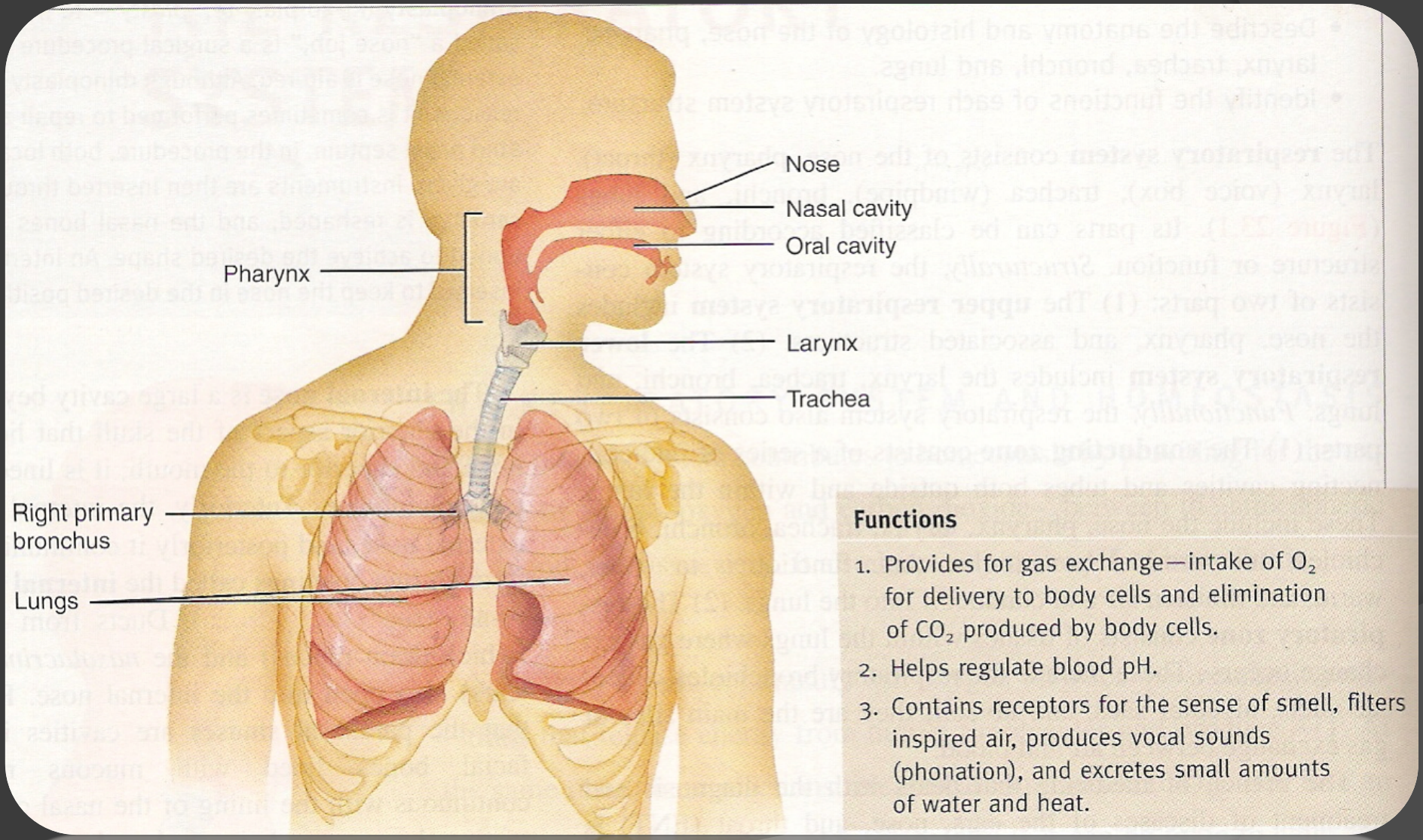
# SISTEM RESPIRASI

Sesilia Andriani Keban., MSi., Apt.

# Anatomy & Function of Respiratory System




**Functions**

1. Provides for gas exchange—intake of $O_2$ for delivery to body cells and elimination of $CO_2$ produced by body cells.
2. Helps regulate blood pH.
3. Contains receptors for the sense of smell, filters inspired air, produces vocal sounds (phonation), and excretes small amounts of water and heat.

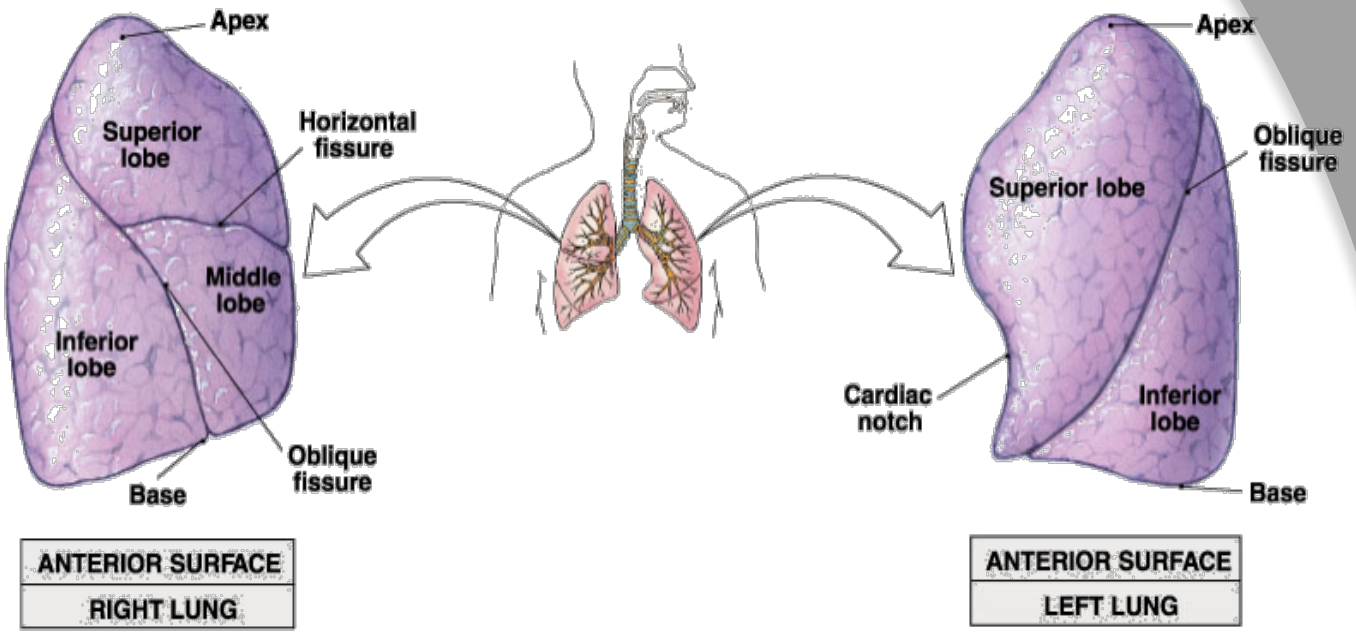
# Upper Respiratory Tract Functions

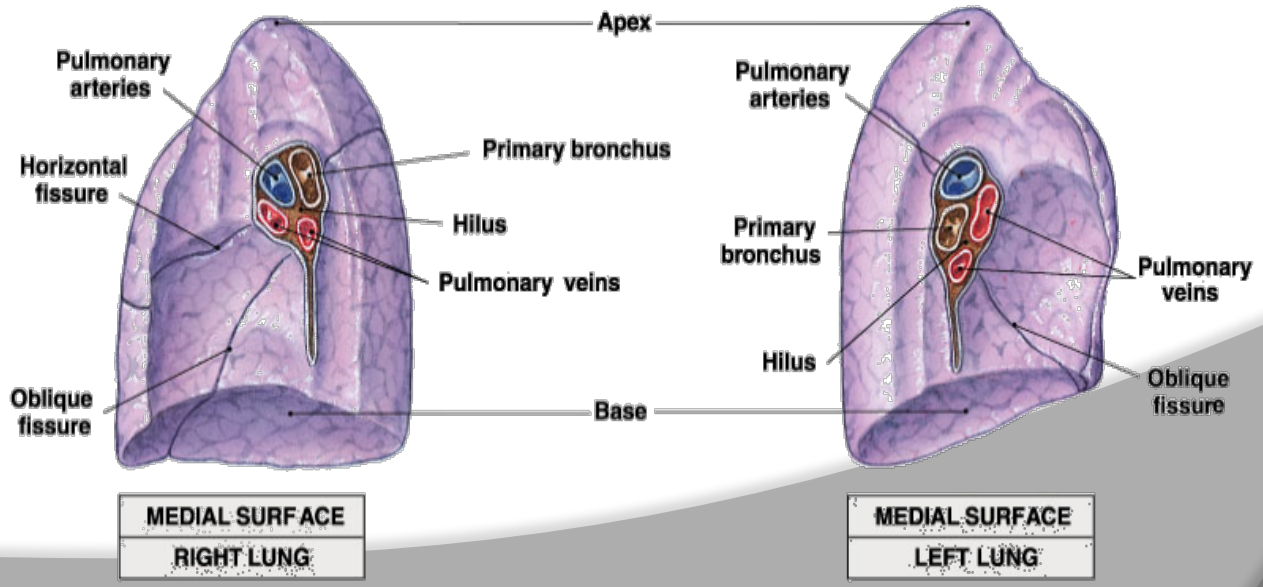
- Passageway for respiration
- Receptors for smell
- Filters incoming air to filter larger foreign material
- Moistens and warms incoming air
- Resonating chambers for voice

# Lower Respiratory Tract

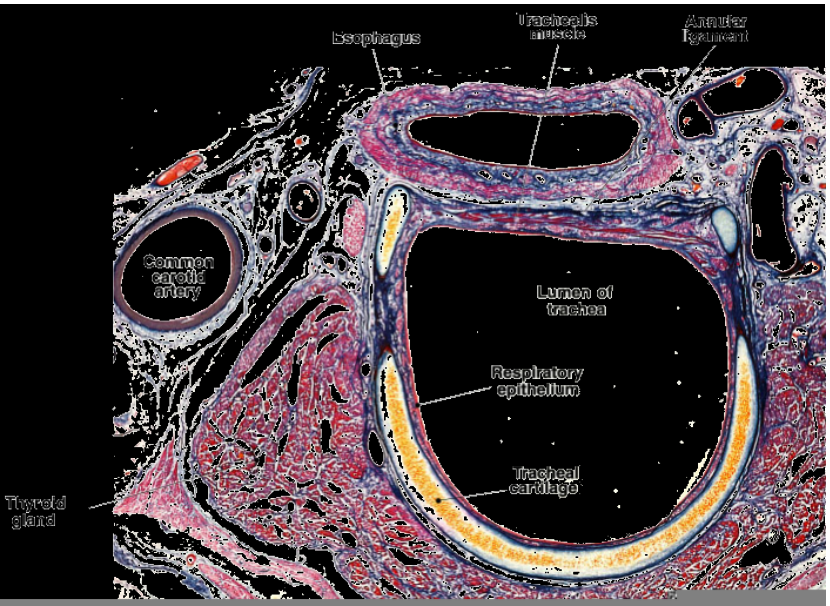
- Functions:
  - Larynx: maintains an open airway, routes food and air appropriately, assists in sound production
  - Trachea: transports air to and from lungs
  - Bronchi: branch into lungs
  - Lungs: transport air to alveoli for gas exchange

# Paru Paru


Apex
Superior lobe
Horizontal fissure
Middle lobe
Inferior lobe
Oblique fissure
Base
ANTERIOR SURFACE
RIGHT LUNG
Apex
Oblique fissure
Superior lobe
Cardiac notch
Inferior lobe
Base
ANTERIOR SURFACE
LEFT LUNG


Apex
Pulmonary arteries
Primary bronchus
Horizontal fissure
Hilus
Pulmonary veins
Oblique fissure
Base
MEDIAL SURFACE
RIGHT LUNG
Pulmonary arteries
Primary bronchus
Pulmonary veins
Hilus
Oblique fissure
MEDIAL SURFACE
LEFT LUNG

# Trakhea

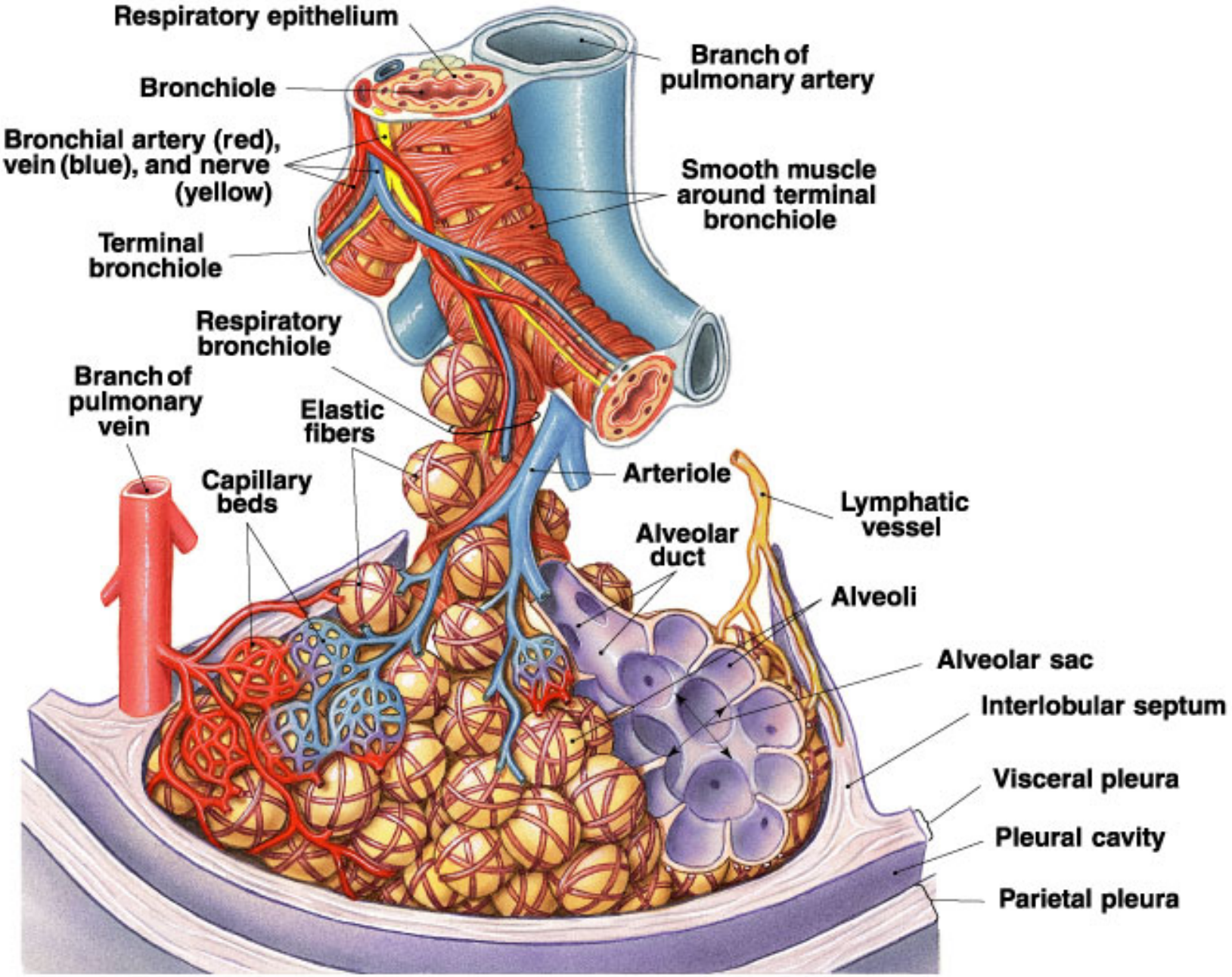



Merupakan pipa udara yang senantiasa terbuka guna menjamin kelancaran pergerakan udara dari dan ke paru paru

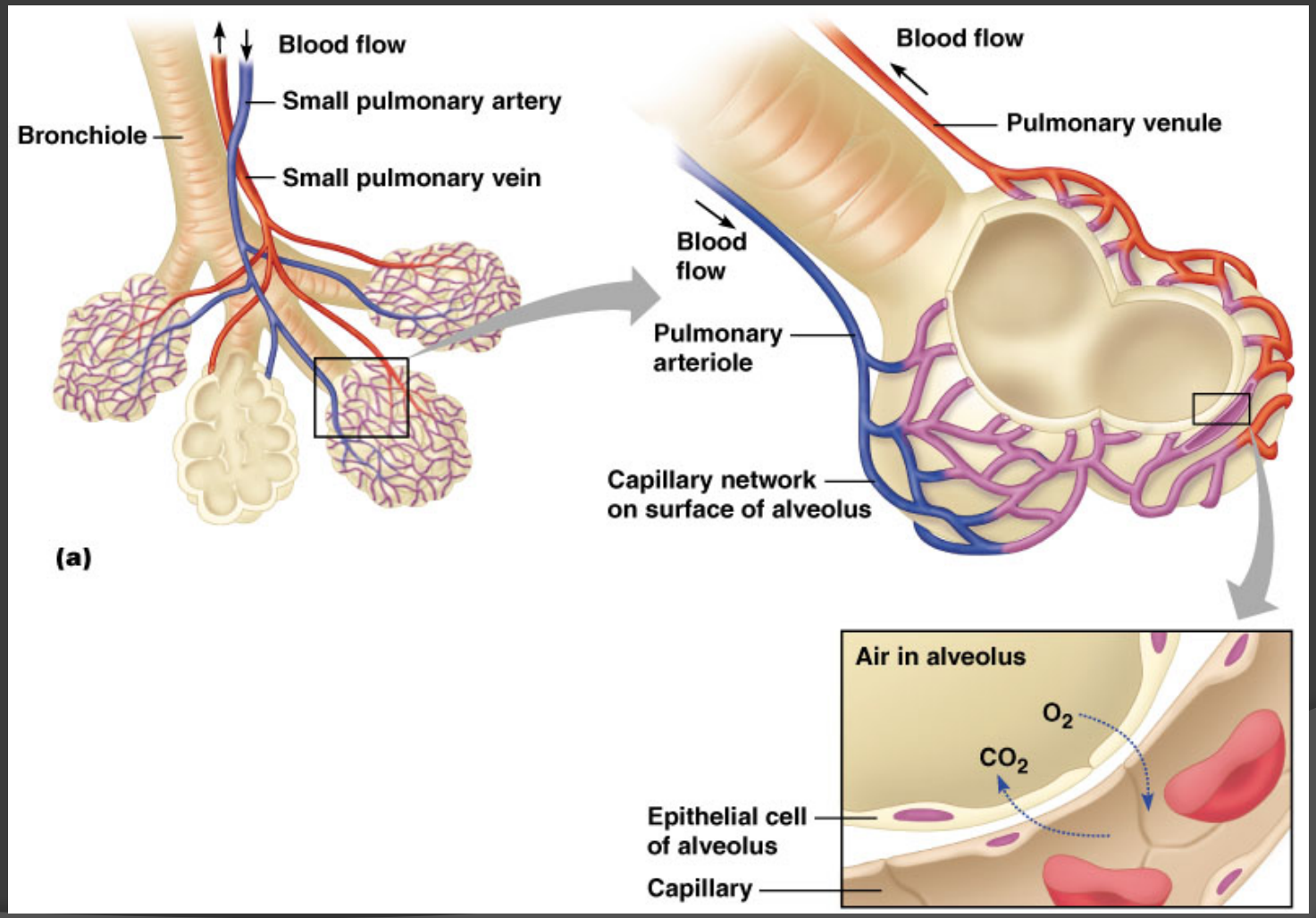
Filtrasi udara maupun pembersihan udara sebelum masuk kedalam paru

- Trakea merupakan ***first generation*** dari saluran pernafasan bawah
- Bronkus kiri dan kanan merupakan ***second generation*** saluran pernafasan bawah
- Tiap tiap bagian setelah itu disebut ***additional generation***

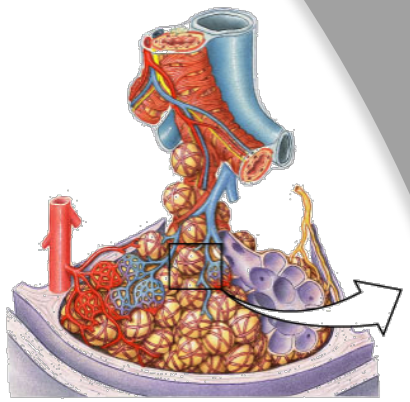
# Bronchioles and Alveoli

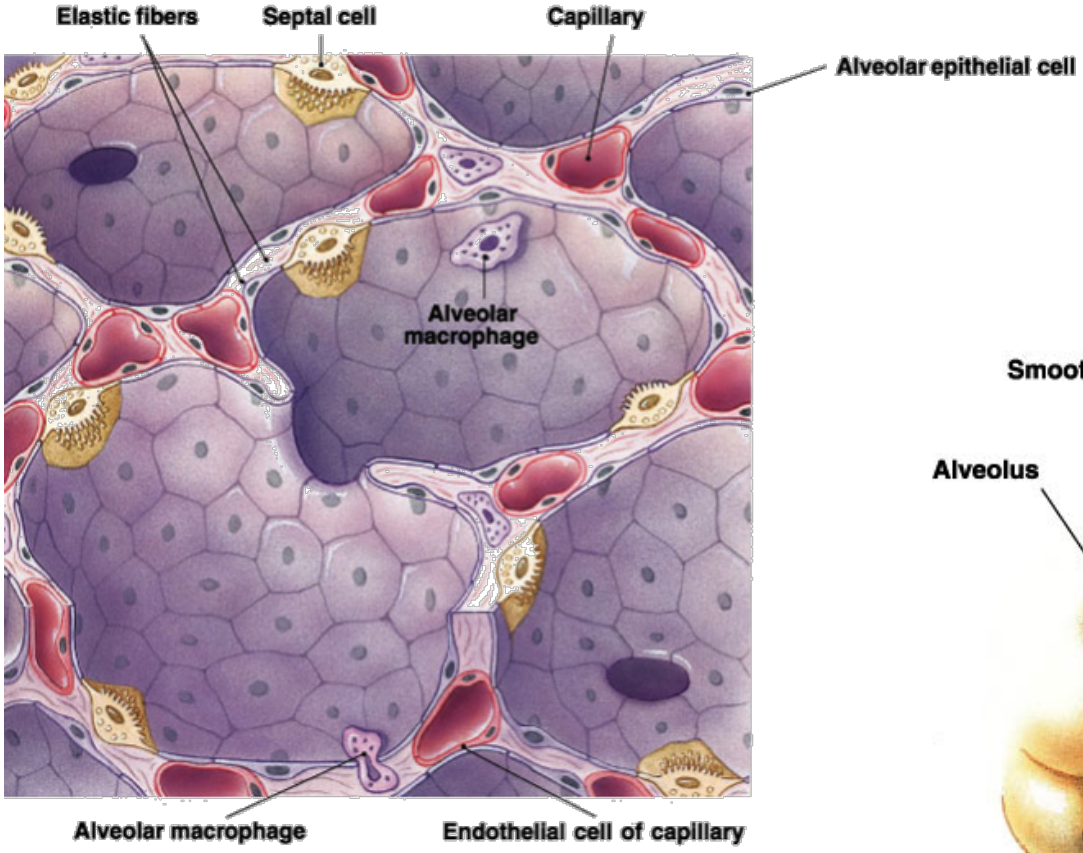


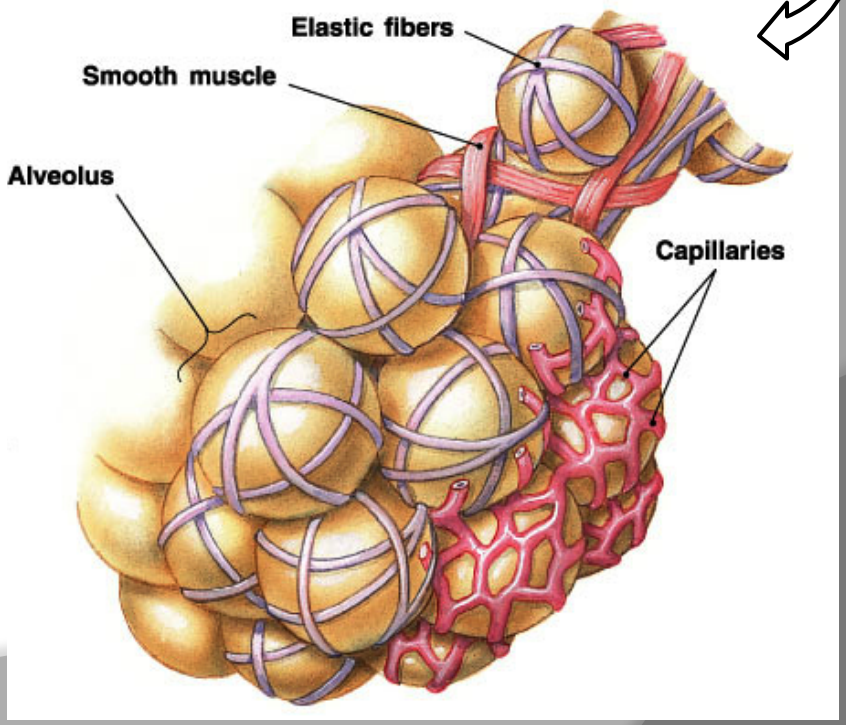
# Gas Exchange Between the Blood and Alveoli



# Alveolus dan Membran Respiratori





# Classification of Respiratory System

**Struktural**

- *Upper respiratory tract* → hidung, faring, dan struktur-struktur lain yang berkaitan.
- *Lower respiratory tract* → laring, trakea, bronkus, dan paru-paru.

**Fungsional**

- *Conducting zone* → hidung, faring, laring, trakea, bronkus, bronkiolus, dan bronkiolus terminal.

  Fungsi : menyaring, menghangatkan, dan melembabkan udara, dan membawanya masuk ke paru-paru.
- *Respiratory zone* → bronkiolus yang terlibat dalam respirasi, saluran alveolar, kantung alveolar, dan alveolus.

  Fungsi : situs / tempat pertukaran gas (antara udara dan darah).

## *Upper respiratory tract*

Hidung ⇄ Faring

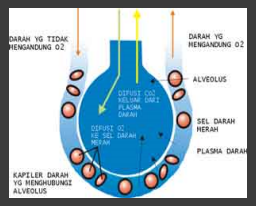
***Conducting zone*** ; Fungsi : menyaring, menghangatkan, dan melembabkan udara, dan membawanya masuk ke paru-paru.

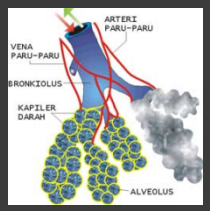
## *Lower respiratory tract*

Inhalasi →

← Ekspirasi

Bronkus ⇄ Trakea ⇄ Laring




bronkiolus

- ***Respiratory zone*** → bronkiolus yang terlibat dalam respirasi, saluran alveolar, kantung alveolar, dan alveolus.
  Fungsi : situs / tempat pertukaran gas (antara udara dan darah).

# RESPIRATION

**Proses pertukaran gas dalam tubuh**

## Three Basic Step

1. Pulmonary ventilation (breathing) → inhalasi (masuk) dan ekshalasi (keluar) udara dan melibatkan pertukaran udara antara atmosfer dan alveoli paru-paru.
2. External respiration→ pertukaran gas antara alveoli dan darah di dalam kapiler paru-paru melewati membran respiratori.
3. Internal respiration→ pertukaran gas antar darah (di dalam kapiler sistemik) dan sel jaringan.
    - Cellular respiration : penggunaan oksigen untuk menghasilkan ATP dan karbondioksida sebagai sampah

# Pressure Changes During Pulmonary Ventilation

## Boyle's Law

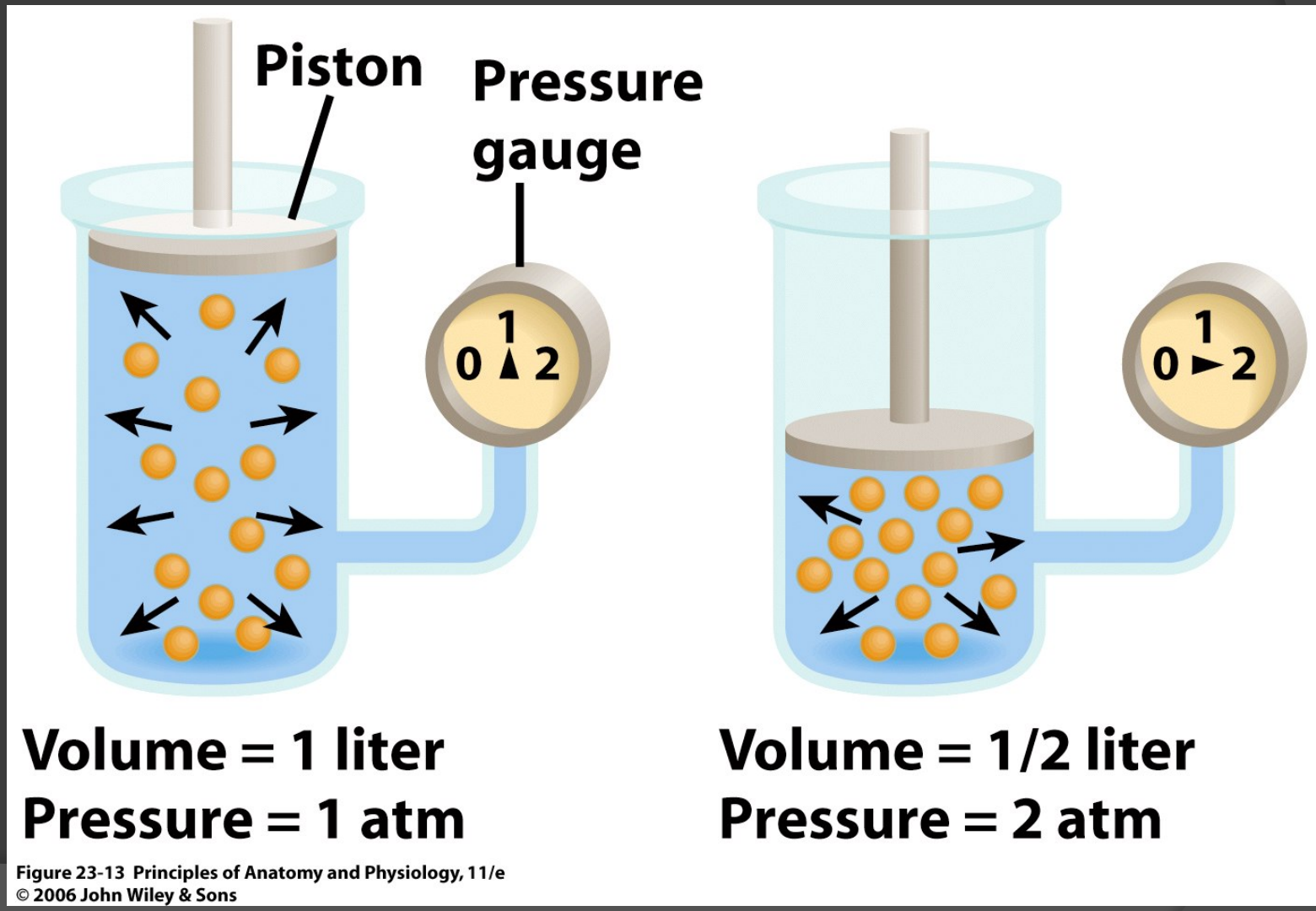
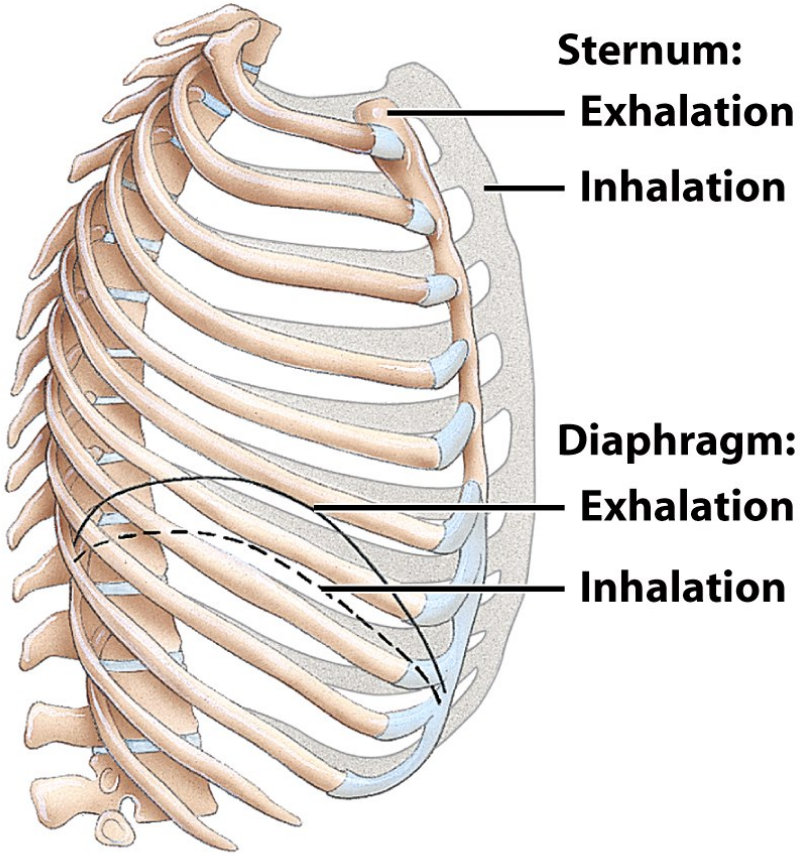



Figure 23-13 Principles of Anatomy and Physiology, 11/e




**Changes in size of thoracic cavity during inhalation and exhalation**

Figure 23-14b Principles of Anatomy and Physiology, 11/e


**During inhalation, the ribs move upward and outward like the handle on a bucket**

Figure 23-14c Principles of Anatomy and Physiology, 11/e

# Pressure Changes in Pulmonary Ventilation

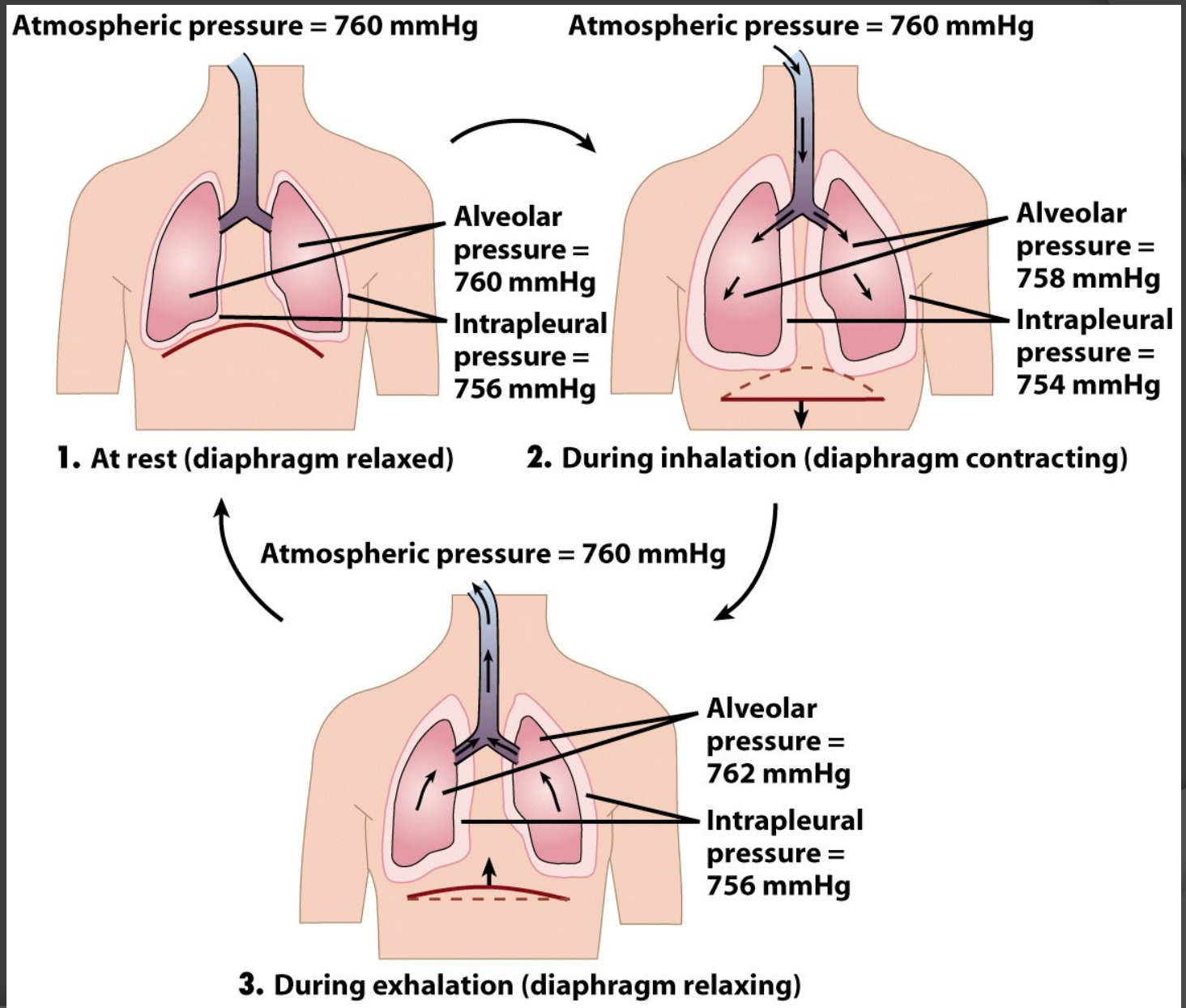



Figure 23-15 Principles of Anatomy and Physiology, 11/e

# Muscle of Respiration

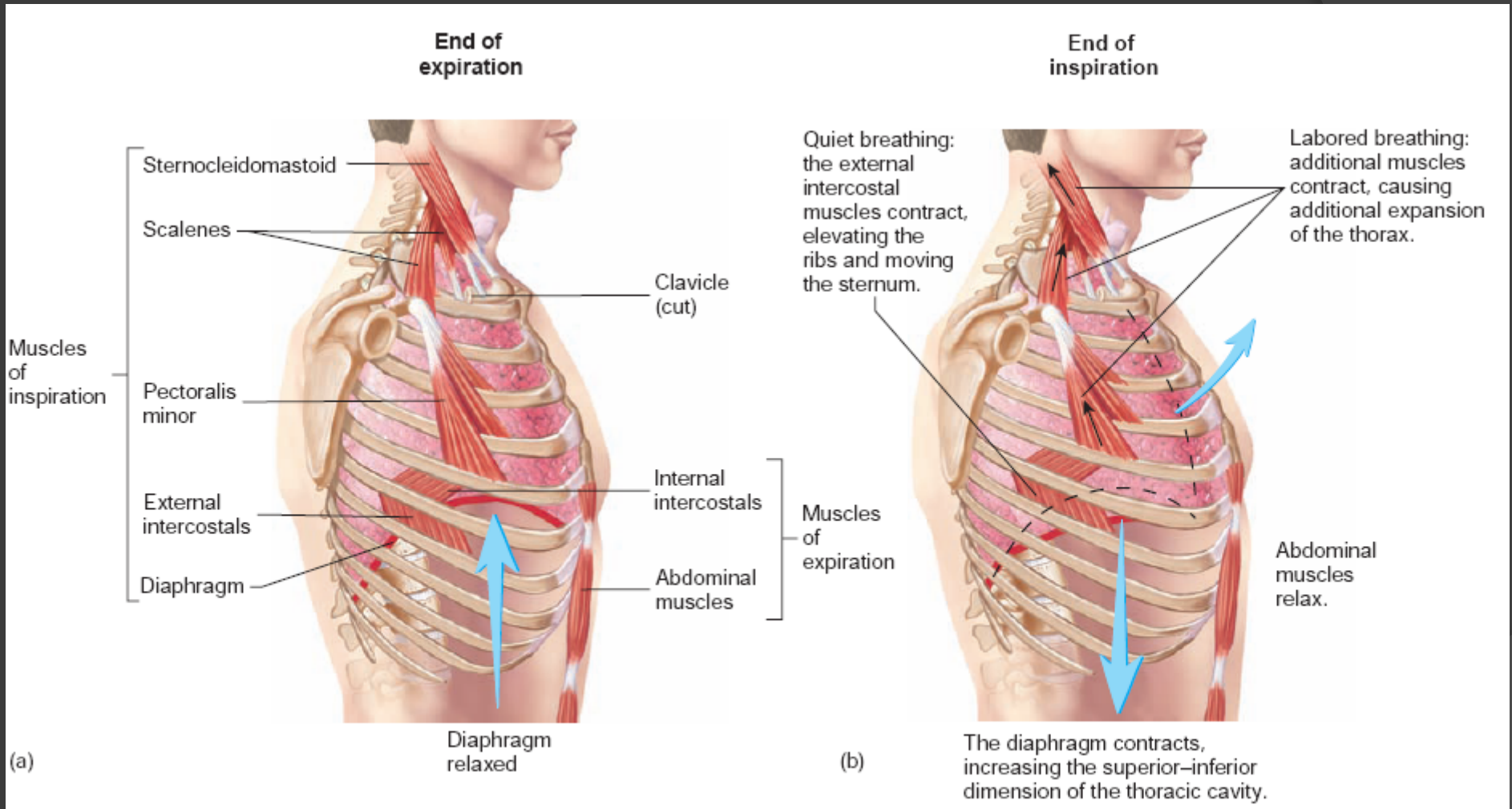



**FIGURE 23.10** **Effect of the Muscles of Respiration on Thoracic Volume**

(*a*) Muscles of respiration at the end of expiration. (*b*) Muscles of respiration at the end of inspiration.

# Airflow

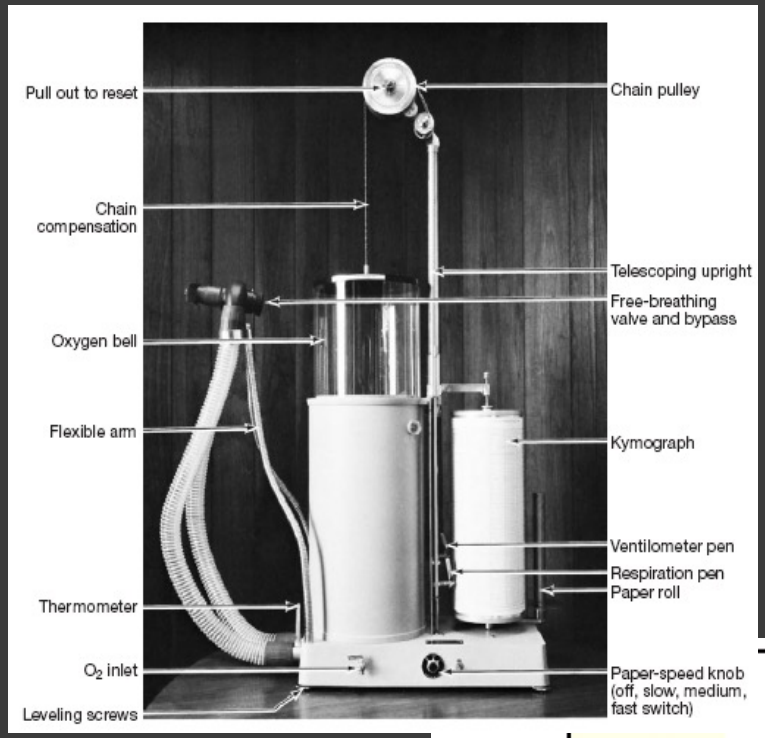
- Air pressure differences drive airflow
- 3 other factors affect rate of airflow and ease of pulmonary ventilation
  - Surface tension of alveolar fluid
    - Causes alveoli to assume smallest possible diameter
    - Accounts for 2/3 of lung elastic recoil
    - Prevents collapse of alveoli at exhalation
  - Lung compliance
    - High compliance means lungs and chest wall expand easily
    - Related to elasticity and surface tension
  - Airway resistance
    - Larger diameter airway has less resistance
    - Regulated by diameter of bronchioles & smooth muscle tone

# Lung volumes and capacities

- Minute ventilation (MV) = total volume of air inhaled and exhaled each minute
- Normal healthy adult averages 12 breaths per minute
- moving about 500 ml of air in and out of lungs (tidal volume)
- MV = 12 breaths/min x 500 ml/ breath

  = 6 liters/ min

# Spirogram of Lung Volumes and Capacities



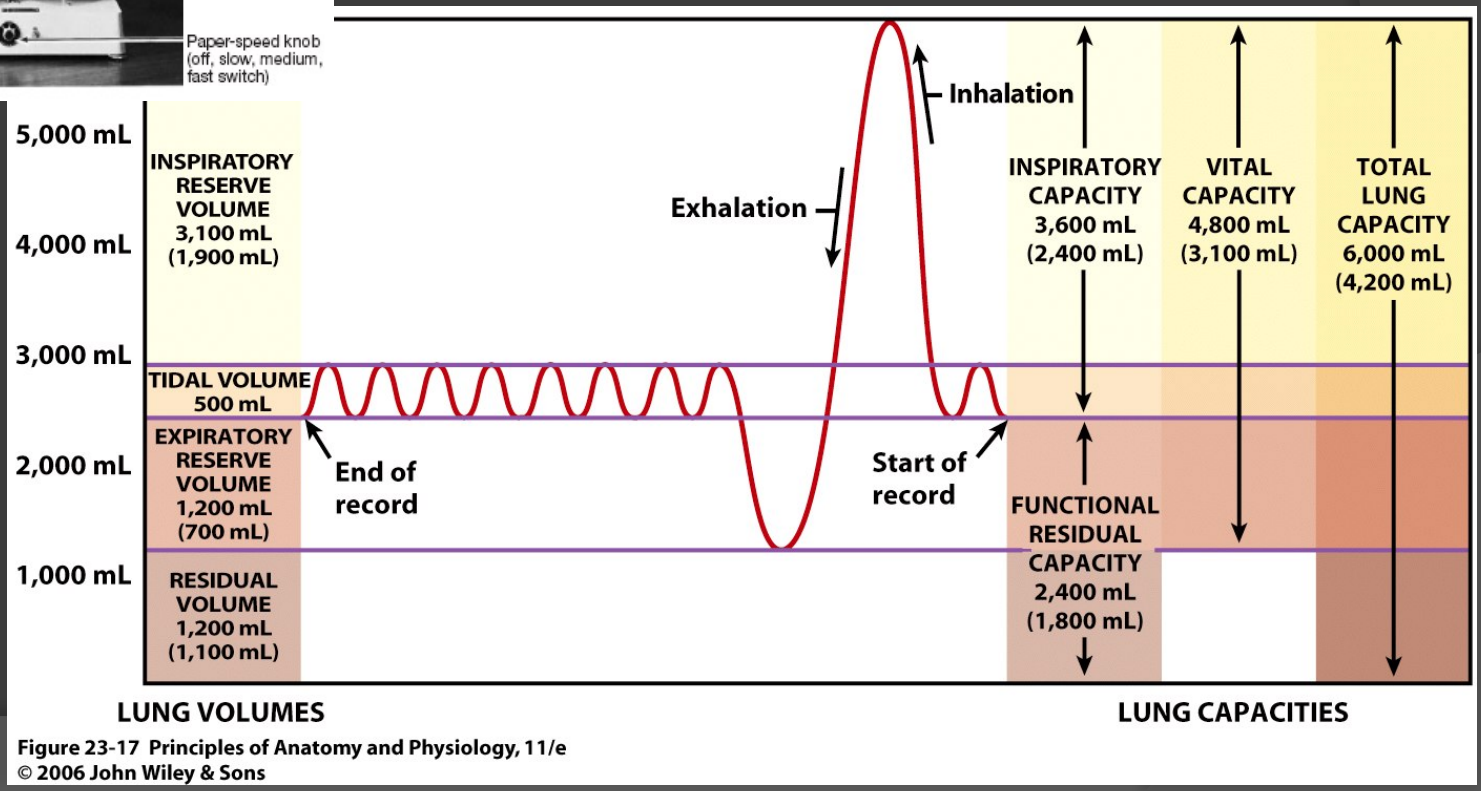




Figure 23-17 Principles of Anatomy and Physiology, 11/e

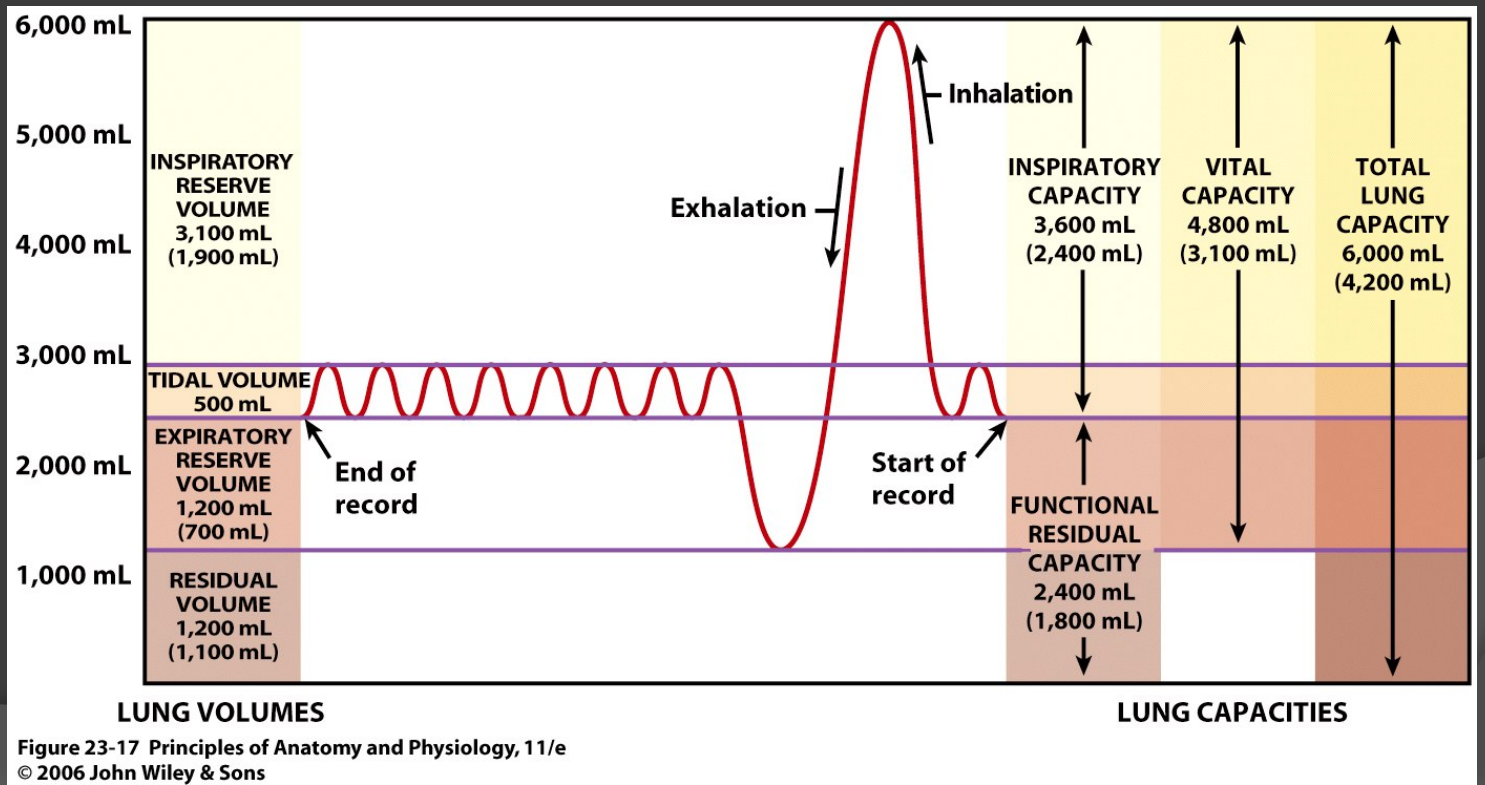
# Volume Paru Paru

Volume Tidal (**VT)** = Volume udara yang diinspirasi atau diekspirasi setiap kali bernafas normal (~ 500 mL)

Volume Cadangan Inspirasi (**VCI)** = volume udara ekstra yang masih dapat diinpirasi setelah /diatas volume tidal / volume alun nafas (3000 mL)

Volume Cadangan Ekspirasi (**VCE)**=volume udara ekstra yang masih dapat diekspirasi setelah /diatas volume tidal (1100 mL)

Volume Residual (**VR)**=volume udara yang masih tetap tinggal di paru paru setelah ekspirasi paling kuat (1200 mL)

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# Kapasitas Paru Paru

**Kapasitas Inspirasi (CI) =** VT + VCI= jumlah udara yang dapat diinspirasi secara normal sampai maksimal (~3500 mL)

**Kapasitas Residu Fungsional (CRF)=** VCE + VR = jumlah udara yang tersisa dalam paru paru setelah ekspirasi normal (~ 2300 mL)

**Kapasitas Vital (CV) =** VCI + VT + VCE = jumlah udara yang dapat diekspirasi maksimal setelah inspirasi maksimal (~ 4600 mL)

**Kapasitas Total (CT) =** CV + VR = volume maksimum dimana paru paru dapat dikembangkan secara maksimal pada inspirasi yang dipaksakan maks.(~ 5800 mL)

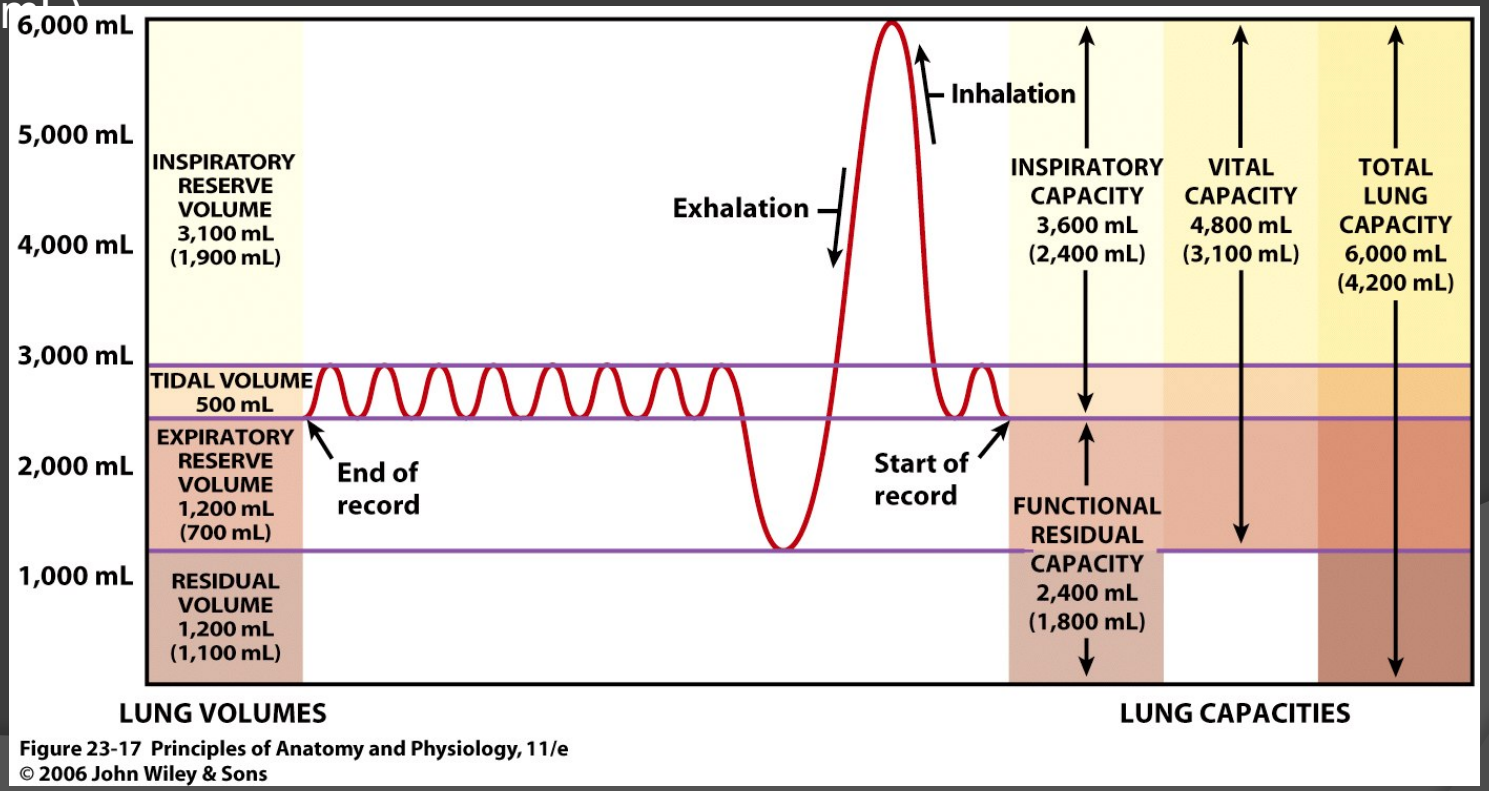


Figure 23-17 Principles of Anatomy and Physiology, 11/e

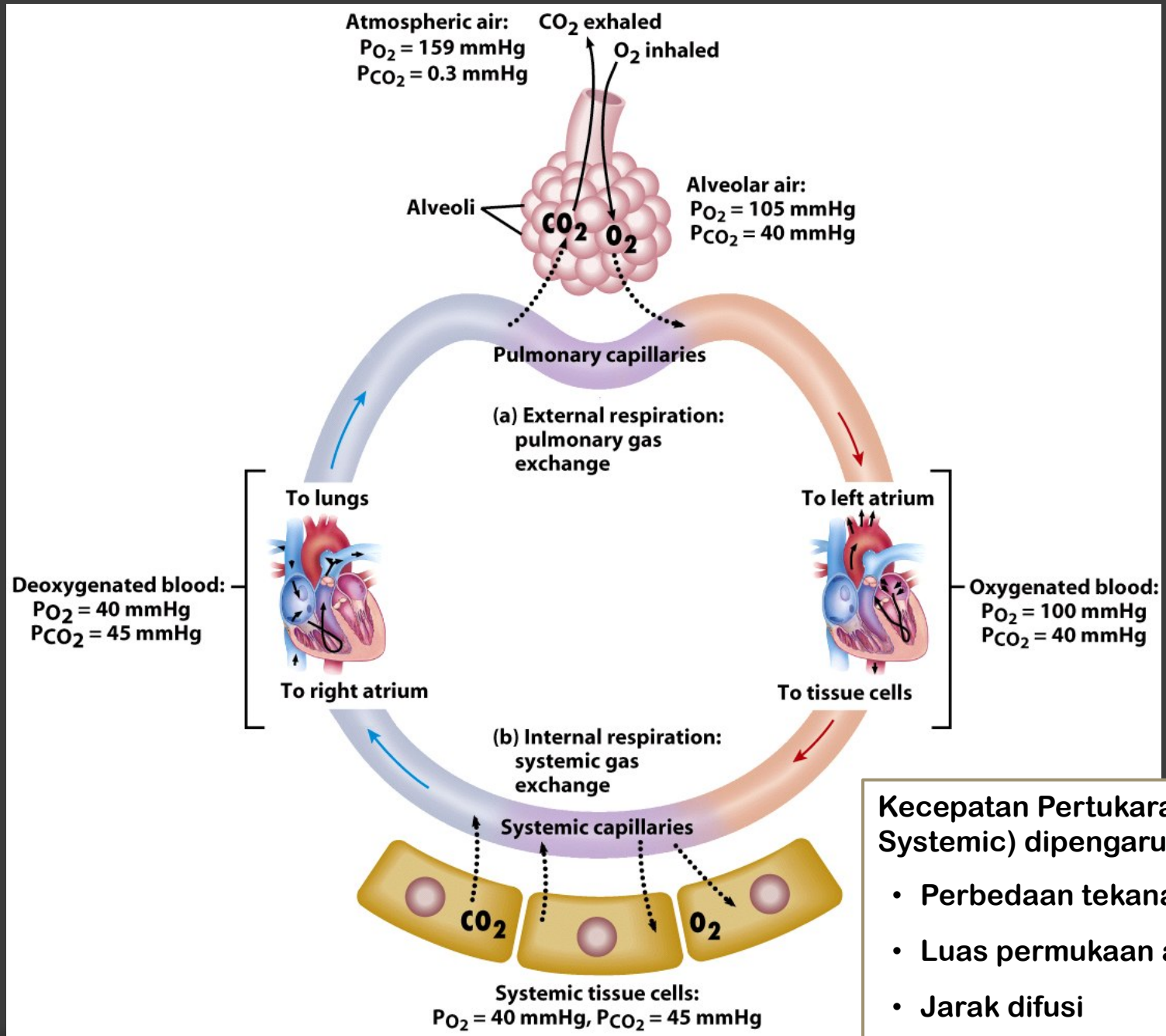



Figure 23-18 Principles of Anatomy and Physiology, 11/e



## Changes of Partial Pressures of Oxygen and Carbon Dioxide during External and Internal Respiration

Kecepatan Pertukaran Gas (Pulmonary & Systemic) dipengaruhi oleh :

- Perbedaan tekanan parsial antar gas
- Luas permukaan area pertukaran gas
- Jarak difusi
- Berat molekul tingkat kelarutan gas

# Oxygen Transport

Oxygen transport

- Only about 1.5% dissolved in plasma
- 98.5% bound to hemoglobin in red blood cells
  - Heme portion of hemoglobin contains 4 iron atoms – each can bind one $O_2$ molecule
  - Oxyhemoglobin
  - Only dissolved portion can diffuse out of blood into cells
  - Oxygen must be able to bind and dissociate from heme

# Carbon Dioxide Transport

- Dissolved $CO_2$
  - Smallest amount, about 7%
- Carbamino compounds
  - About 23% combines with amino acids including those in Hb
  - Carbaminohemoglobin
- Bicarbonate ions
  - 70% transported in plasma as $HCO_3^-$
  - Enzyme carbonic anhydrase forms carbonic acid ($H_2CO_3$) which dissociates into $H^+$ and $HCO_3^-$

# Transport of Oxygen and Carbon Dioxide in Blood

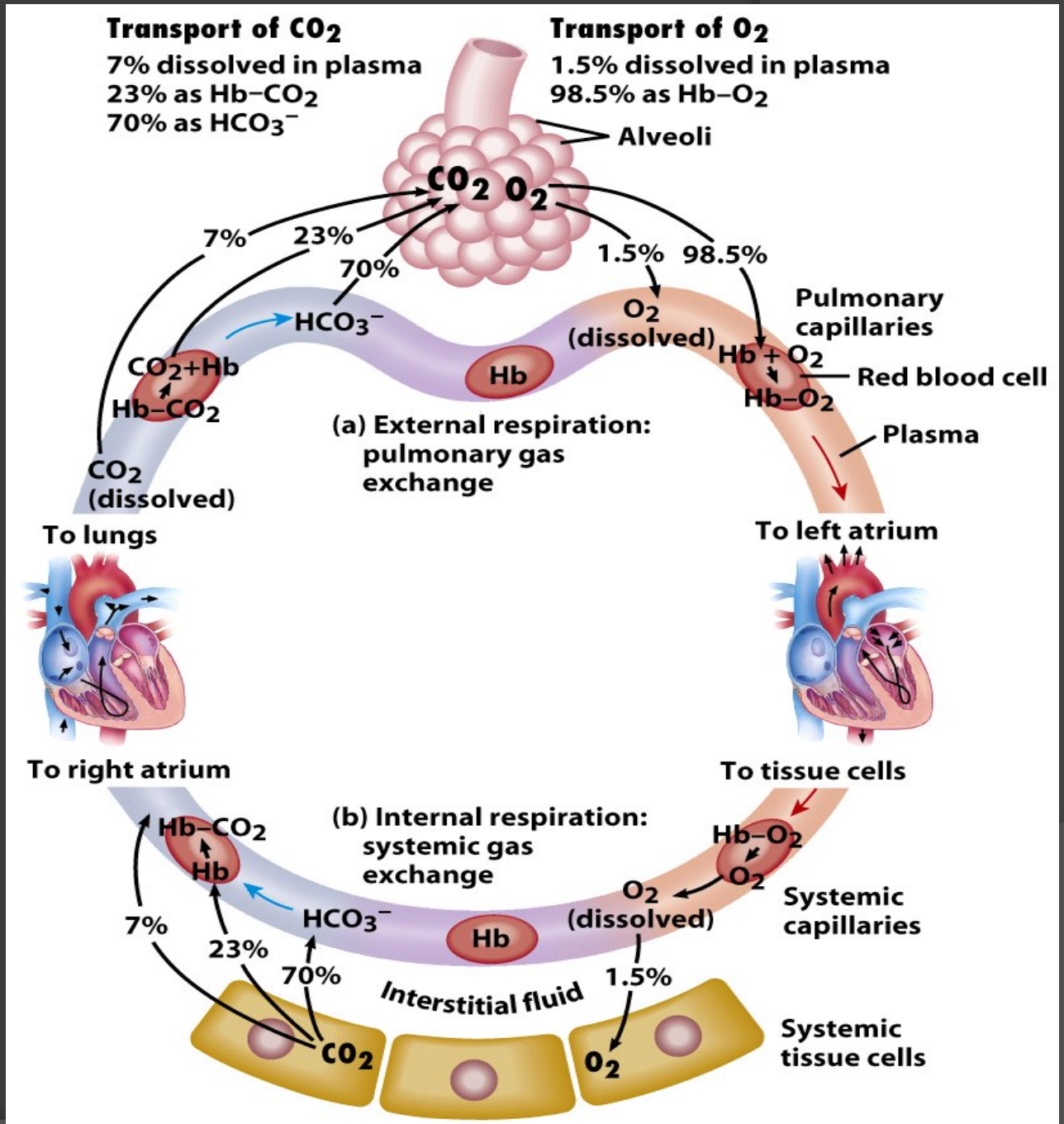


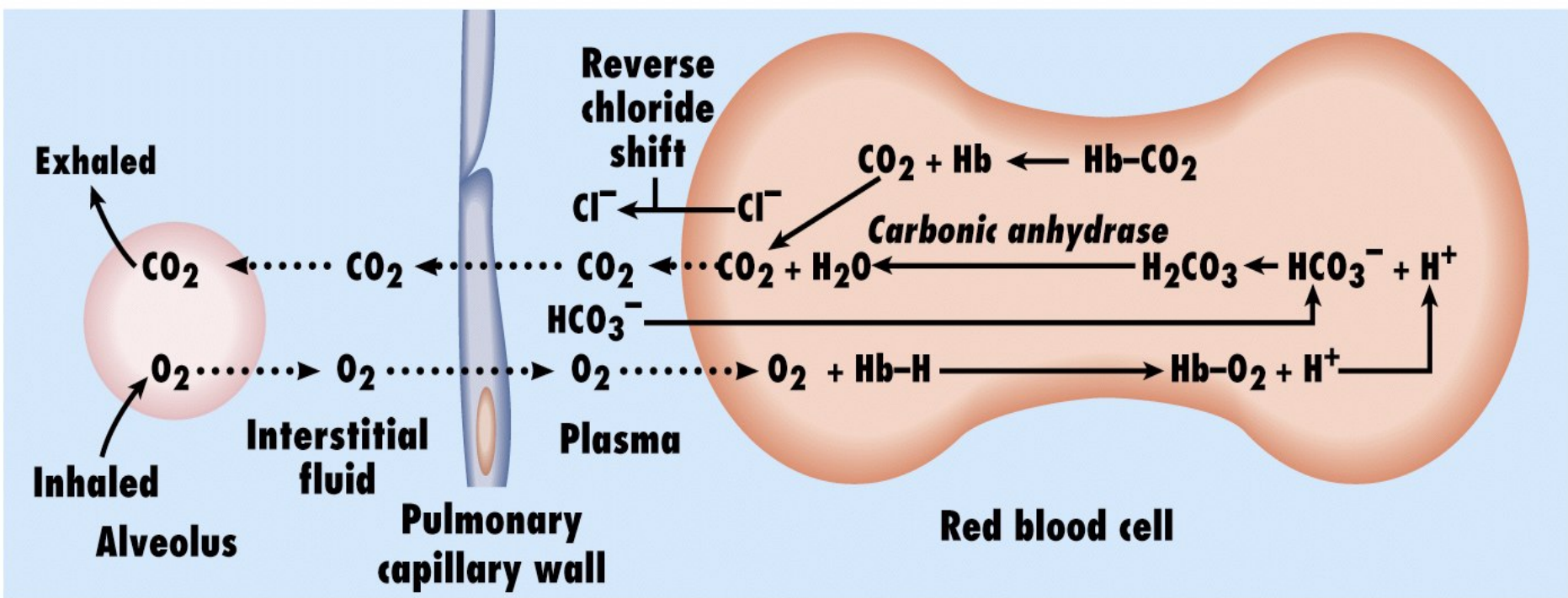

Figure 23-19 Principles of Anatomy and Physiology, 11/e

# Relationship to digestive system

- **Cellular respiration requires glucose and oxygen to release energy to the body**
- **$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6\,H_2O +$ Energy**

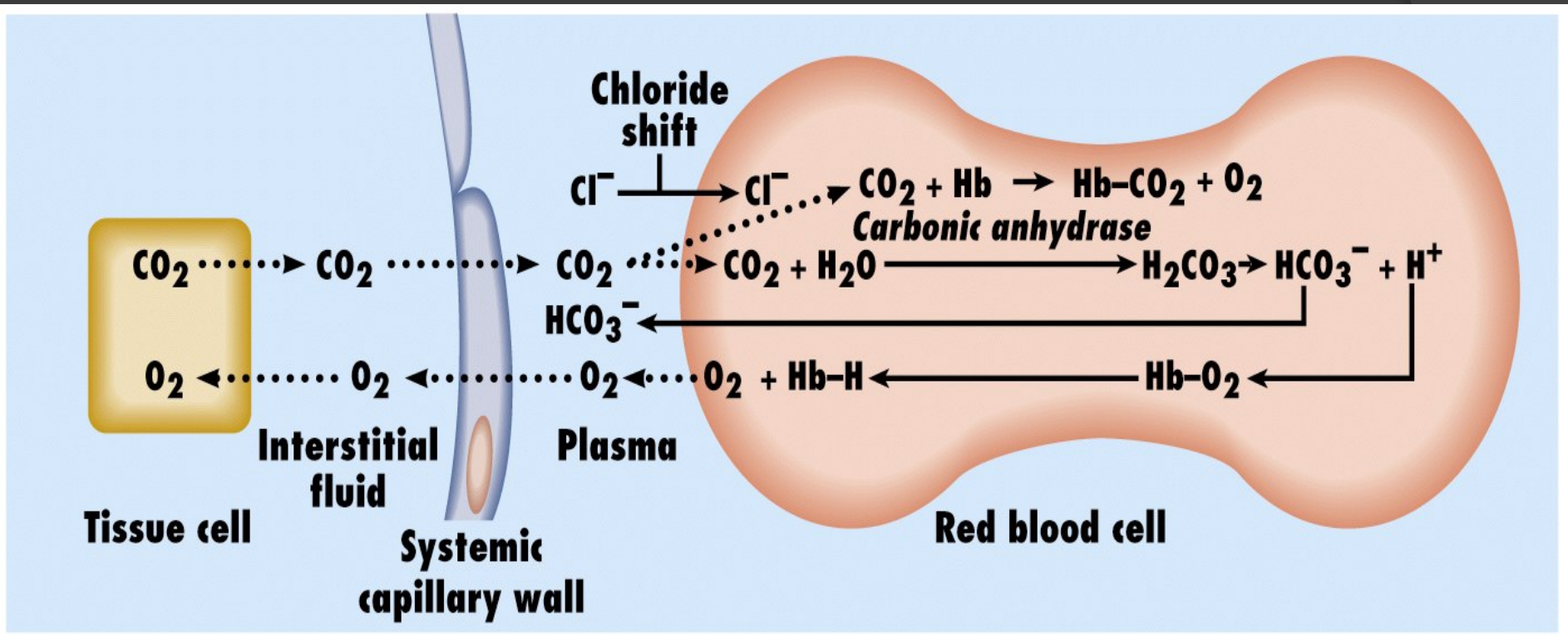
- **Oxygen is provided by the respiratory system**
- **Glucose is provided by the digestive system**
- **(glucose is made during *photosynthesis*)**

# Chemical Reactions During Gas Exchange




**Exchange of $O_2$ and $CO_2$ in pulmonary capillaries (external respiration)**

Figure 23-24a Principles of Anatomy and Physiology, 11/e




**Exchange of $O_2$ and $CO_2$ in systemic capillaries (internal respiration)**

Figure 23-24b Principles of Anatomy and Physiology, 11/e

# Respiratory Center

***Medullary Rhytmicity Area***

- Letak : medula oblongata
- Fungsi : mengontrol ritme dasar respirasi
- Tersusun atas dua area yi : area inspiratori dan area ekspiratori

***Pneumotaxic Area***

- Letak : pons bagian atas
- Fungsi : membantu koordinasi transisi antara inhalasi dan ekshalasi
- Mekanisme kerja : mengirimkan impuls inhibitori ke area inspiratori → membatasi inspirasi dan menfasilitasi ekspirasi

***Apneustic Area***

- Letak : pons bagian bawah
- Fungsi : membantu koordinasi transisi antara inhalasi dan ekshalasi
- Mekanisme kerja : mengirimkan impuls stimulatori ke area inspiratori →inspirasi diperpanjang dan menghambat ekspirasi ketika *pneumotaxic area* inaktif

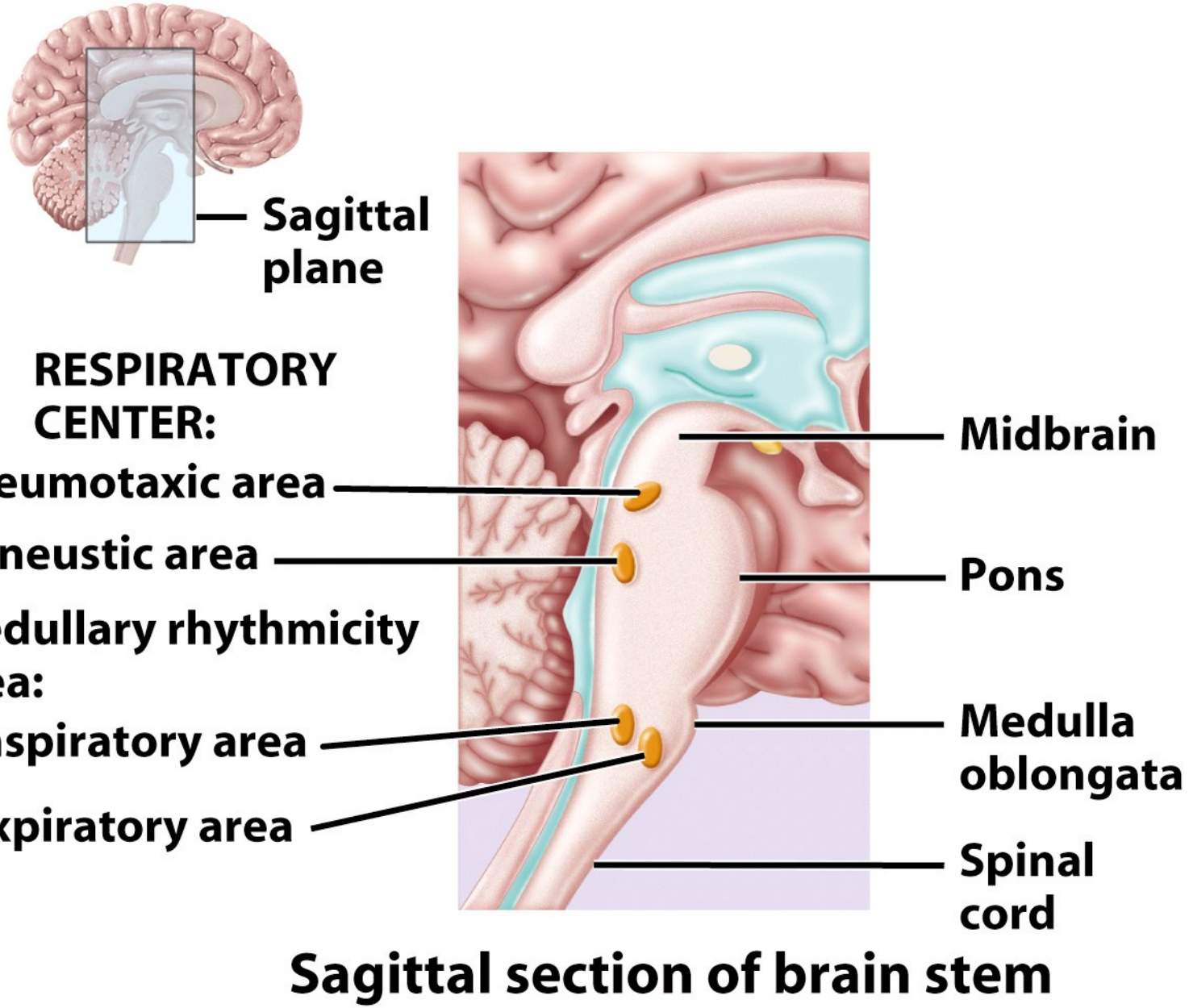



Figure 23-25 Principles of Anatomy and Physiology, 11/e

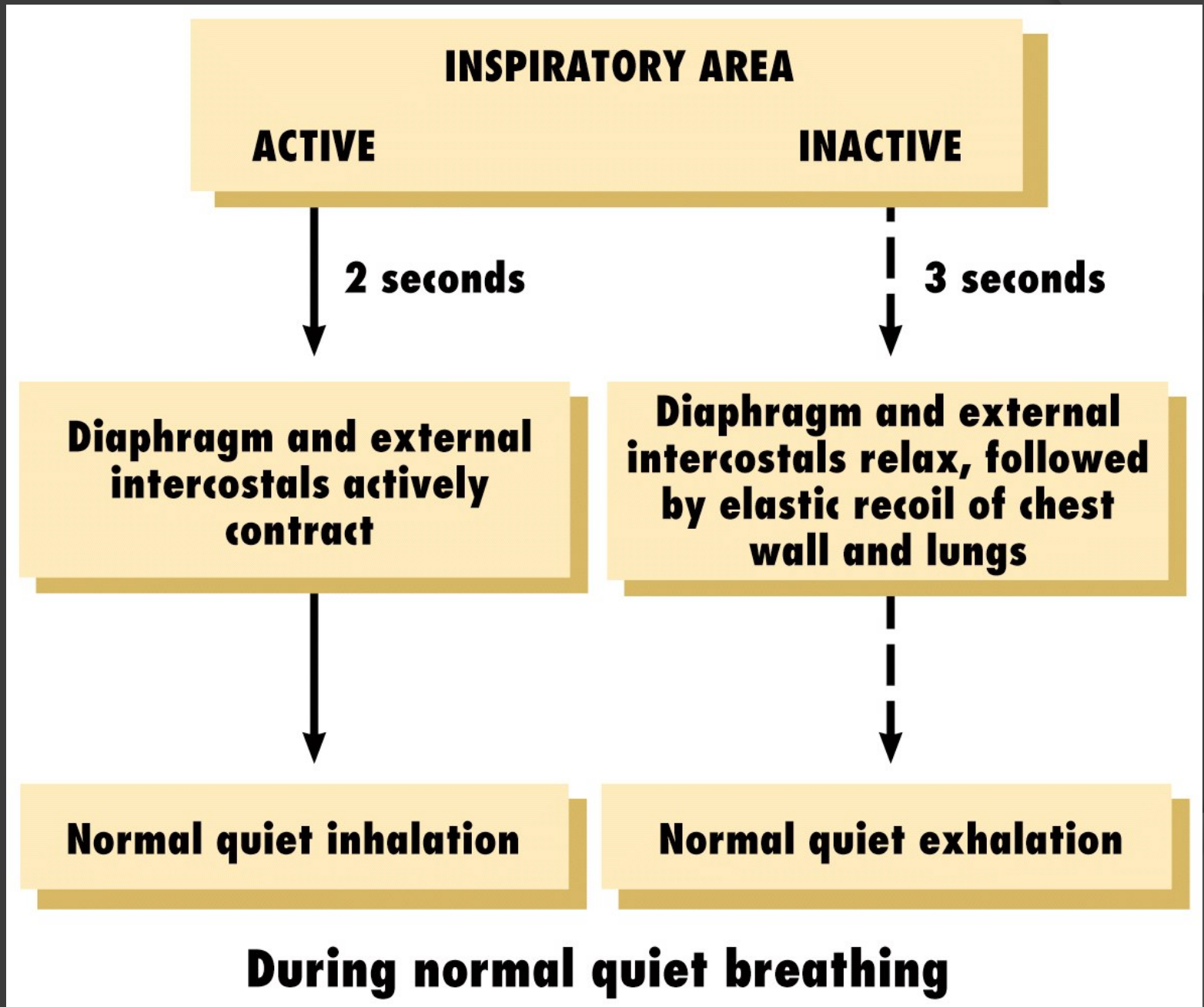



Figure 23-26a Principles of Anatomy and Physiology, 11/e

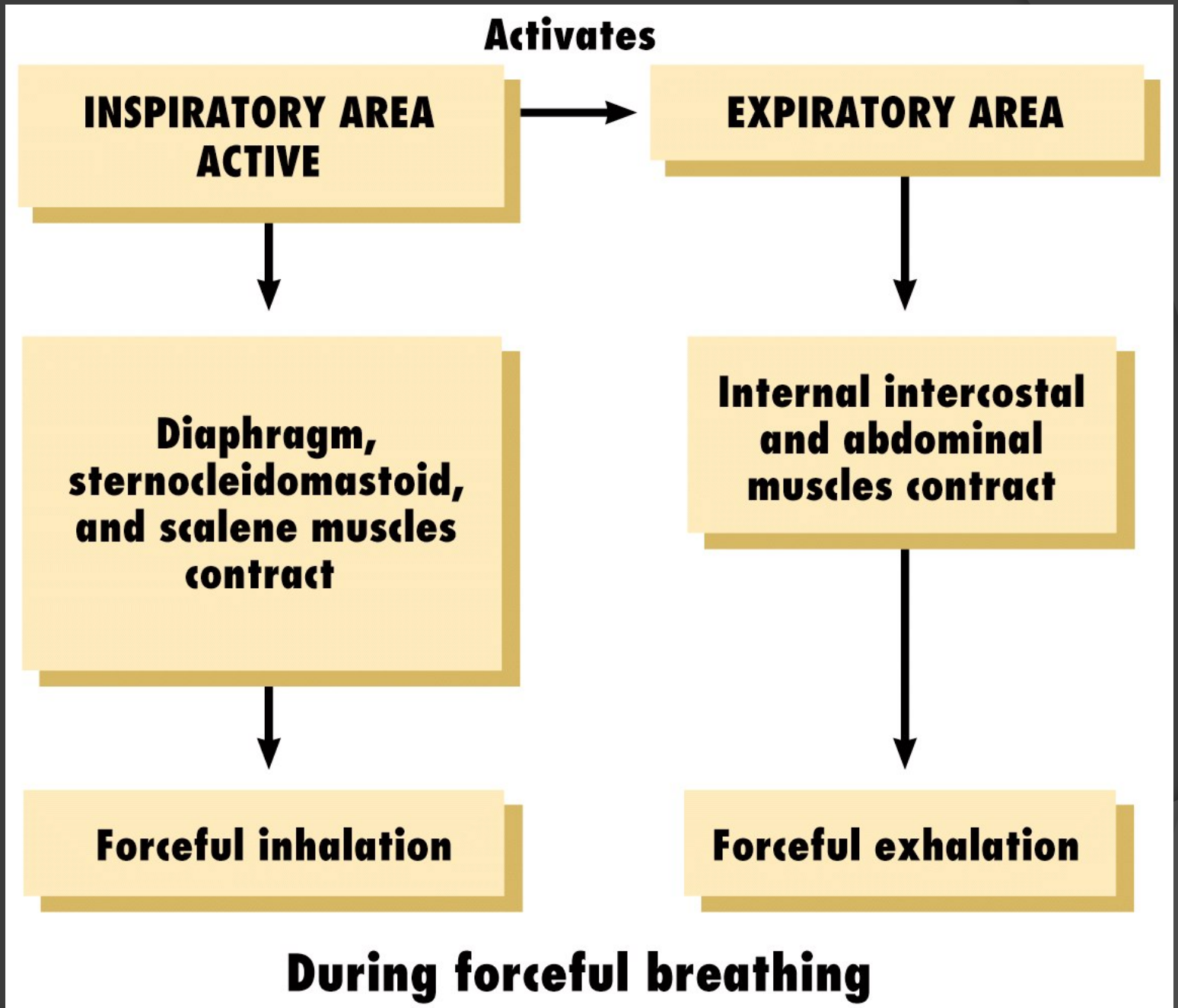



Figure 23-26b Principles of Anatomy and Physiology, 11/e

# Chemoreceptor Regulation of Respiration

a. Kemoreseptor Sentral (sistem saraf pusat)

- Letak : medulla oblongata
- Fungsi : monitor kimiawi cairan serebrospinal

b. Kemoreseptor Perifer sistem sarf perifer)

- Letak : aortic bodies (di dalam dinding arkus aorta) dan carotid bodies (di dalam dinding arteri karotid)
- Fungsi : monitor kimiawi darah

# Location of Chemoreceptors

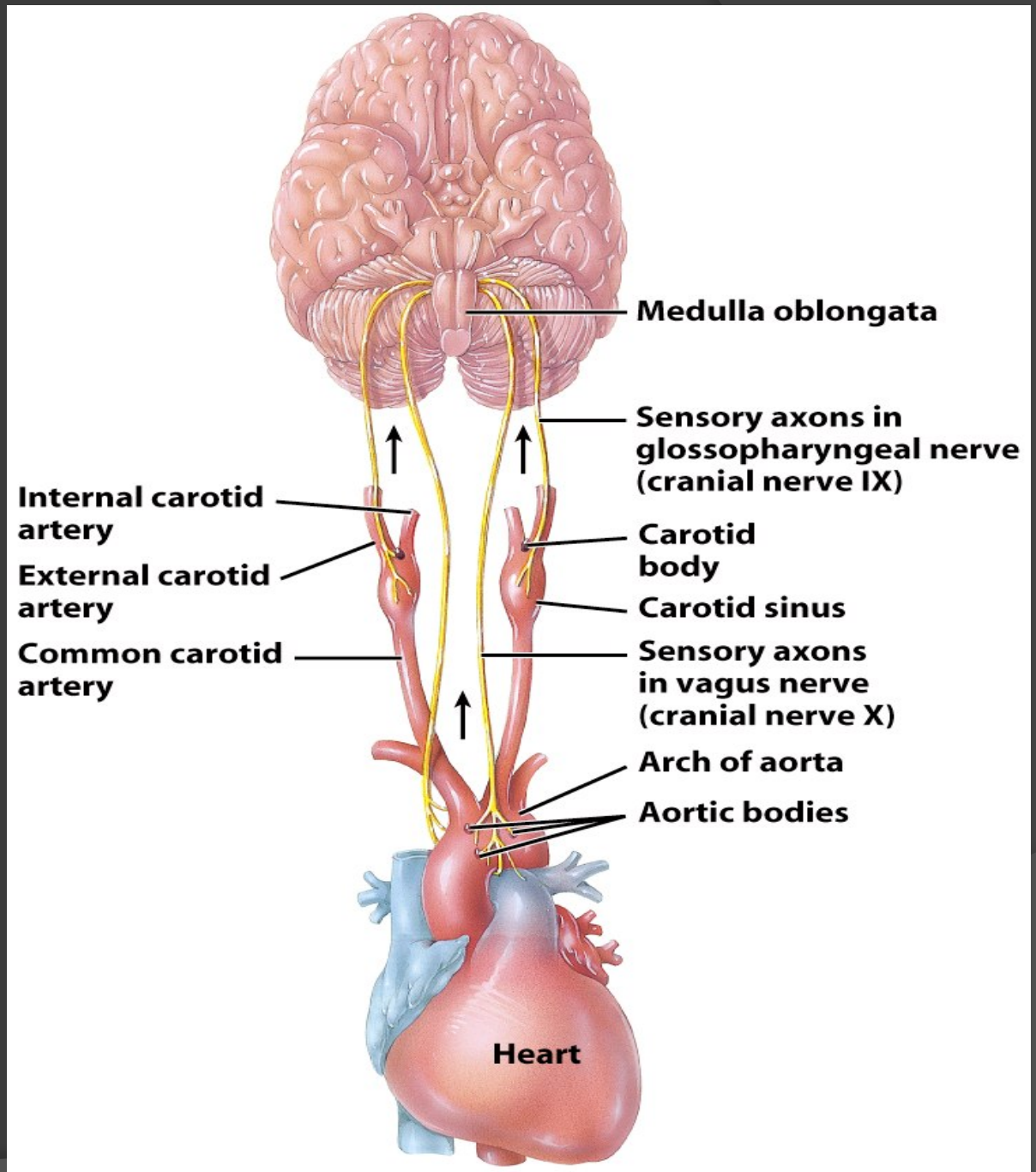


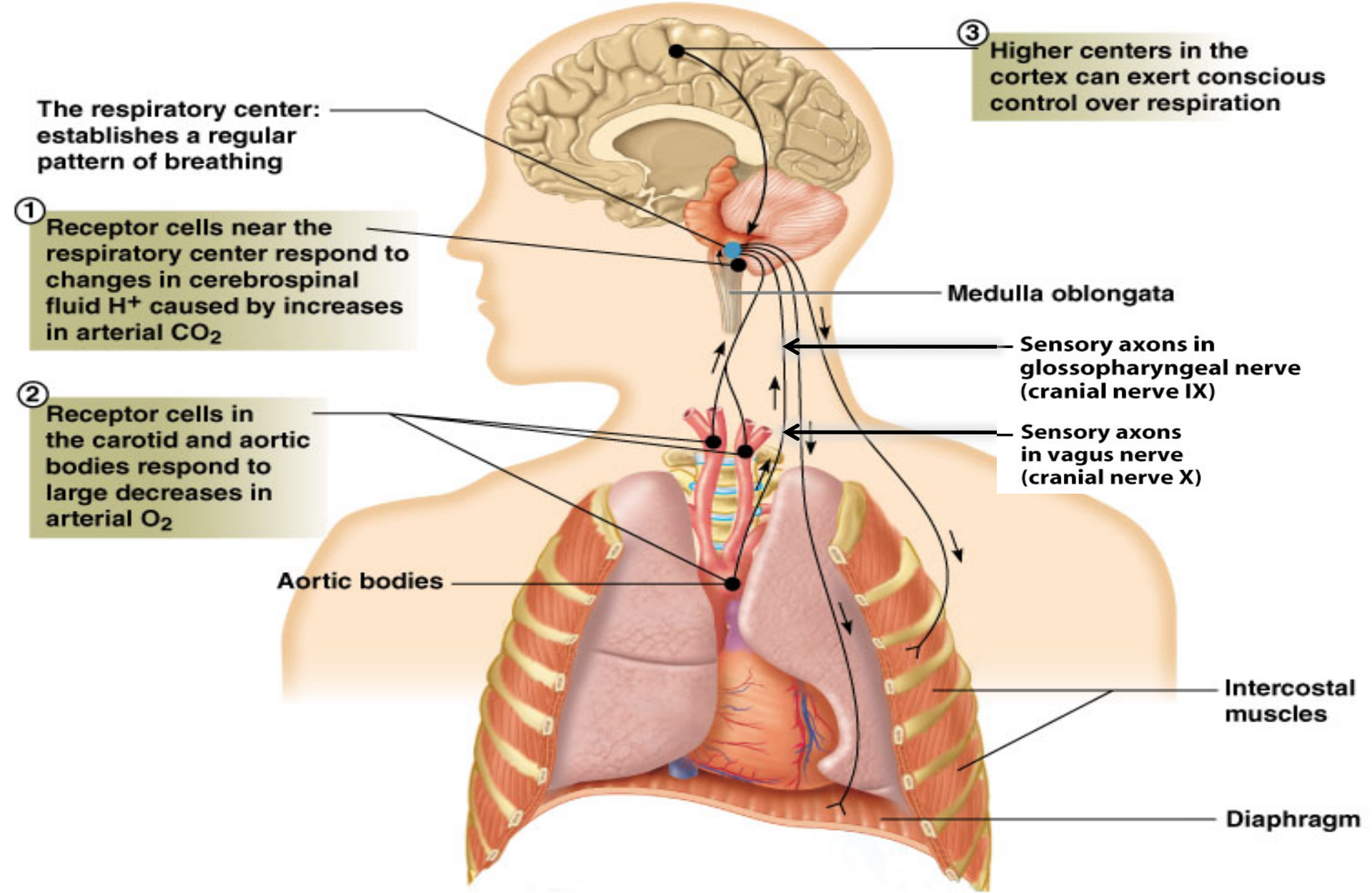

Figure 23-27 Principles of Anatomy and Physiology, 11/e

# Cortical influence on Respiration

- Korteks serebral memiliki koneksi dg pusat respirasi → merubah pola pernafasan secara volunter (menahan nafas dlm waktu ttt) → gas berbahaya / air tidak masuk paru-paru → tgt pd jumlah $CO_2$ dan $H^+$ di dlm tubuh.

- $PCO_2$ dan $H^+$ meningkat pd level ttt → area inspiratori terstimulasi → impuls syaraf dikirim ke syaraf *phrenic* dan *intercostal* ke otot inspiratori → bernafas kembali.

# Regulation of Breathing



# Factors that Contribute to Regulation of Respiration

- Limbic system stimulation → antisipasi thd suatu aktifitas / kecemasan emosional →stimulasi area inspiratori → kecepatan dan kedalaman ventilasi meningkat
- Temperature → suhu tubuh meningkat / olahraga muskular yg berlebihan →meningkatkan kecepatan respirasi; suhu tubuh menurun → kecepatan respirasi menurun
- Pain → nyeri hebat → apnea; nyeri somatik yg lama → meningkatkan kecepatan respirasi; nyeri viseral → menurunkan kecepatan respirasi
- Stretching the anal sphincter muscle → aksi ini meningkatkan kecepatan respirasi
- Irritation of air ways → iritasi fisik/kimiawi pd faring/laring → menghentikan pernafasan seketika, diikuti batuk / bersin-bersin
- Blood pressure → tekanan darah meningkat secara mendadak→ kecepatan respirasi menurun; tekanan darah “drop” → meningkatkan kecepatan respirasi

# Regulation of Breathing in Response to Changes in Blood $PCO_2$, $PO_2$, and pH ($H^+$ Concentration) via Negative Feedback Control

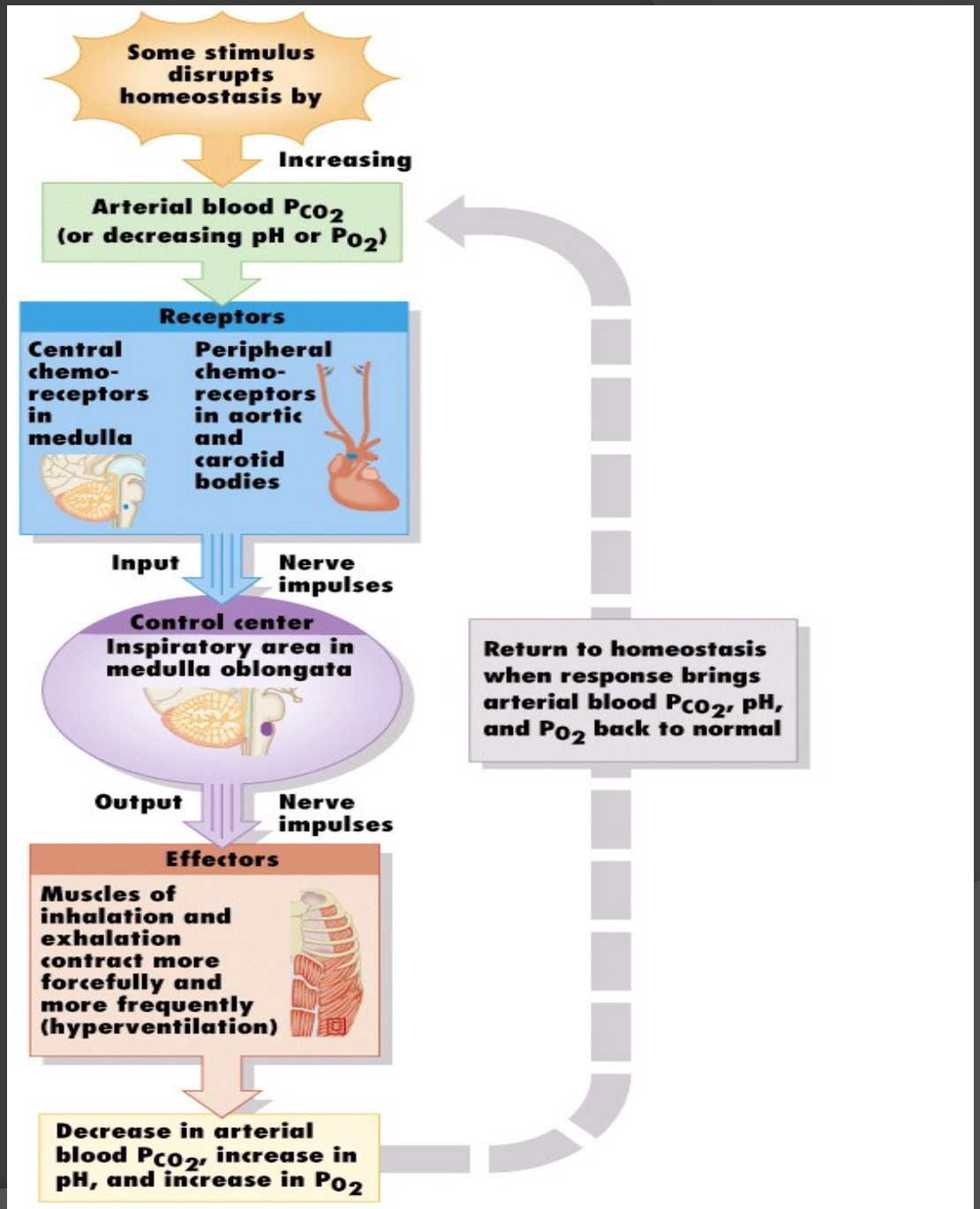



Figure 23-28 Principles of Anatomy and Physiology, 11/e

# Question ??