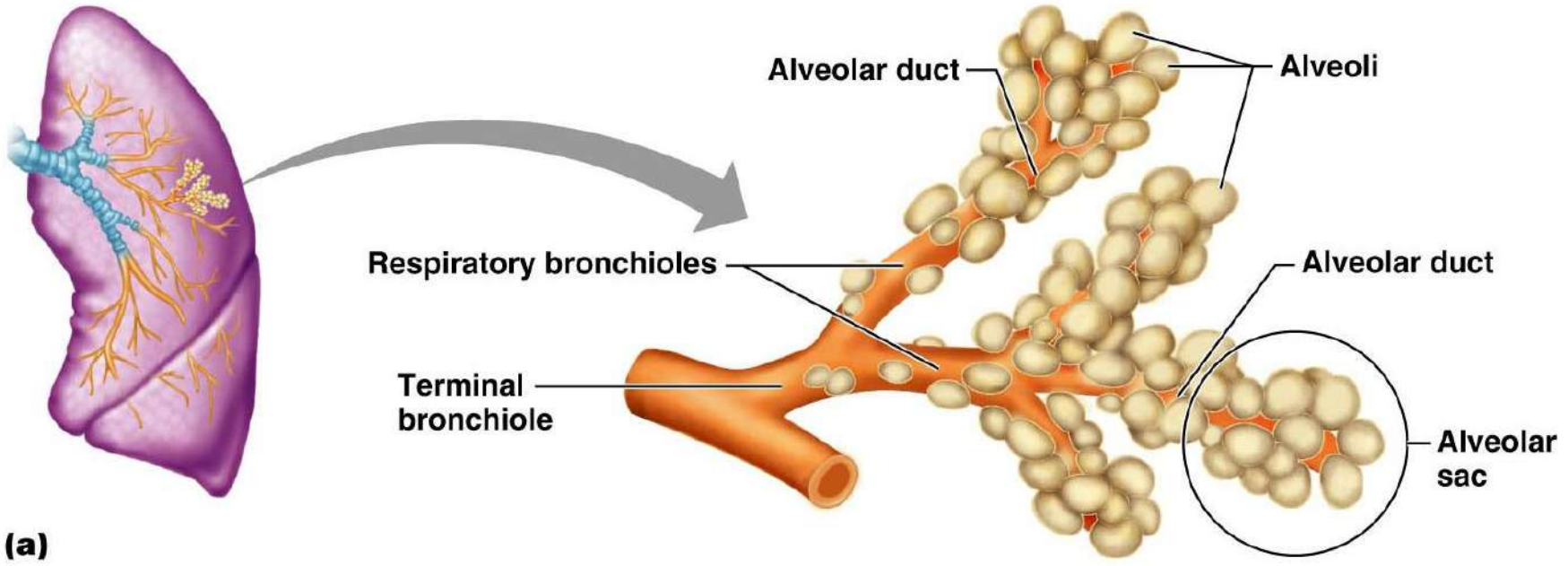


Figure 22.8a

Alveoli

- Surrounded by fine elastic fibers
- Contain open pores that:
  - Connect adjacent alveoli
  - Allow air pressure throughout the lung to be equalized
- House macrophages that keep alveolar surfaces sterile

(f) Structure of lung lobule

Each cluster of alveoli is surrounded by elastic fibers and a network of capillaries.

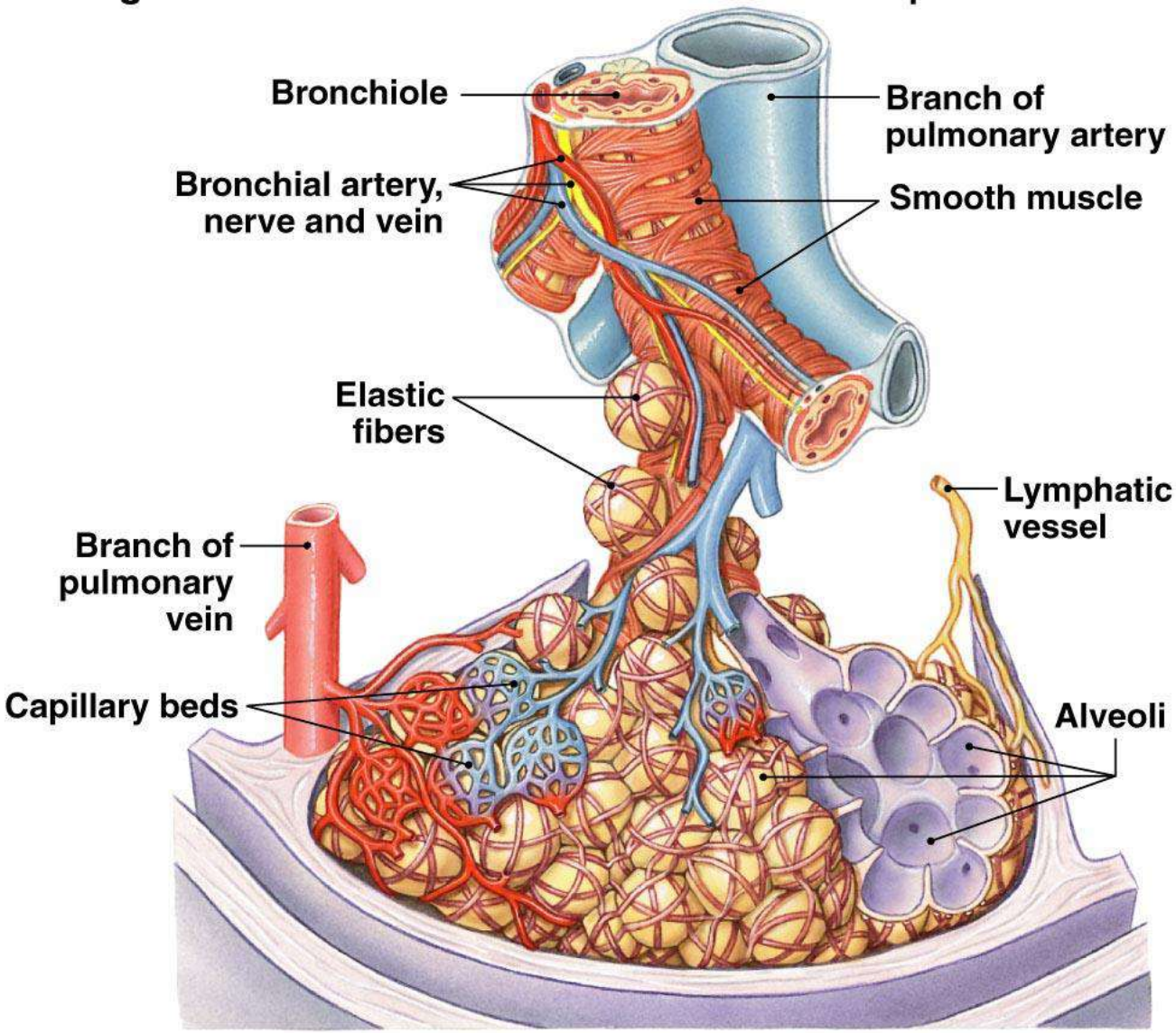


Figure 17-2f

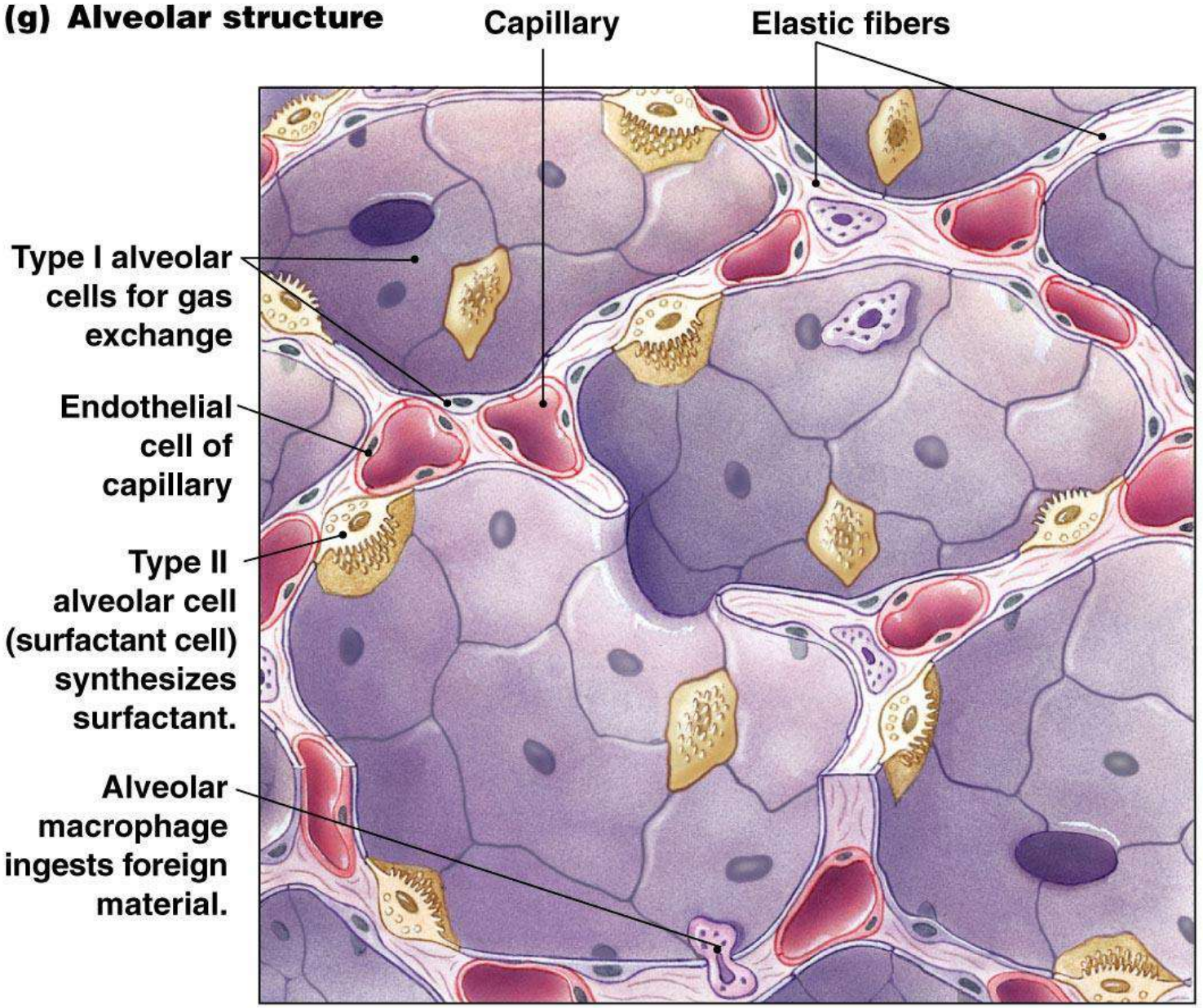


Figure 17-2g

Respiratory Membrane

- This air-blood barrier is composed of:
  - **Alveolar and capillary walls**
  - **Their fused basal laminas**
- Alveolar walls:
  - Are a single layer of type I epithelial cells
  - Permit gas exchange by simple diffusion
  - Secrete angiotensin converting enzyme (ACE)

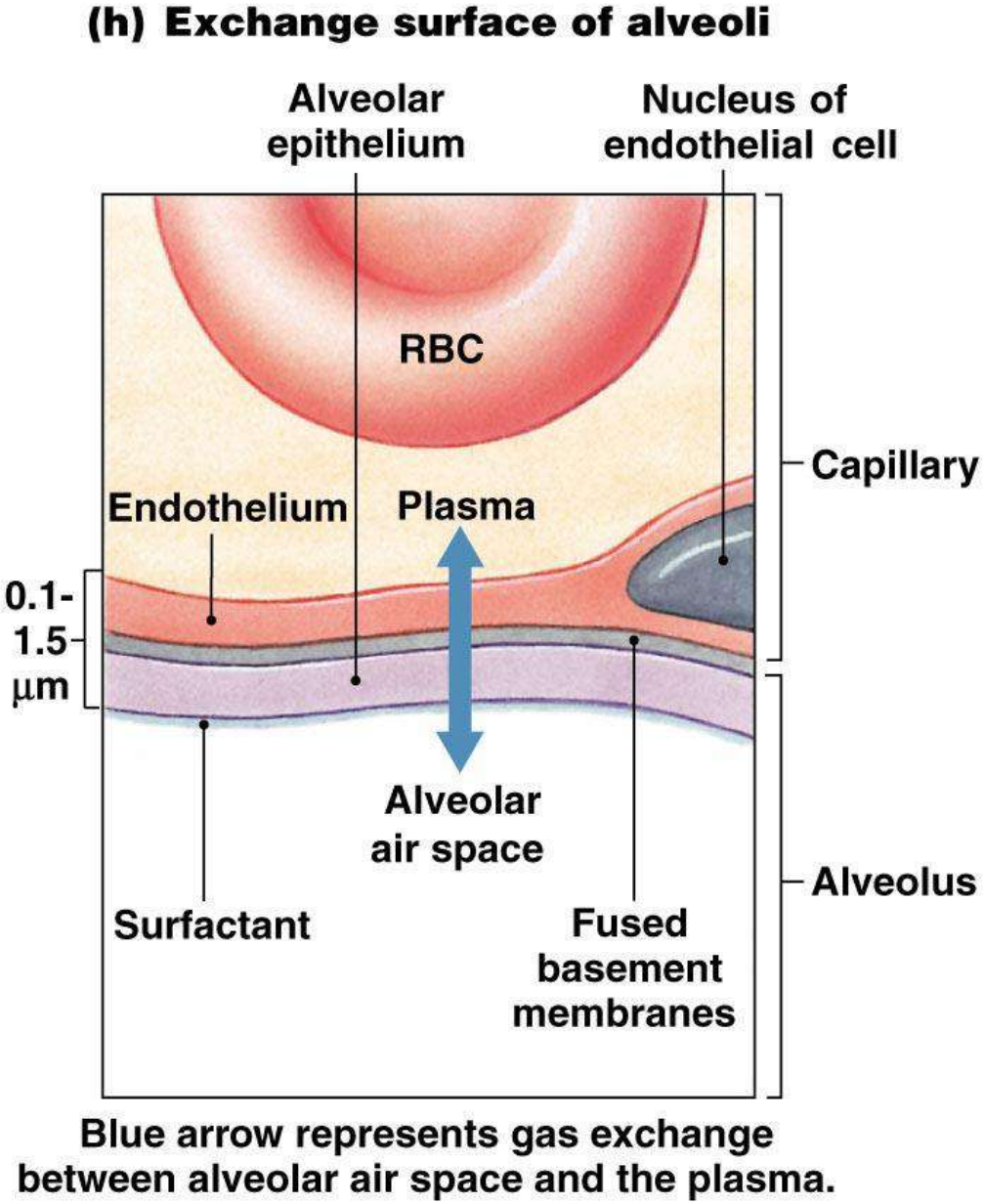
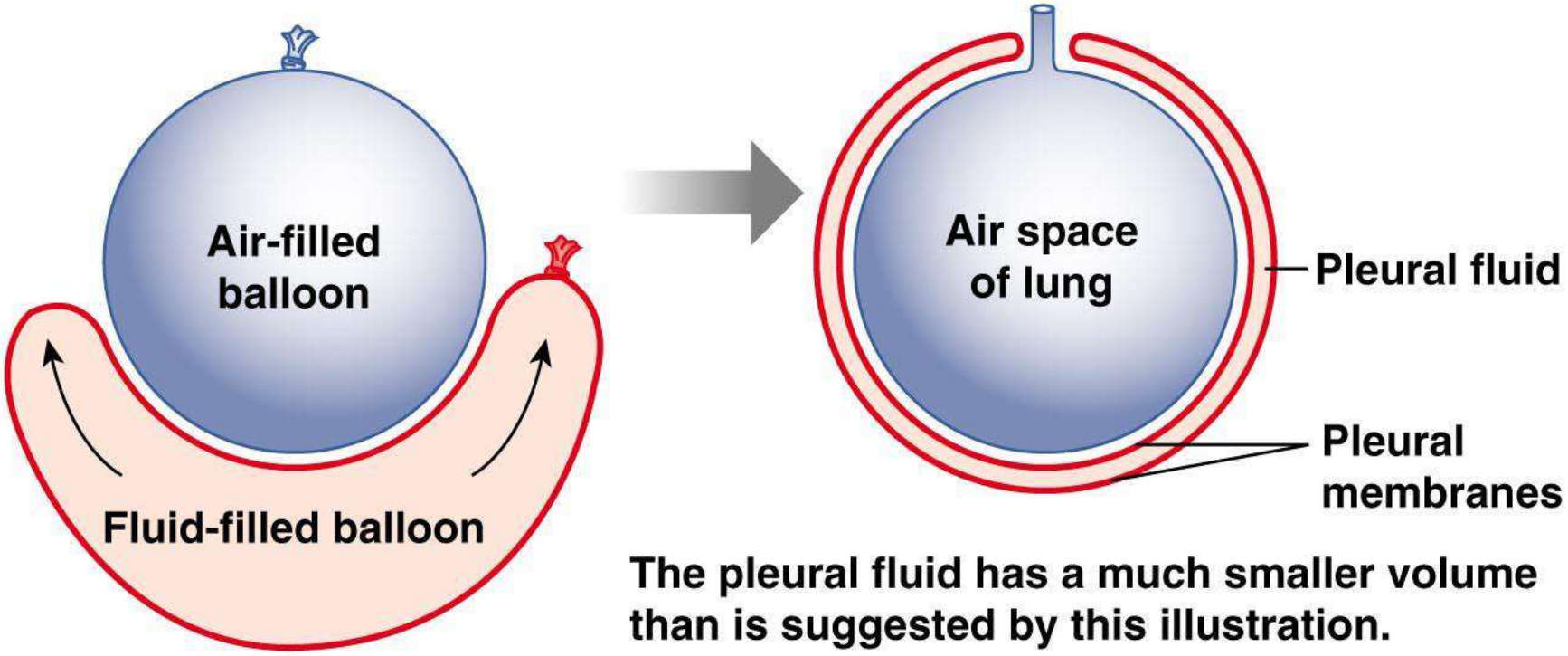


Figure 17-2h

Pleurae

- Thin, double-layered serosa
- **Parietal pleura**
  - Covers the thoracic wall and superior face of the diaphragm
  - Continues around heart and between lungs
- **Visceral pleura**
- Covers the lungs

The pleural sac forms a double membrane surrounding the lung, similar to a fluid-filled balloon surrounding an air-filled balloon.



The pleural fluid has a much smaller volume than is suggested by this illustration.

Figure 17-3

TABLE 17-1 Gas Laws

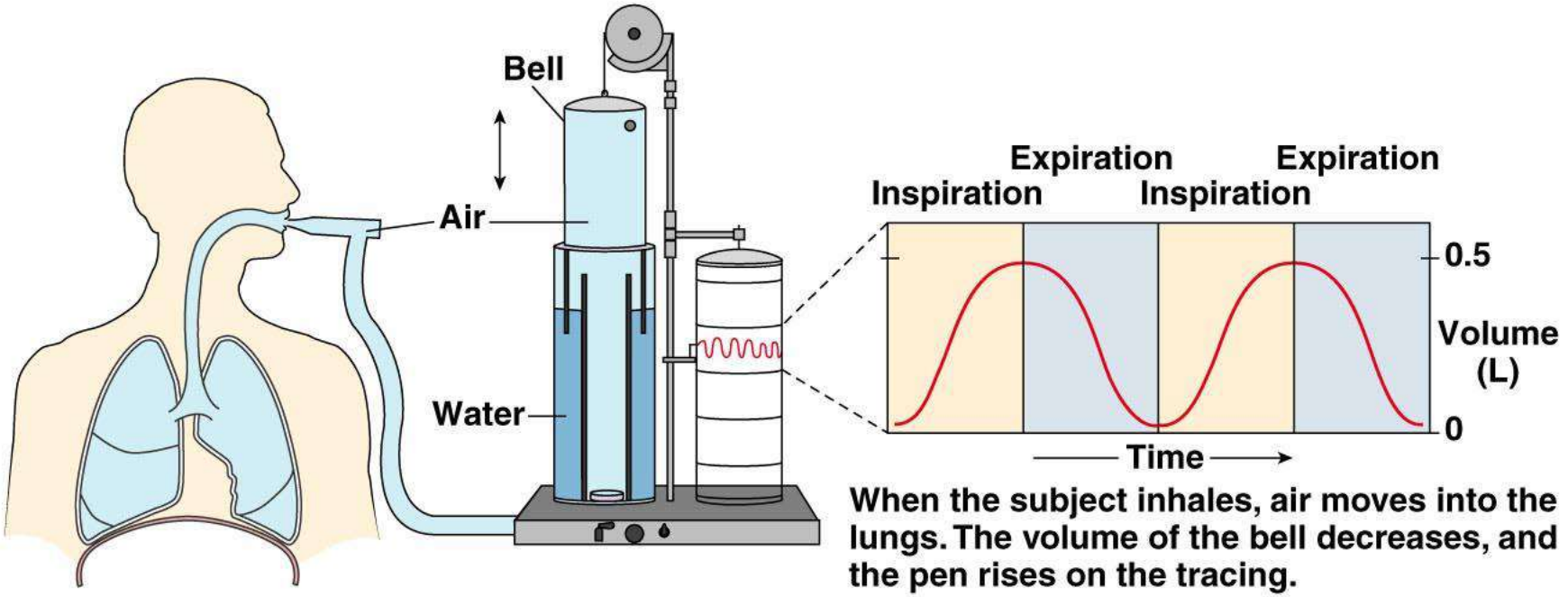
1. The total pressure of a mixture of gases is the sum of the pressures of the individual gases (Dalton's law).
2. Gases, singly or in a mixture, move from areas of higher pressure to areas of lower pressure.
3. If the volume of a container of gas changes, the pressure of the gas will change in an inverse manner (Boyle's law).

TABLE 17-2 Partial Pressures (P_{gas}) of Atmospheric Gases at 760 mm Hg

GAS AND ITS PERCENTAGE IN AIR	P_{gas} IN DRY, 25° C AIR	P_{gas} IN 25° C AIR, 100% HUMIDITY	P_{gas} IN 37° C AIR, 100% HUMIDITY
Nitrogen (N_2) 78%	593 mm Hg	574 mm Hg	556 mm Hg
Oxygen (O_2) 21%	160 mm Hg	155 mm Hg	150 mm Hg
Carbon dioxide (CO_2) 0.033%	0.25 mm Hg	0.24 mm Hg	0.235 mm Hg
Water vapor	0 mm Hg	24 mm Hg	47 mm Hg

Respiratory Volumes

- **Tidal volume (TV)** – air that moves into and out of the lungs with each breath (approximately 500 ml)
- **Inspiratory reserve volume (IRV)** – air that can be inspired forcibly beyond the tidal volume (2100–3200 ml)
- **Expiratory reserve volume (ERV)** – air that can be evacuated from the lungs after a tidal expiration (1000–1200 ml)
- **Residual volume (RV)** – air left in the lungs after strenuous expiration (1200 ml)



When the subject inhales, air moves into the lungs. The volume of the bell decreases, and the pen rises on the tracing.

Figure 17-6

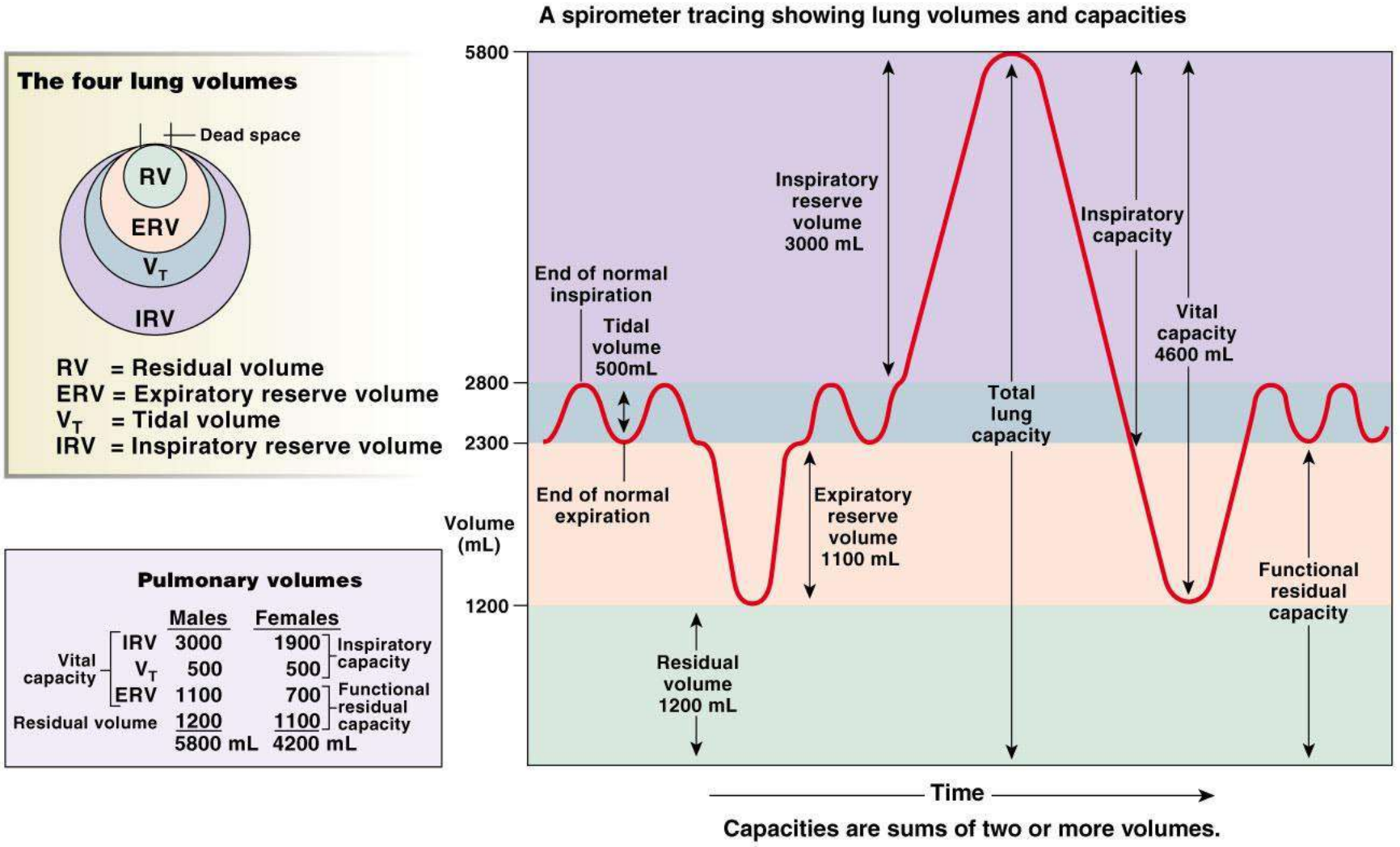


Figure 17-7

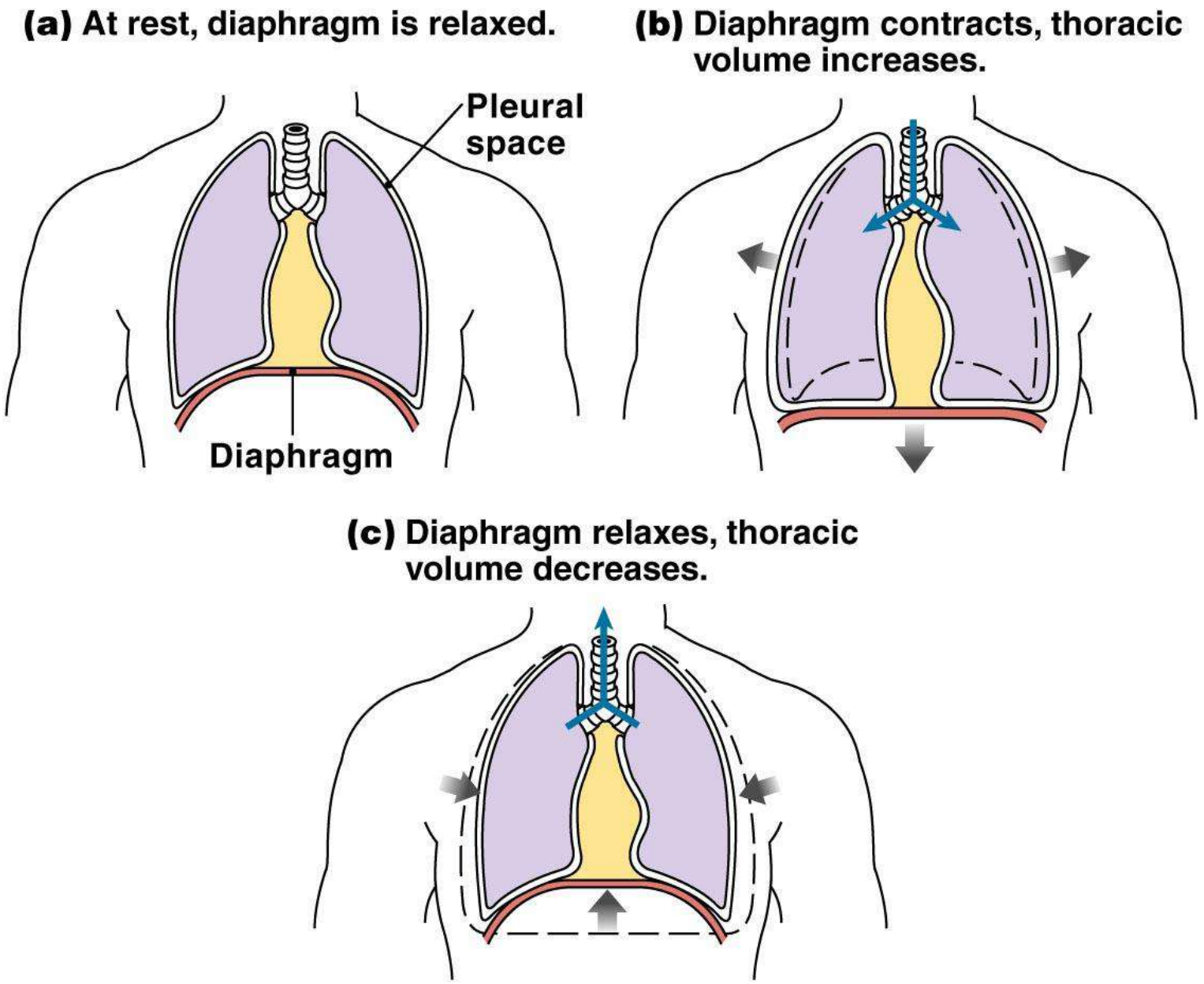


Figure 17-9 - Overview

(a) "Pump handle" motion increases anterior-posterior dimension of rib cage.

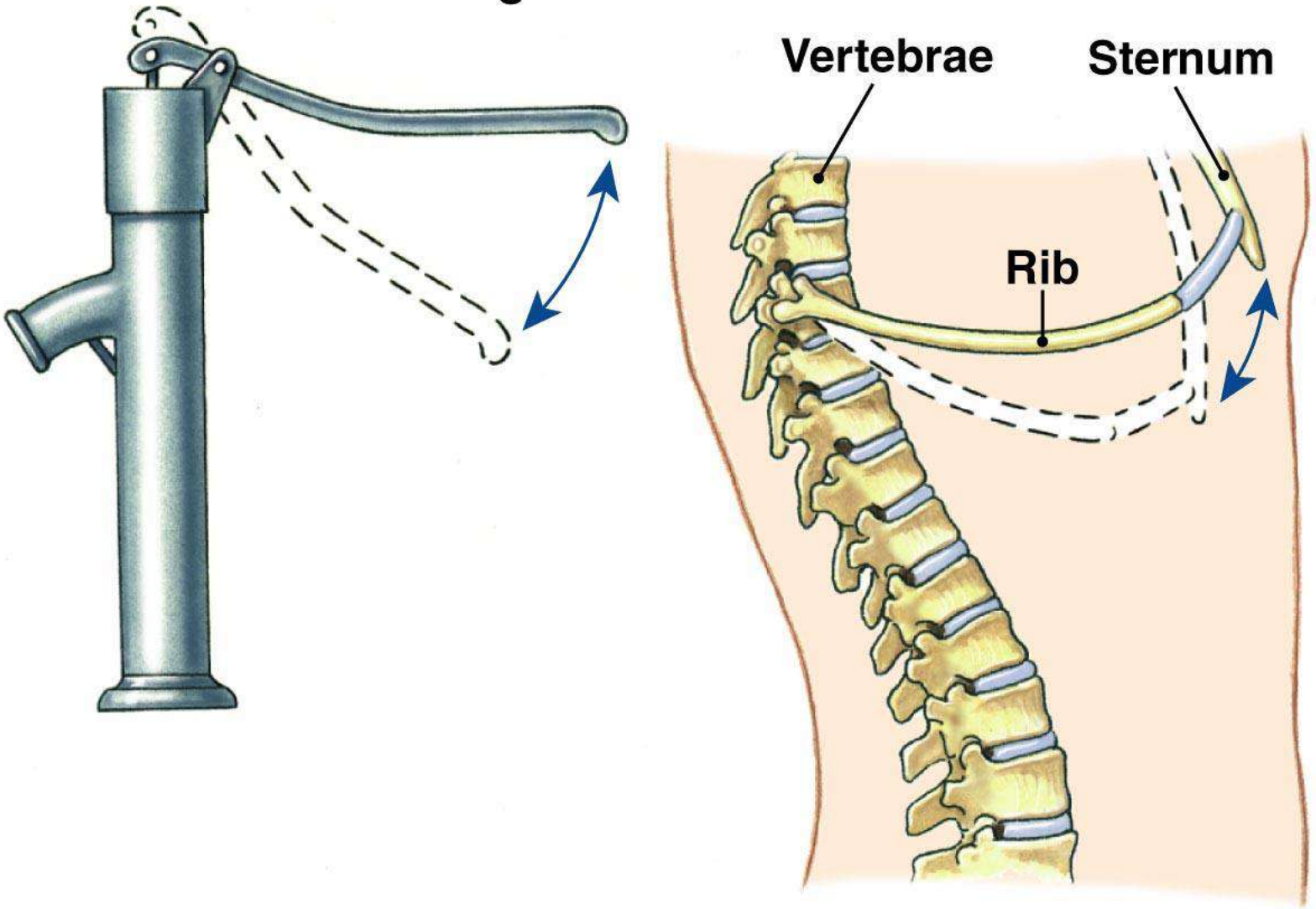


Figure 17-10a

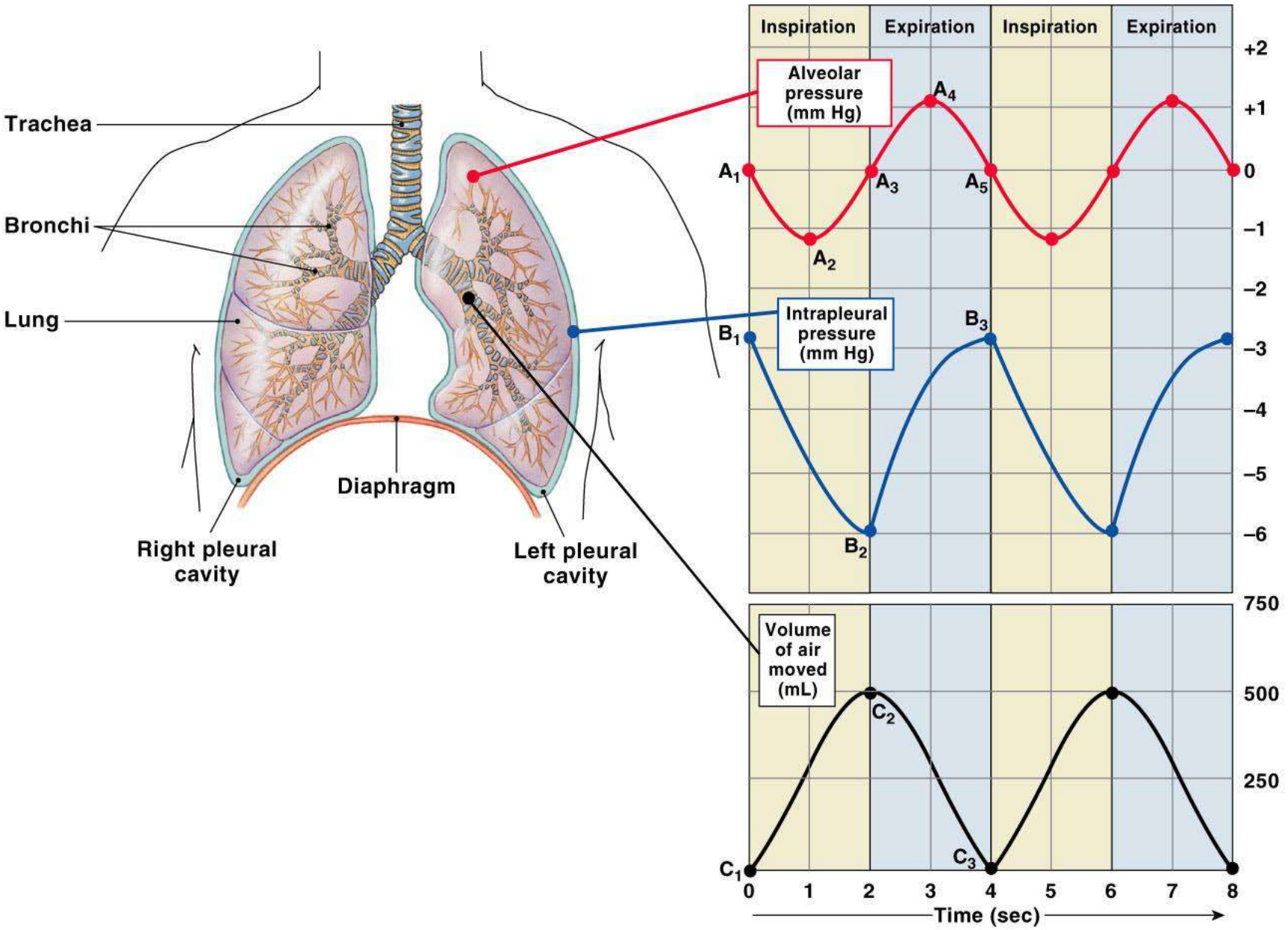


Figure 17-11

Lung Collapse

- Caused by equalization of the intrapleural pressure with the intrapulmonary pressure
- Transpulmonary pressure keeps the airways open
  - Transpulmonary pressure – difference between the intrapulmonary and intrapleural pressures
    ($P_{pul} – P_{ip}$)

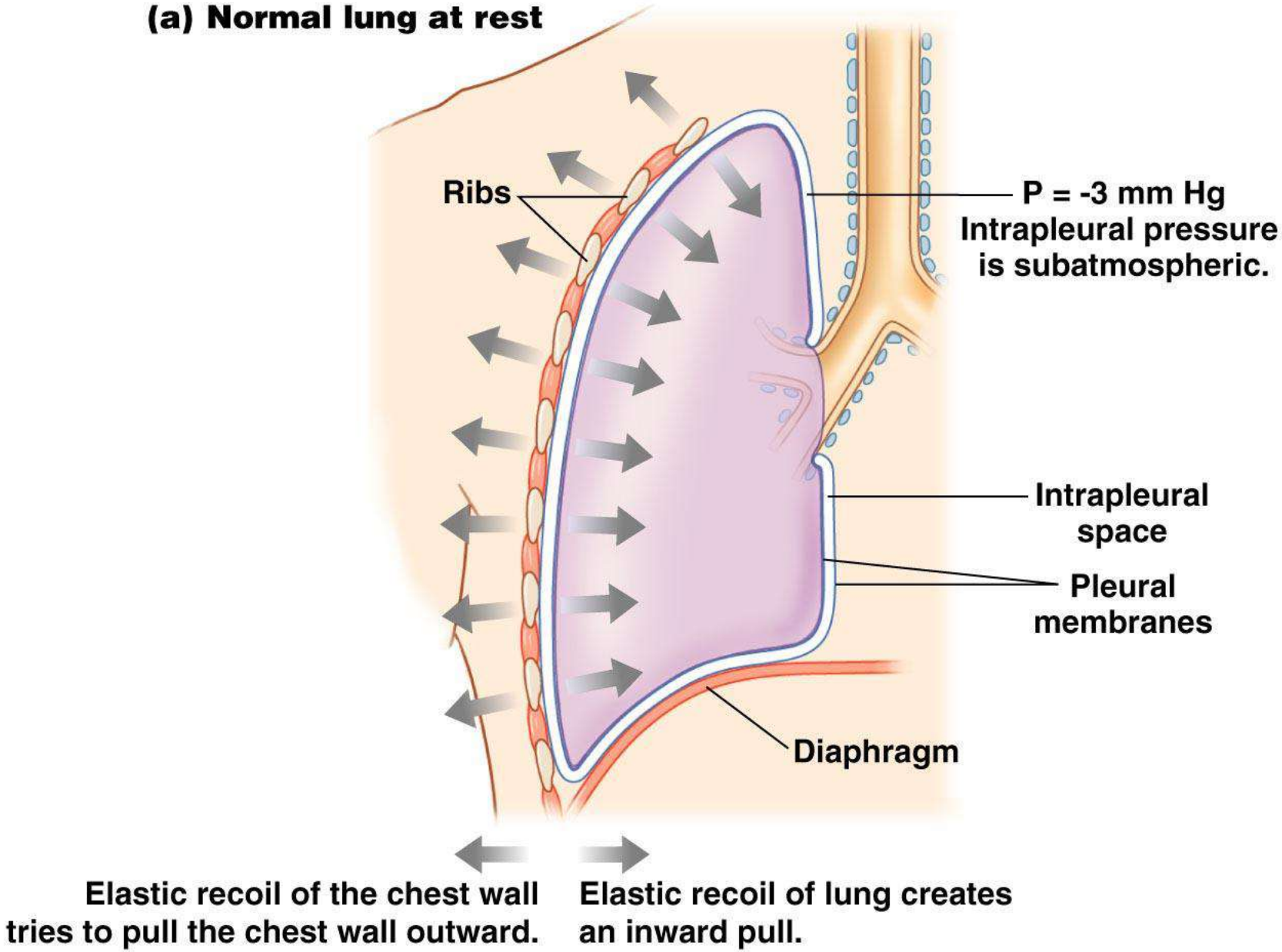


Figure 17-12a

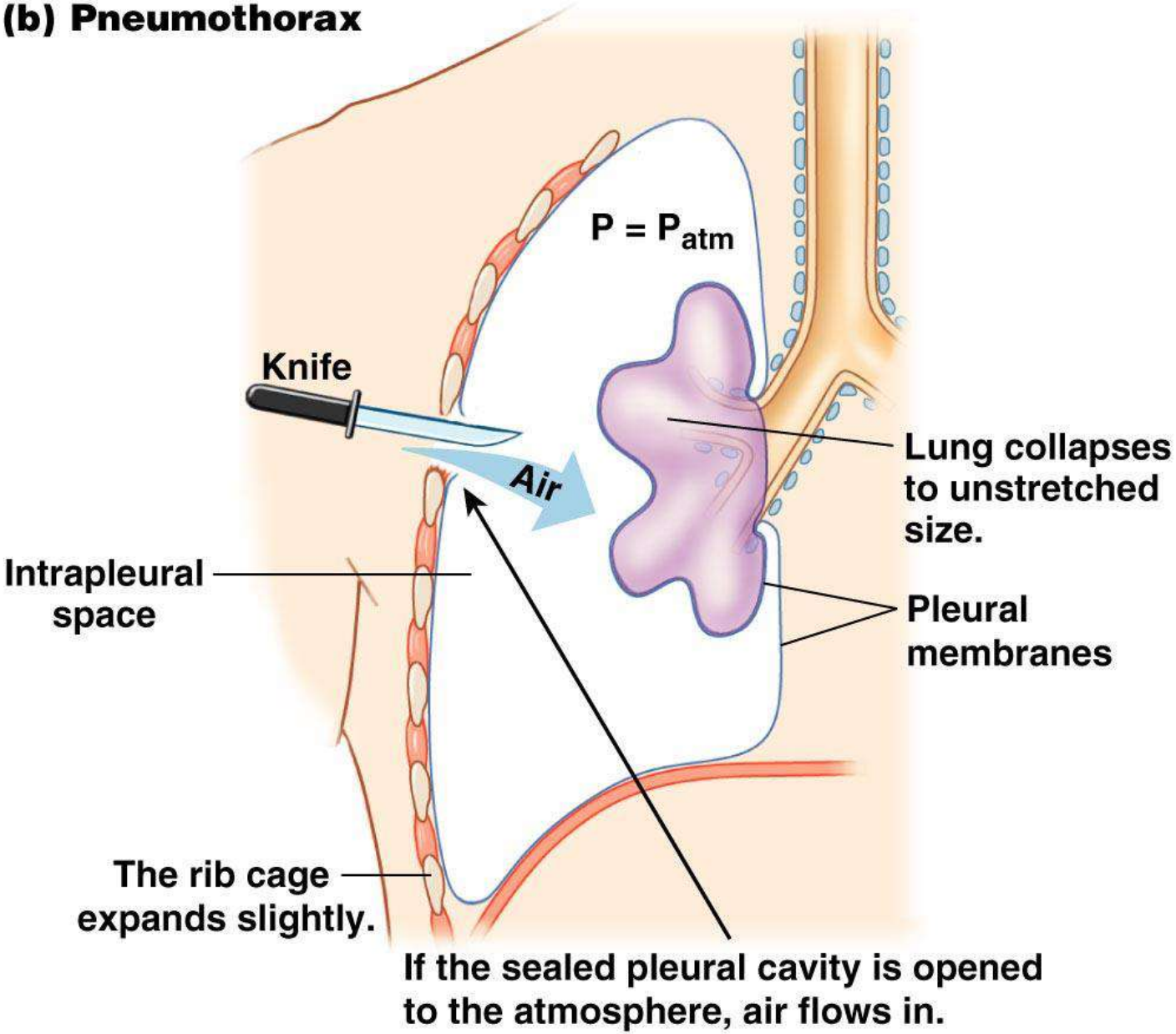


Figure 17-12b

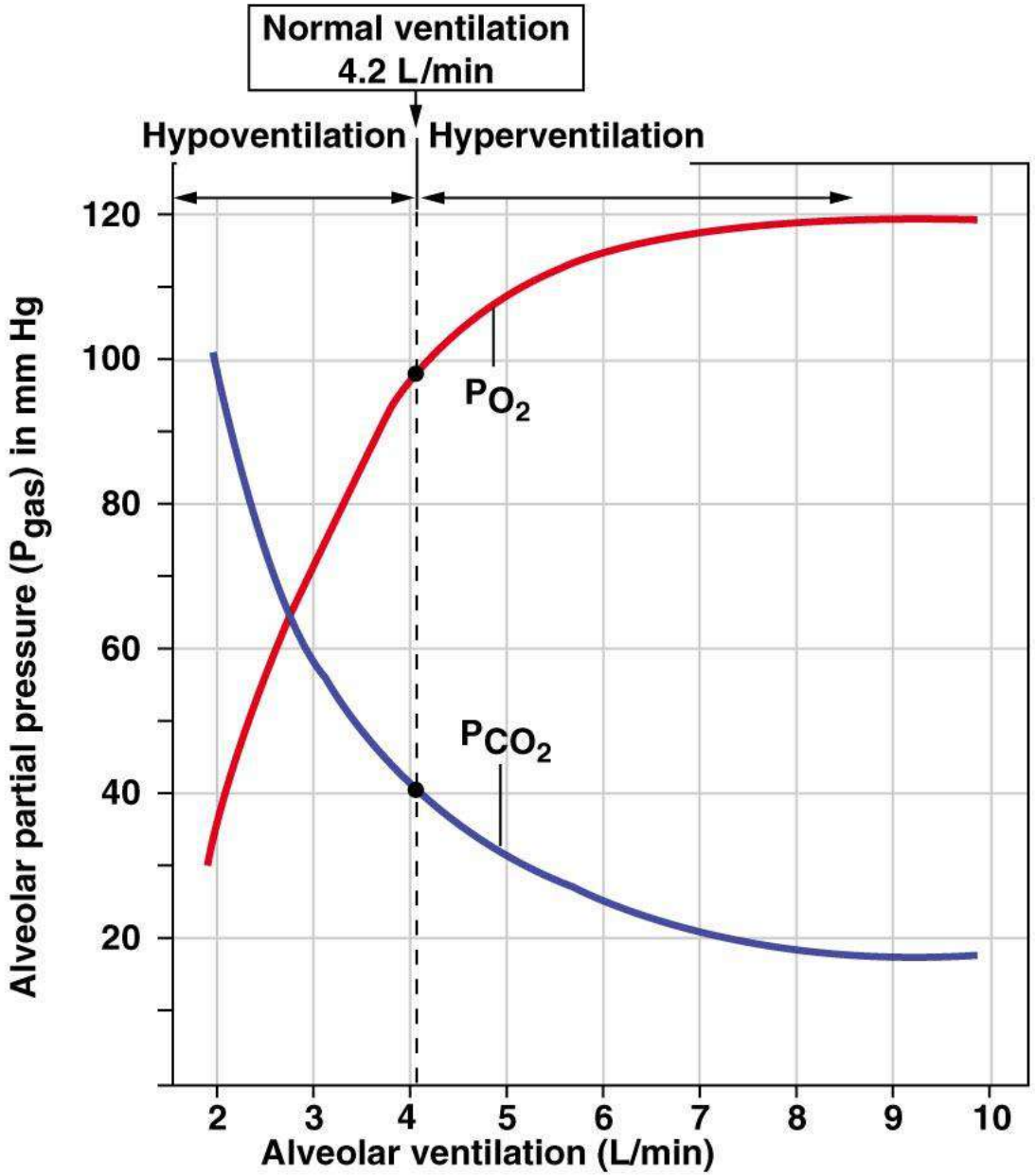


Figure 17-15

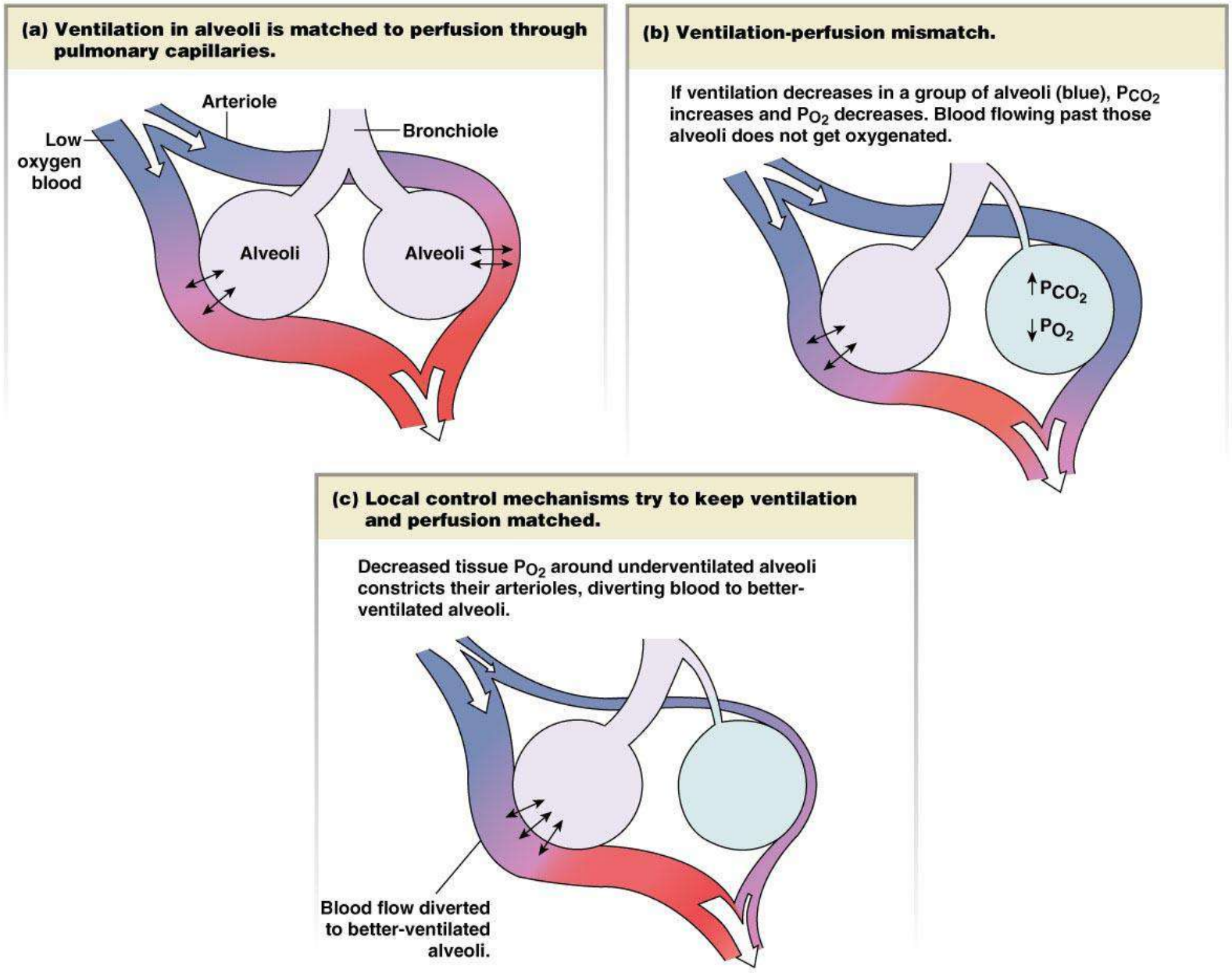
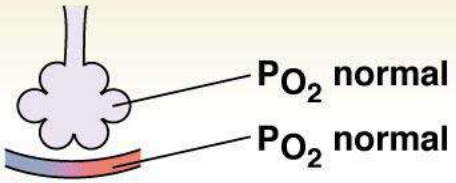
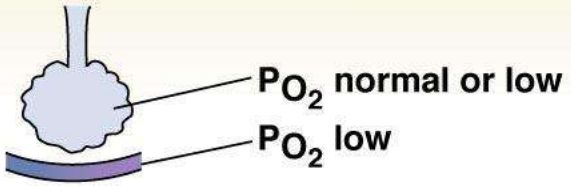


Figure 17-16 - Overview

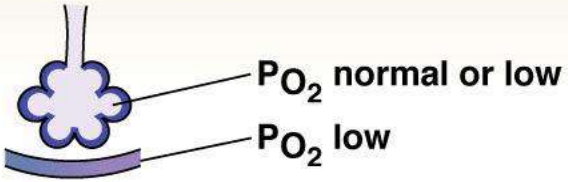
(a) Normal lung



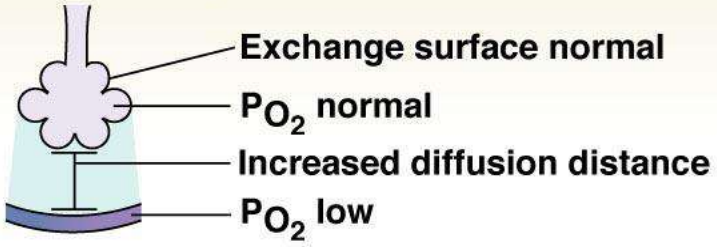
(b) Emphysema: destruction of alveoli reduces surface area for gas exchange.



(c) Fibrotic lung disease: thickened alveolar membrane slows gas exchange. Loss of lung compliance may decrease alveolar ventilation.



(d) Pulmonary edema: fluid in interstitial space increases diffusion distance. Arterial P_{CO_2} may be normal due to higher CO_2 solubility in water.



(e) Asthma: increased airway resistance decreases airway ventilation.

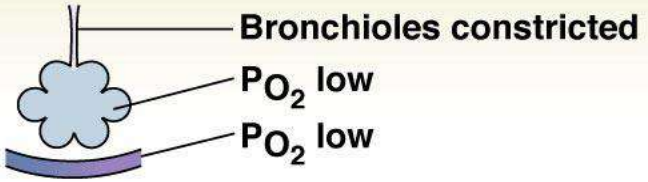


Figure 18-4 - Overview

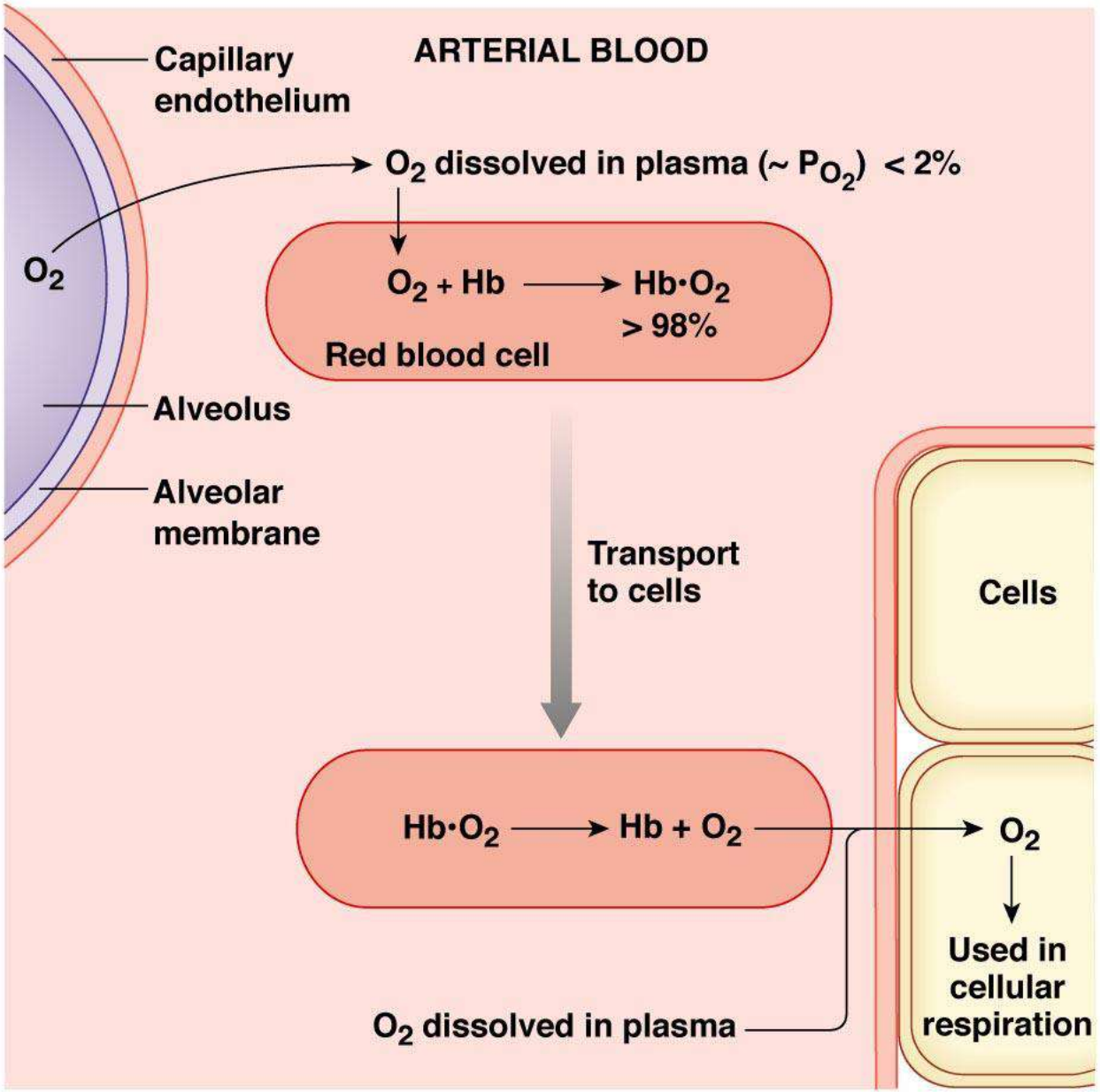


Figure 18-6

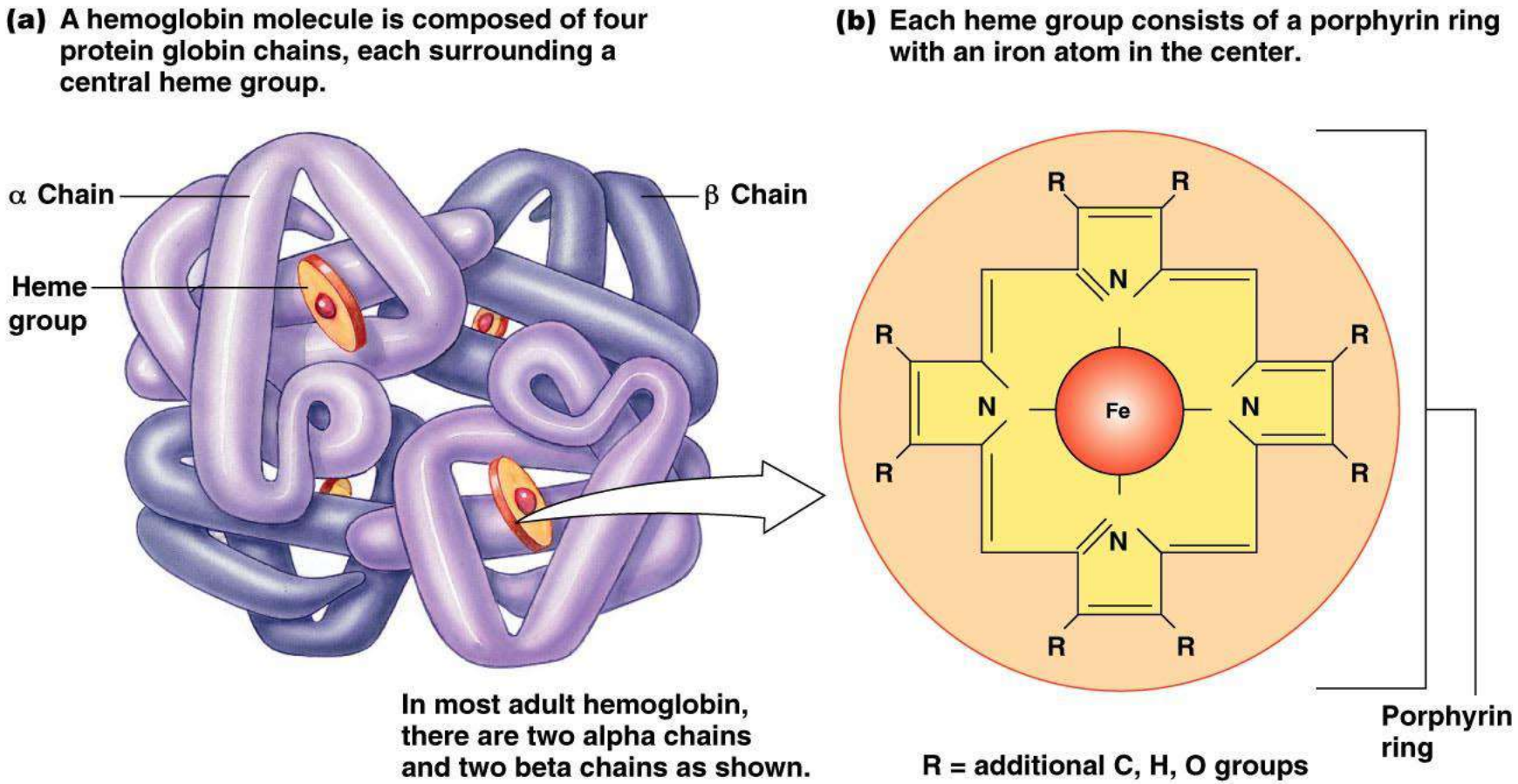


Figure 18-8 - Overview

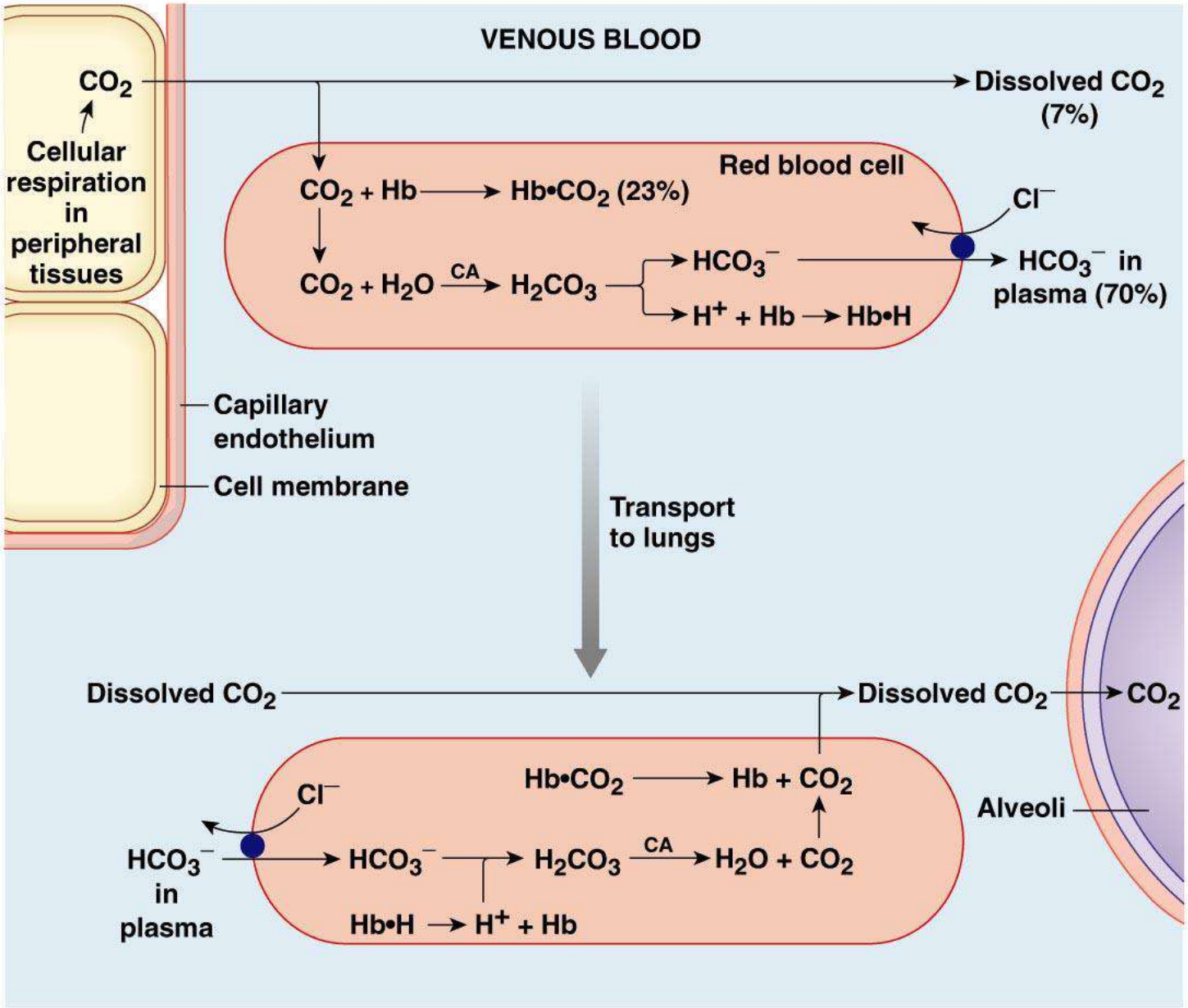


Figure 18-14

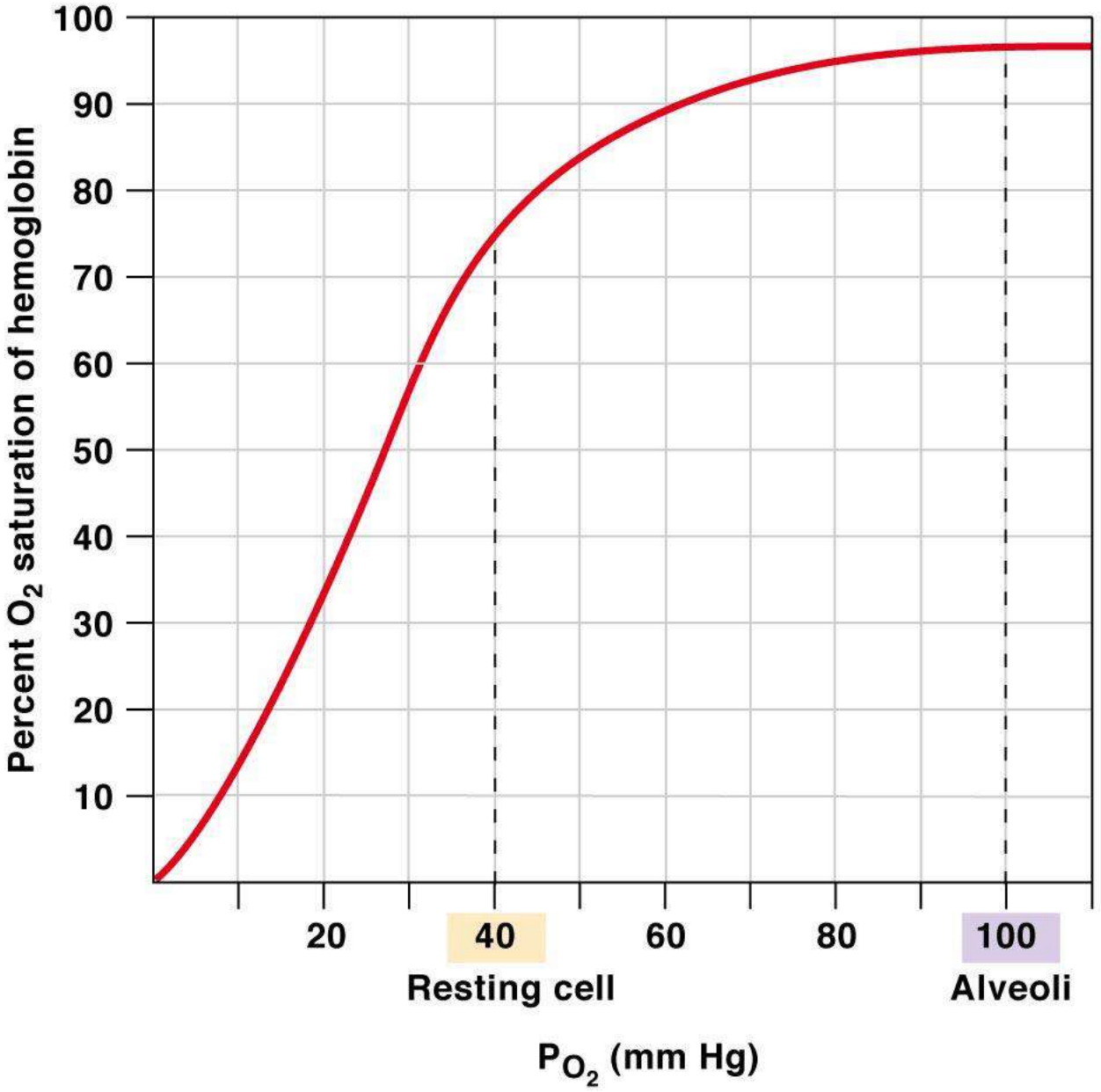


Figure 18-9

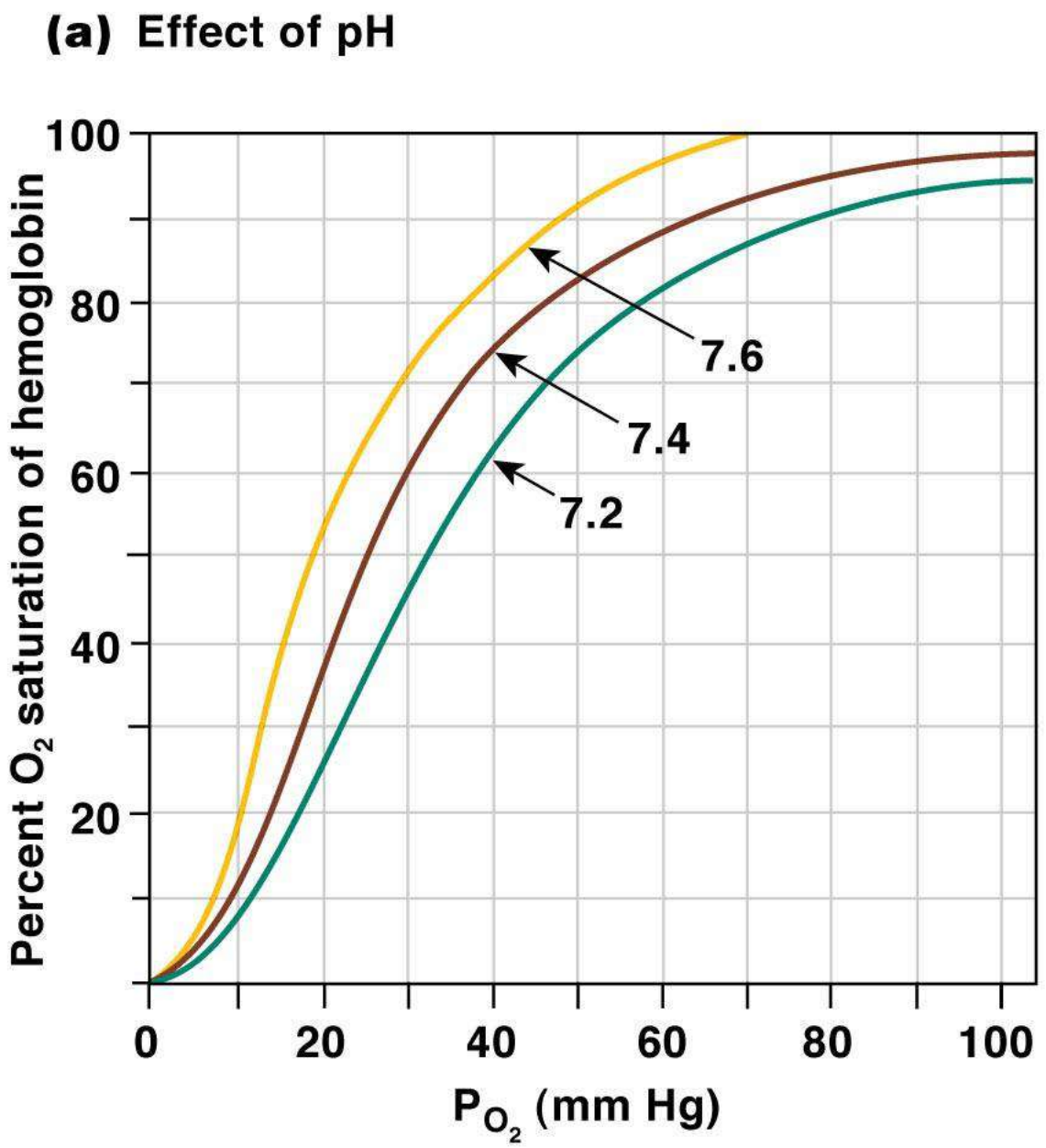


Figure 18-10a

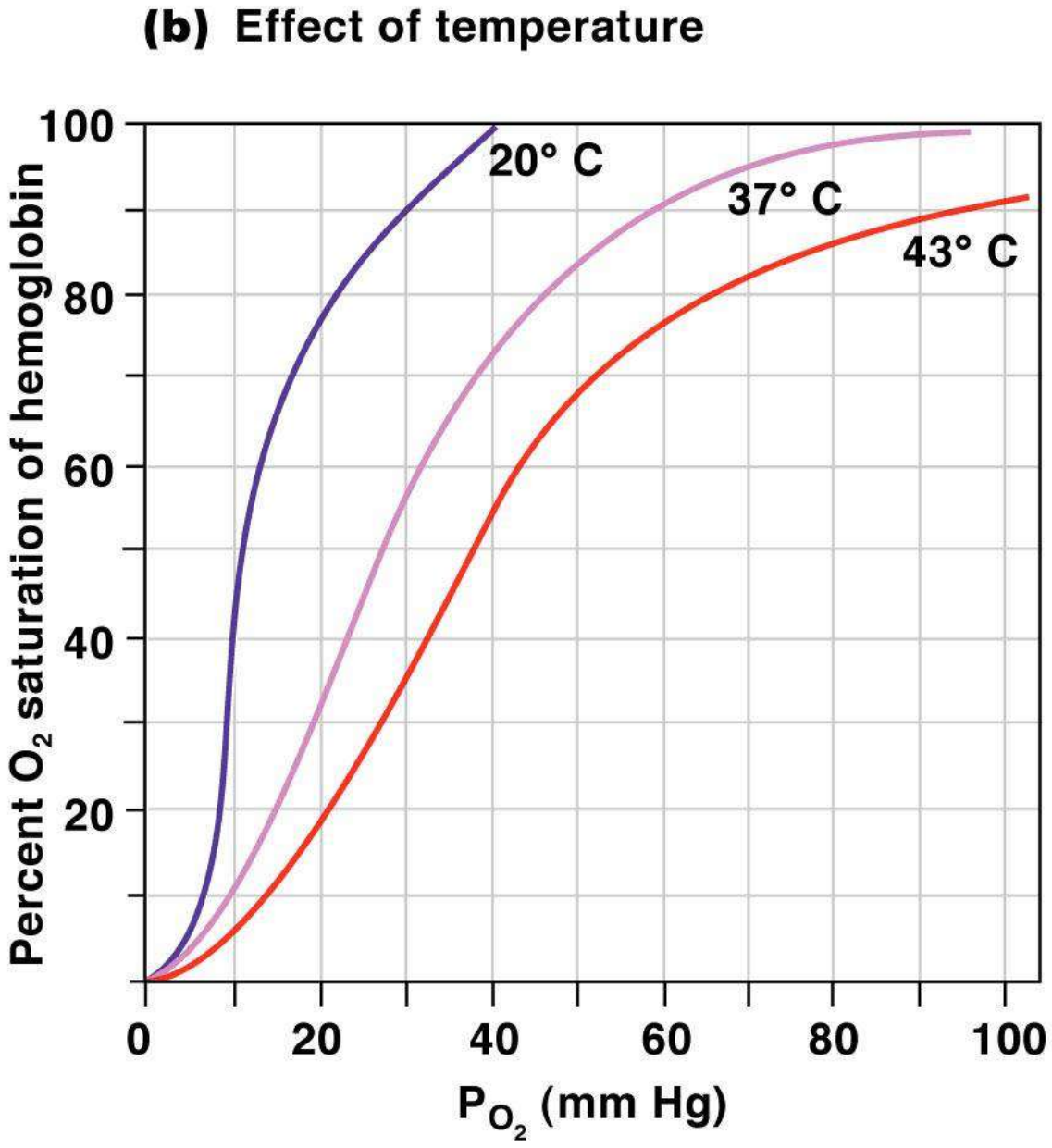


Figure 18-10b

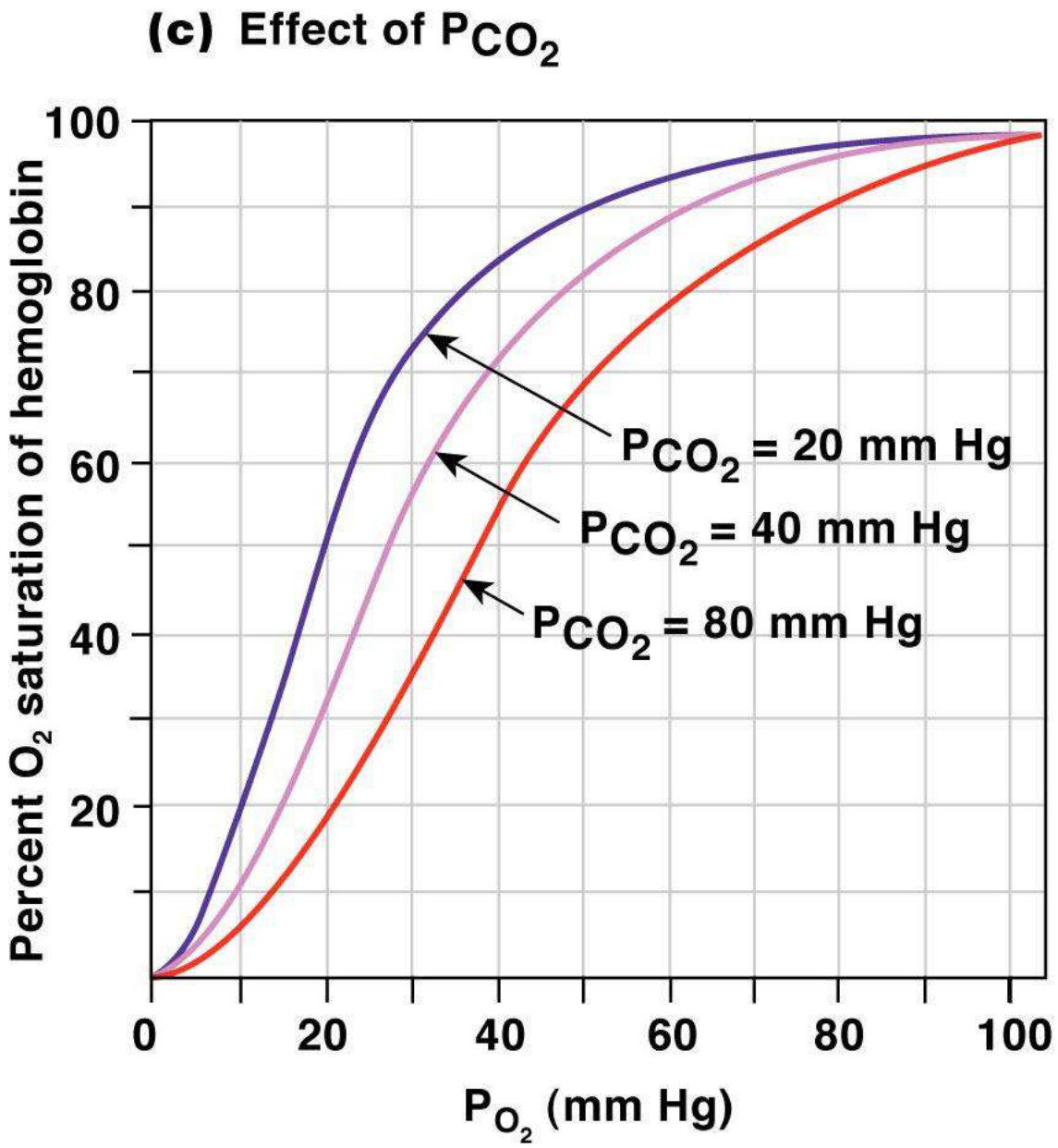


Figure 18-10c

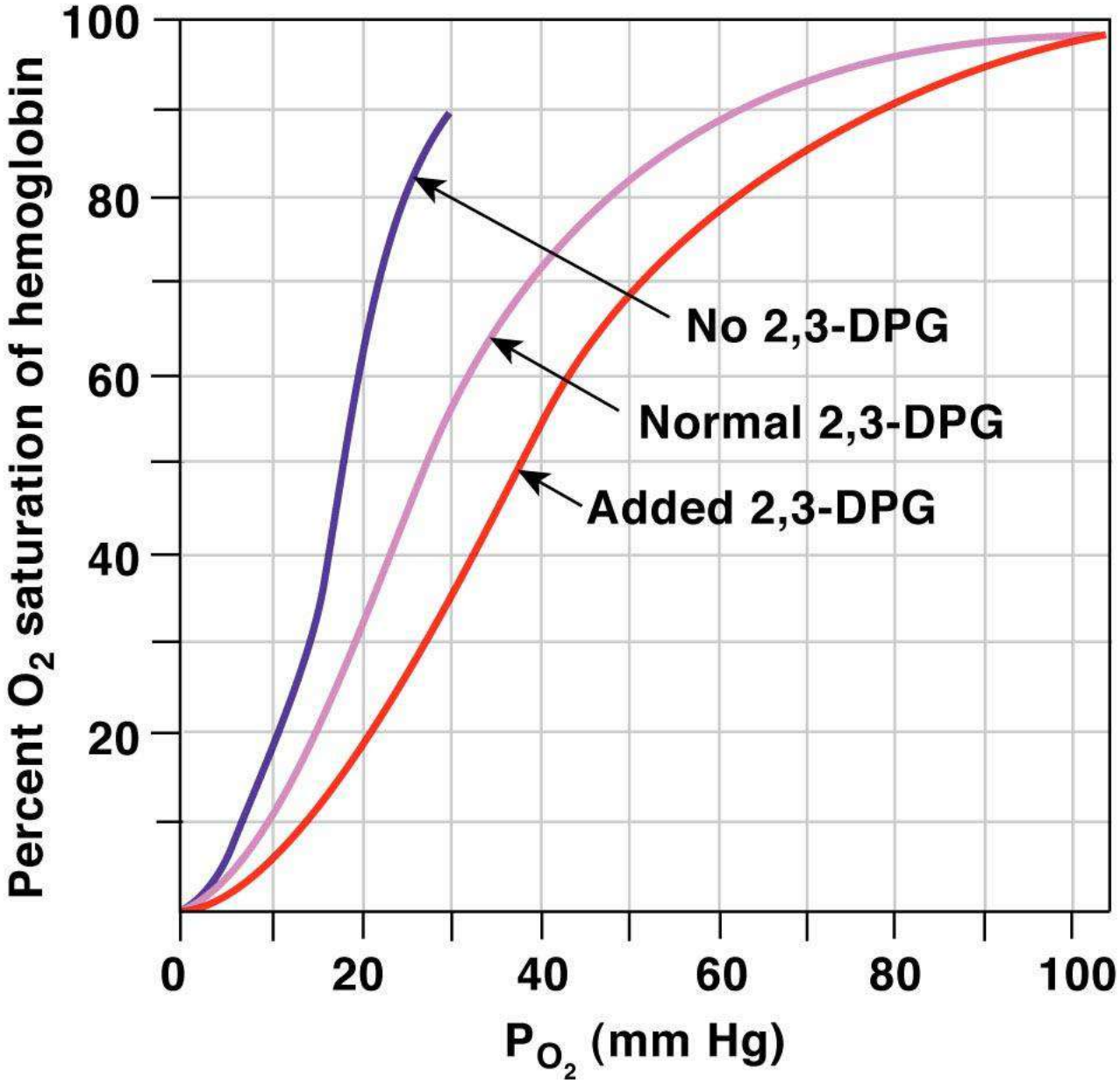


Figure 18-11

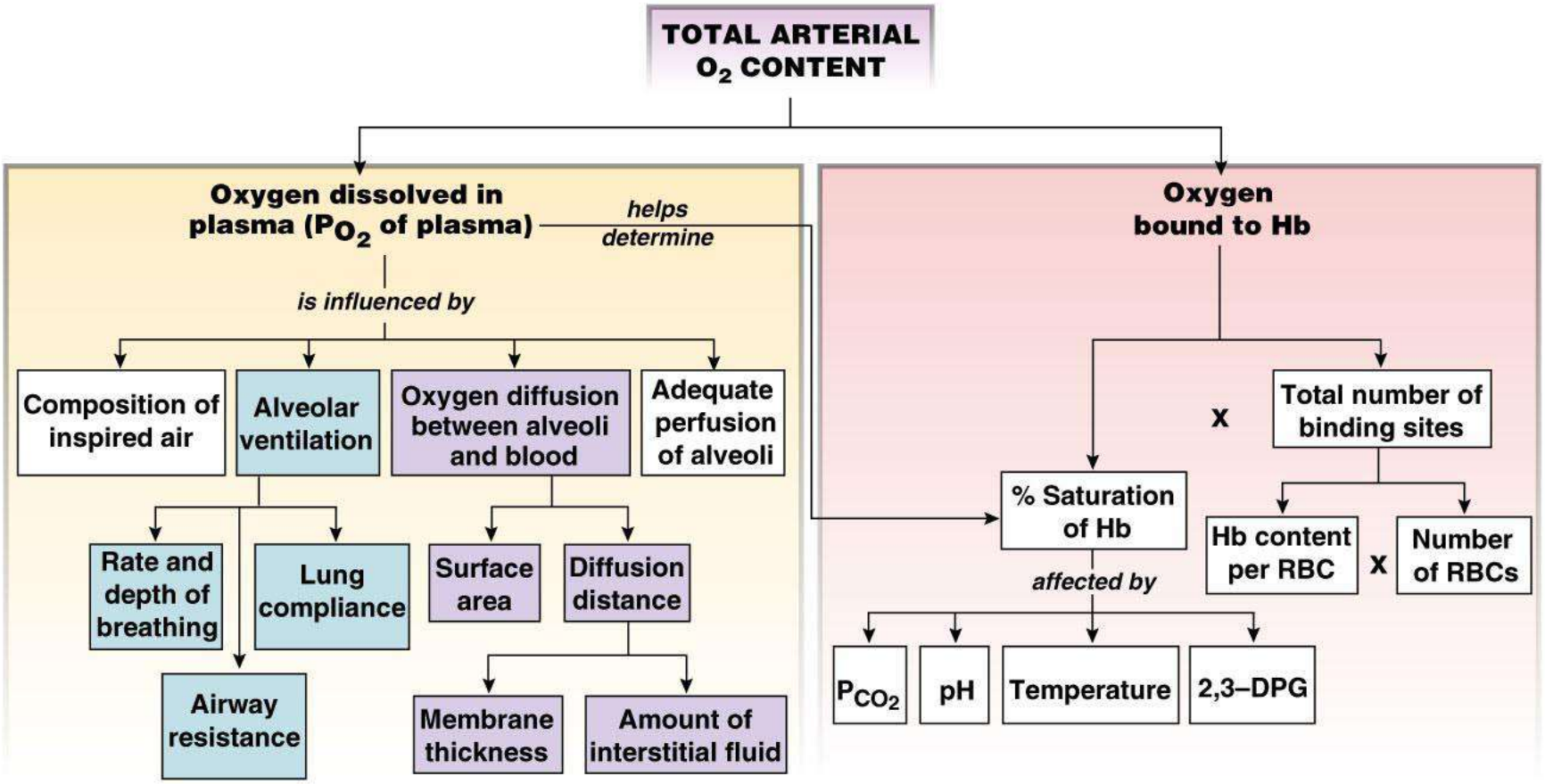


Figure 18-13

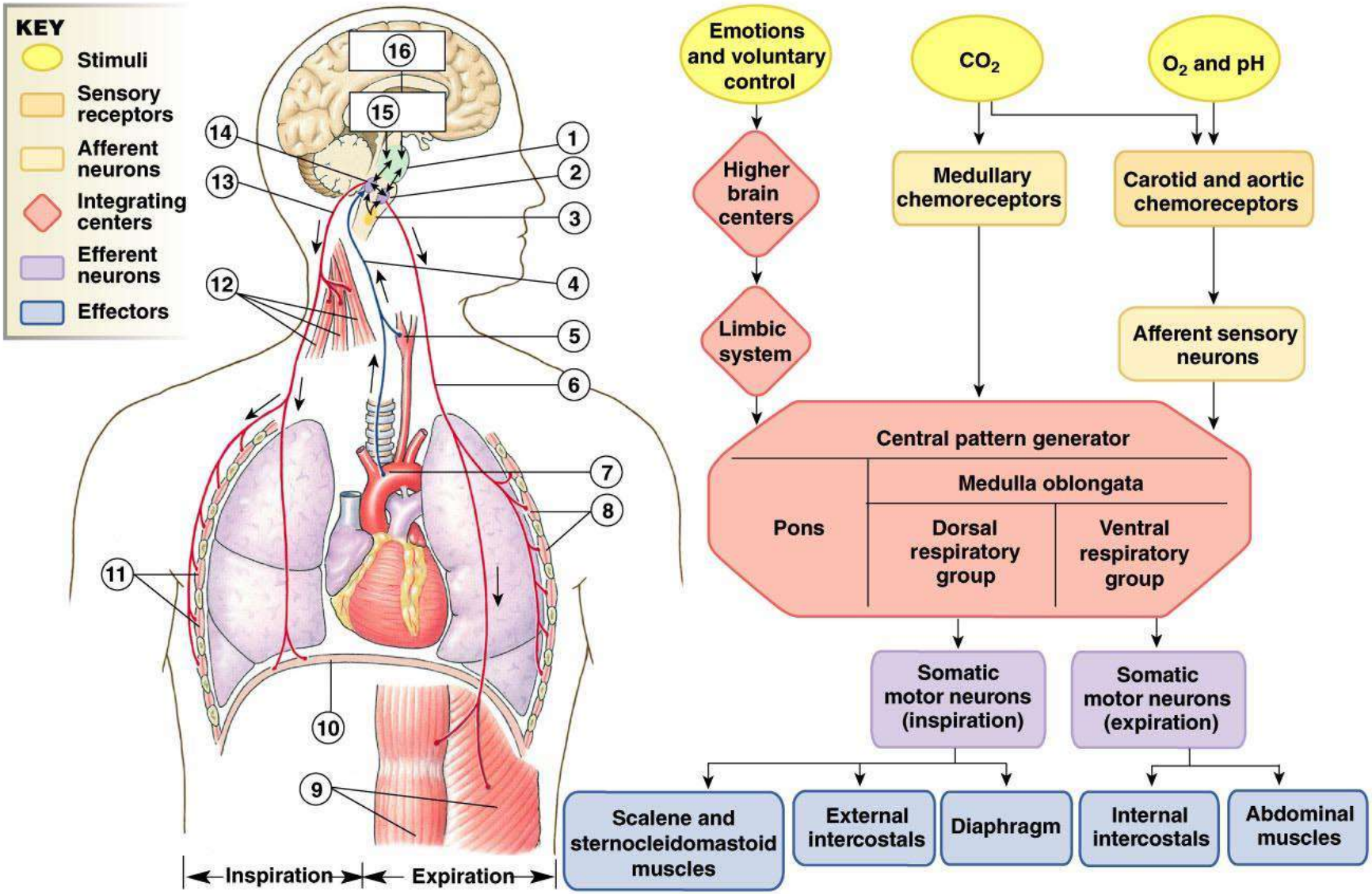


Figure 18-16

Medullary Respiratory Centers

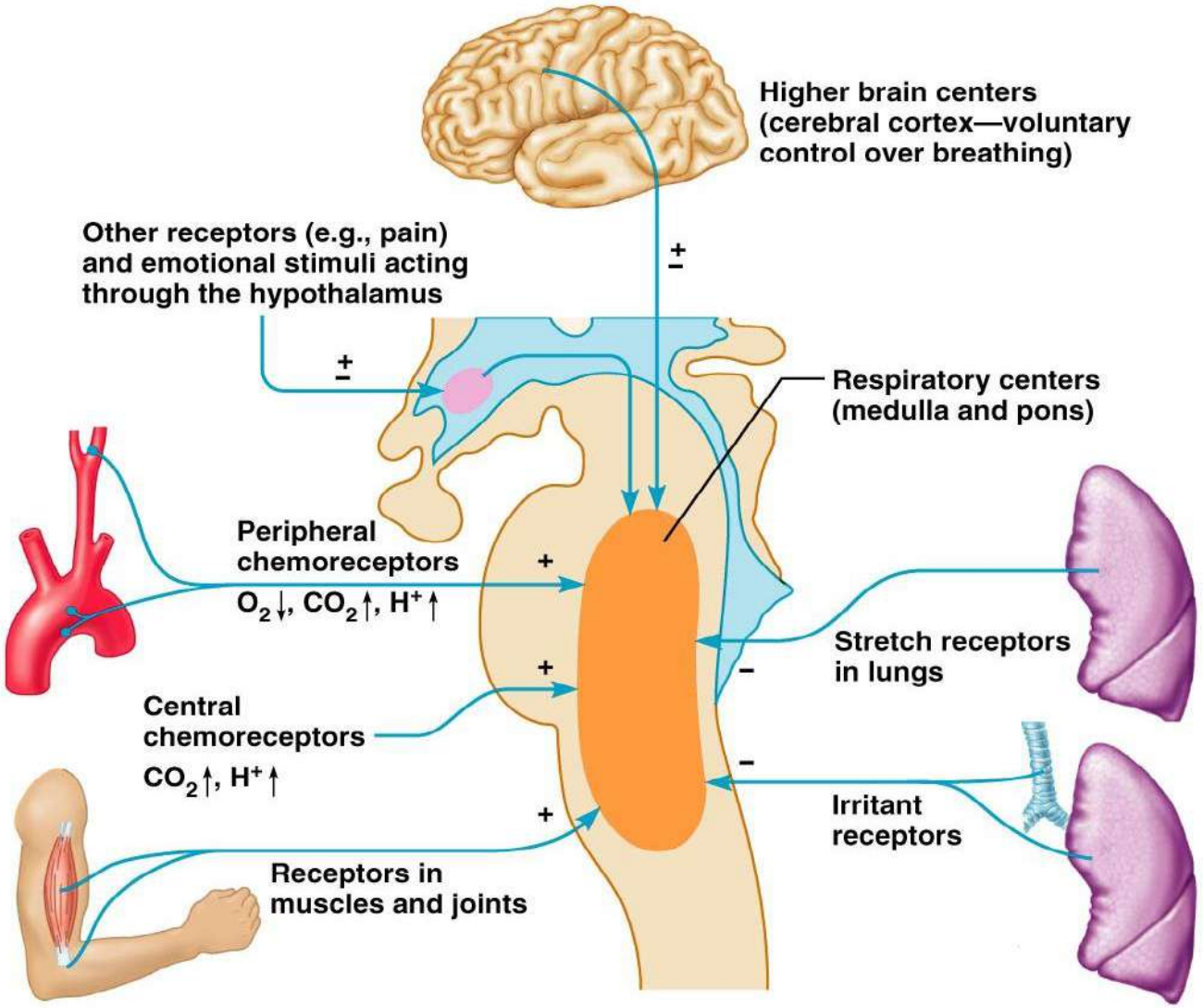


Figure 22.25

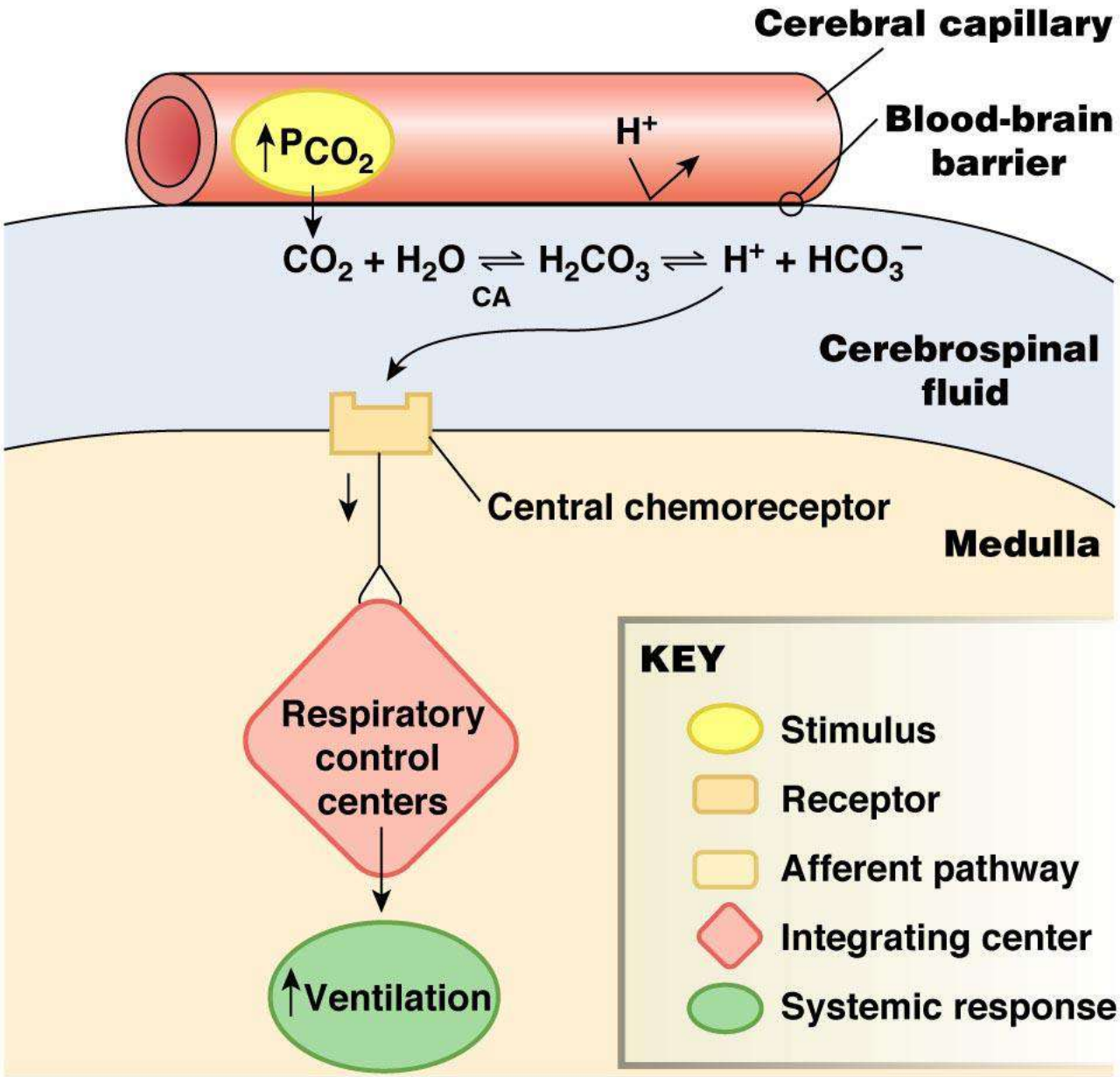


Figure 18-19

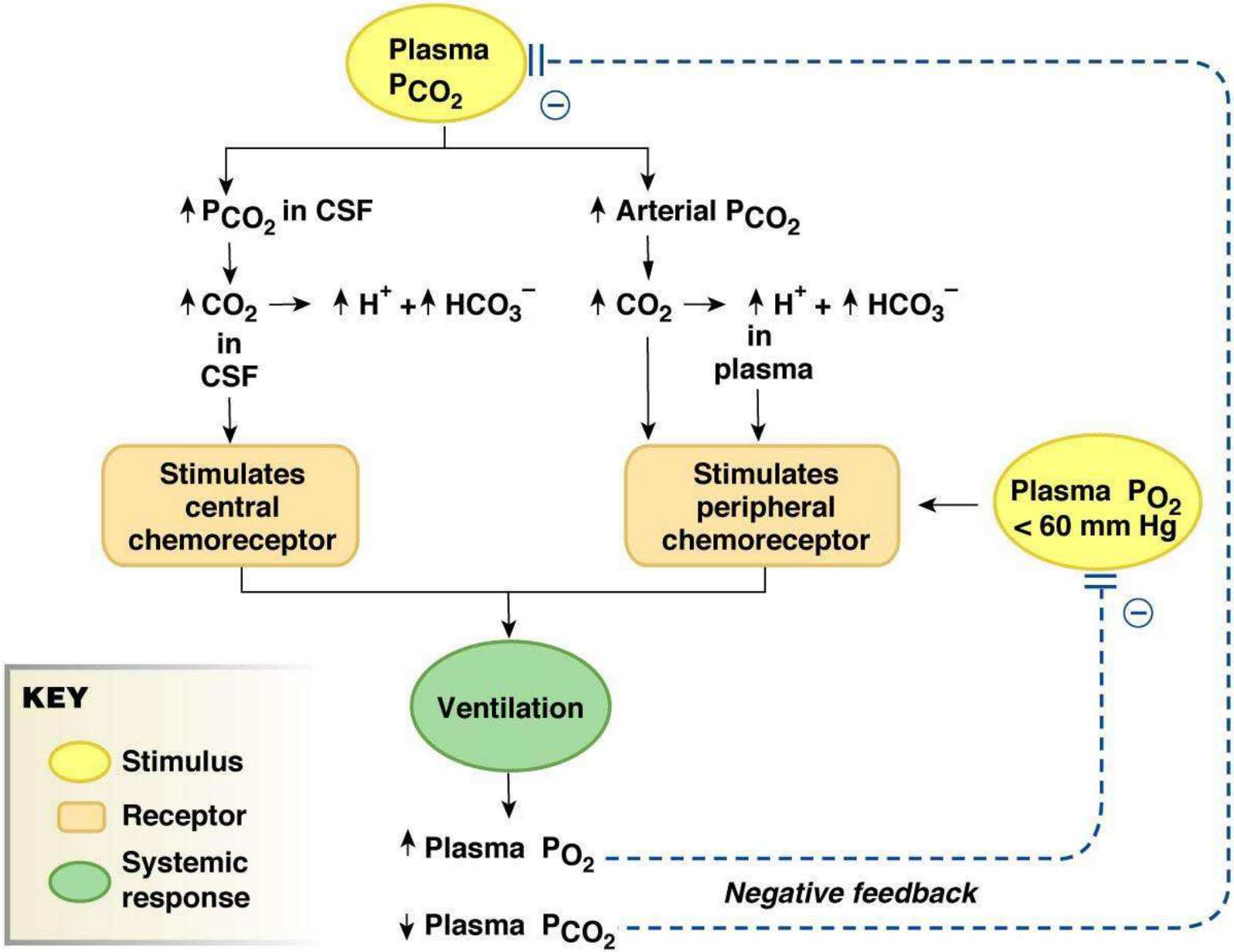


Figure 18-20