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 and other muscles that promote ventilation

Respiratory System

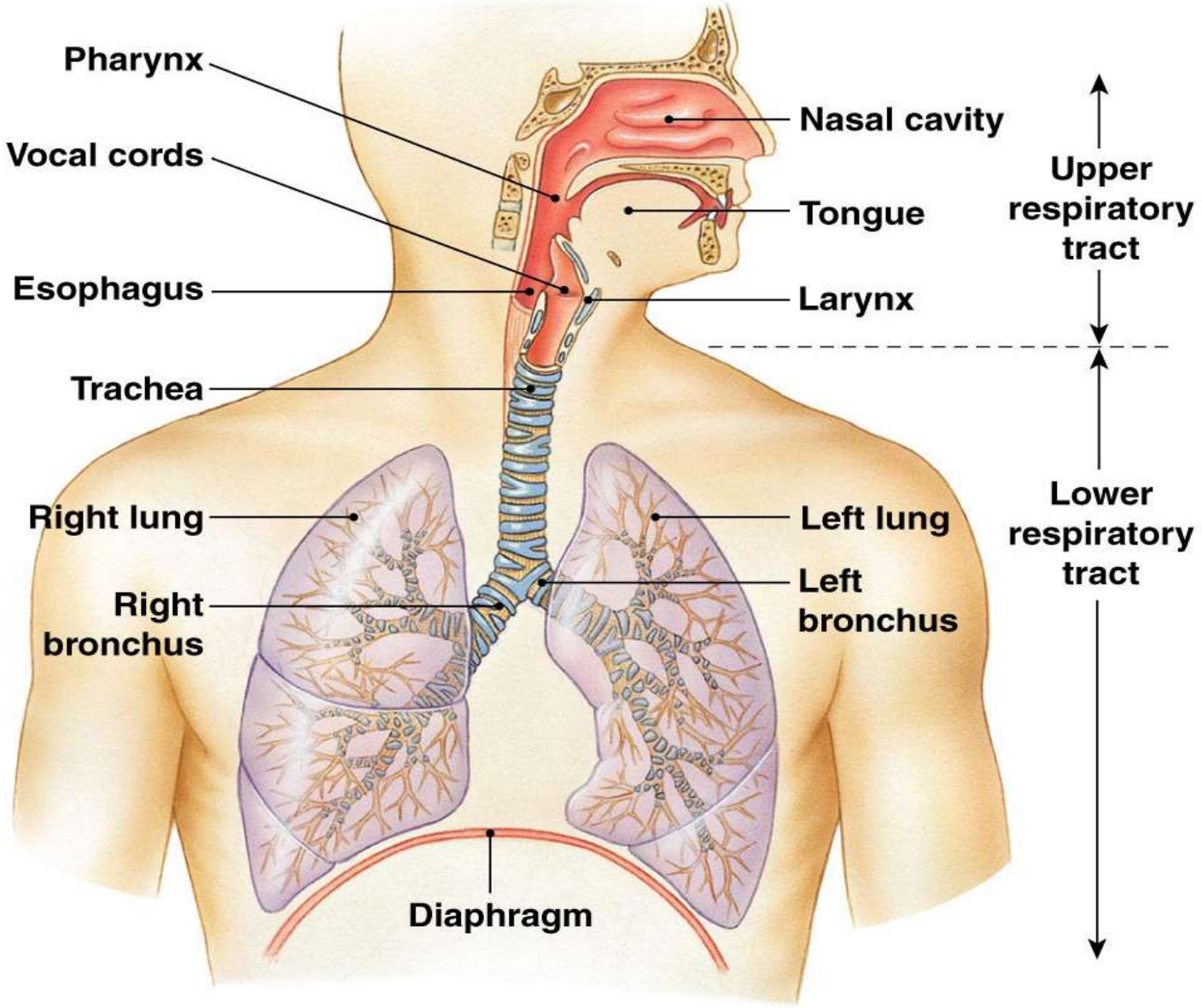


Figure 22.1

Major Functions of the Respiratory System

- To supply the body with oxygen and dispose of carbon dioxide
- Respiration – four distinct processes must happen
  - Pulmonary ventilation – moving air into and out of the lungs
  - External respiration – gas exchange between the lungs and the blood

Major Functions of the Respiratory System

- Transport – transport of oxygen and carbon dioxide between the lungs and tissues
- Internal respiration – gas exchange between systemic blood vessels and tissues

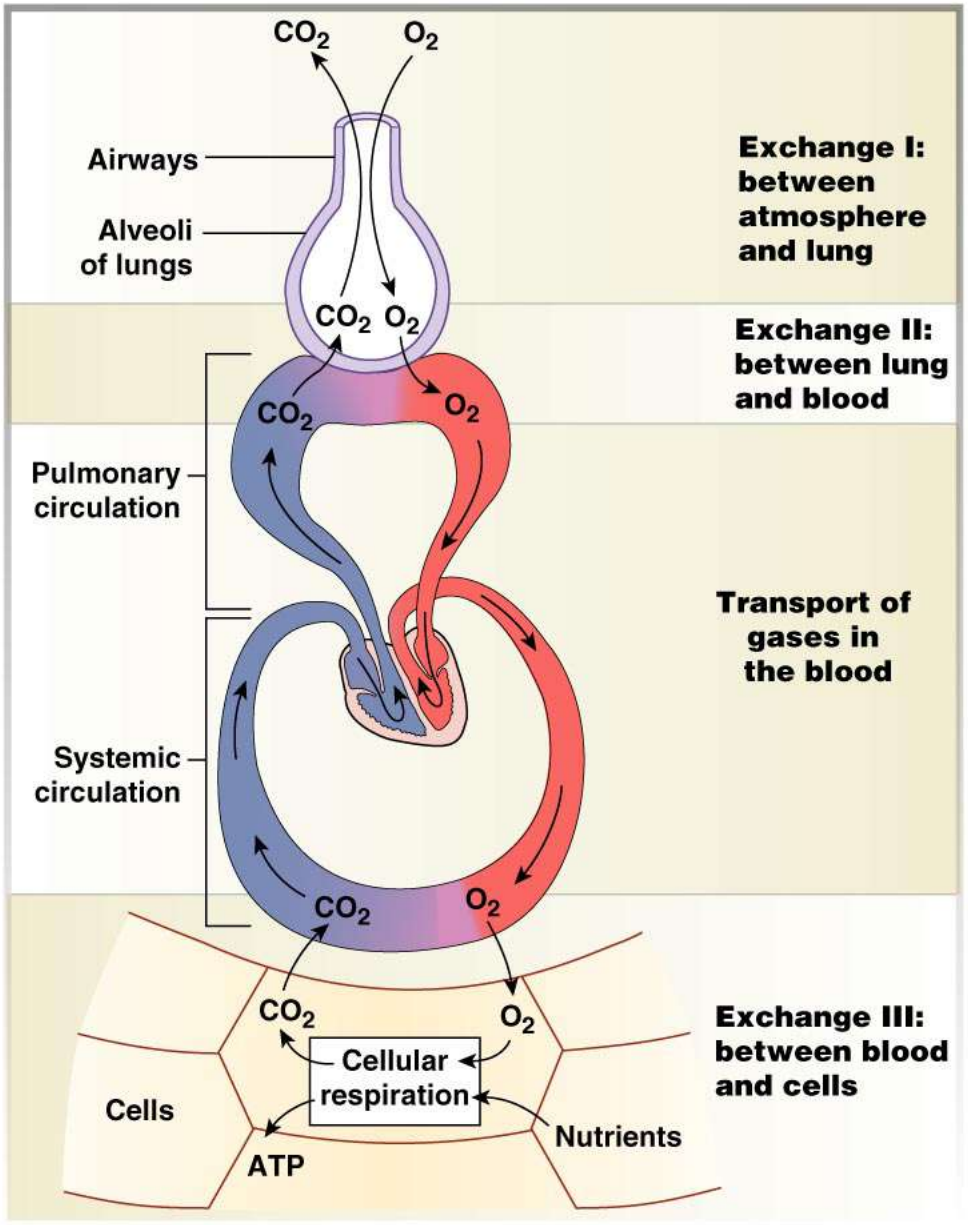


Figure 17.1

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

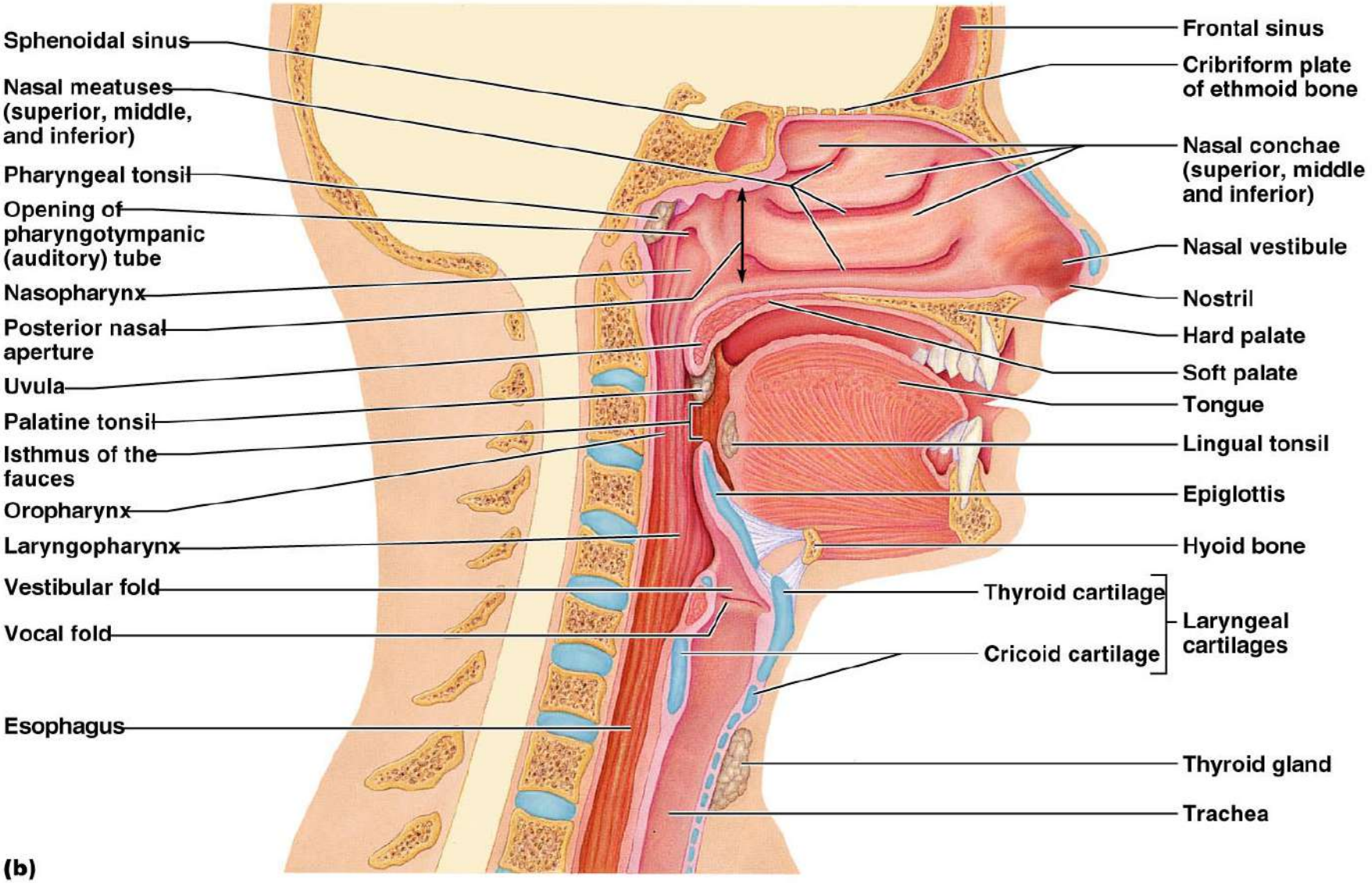


Figure 22.3b

Functions of the Nasal Mucosa and Conchae

- 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

Pharynx

- It is divided into three regions
  - Nasopharynx
  - Oropharynx
  - Laryngopharynx

Larynx (Voice Box)

- Attaches to the hyoid bone and opens into the laryngopharynx superiorly
- Continuous with the trachea posteriorly
- The three functions of the larynx are:
  - To provide a patent airway
  - To act as a switching mechanism to route air and food into the proper channels
  - To function in voice production

Framework of the Larynx

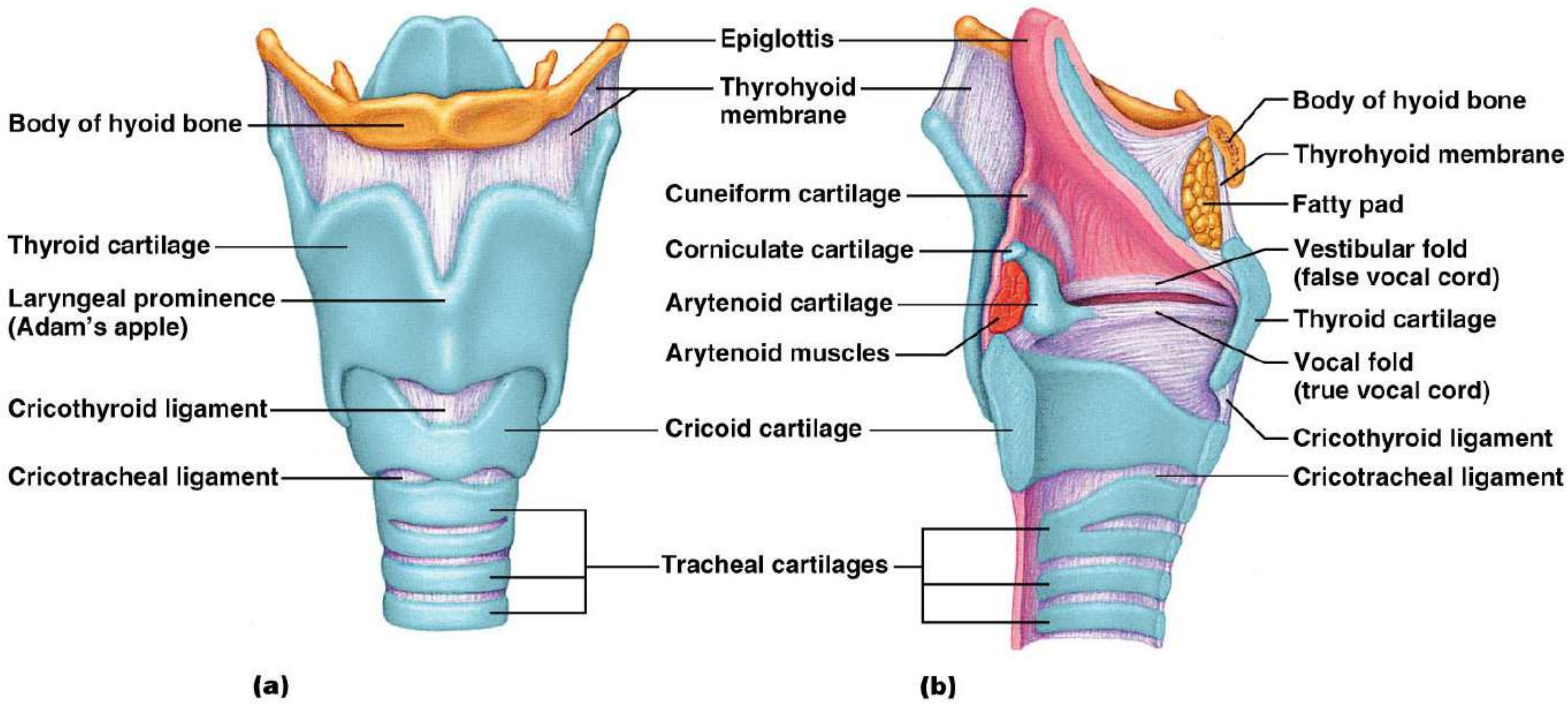


Figure 22.4a, b

Movements of Vocal Cords

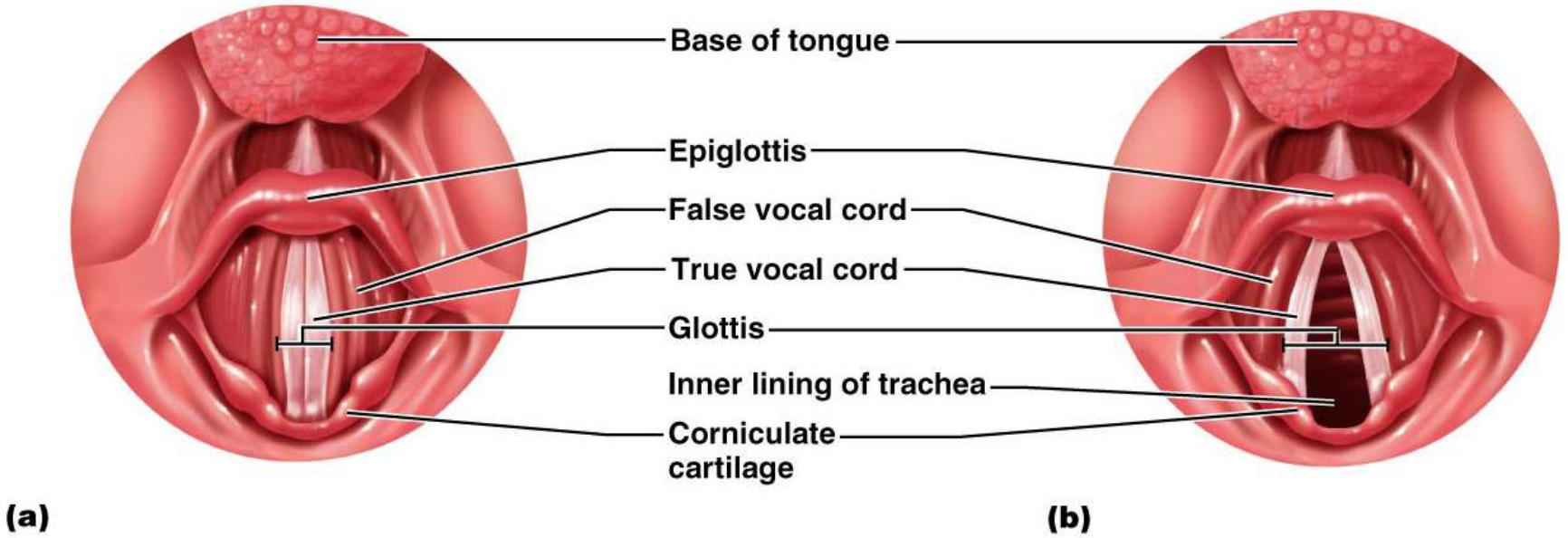


Figure 22.5

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

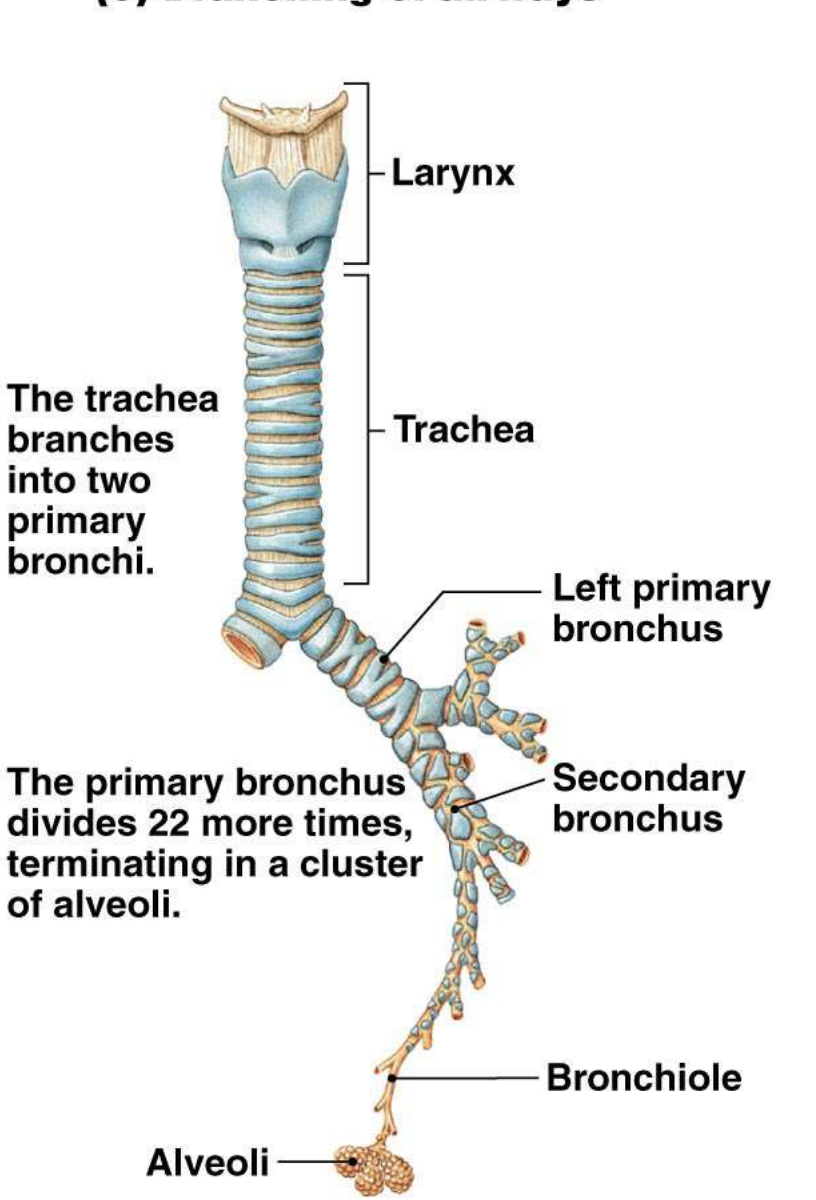


Figure 17.2e

Trachea

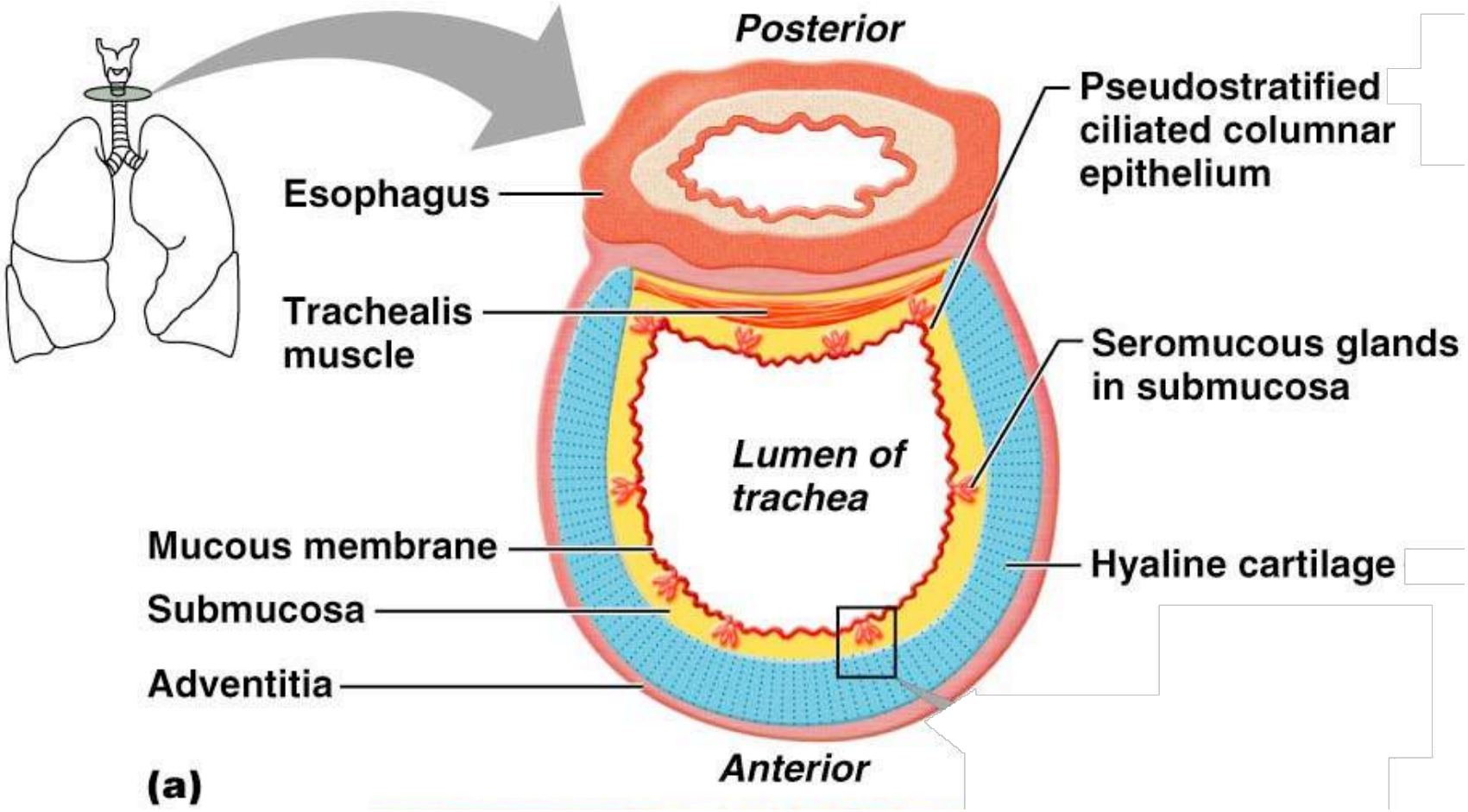


Figure 22.6a

Conducting Zone: Bronchi

- 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

Conducting Zones

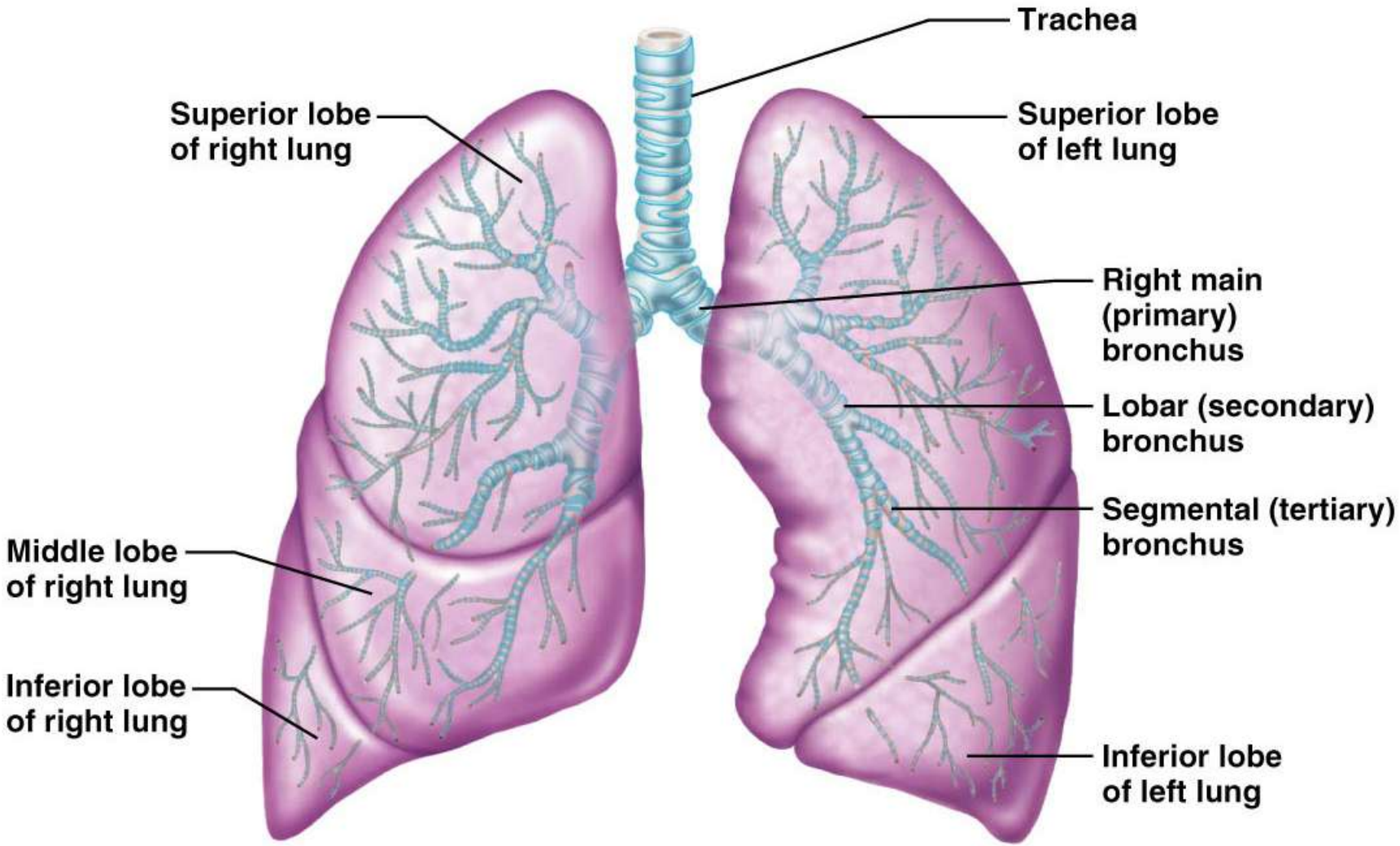


Figure 22.7

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 Membrane

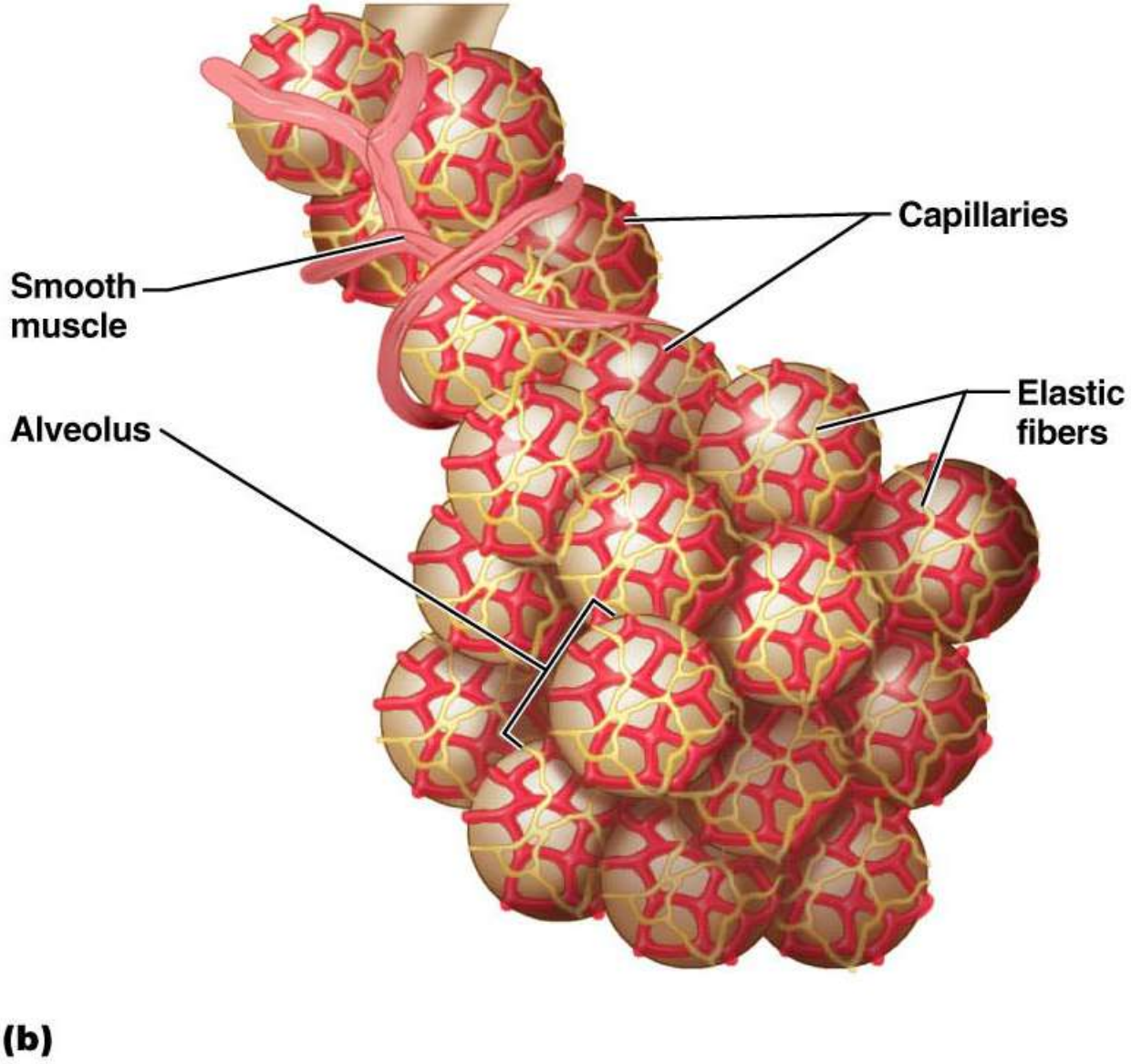


Figure 22.9b

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)
- Type II cells secrete surfactant

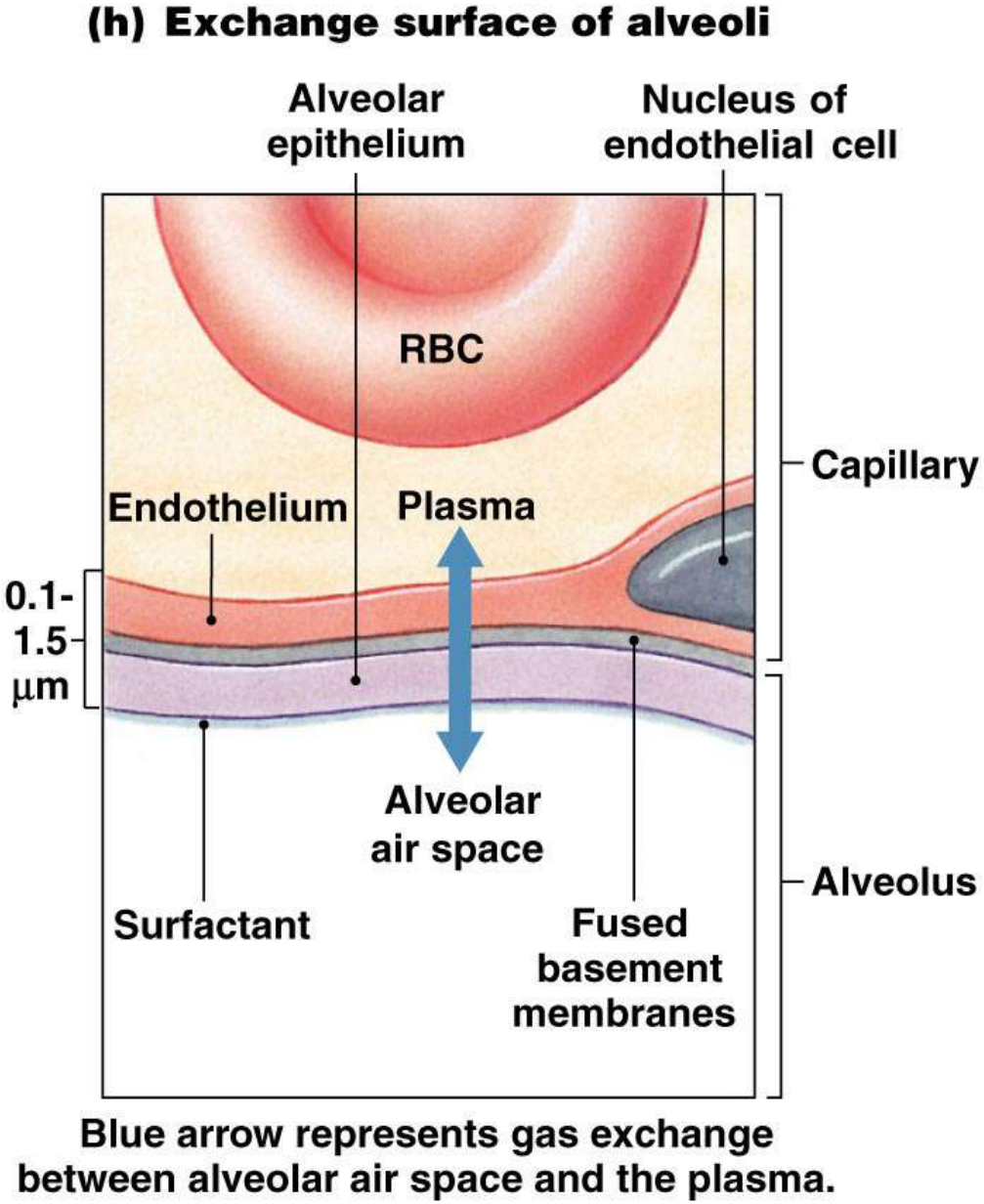


Figure 17.2h

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

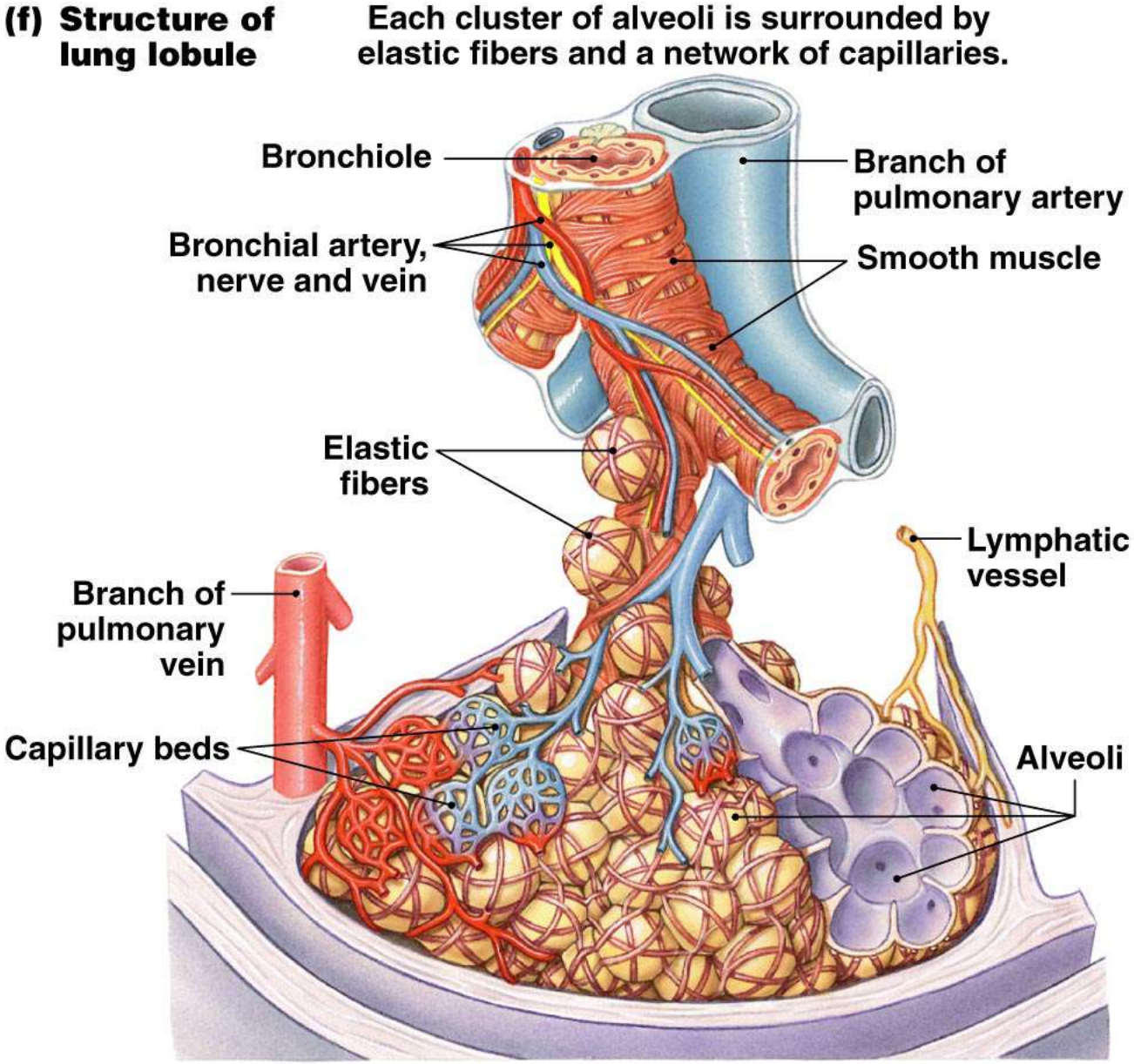


Figure 17.2f

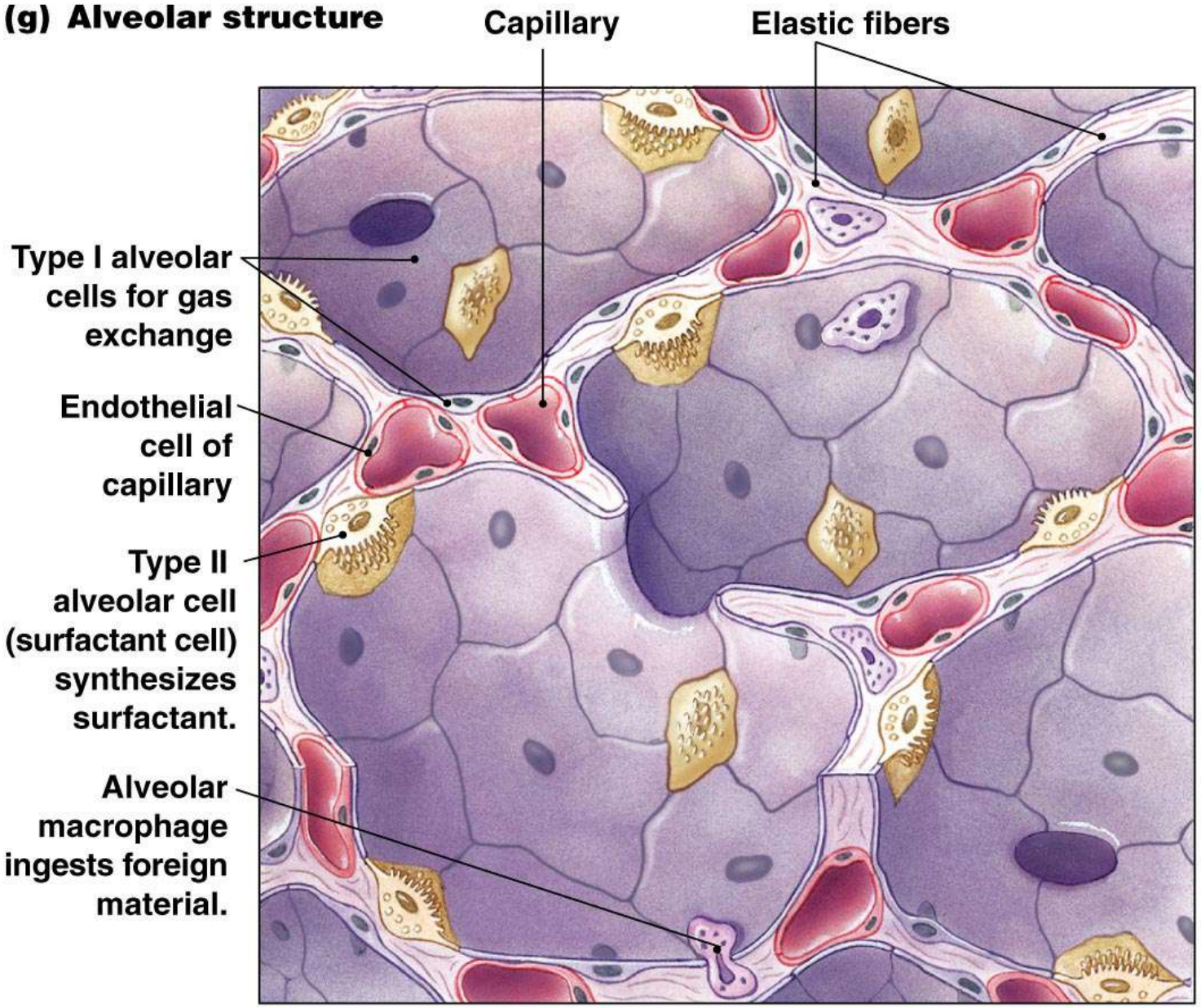


Figure 17.2g

Gross Anatomy of the Lungs

- Lungs occupy all of the thoracic cavity except the mediastinum
  - Root – site of vascular and bronchial attachments
  - Costal surface – anterior, lateral, and posterior surfaces in contact with the ribs
  - Apex – narrow superior tip
  - Base – inferior surface that rests on the diaphragm
  - Hilus – indentation that contains pulmonary and systemic blood vessels

Conducting Zones

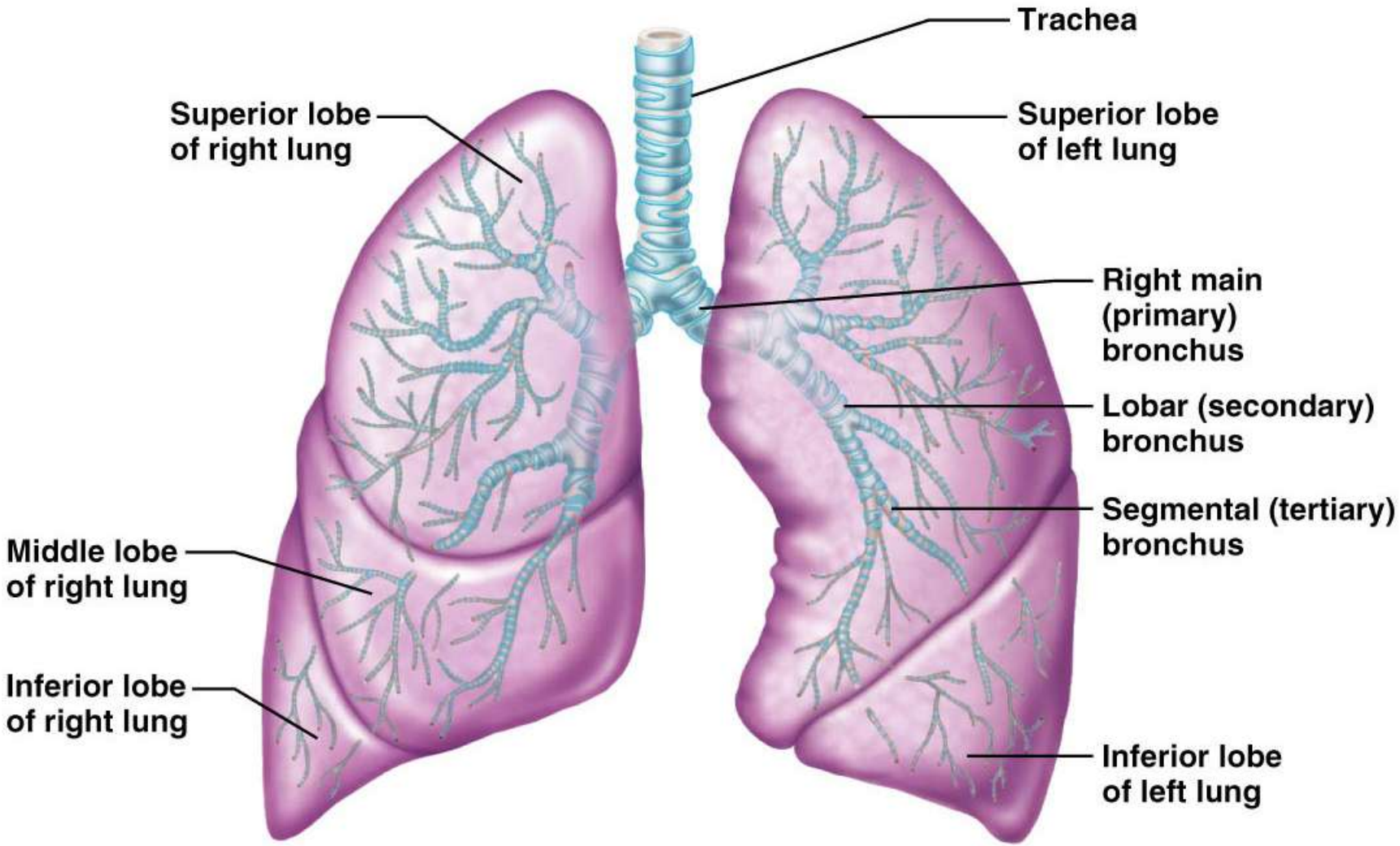


Figure 22.7

Organs in the Thoracic Cavity

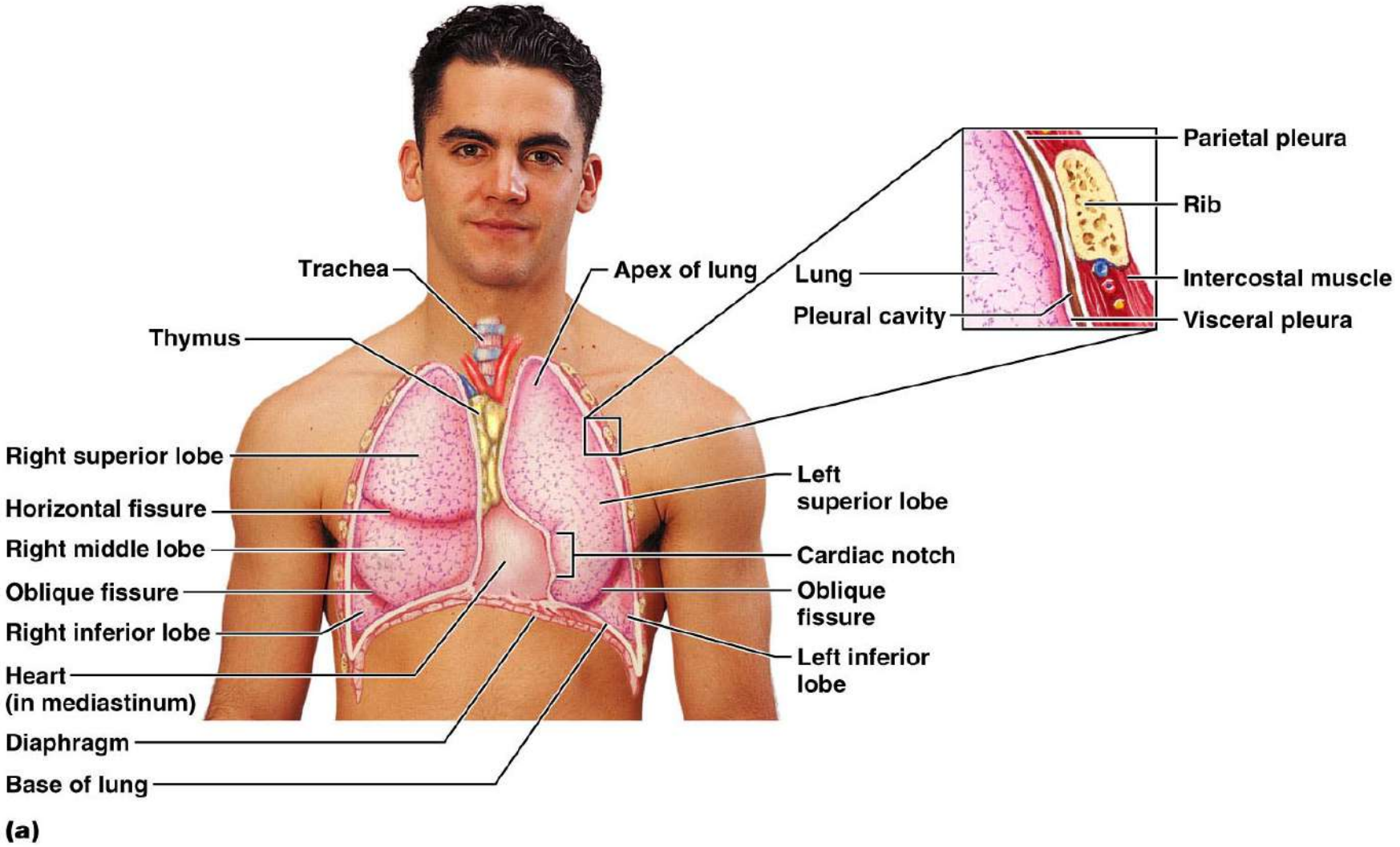


Figure 22.10a

Transverse Thoracic Section

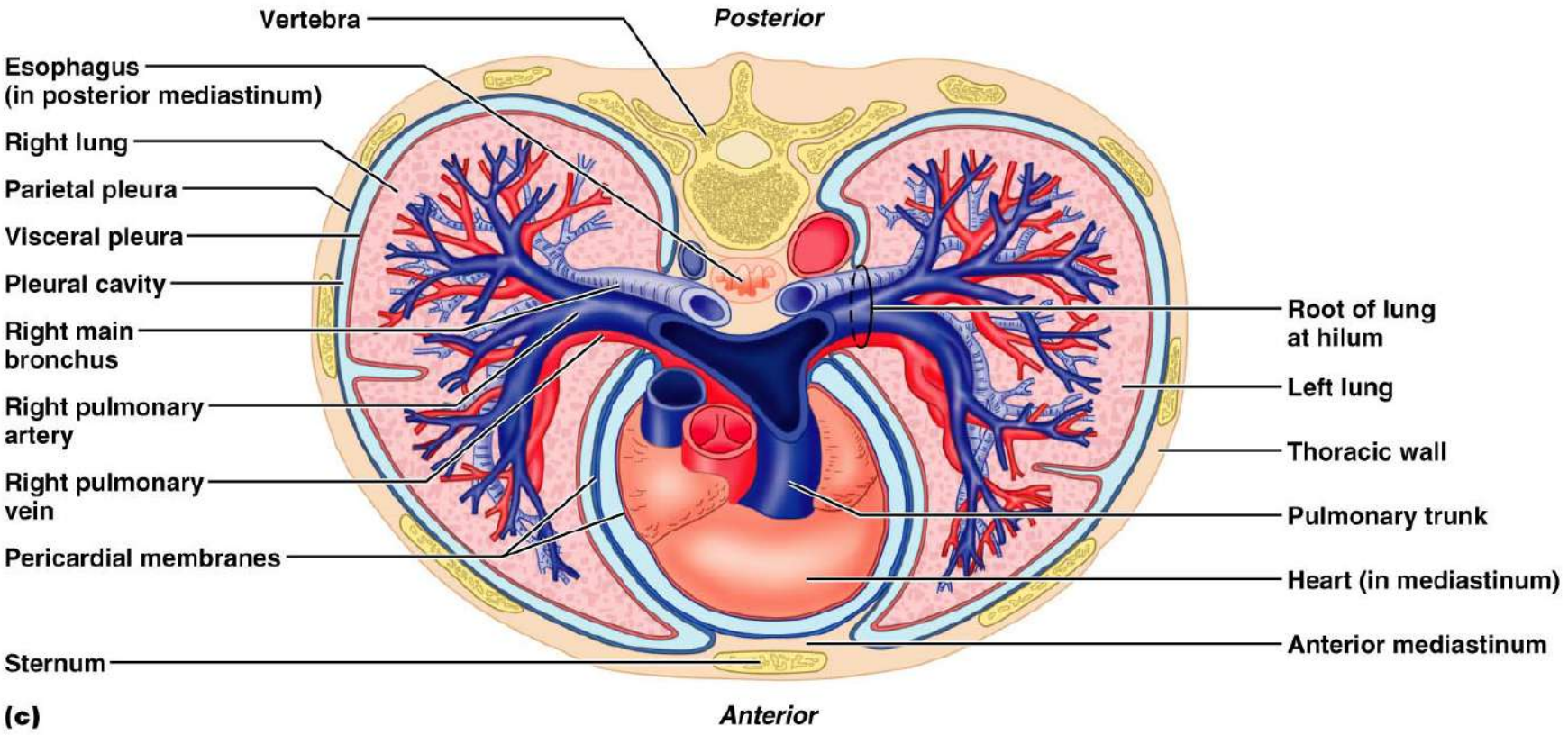


Figure 22.10c

Blood Supply to Lungs

- Bronchial arteries – provide systemic blood to the lung tissue
  - Arise from aorta and enter the lungs at the hilus
  - Supply all lung tissue except the alveoli
- Bronchial veins anastomose with pulmonary veins
- Pulmonary veins carry most venous blood back to the heart

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

Pressure Relationships in the Thoracic Cavity

- Intrapulmonary pressure (P_{pul}) – pressure within the alveoli
- Intrapleural pressure (P_{ip}) – pressure within the pleural cavity

Pressure Relationships

- Two forces act to pull the lungs away from the thoracic wall, promoting lung collapse
  - Elasticity of lungs causes them to assume smallest possible size
  - Surface tension of alveolar fluid draws alveoli to their smallest possible size
- Opposing force – elasticity of the chest wall pulls the thorax outward to enlarge the lungs

Pressure Relationships

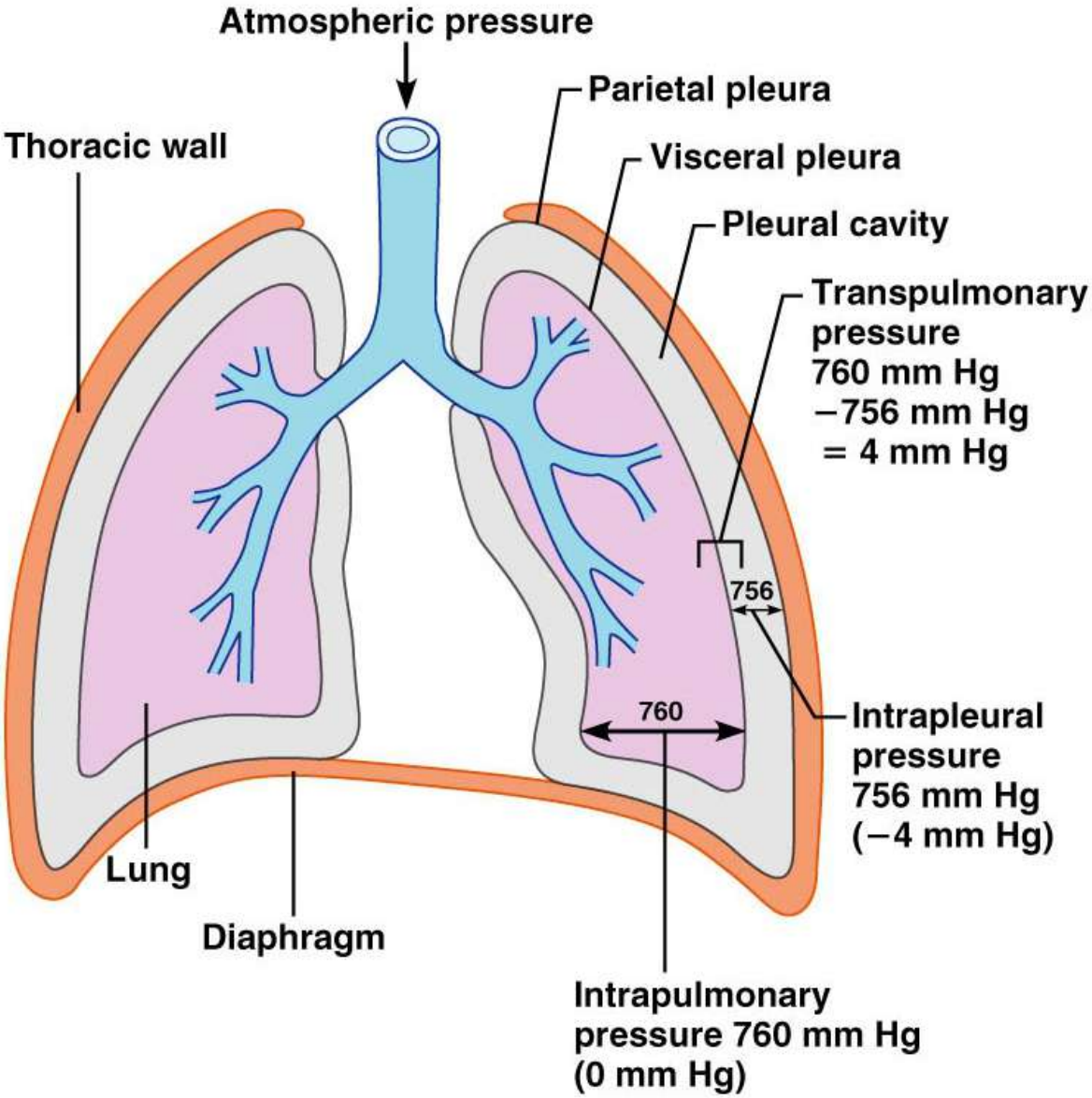
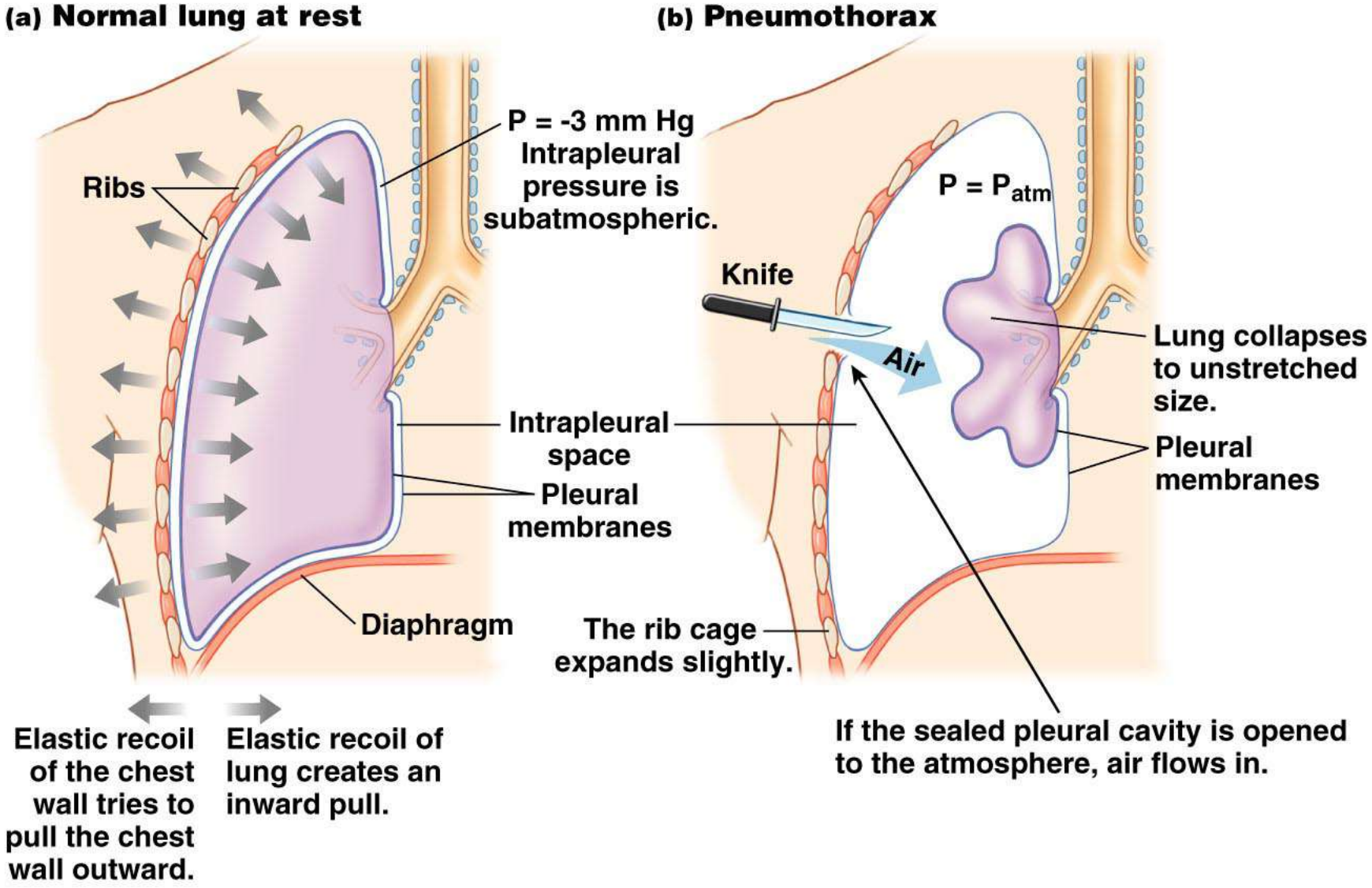


Figure 22.12

Lung Collapse

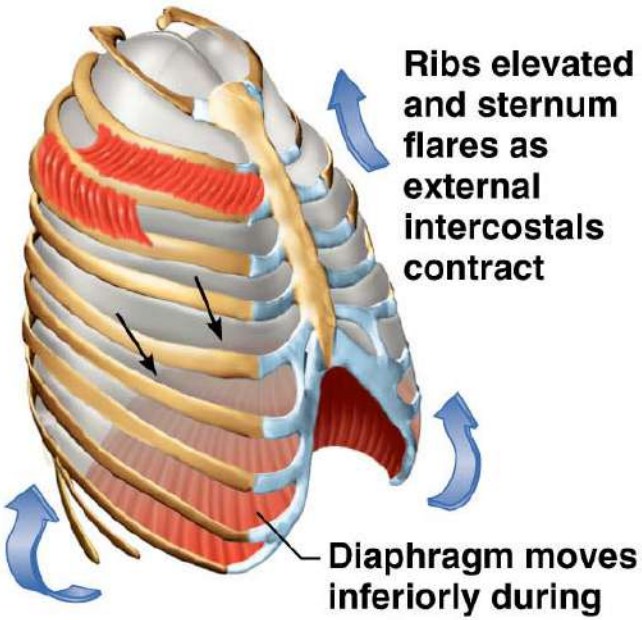
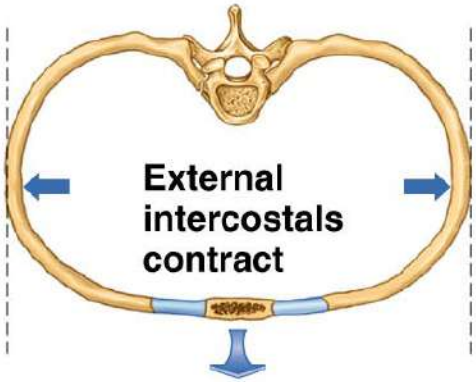
- Caused by equalization of the intrapleural pressure with the intrapulmonary pressure
- Transpulmonary pressure keeps the airways open
  - Transpulmonary pressure – difference between the intrapulmonary and intrapleural pressures ($P_{pul} - P_{ip}$)



Inspiration

- The diaphragm and external intercostal muscles (inspiratory muscles) contract and the rib cage rises
- The lungs are stretched and intrapulmonary volume increases
- Intrapulmonary pressure drops below atmospheric pressure (-1 mm Hg)
- Air flows into the lungs, down its pressure gradient, until intrapleural pressure = atmospheric pressure

Inspiration

	Sequence of events	Changes in anterior-posterior and superior-inferior dimensions	Changes in lateral dimensions
Inspiration	① Inspiratory muscles contract (diaphragm descends; rib cage rises) ↓ ② Thoracic cavity volume increases ↓ ③ Lungs stretched; intrapulmonary volume increases ↓ ④ Intrapulmonary pressure drops (to –1 mm Hg) ↓ ⑤ Air (gases) flows into lungs down its pressure gradient until intrapulmonary pressure is 0 (equal to atmospheric pressure)		

Expiration

- Inspiratory muscles relax and the rib cage descends due to gravity
- Thoracic cavity volume decreases
- Elastic lungs recoil passively and intrapulmonary volume decreases
- Intrapulmonary pressure rises above atmospheric pressure (+1 mm Hg)
- Gases flow out of the lungs down the pressure gradient until intrapulmonary pressure is 0

Expiration

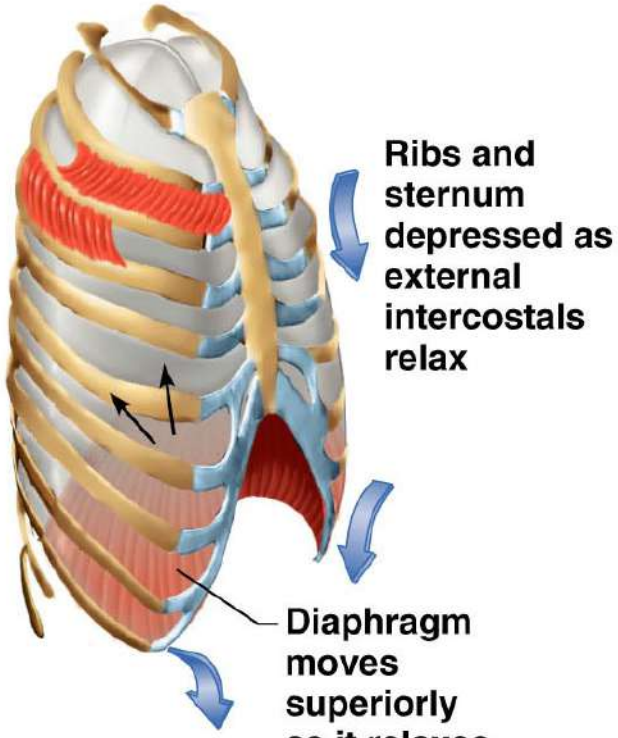
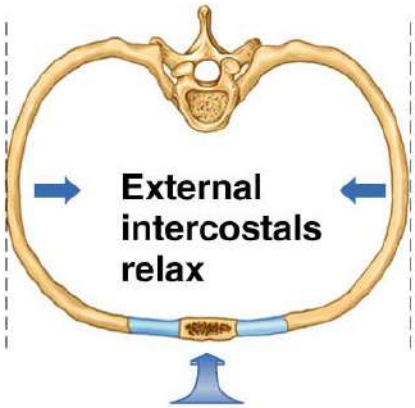
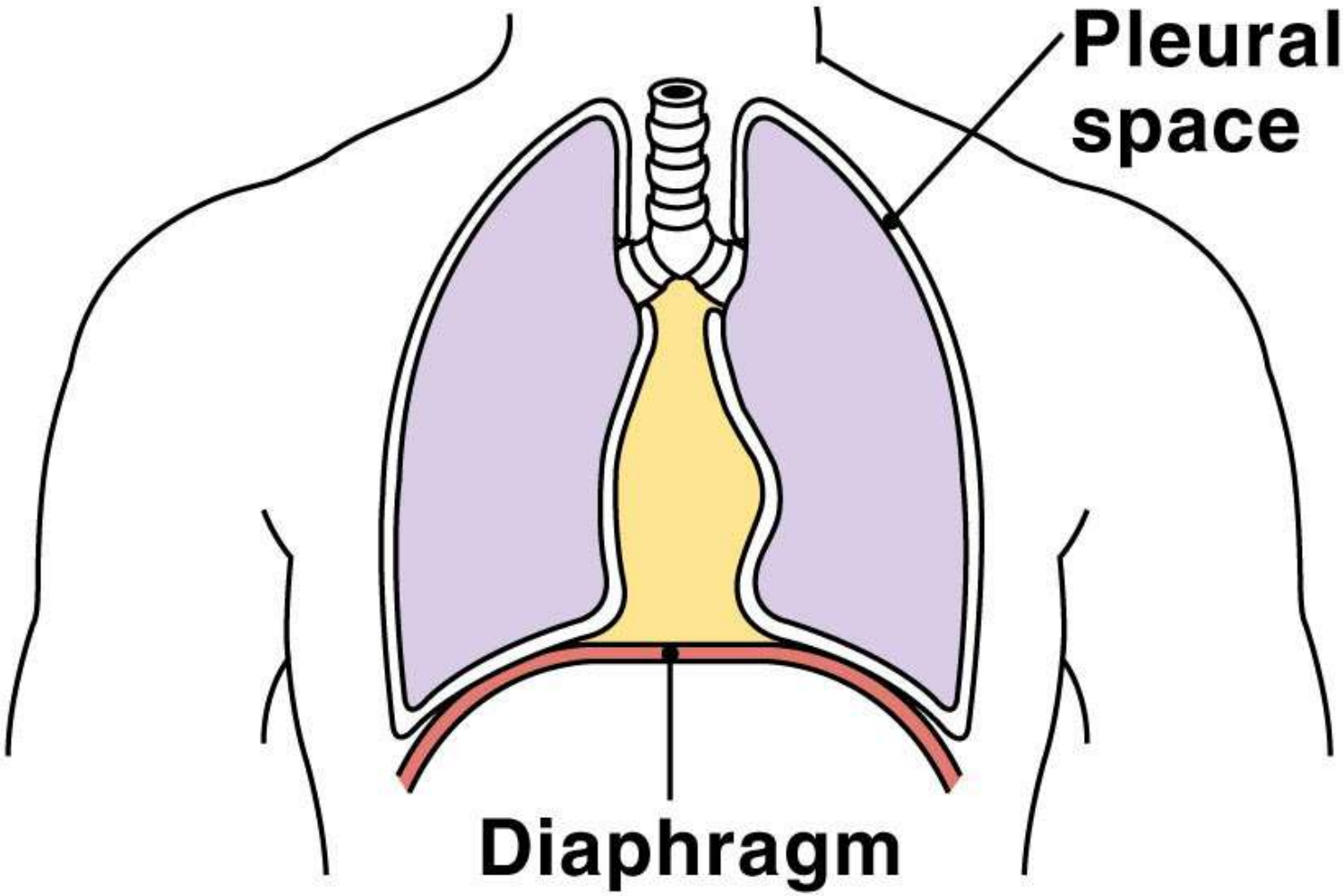
	Sequence of events	Changes in anterior-posterior and superior-inferior dimensions	Changes in lateral dimensions
Expiration	① Inspiratory muscles relax (diaphragm rises; rib cage descends due to recoil of costal cartilages) ↓ ② Thoracic cavity volume decreases ↓ ③ Elastic lungs recoil passively; intrapulmonary volume decreases ↓ ④ Intrapulmonary pressure rises (to +1 mm Hg) ↓ ⑤ Air (gases) flows out of lungs down its pressure gradient until intrapulmonary pressure is 0		

Figure 22.13.2



(b) Diaphragm contracts, thoracic volume increases.

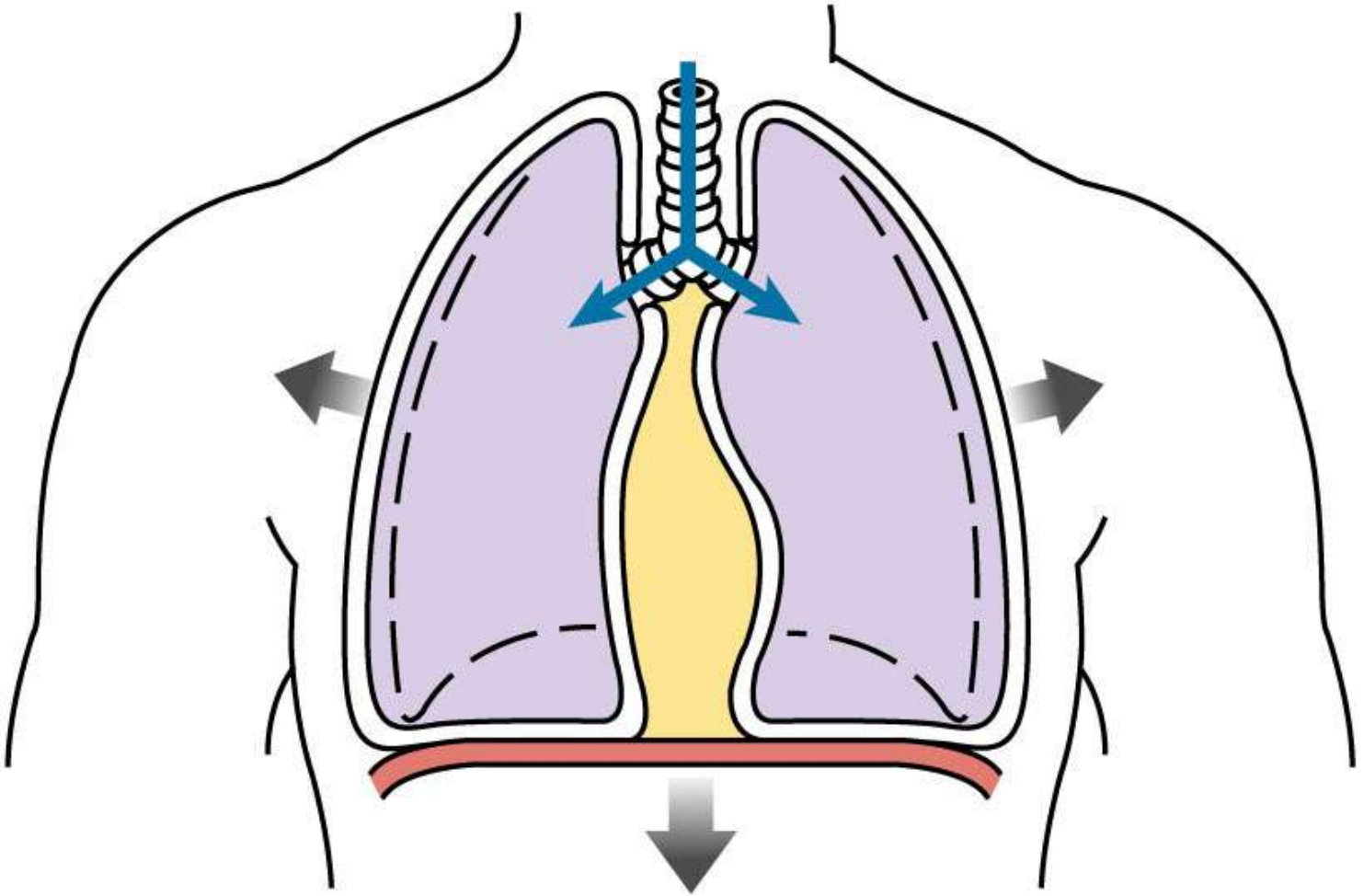


Figure 17.9b

(c) Diaphragm relaxes, thoracic volume decreases.

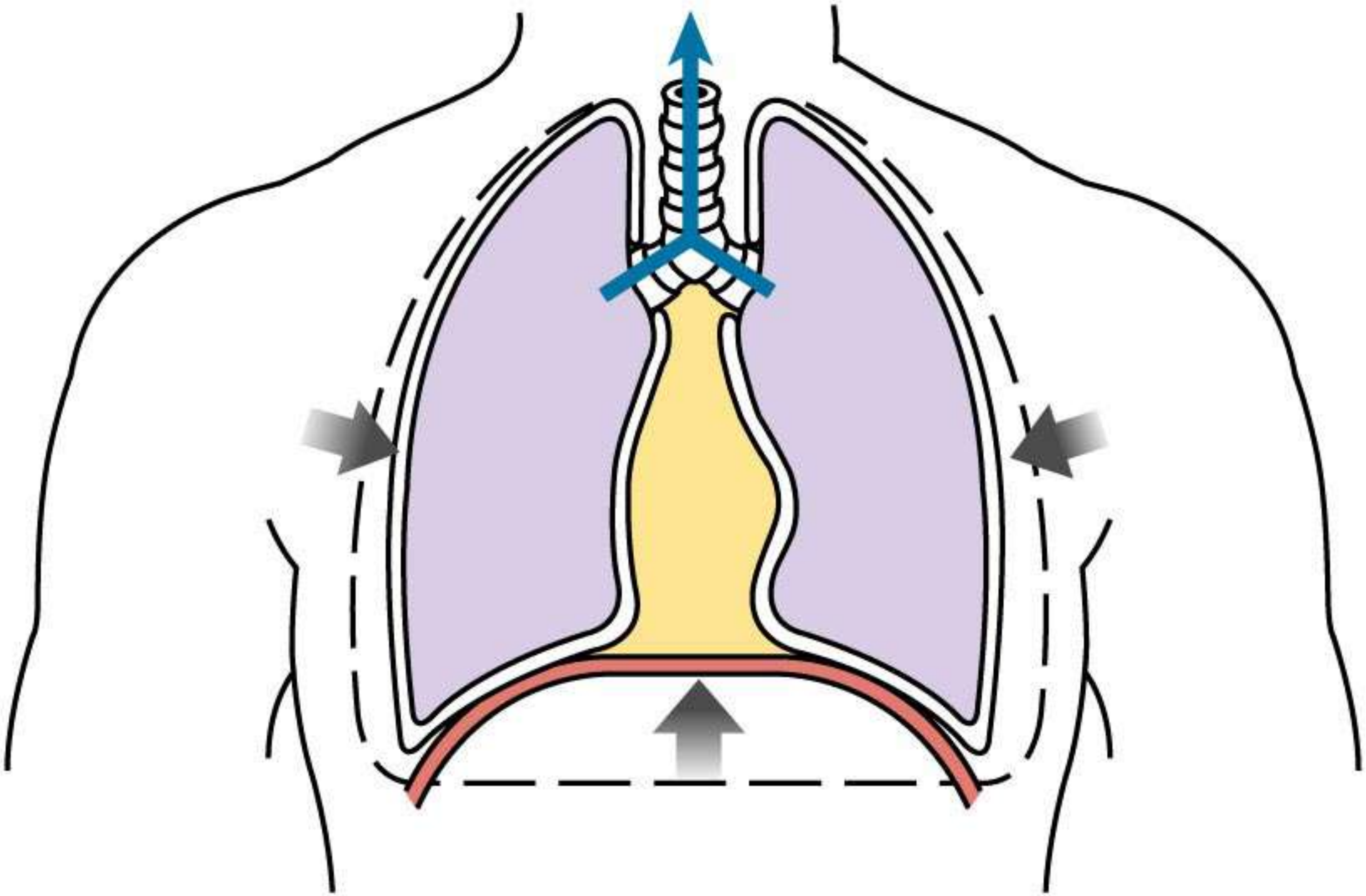


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Figure 17-9c

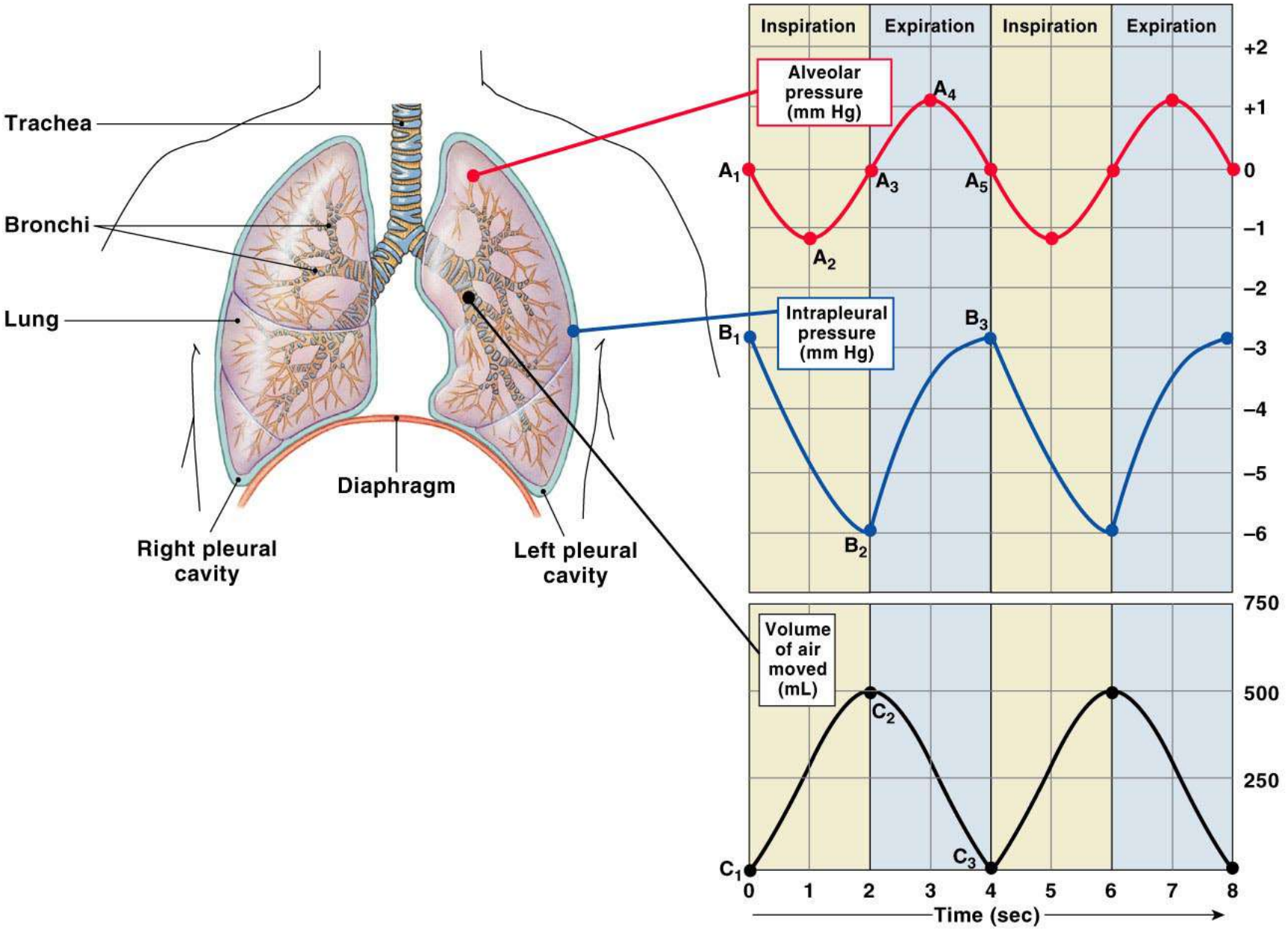


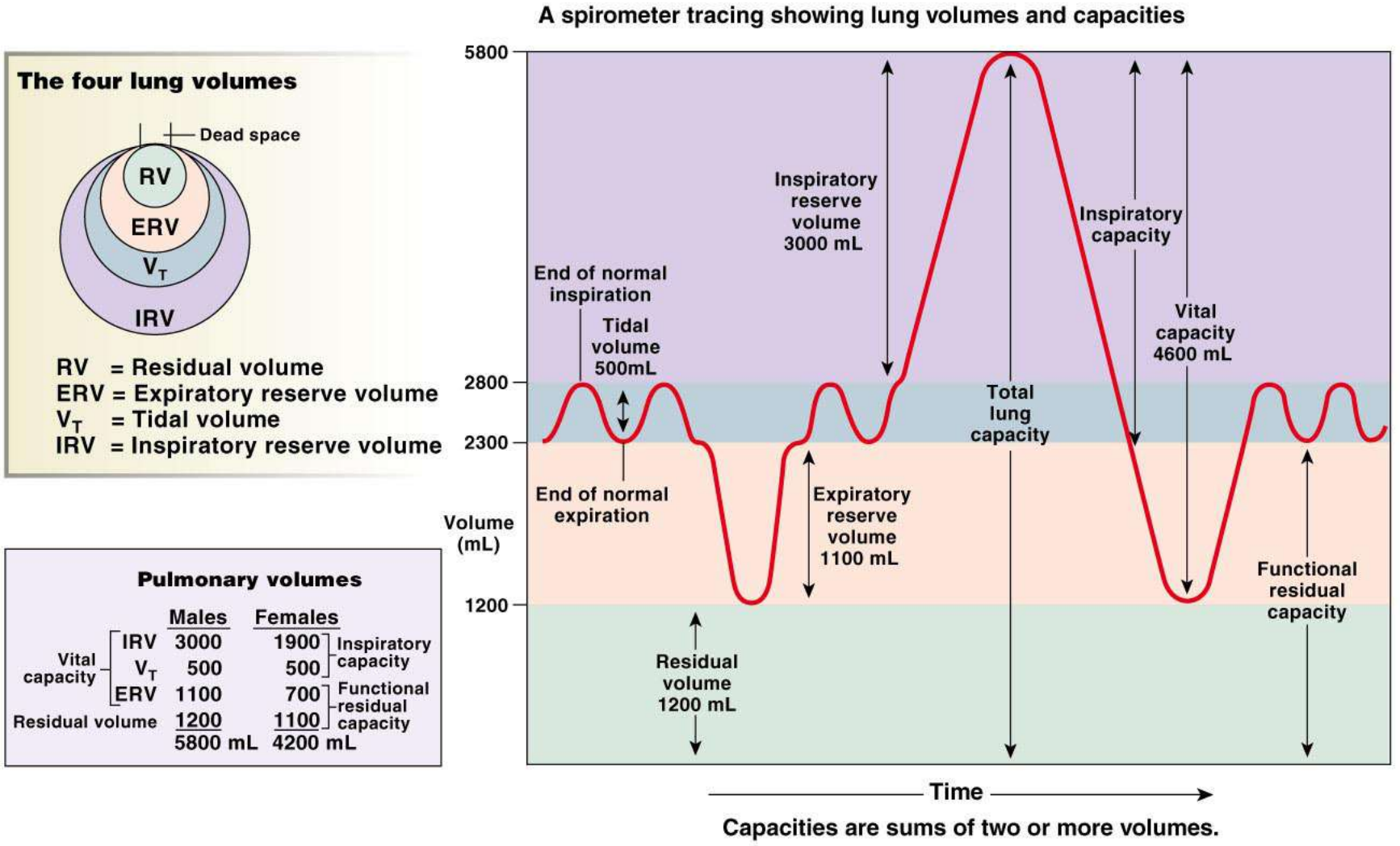
Figure 17.11

Lung Compliance

- The ease with which lungs can be expanded
- Specifically, the measure of the change in lung volume that occurs with a given change in transpulmonary pressure
- Determined by two main factors
  - Distensibility of the lung tissue and surrounding thoracic cage
  - Surface tension of the alveoli

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)



Dead Space

- Anatomical dead space – volume of the conducting respiratory passages (150 ml)
- Physiological dead space – alveoli that cease to act in gas exchange due to collapse or obstruction
- Total dead space – sum of anatomical and physiological dead spaces

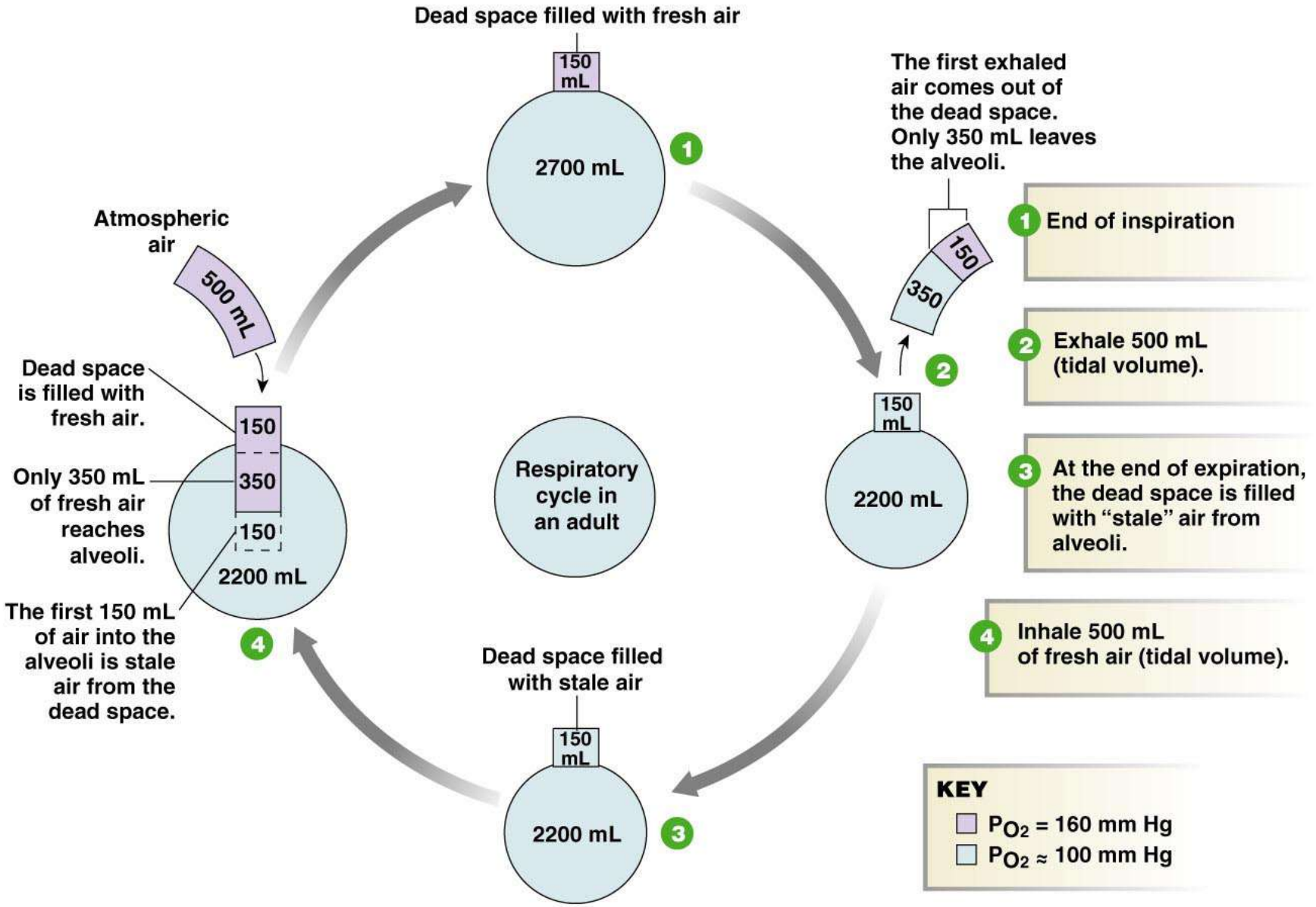


Figure 17.14

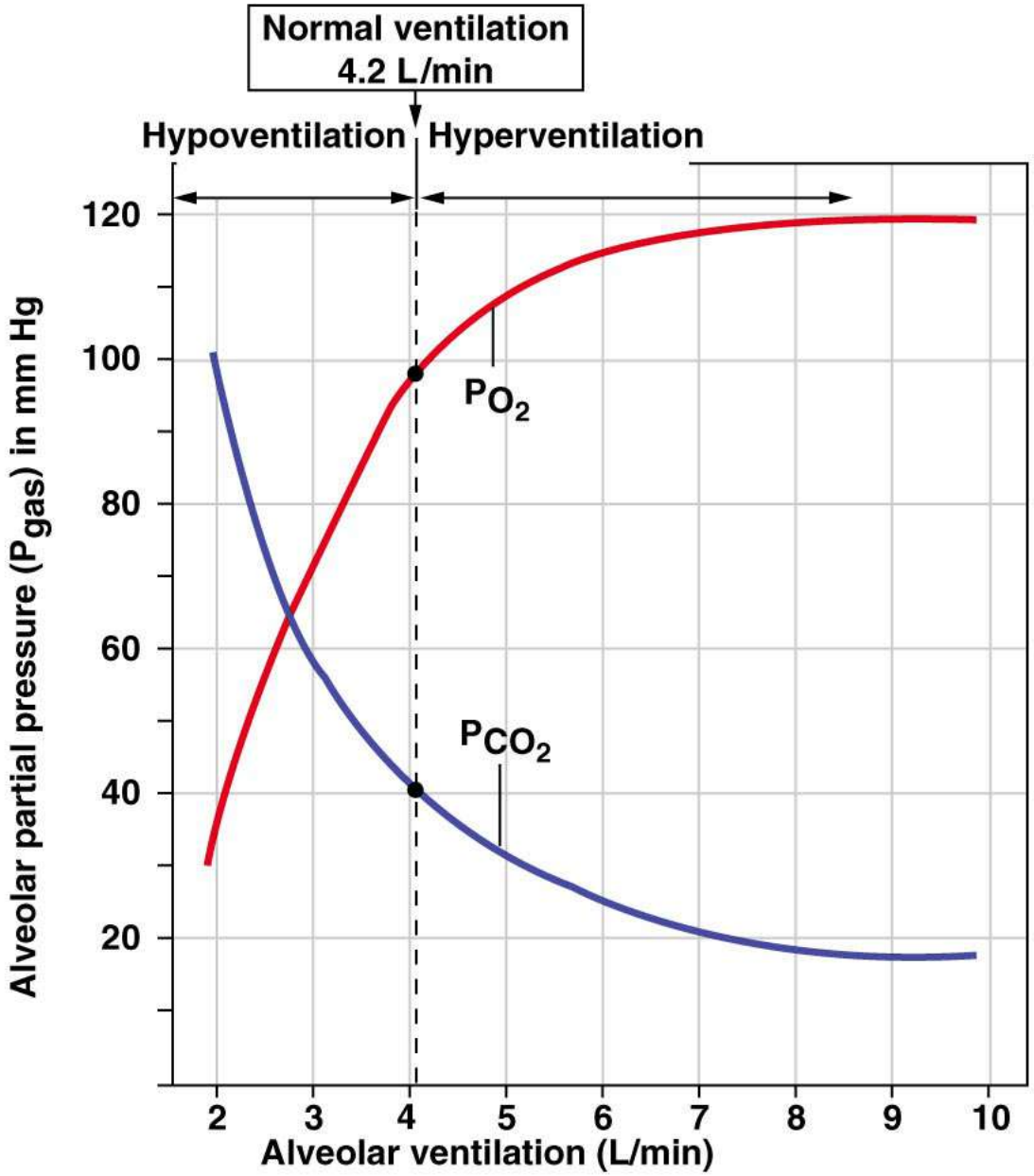
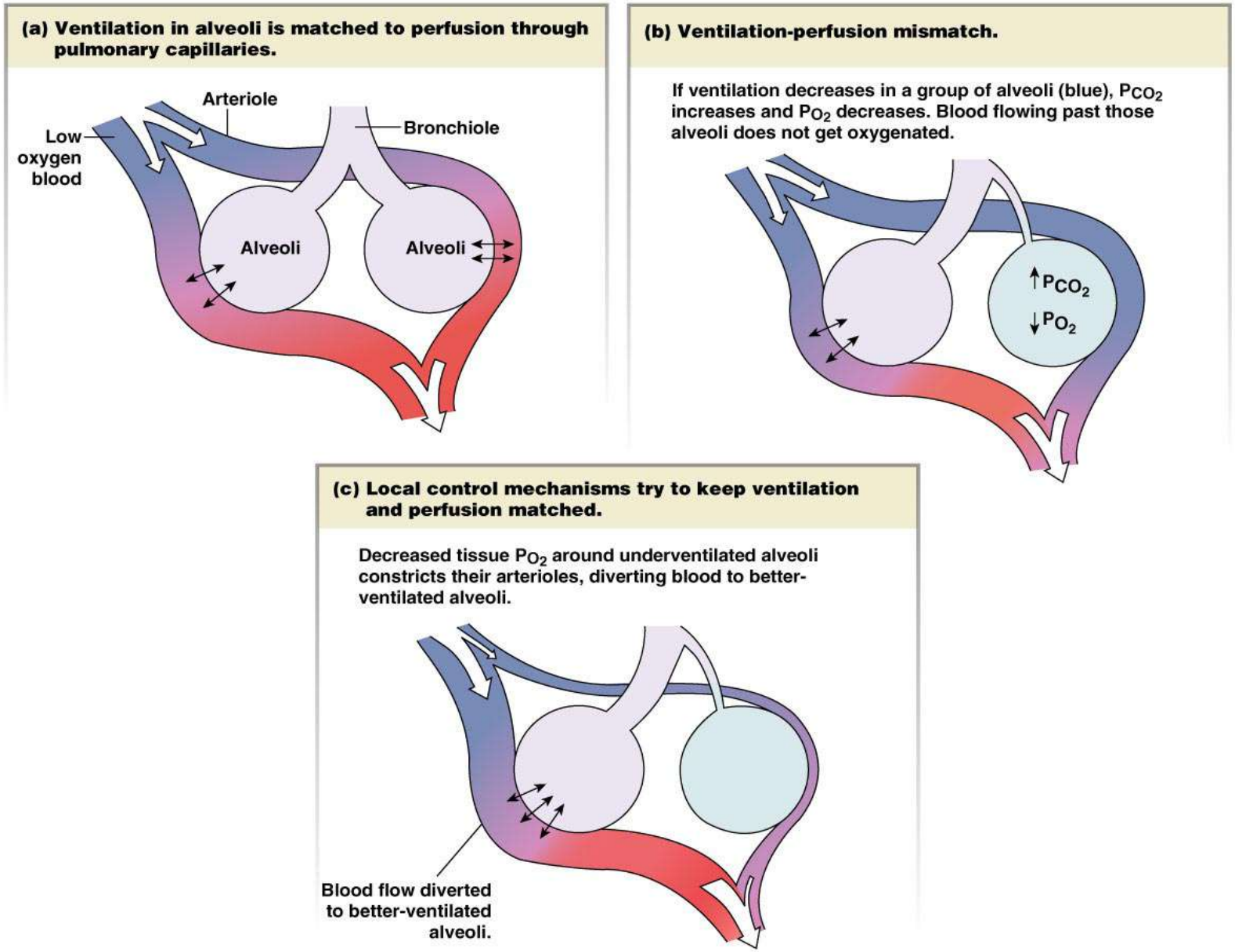


Figure 17.15



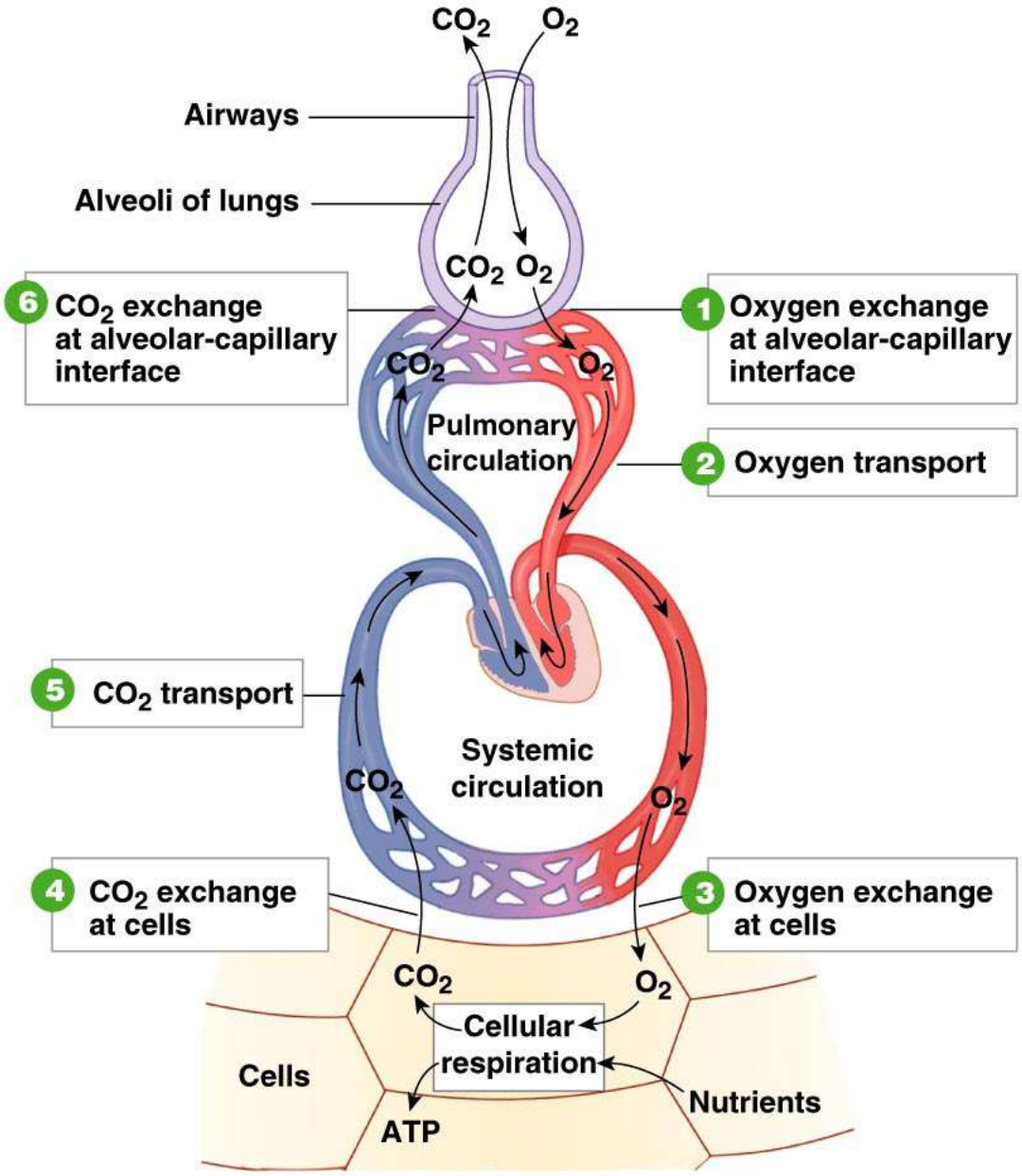


Figure 39-1 Overview

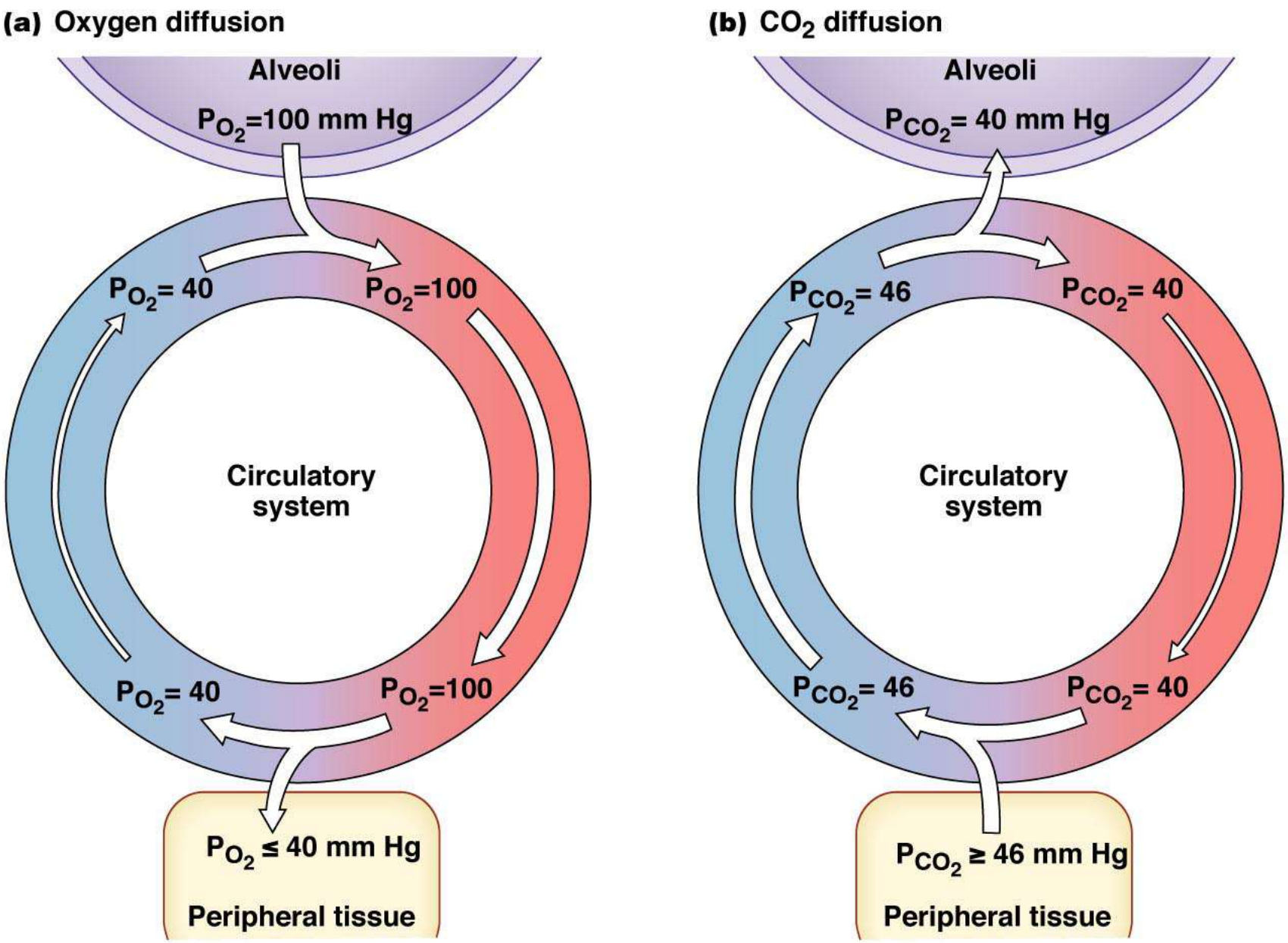


Figure 38-3 Overview

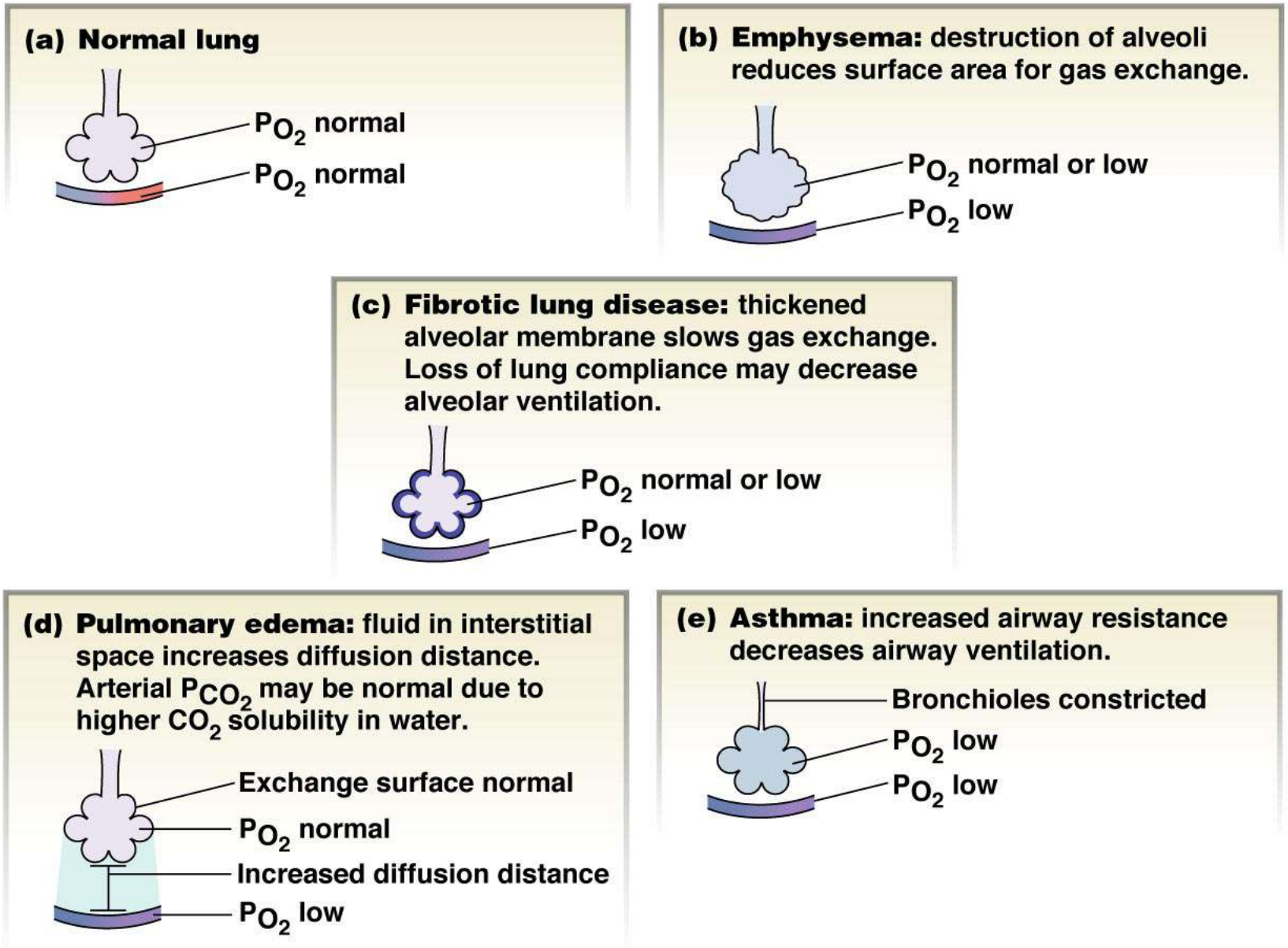


Figure 39.4 Overview

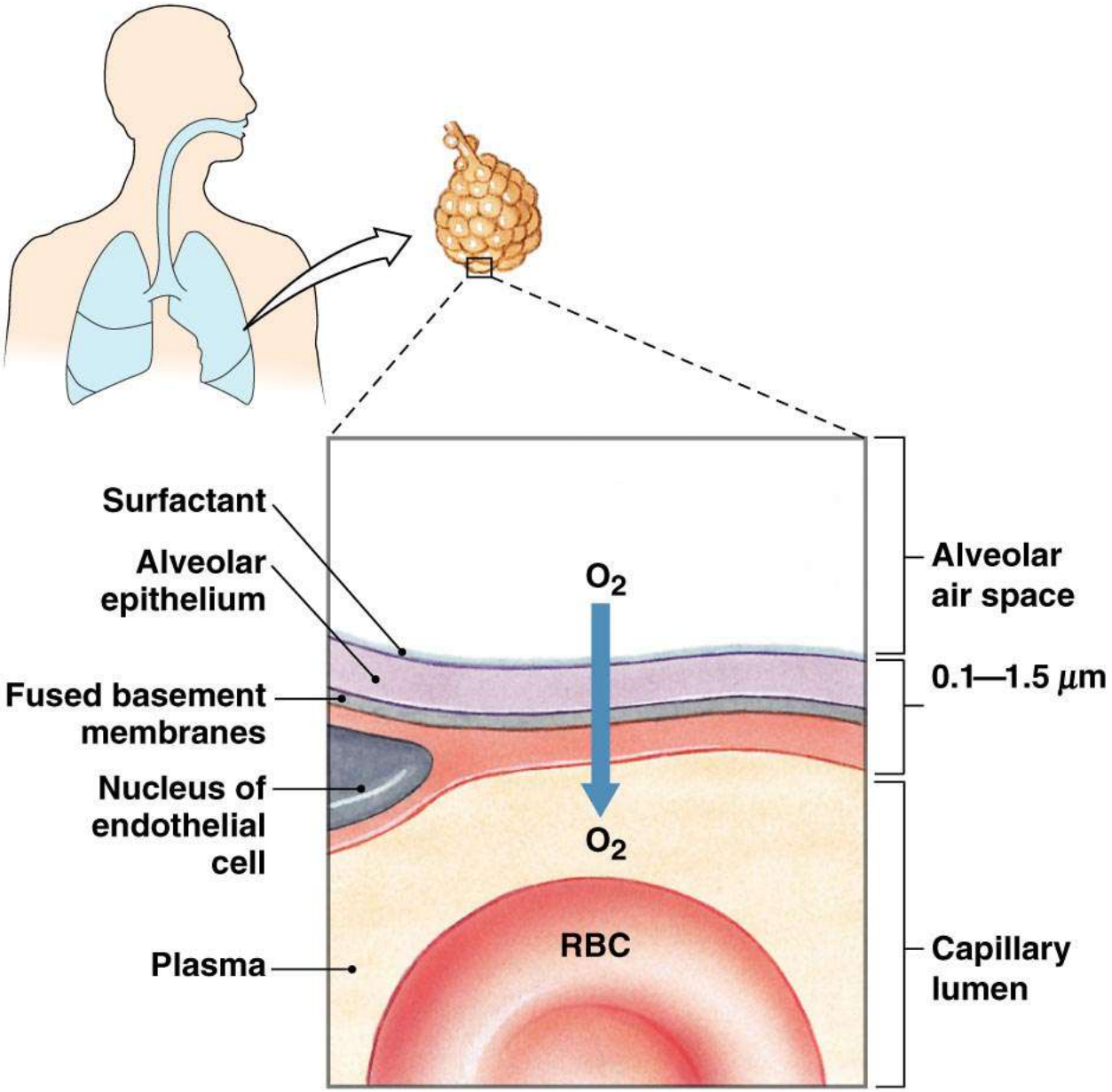


Figure 18.5

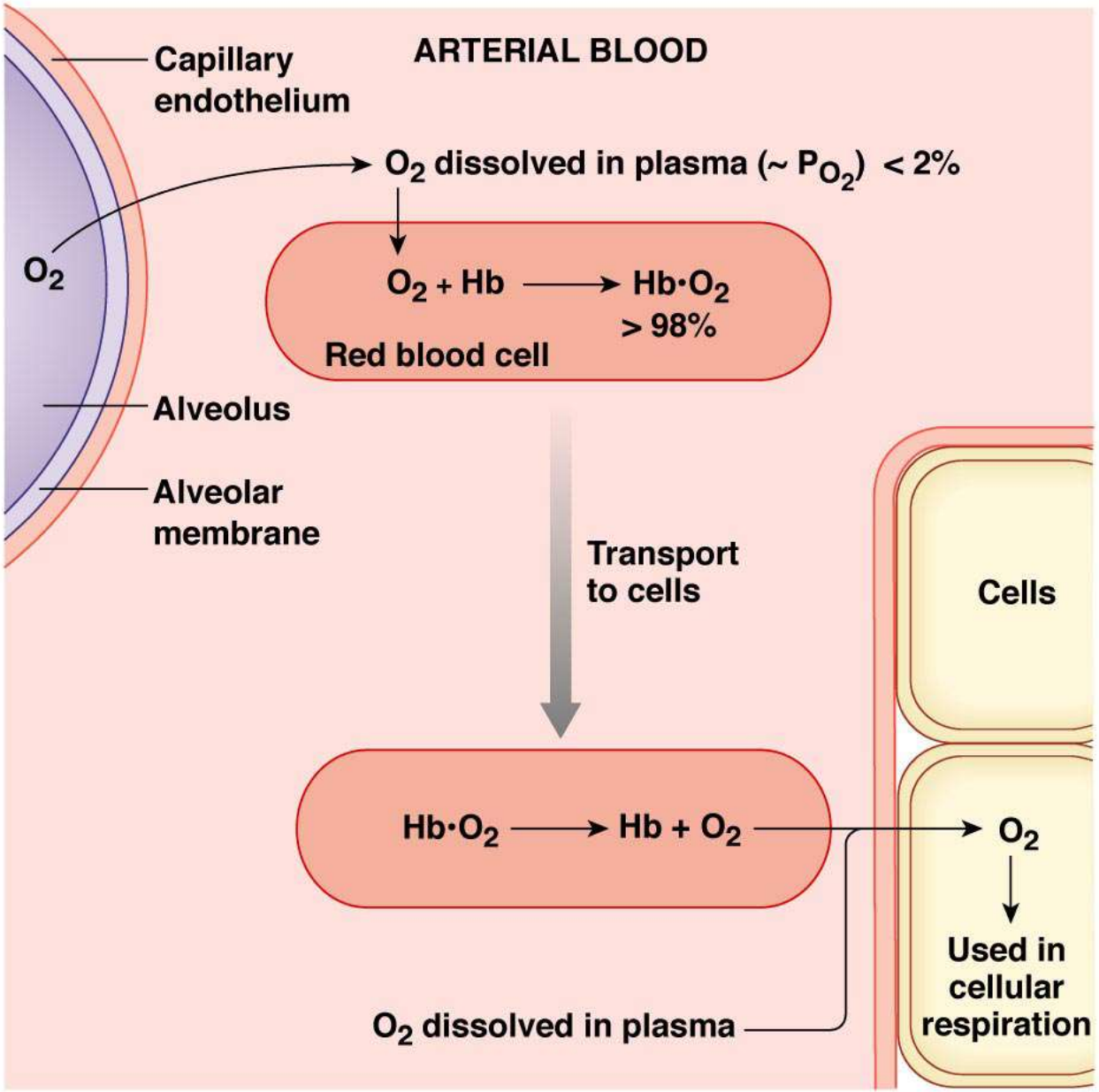
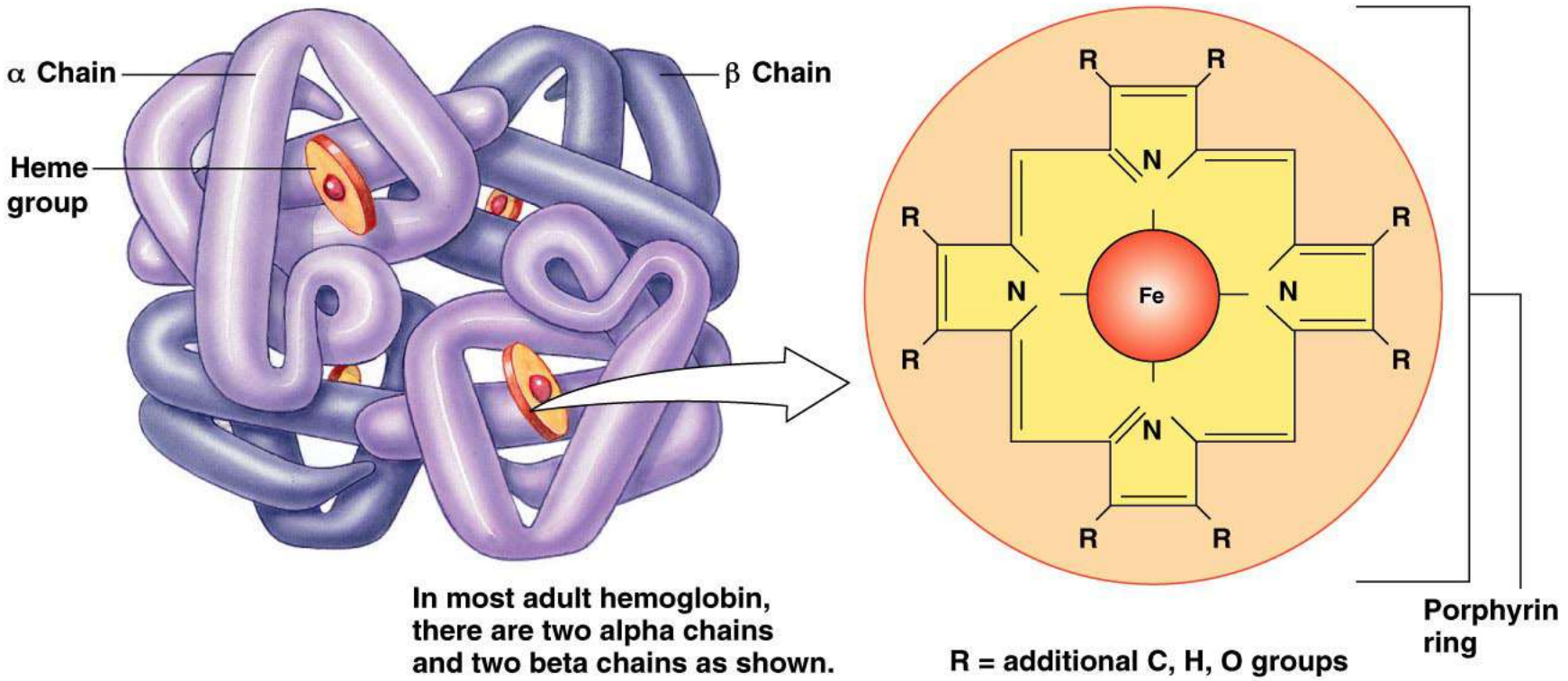


Figure 18.6

(a) A hemoglobin molecule is composed of four protein globin chains, each surrounding a central heme group.

(b) Each heme group consists of a porphyrin ring with an iron atom in the center.



In most adult hemoglobin, there are two alpha chains and two beta chains as shown.

R = additional C, H, O groups

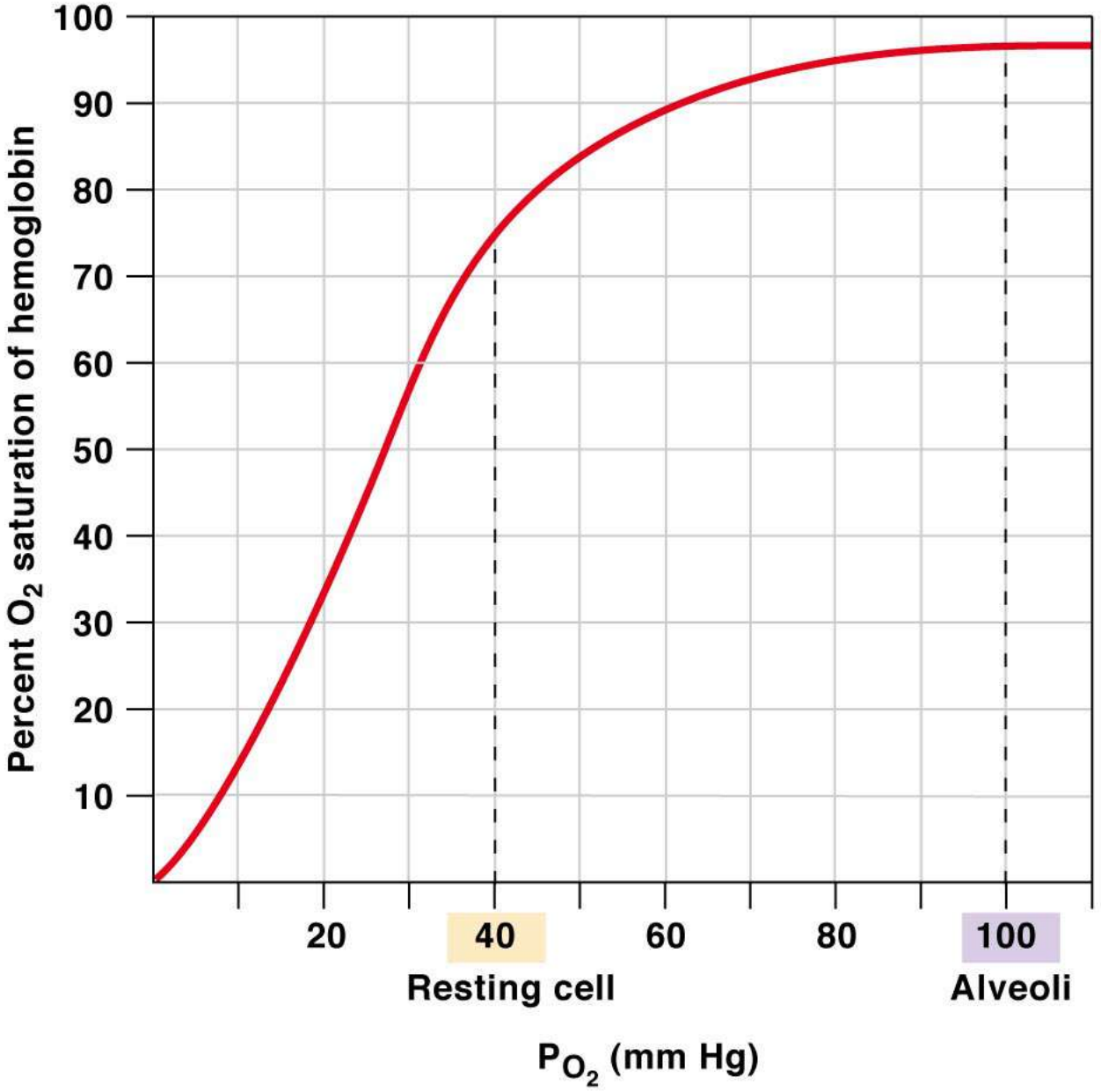


Figure 18.9

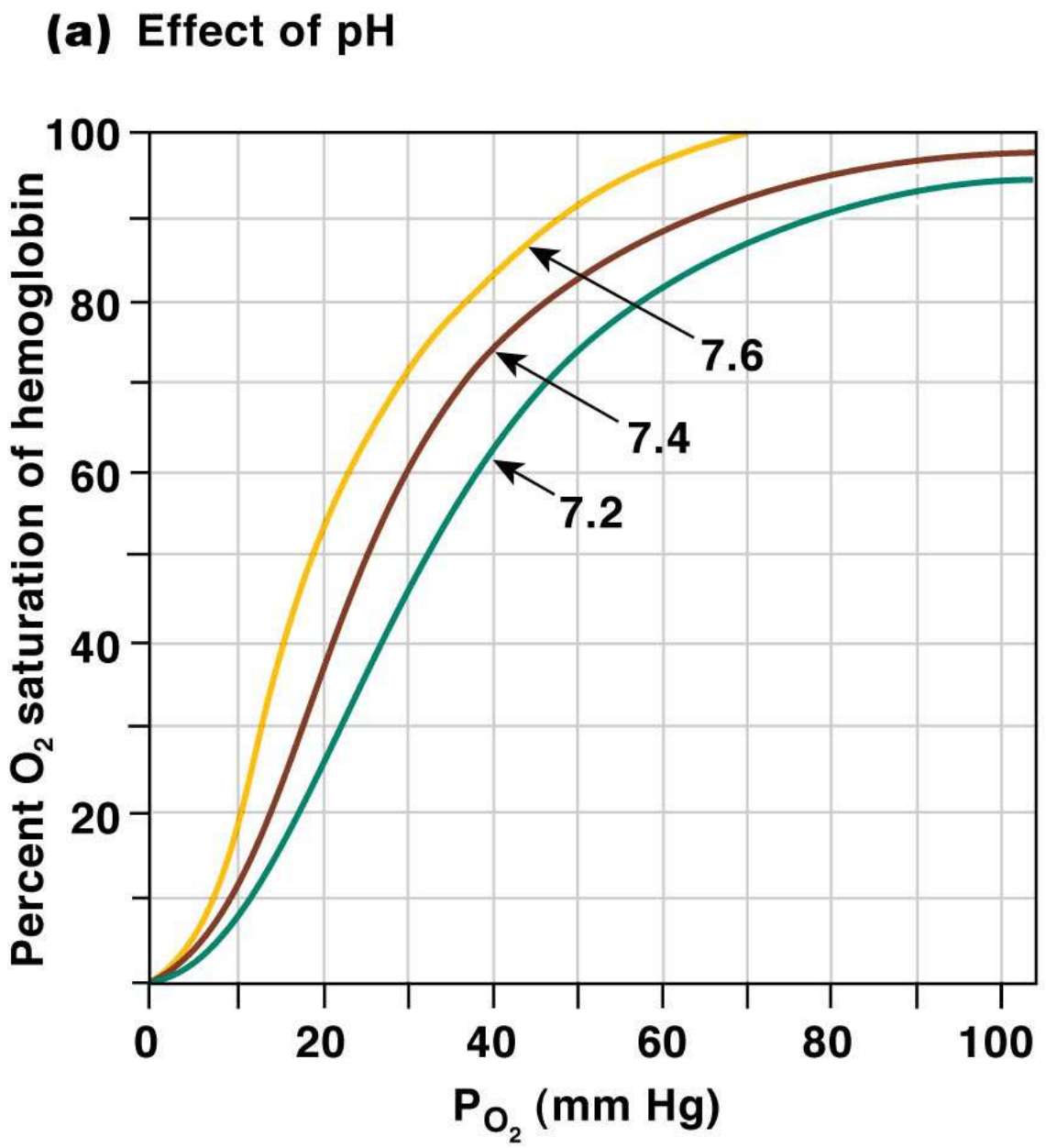


Figure 19.10a

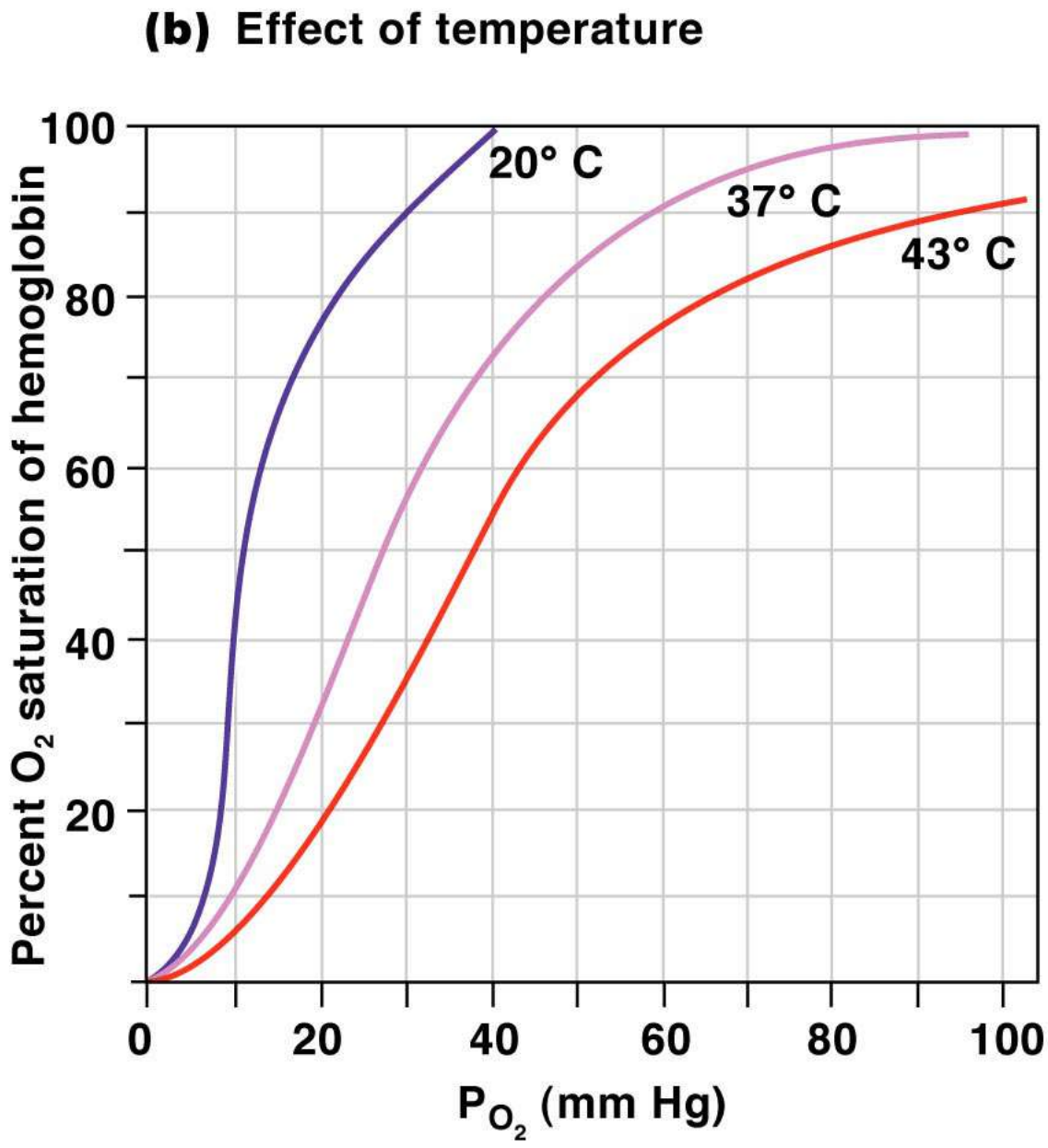


Figure 18.10b

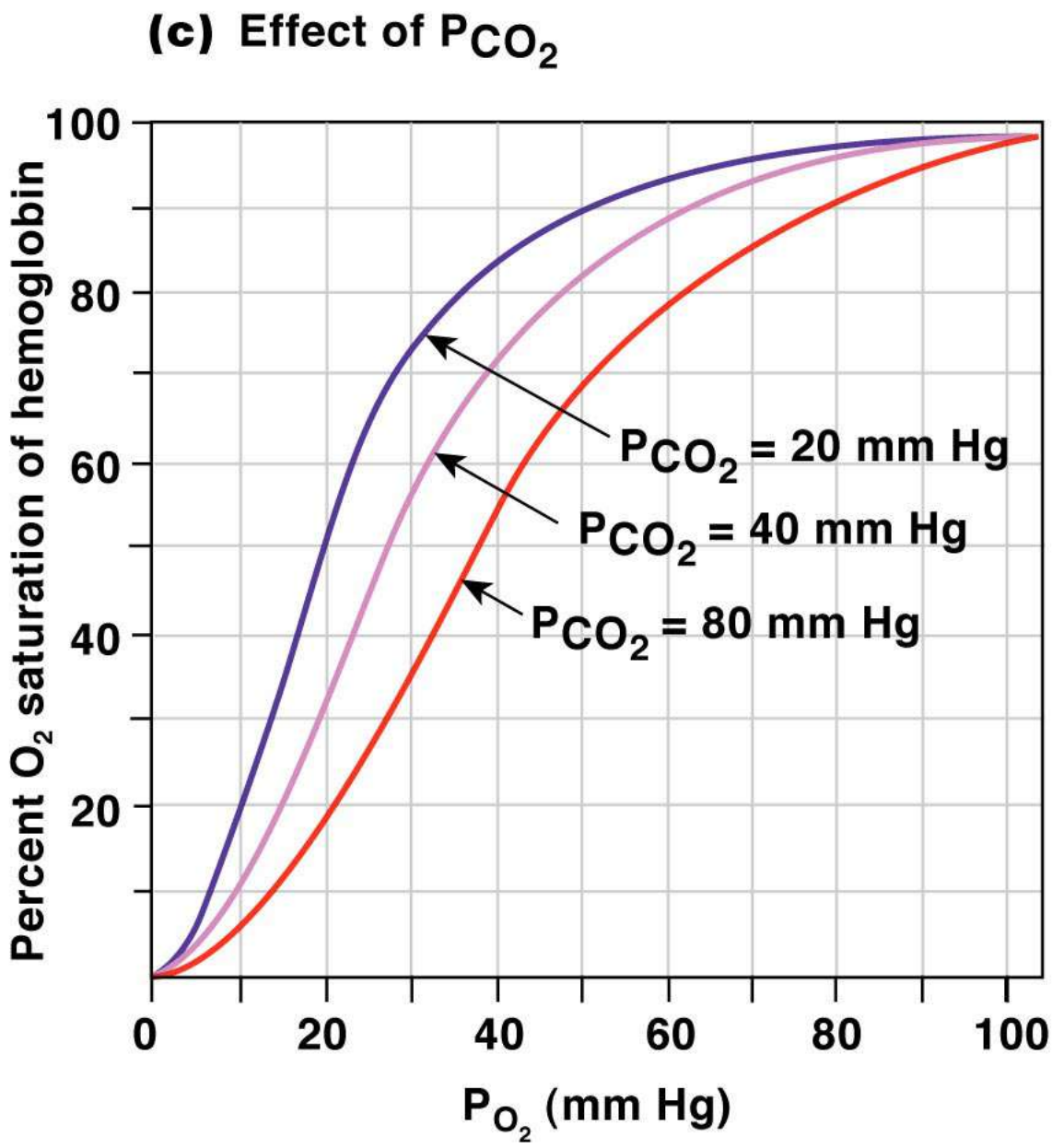


Figure 19.10c

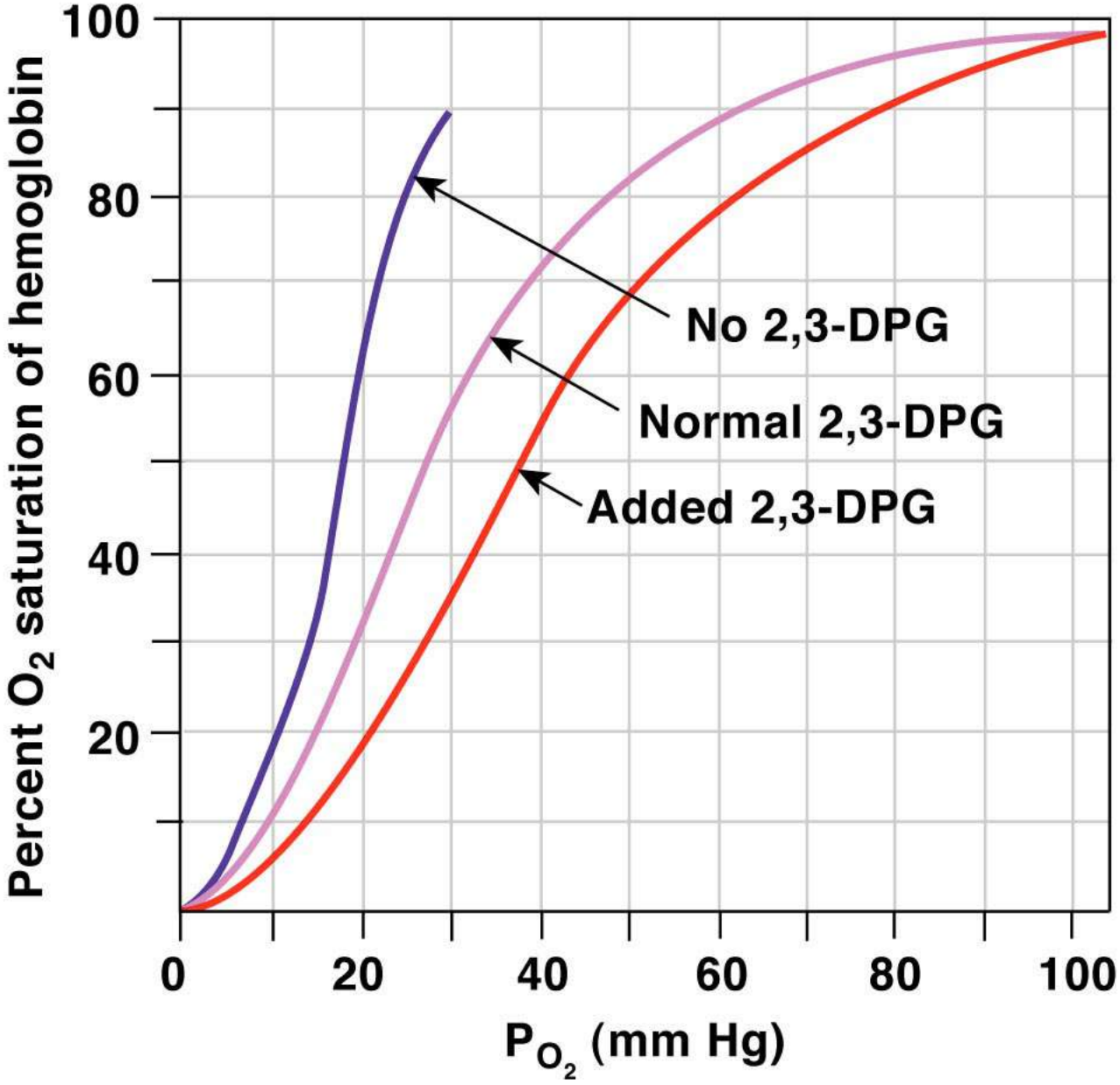


Figure 18-11

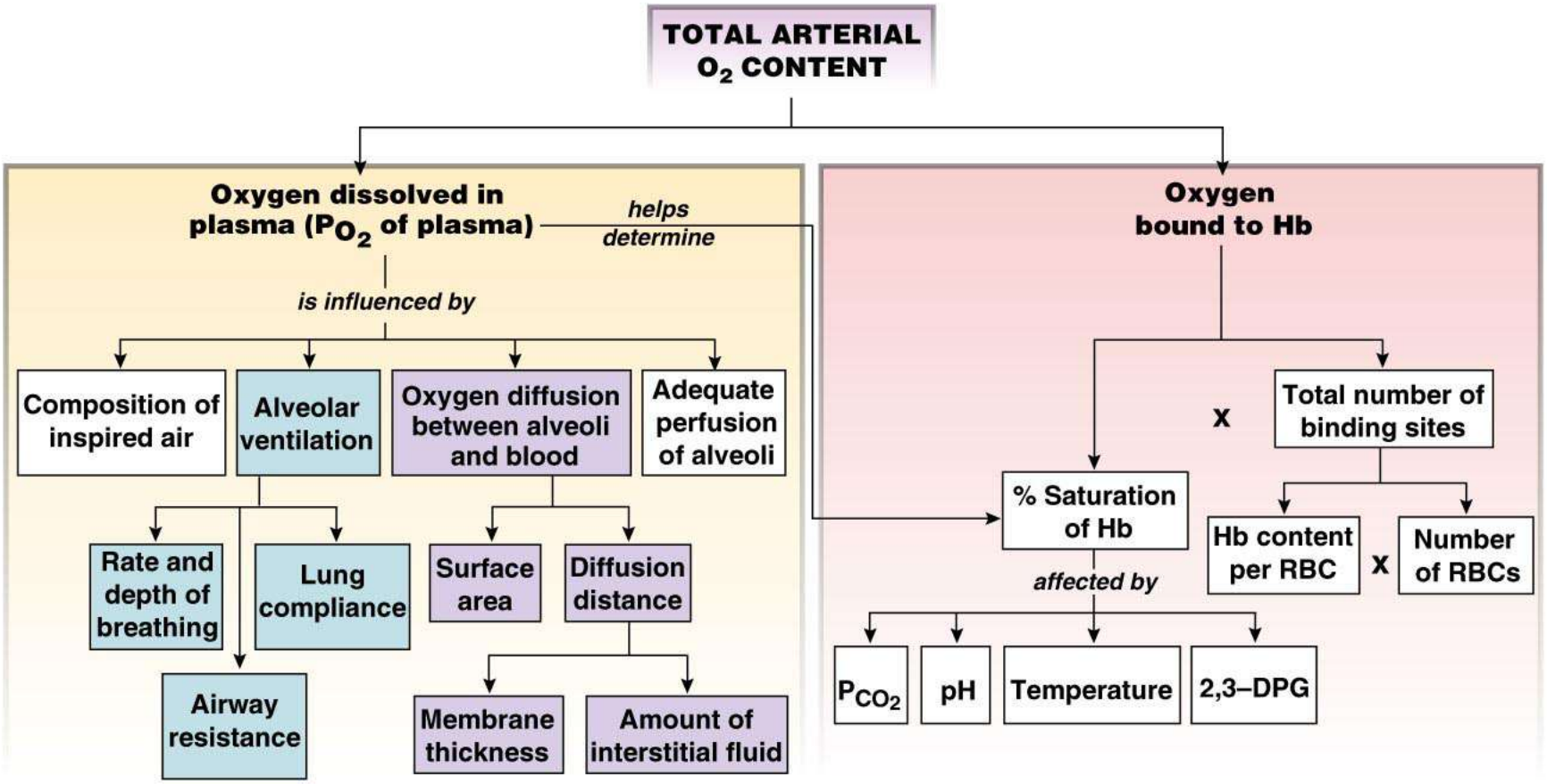


Figure 18-13

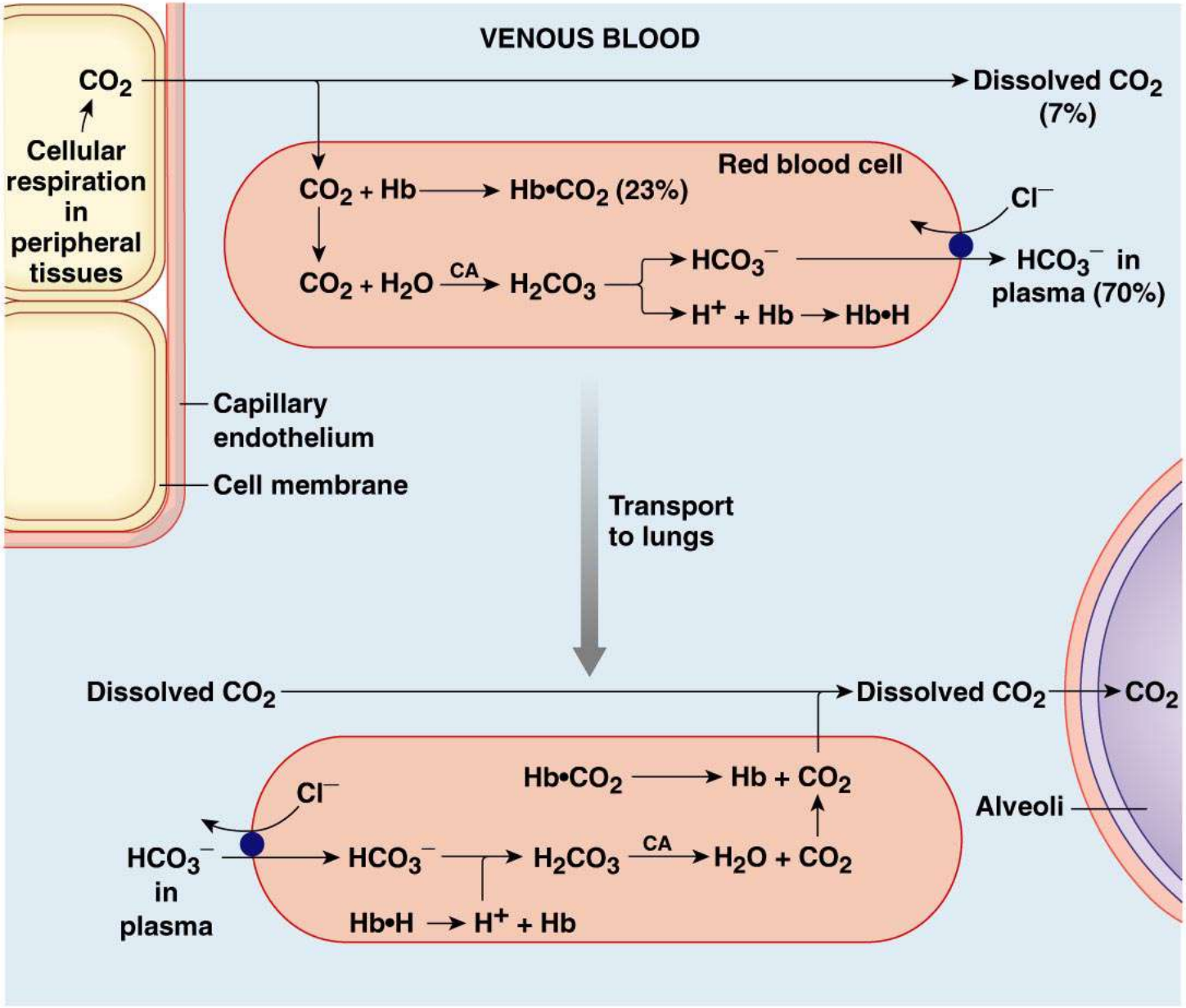


Figure 18.14

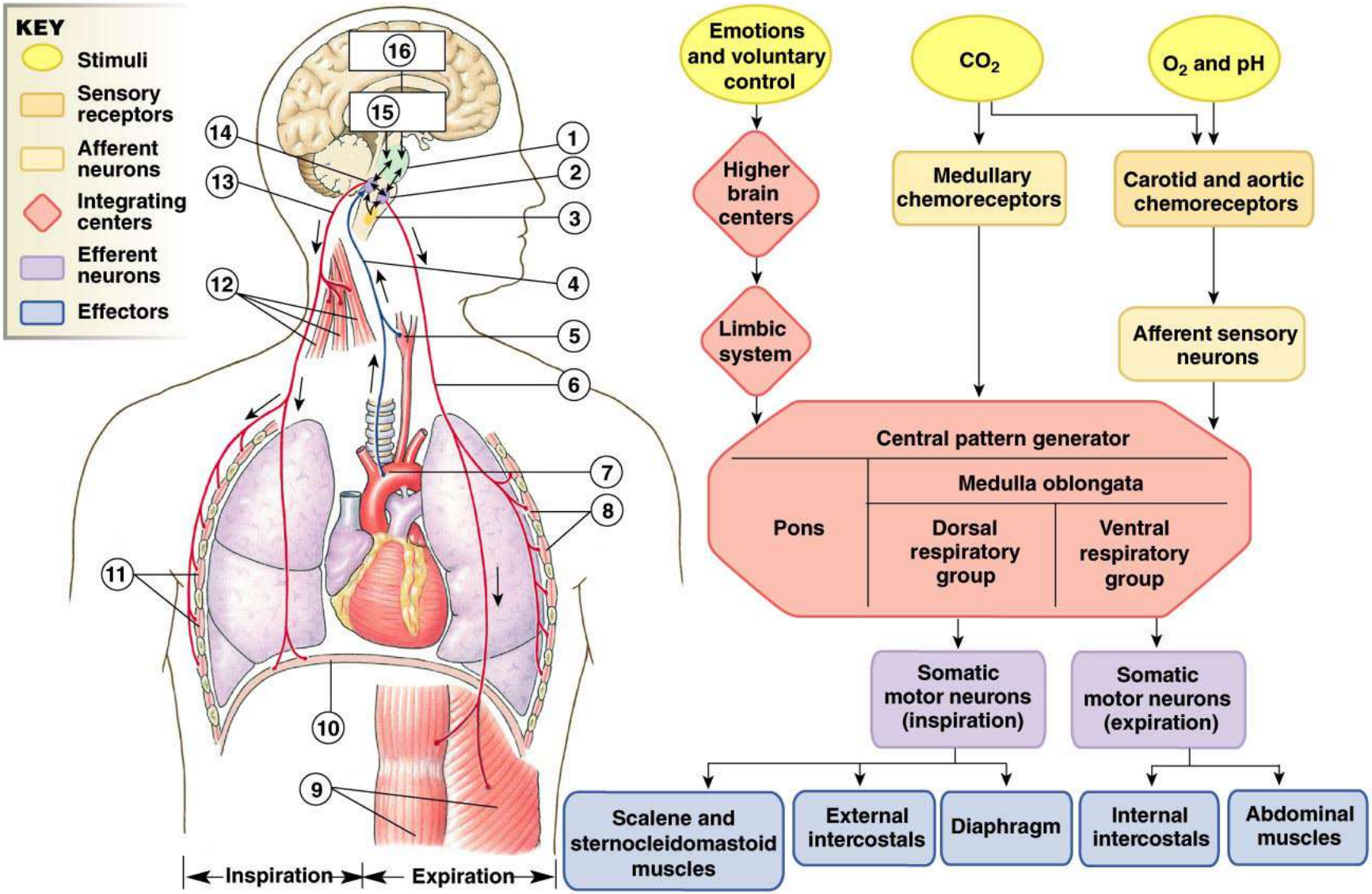


Figure 13.16

Medullary Respiratory Centers

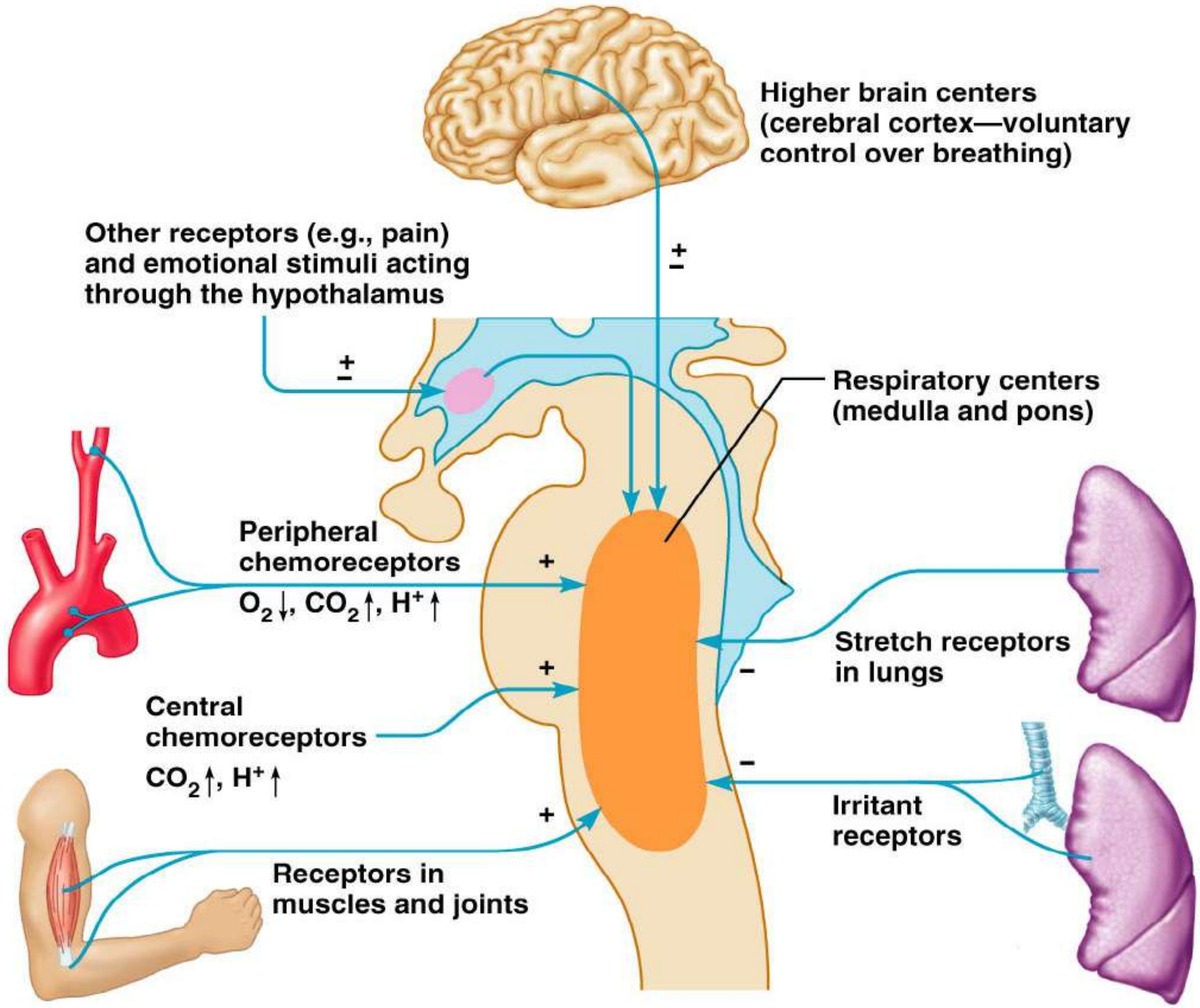


Figure 22.25

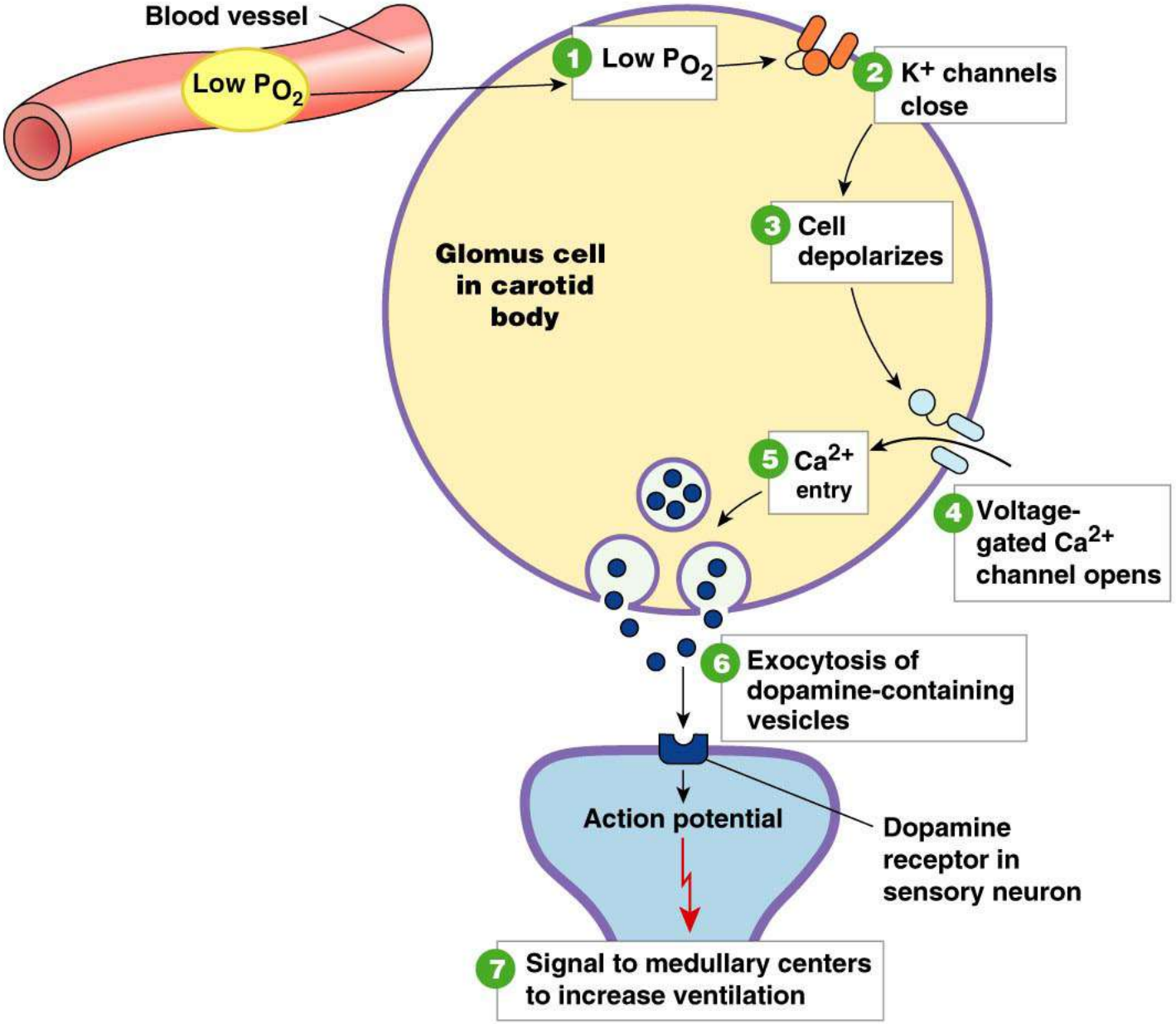


Figure 19.13

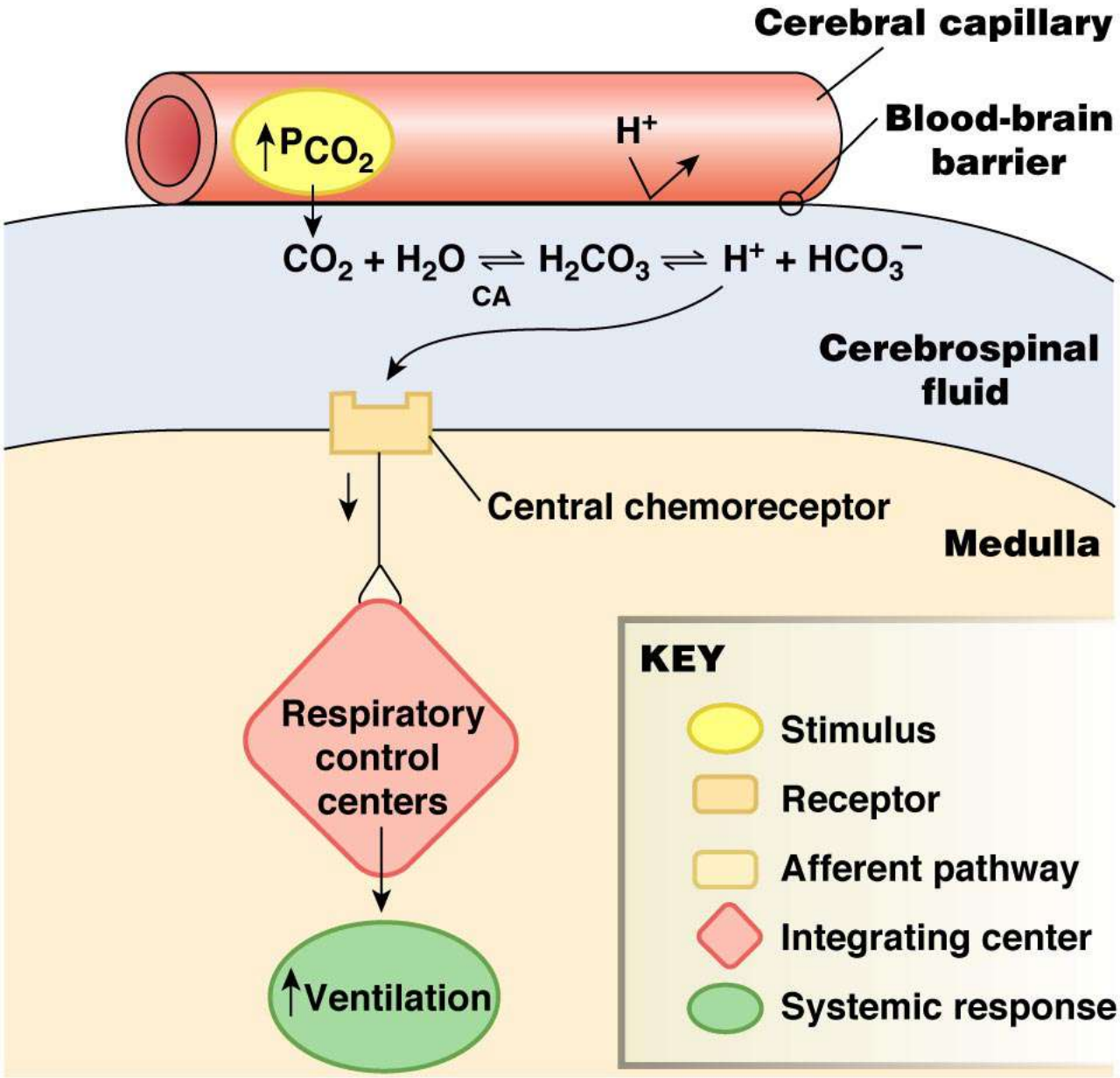


Figure 19.19

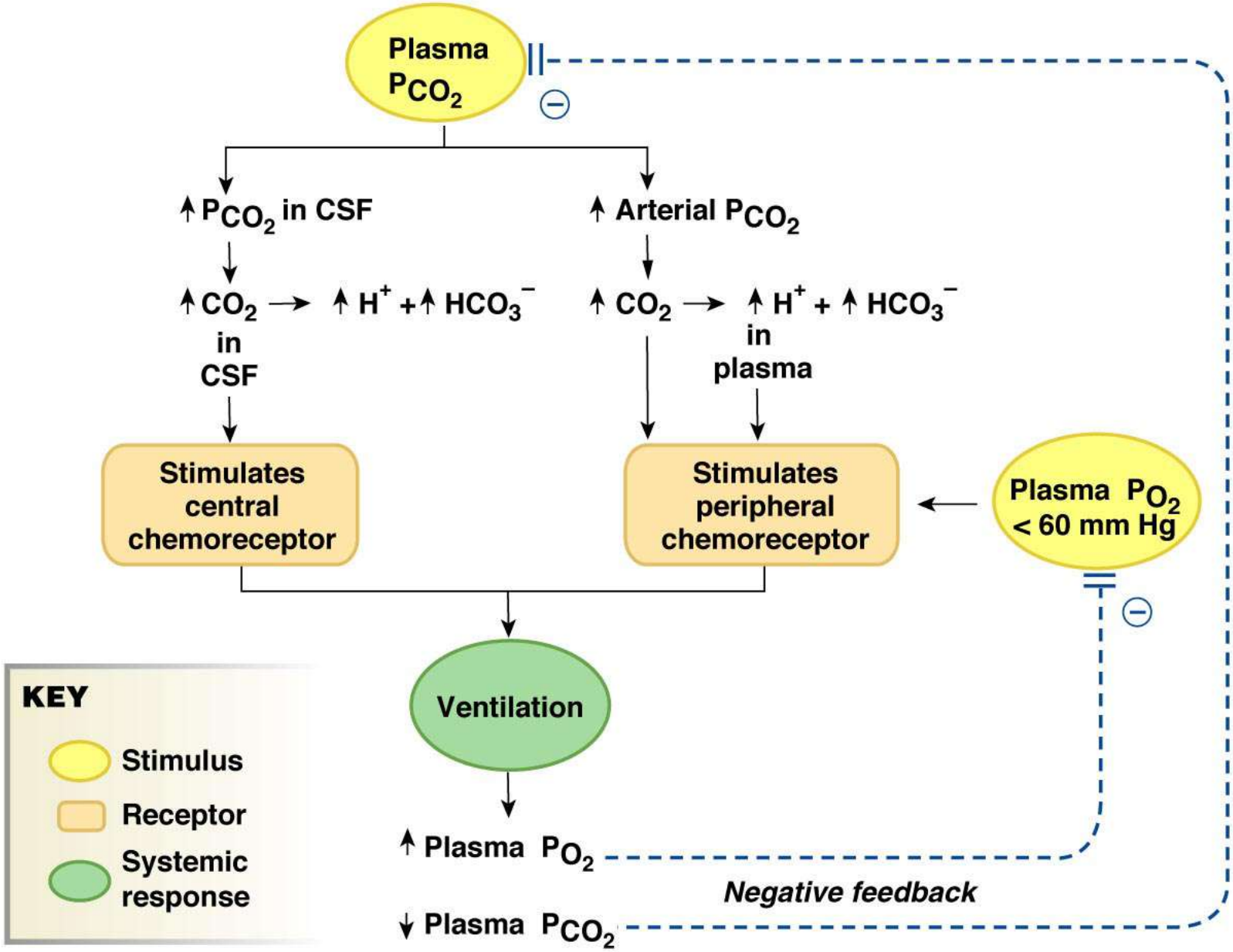


Figure 19.20