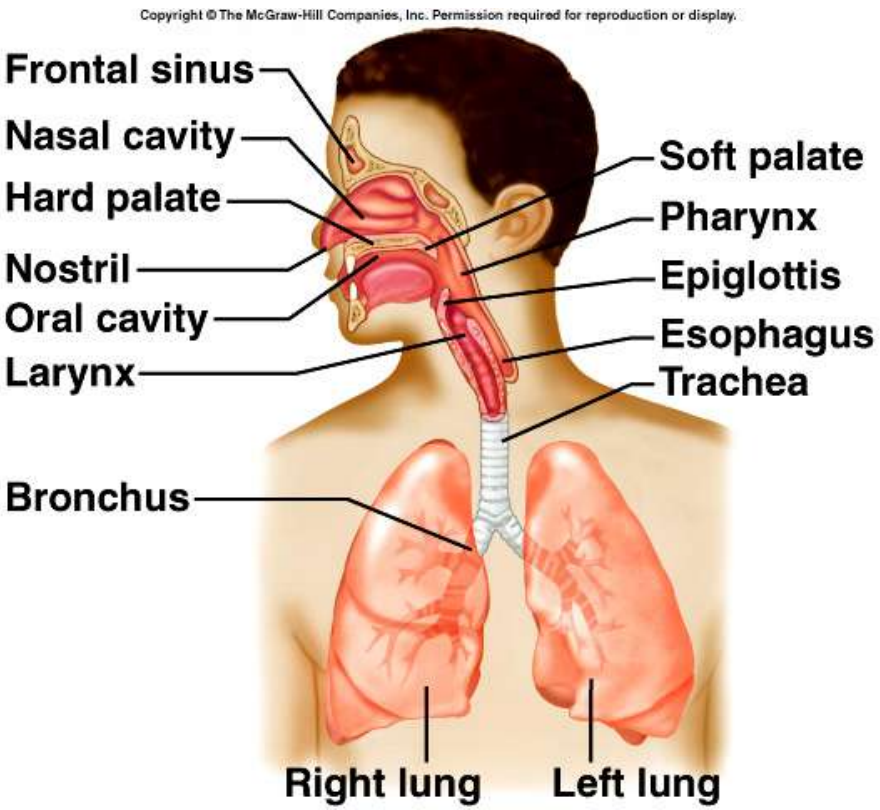
Respiratory System

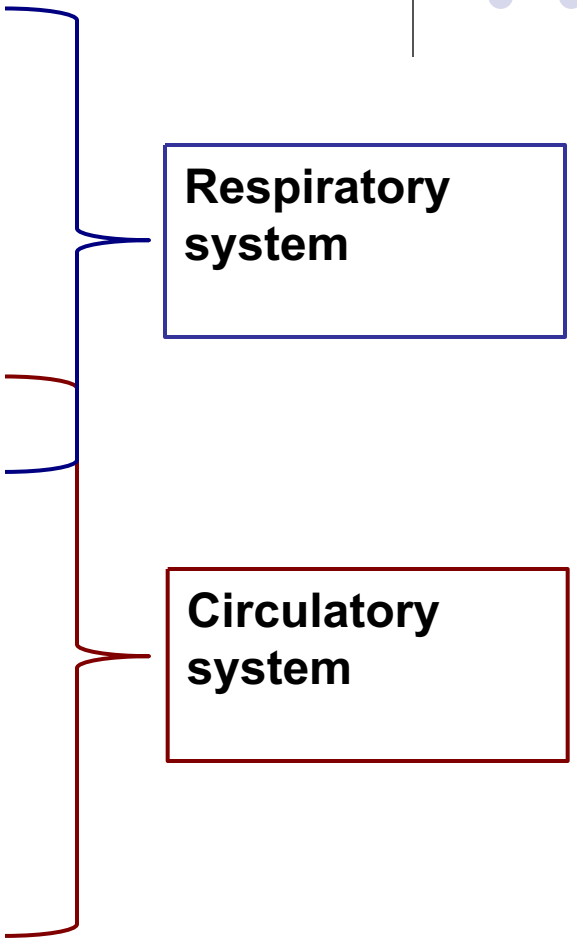


What is It

- **Respiration** is the process of exchanging gases between the atmosphere and body cells
- **Non-Respiratory Air Movements:** coughing, sneezing, laughing, crying, hiccuping, yawning, speech

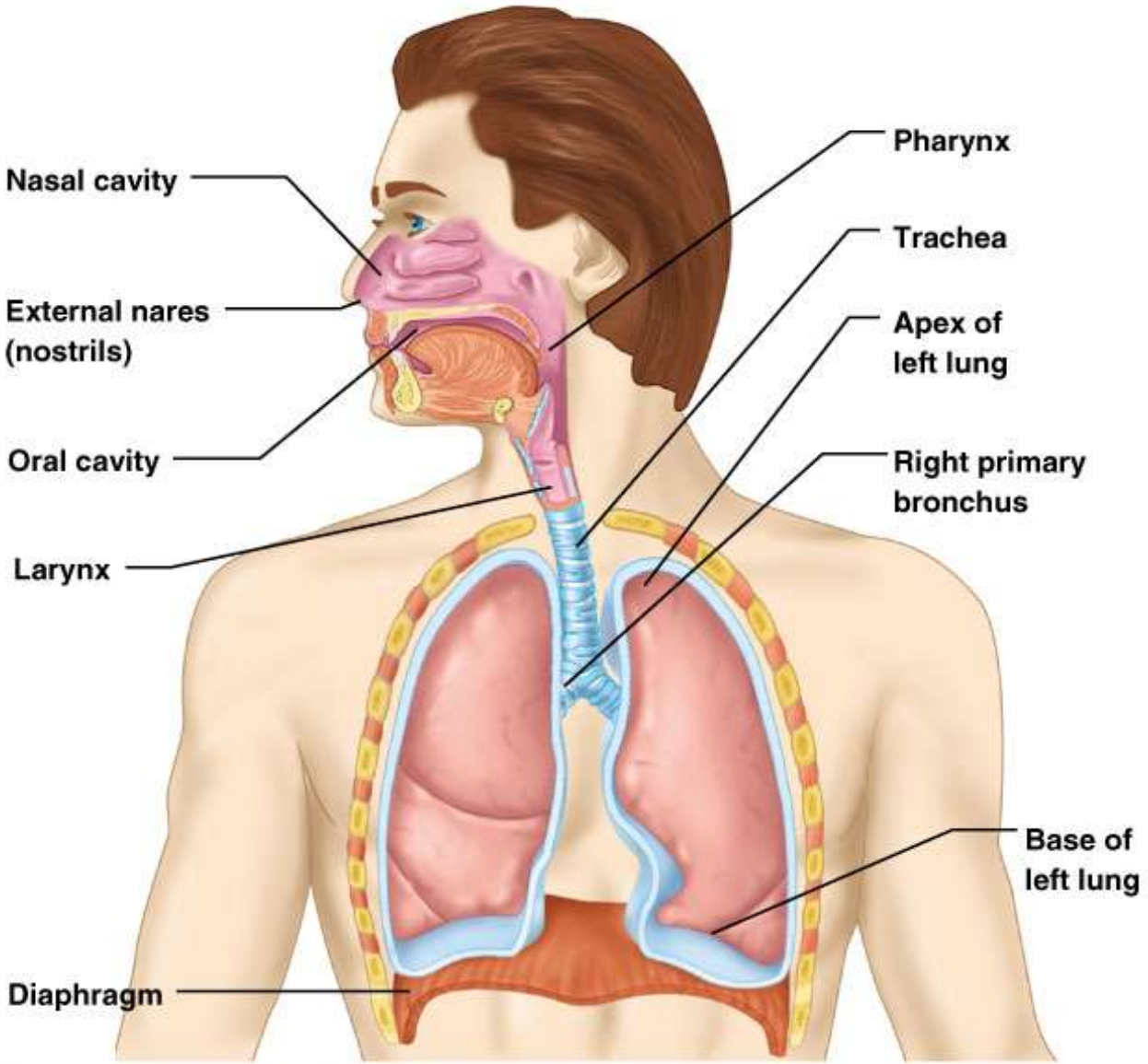
Respiration

- Pulmonary ventilation (breathing): movement of air into and out of the lungs
- External respiration: O_2 and CO_2 exchange between the lungs and the blood
- Transport: O_2 and CO_2 in the blood
- Internal respiration: O_2 and CO_2 exchange between systemic blood vessels and tissues



Organs

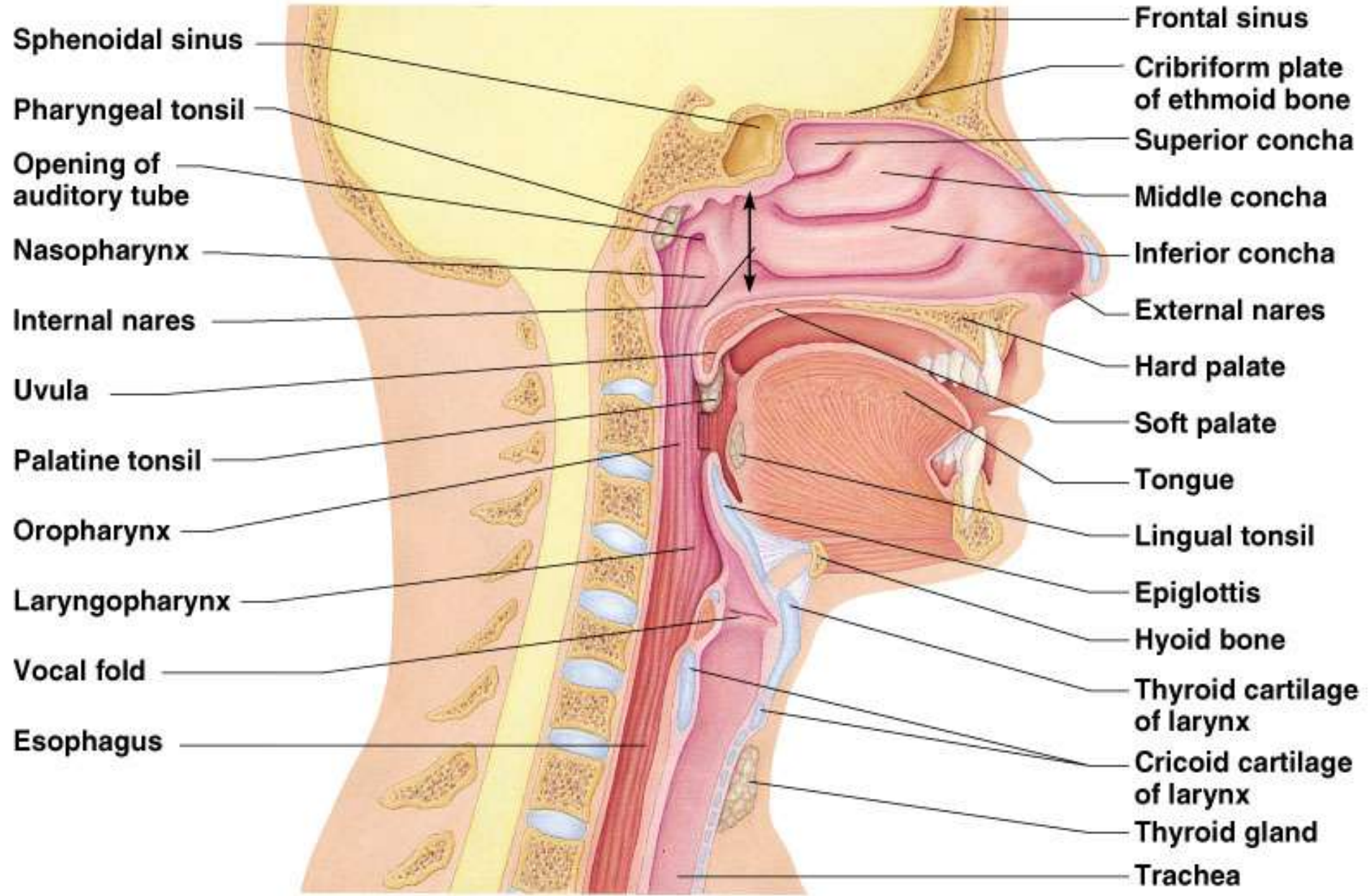
- Nose
- Pharynx
- Larynx
- Trachea
- Bronchi
- Lungs
  - Bronchioles
  - Alveoli



The Nose

- only externally visible part of the respiratory system
- The interior of the nose consists of a nasal cavity divided by a nasal septum
- Nose is the 1st line of defense against airborne antigens so it is also part of our immune system.
- **Functions:** Moisten, warm, filter, olfaction, resonance

Upper Respiratory Tract



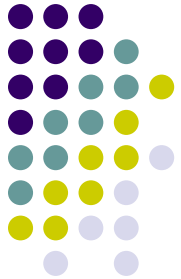
Nasal Cavity

- Olfactory receptors are located in the mucosa on the superior surface
- cavity is lined with respiratory mucosa and cilia
- Lateral walls have projections called **conchae**

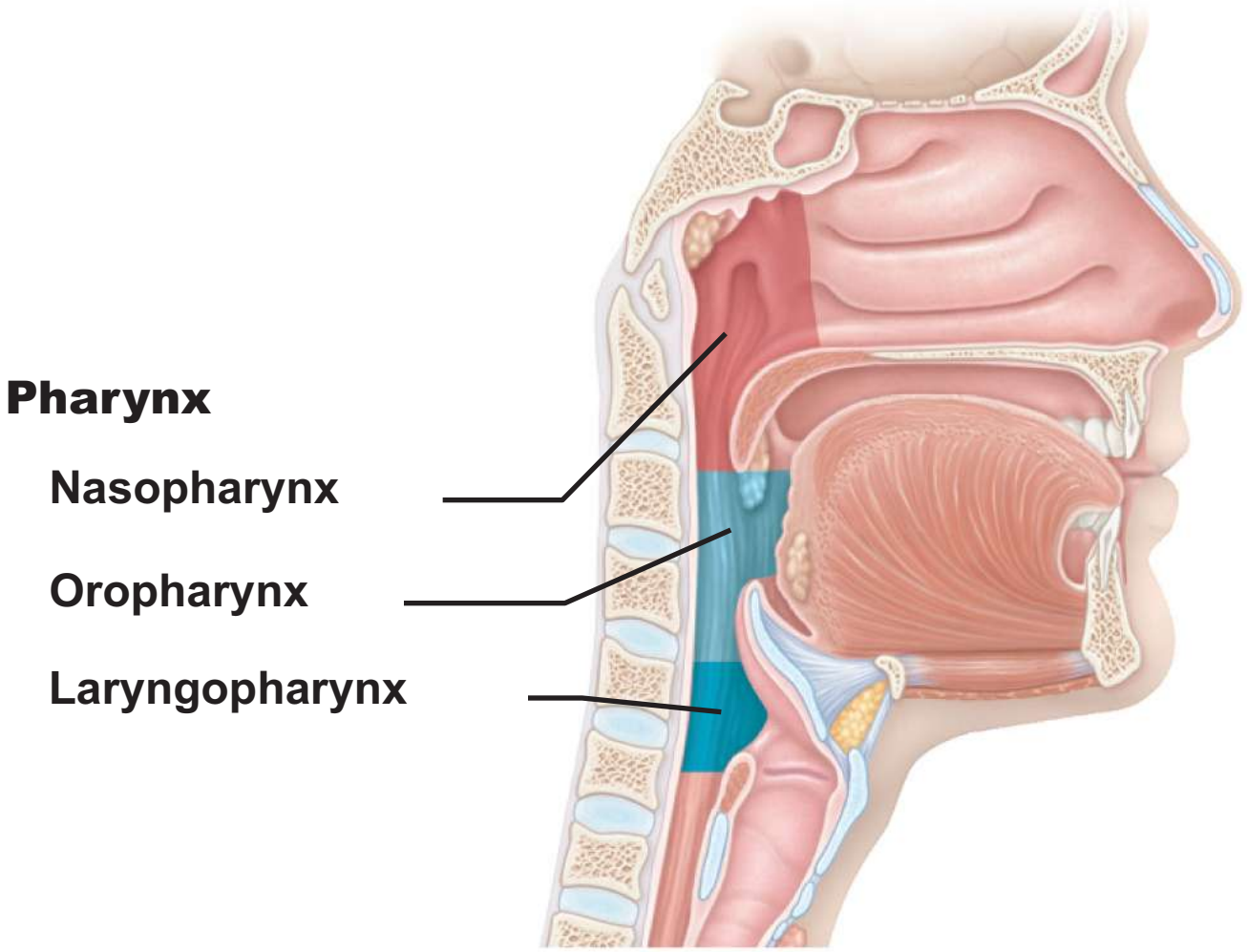
Cont….

- The nasal cavity is separated from the oral cavity by the palate
  - Anterior hard palate (bone)
  - Posterior soft palate (muscle
- Cavities within bones surrounding the nasal cavity are called **sinuses**
- Function of the sinuses
  - Lighten the skull
  - Act as resonance chambers for speech
  - Produce mucus that drains into the nasal cavity

Pharynx (Throat)



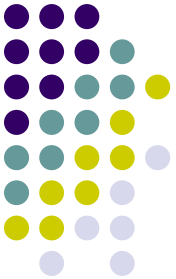
- Three regions of the pharynx
  - Nasopharynx
  - Oropharynx
  - Laryngopharynx



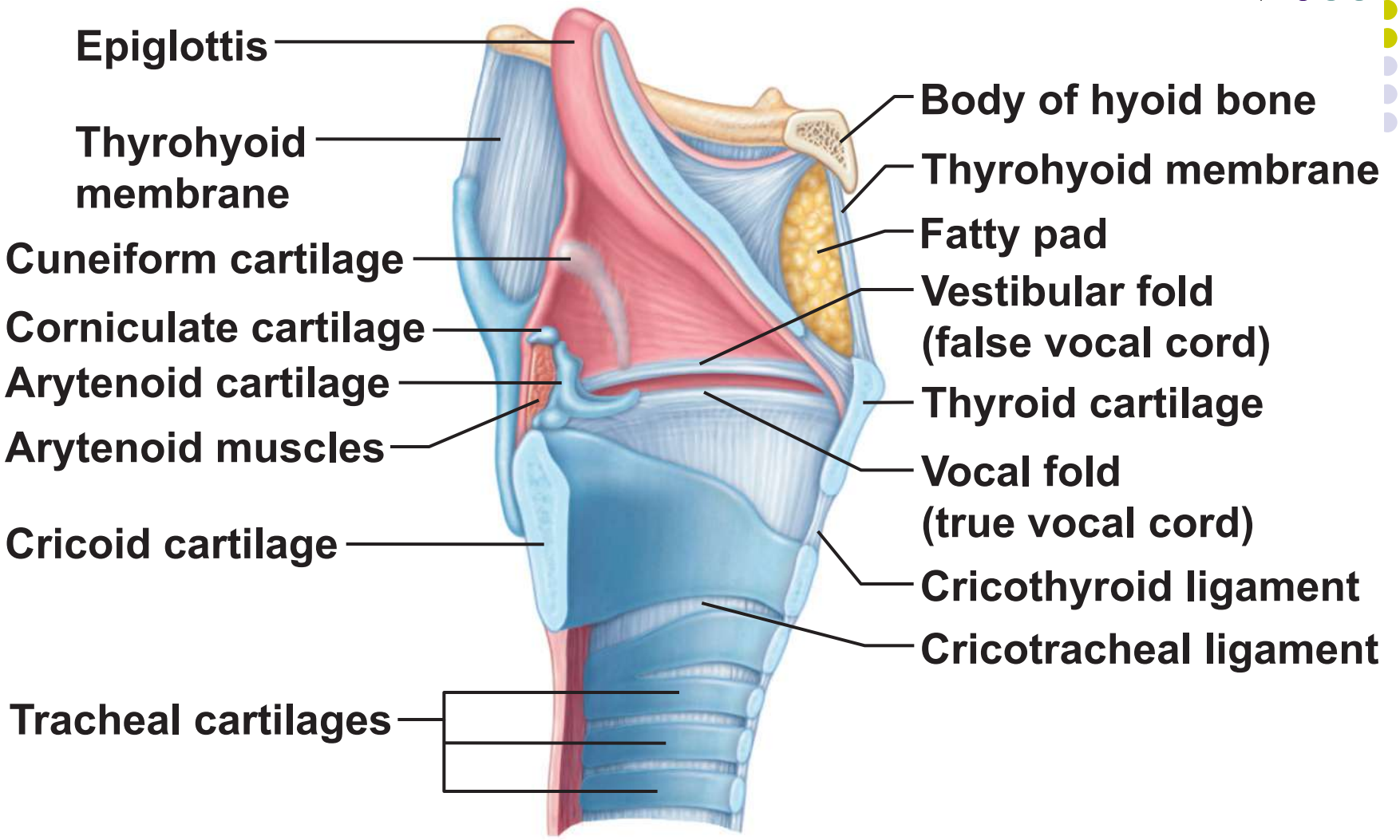
(b) Regions of the pharynx

Figure 22.3b

Larynx or Voice box

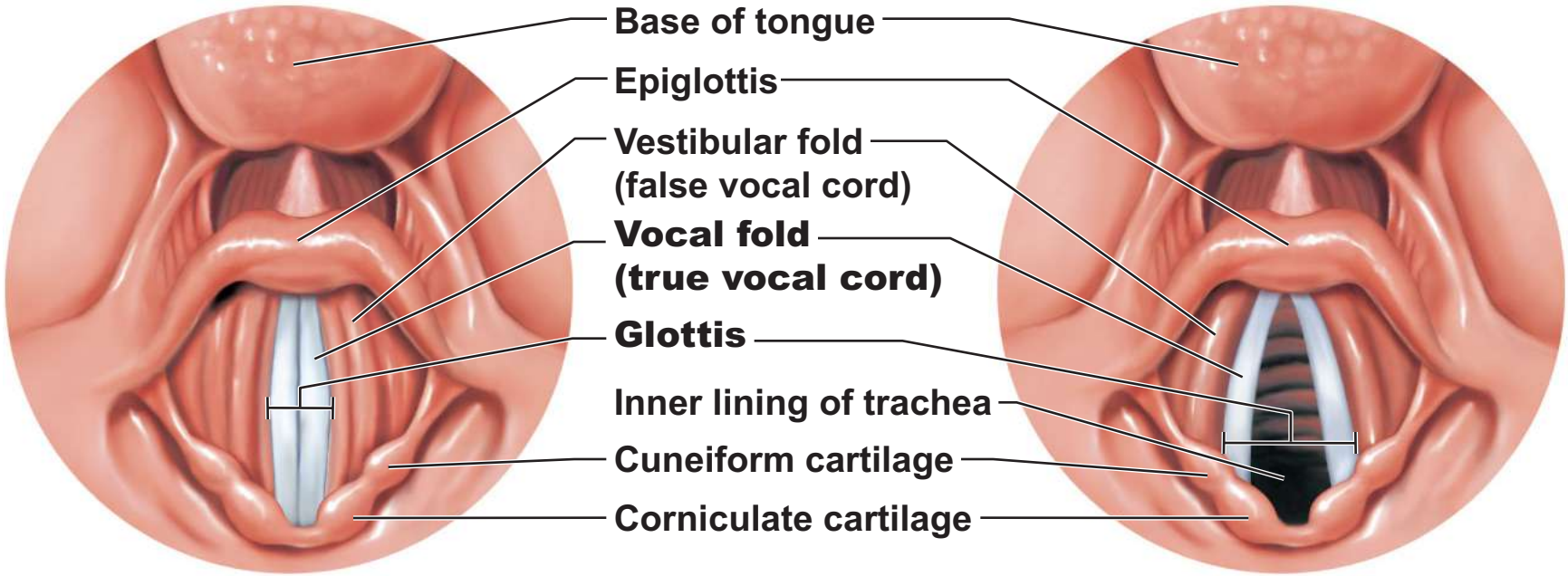


- Routes air and food into proper channels
- Plays a role in speech
- Made of eight rigid hyaline cartilages and a spoon-shaped flap of elastic cartilage (epiglottis)
- Thyroid cartilage
  - (Adam's apple)
- Epiglottis
  - Routes food to the larynx and air toward the trachea



(b) Sagittal view; anterior surface to the right

Figure 22.4b

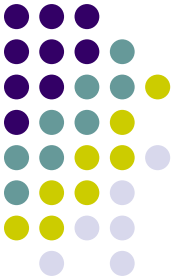


(a) Vocal folds in closed position; closed glottis

(b) Vocal folds in open position; open glottis

Figure 22.5

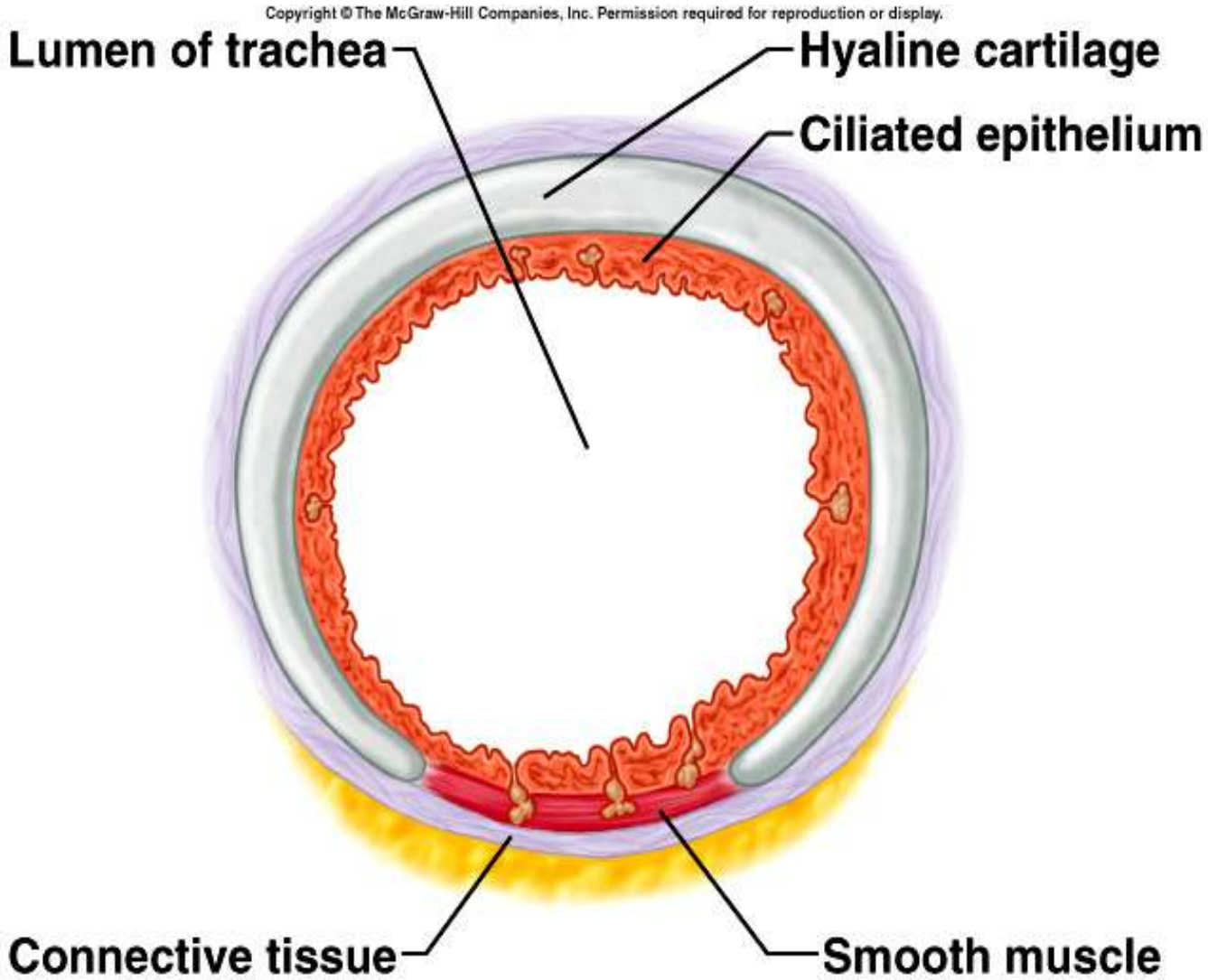
Voice Production

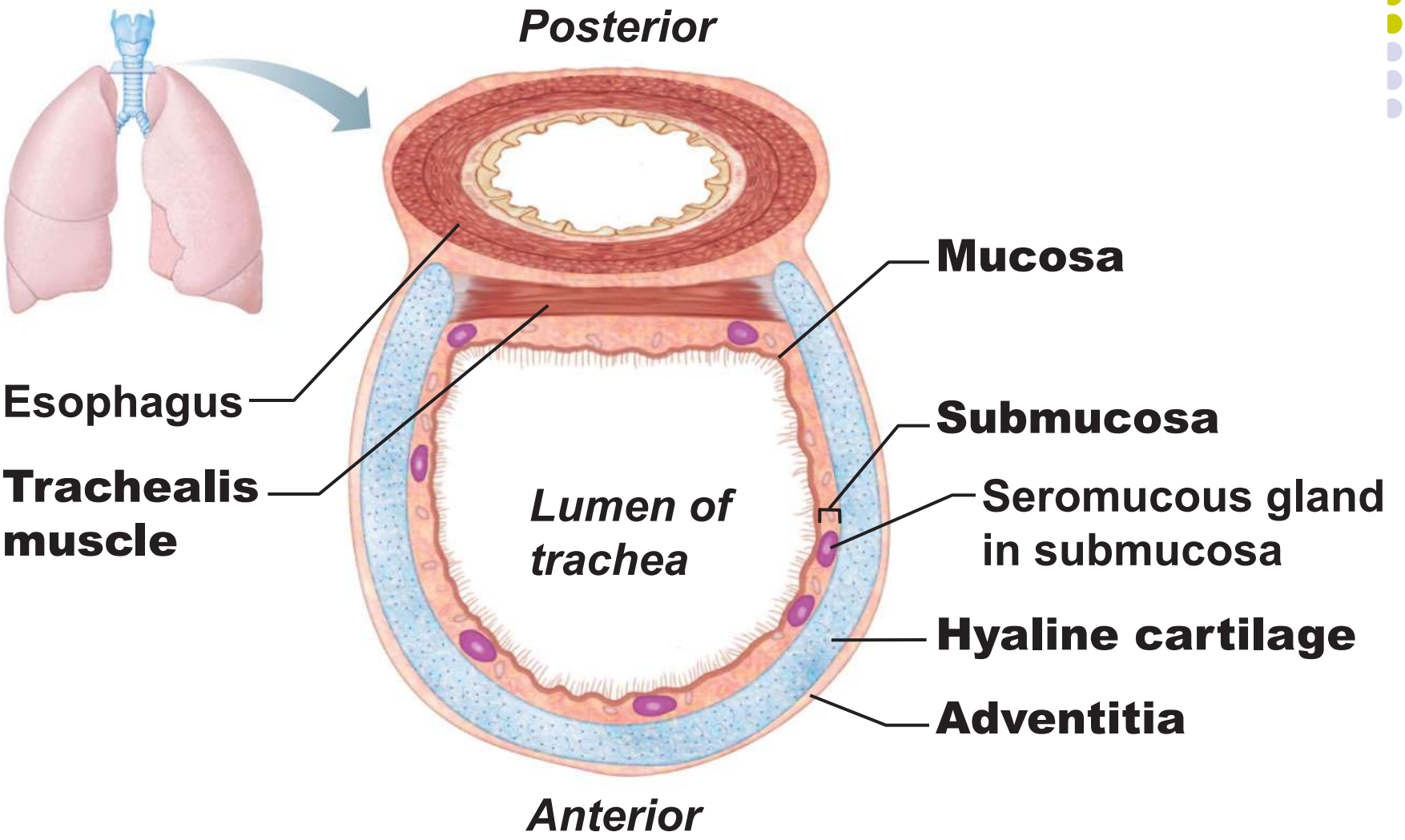


- Speech: intermittent release of expired air while opening and closing the glottis
- Pitch is determined by the length and tension of the vocal cords
- Loudness depends upon the force of air
- Chambers of pharynx, oral, nasal, and sinus cavities amplify and enhance sound quality
- Sound is “shaped” into language by muscles of the pharynx, tongue, soft palate, and lips

Trachea (Windpipe)

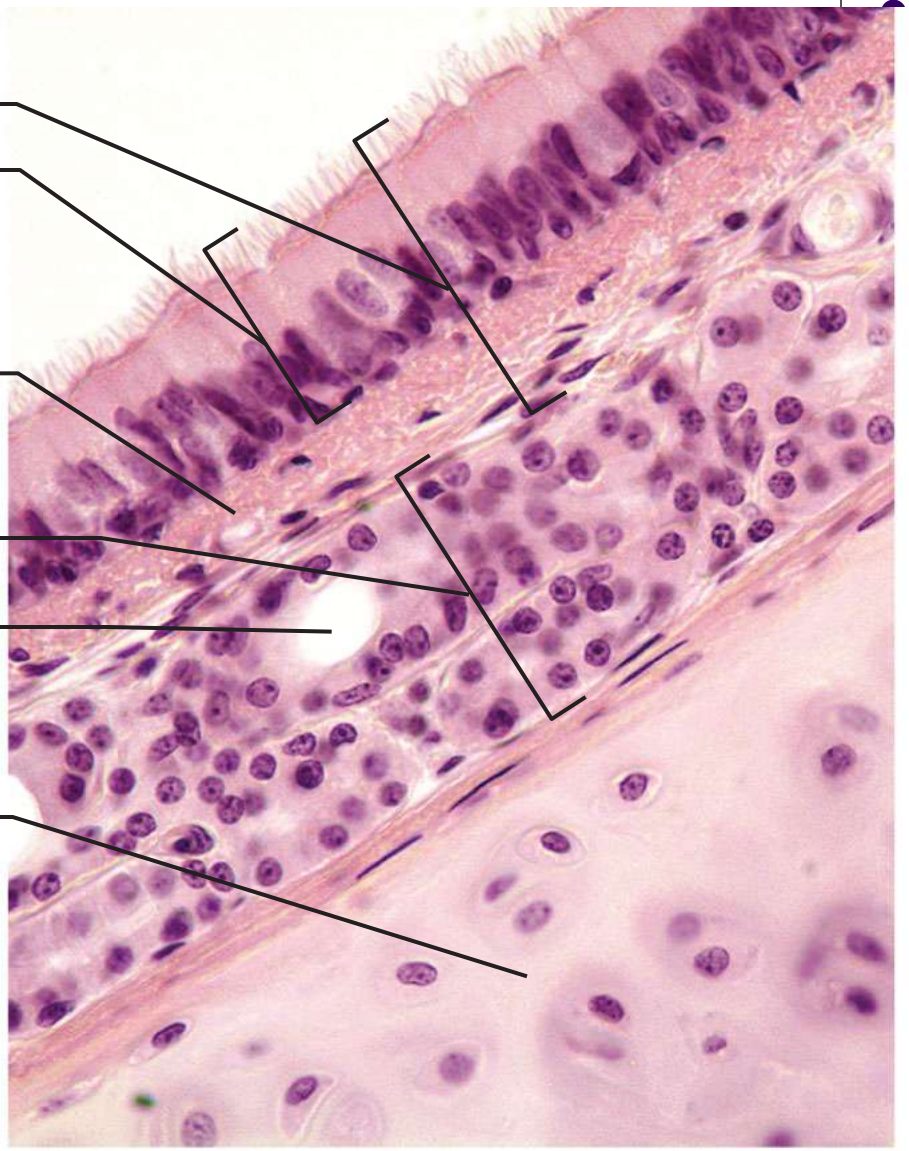
- Lined with pseudo stratified ciliated mucosa
- Goblet cells
- Walls are reinforced with C-shaped hyaline cartilage





(a) Cross section of the trachea and esophagus

Figure 22.6a



(b) Photomicrograph of the tracheal wall (320x)

Figure 22.6b

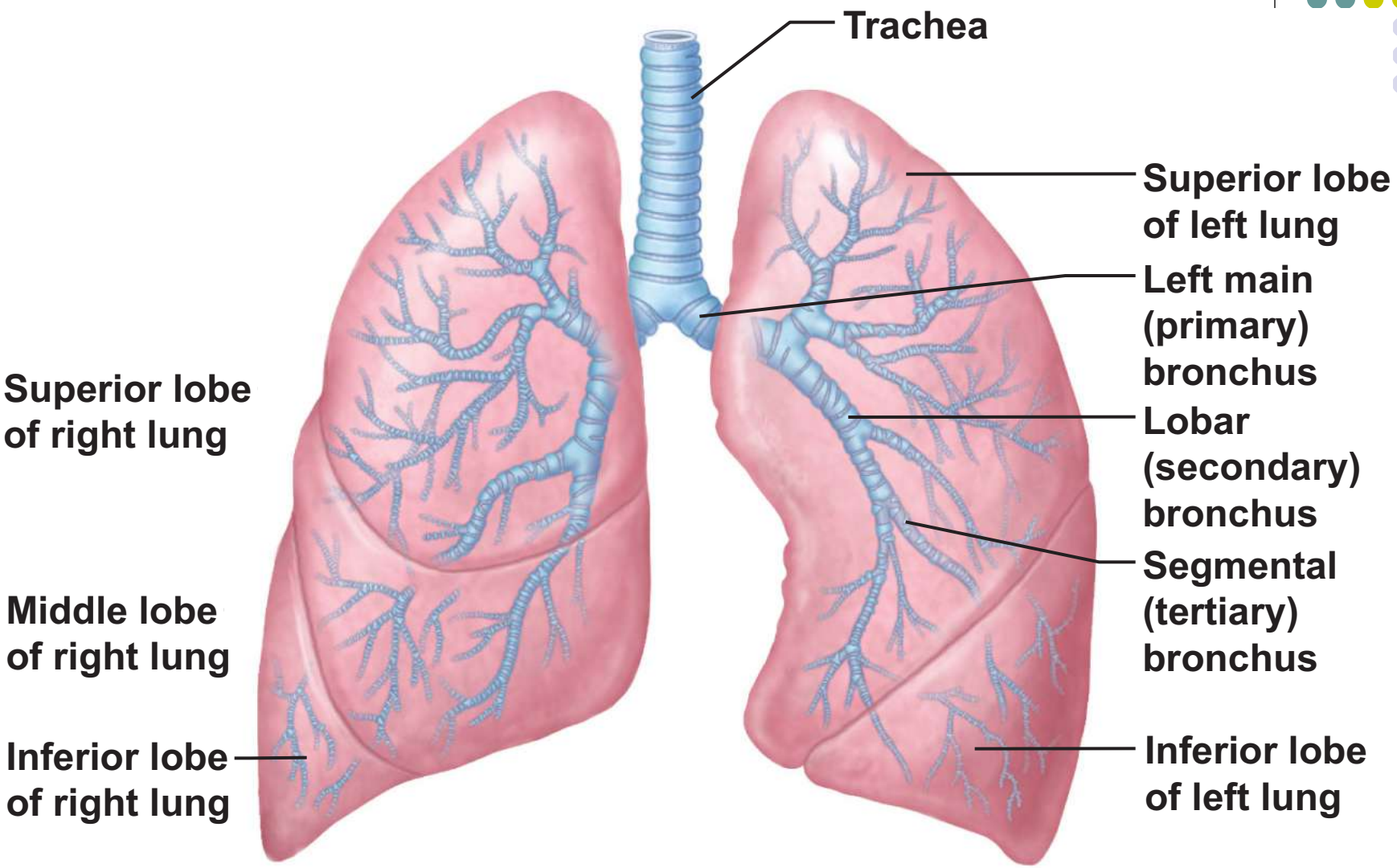
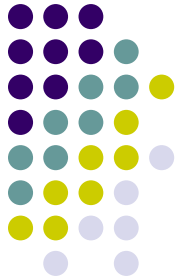

Trachea
Superior lobe of left lung
Left main (primary) bronchus
Lobar (secondary) bronchus
Segmental (tertiary) bronchus
Inferior lobe of left lung
Superior lobe of right lung
Middle lobe of right lung
Inferior lobe of right lung

Figure 22.7

Conducting Zone Structures

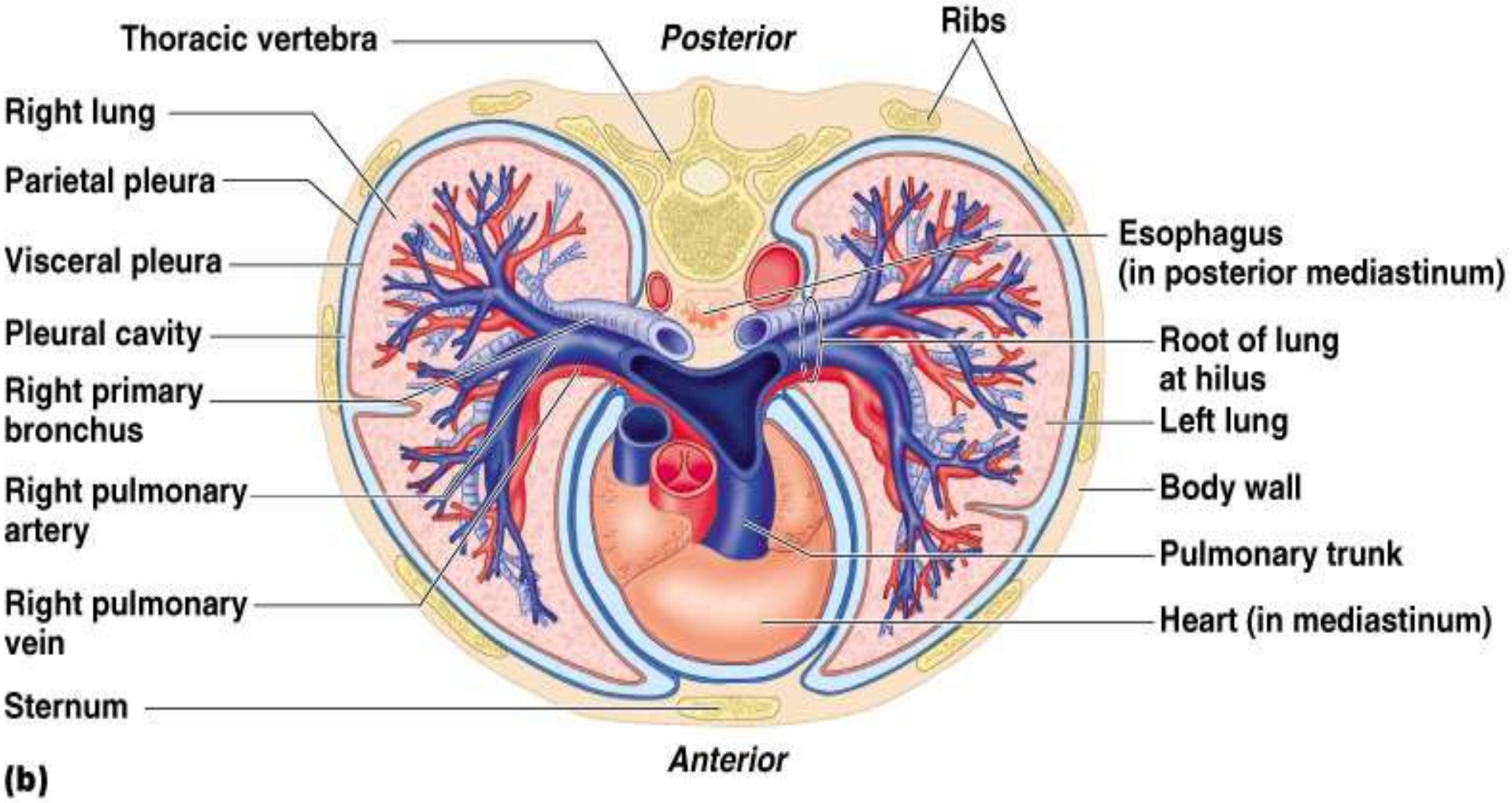


- Trachea branches into brochi that have 23 orders of branching
- Bronchioles are less than 1 mm in diameter
- Terminal bronchioles are the smallest, less than 0.5 mm diameter
- No cartilage on bronchioles

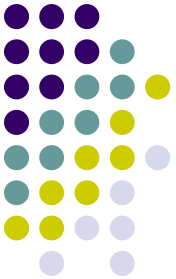
Lungs

- Occupy most of the thoracic cavity
  - Apex is near the clavicle (superior portion)
    - Base rests on the diaphragm (inferior portion)
  - Left lung – two lobes
  - Right lung – three lobes
- **Coverings:** (visceral) pleura
- Parietal pleura

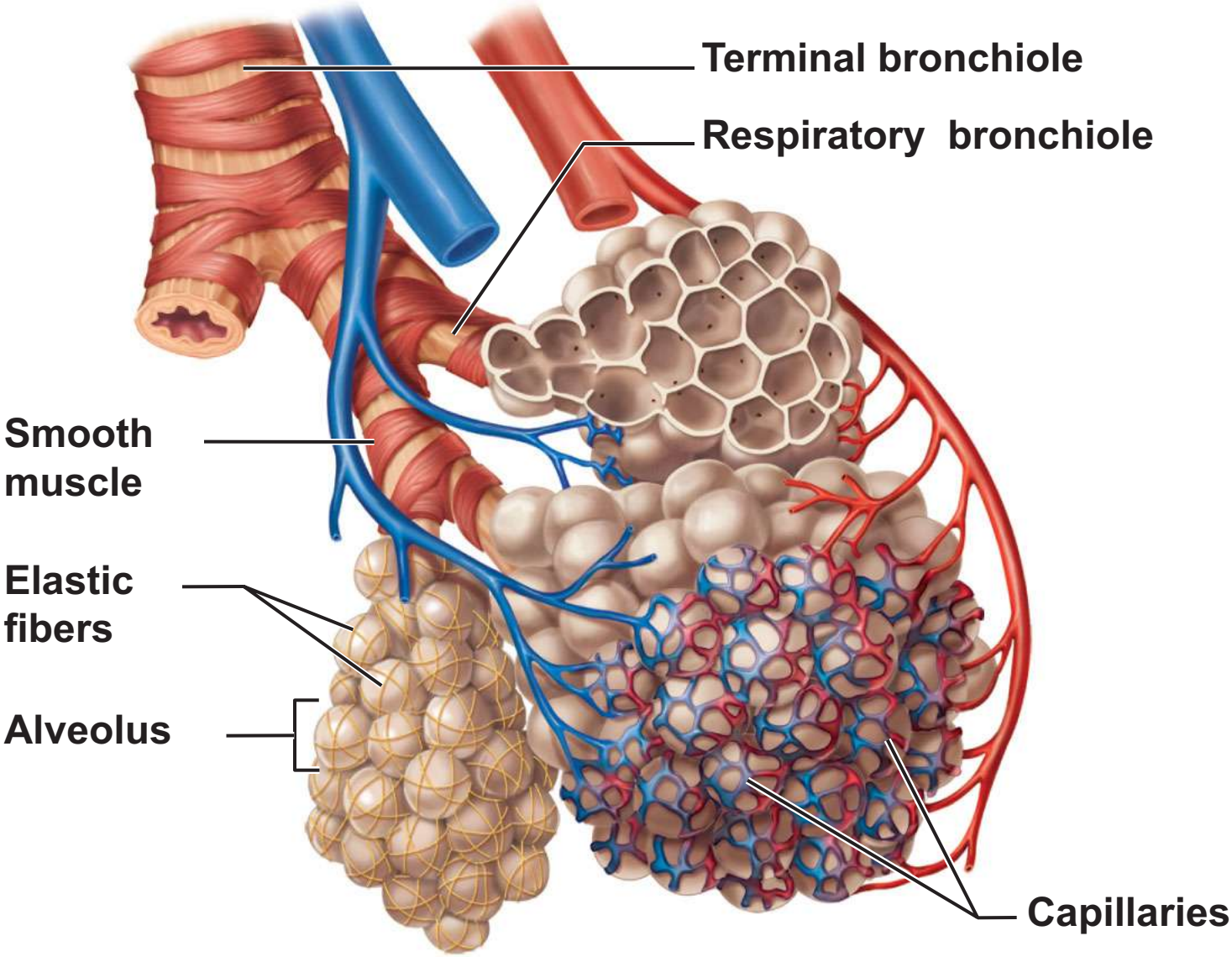
Lung Cross Section



Site of Gas Exchange

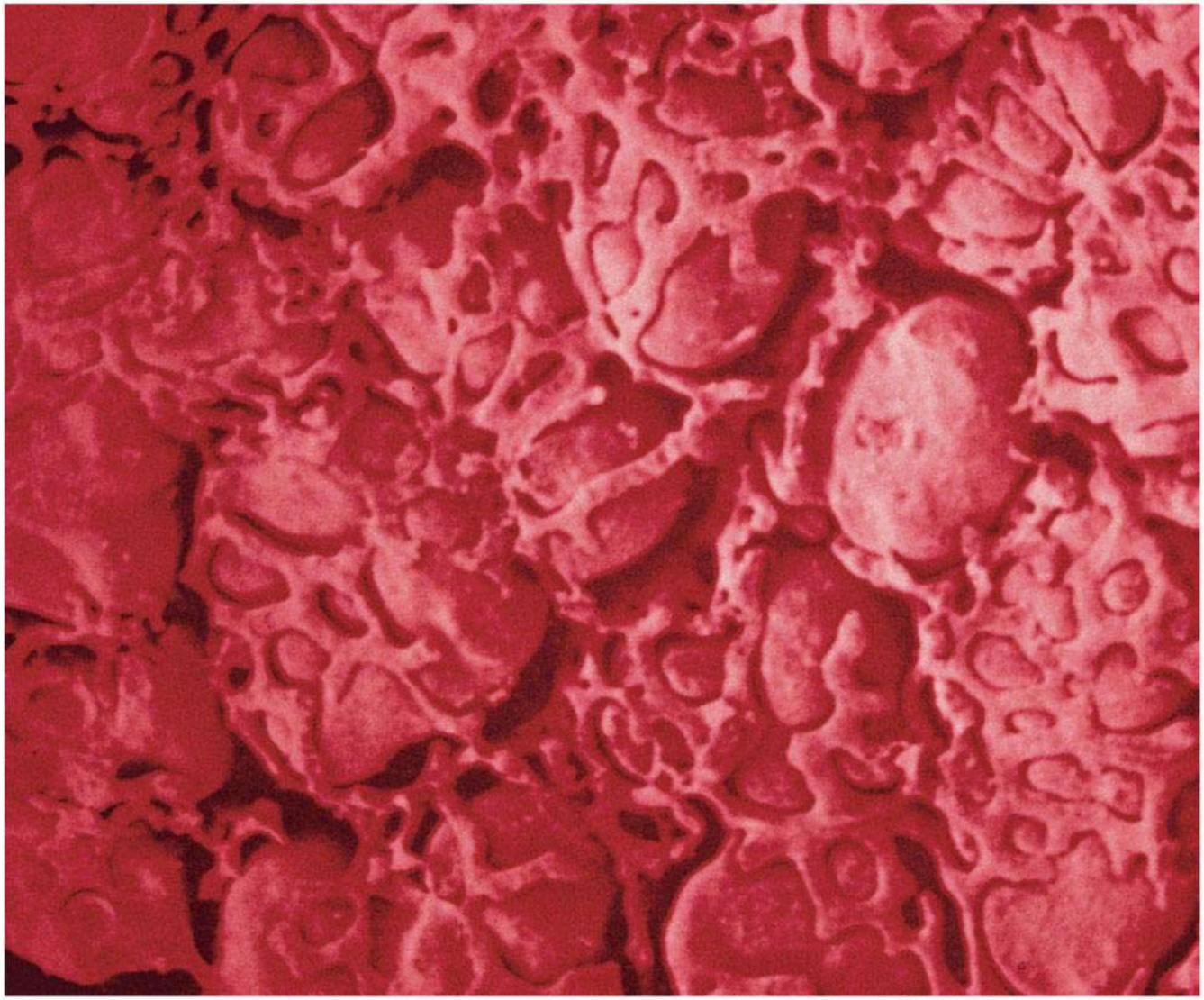


- Gas exchange takes place within the **alveoli**
  - 300 million +
- Pulmonary capillaries cover external surfaces of alveoli and basement membranes connect
  - .5 um thick
- Total surface area = 40 times your skin



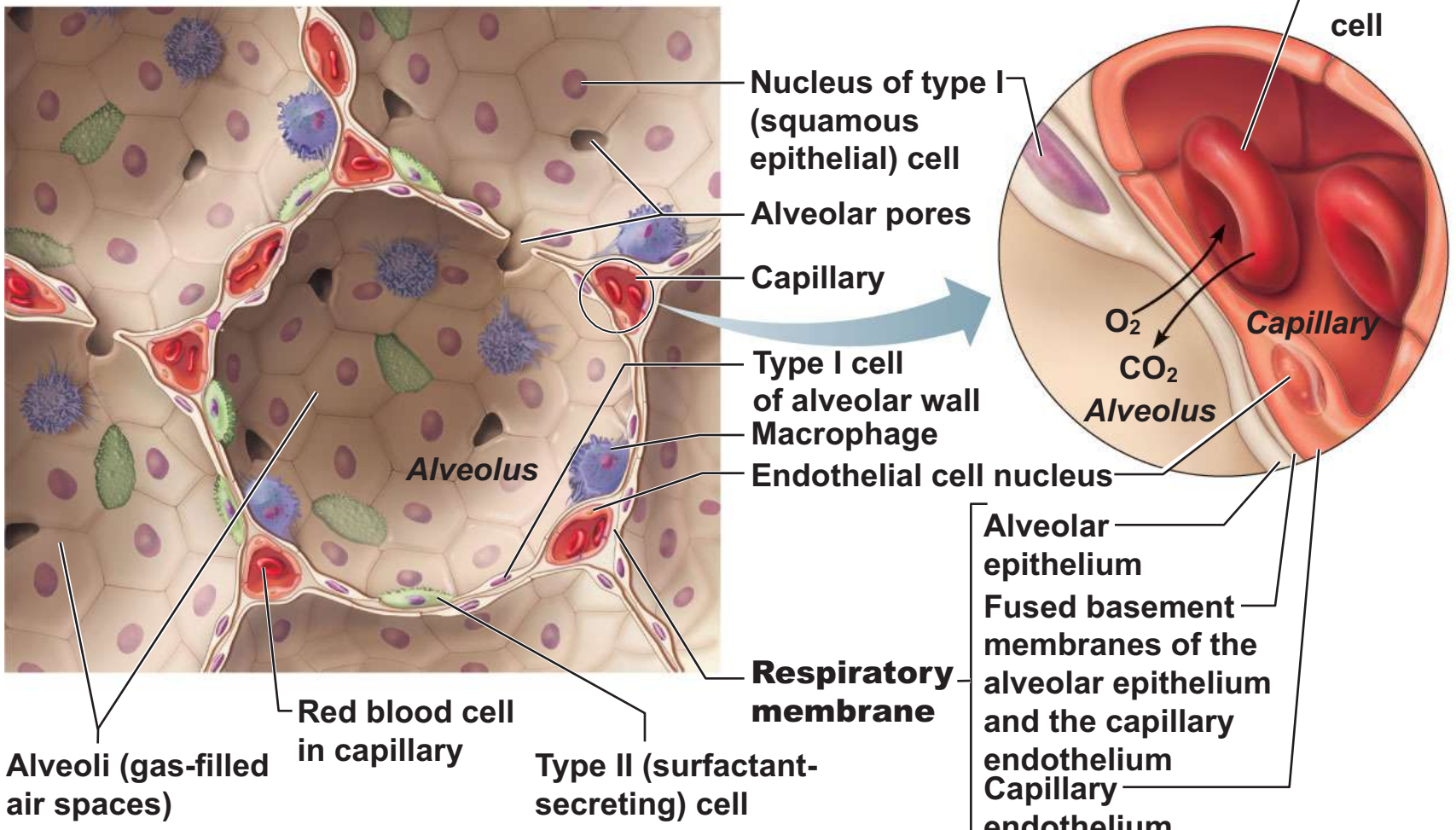
(a) Diagrammatic view of capillary-alveoli relationships

Figure 22.9a



(b) Scanning electron micrograph of casts of alveoli and associated pulmonary capillaries (300x)

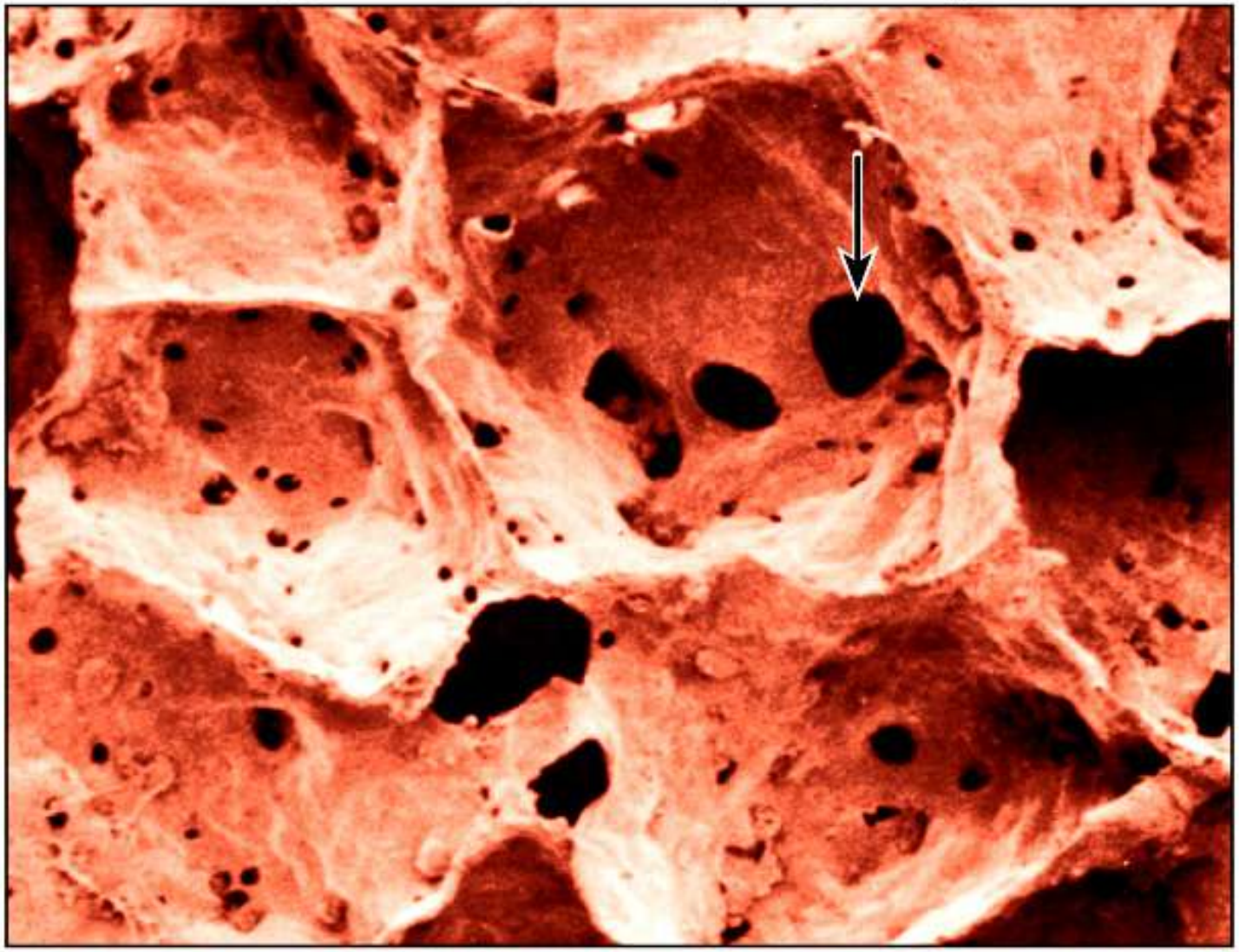
Figure 22.9b



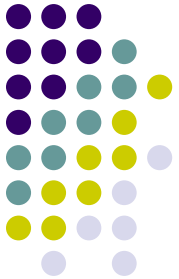
(c) Detailed anatomy of the respiratory membrane

Figure 22.9c

Alveoli Pores for gas exchange between alveoli

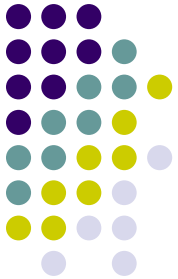


Respiration Events



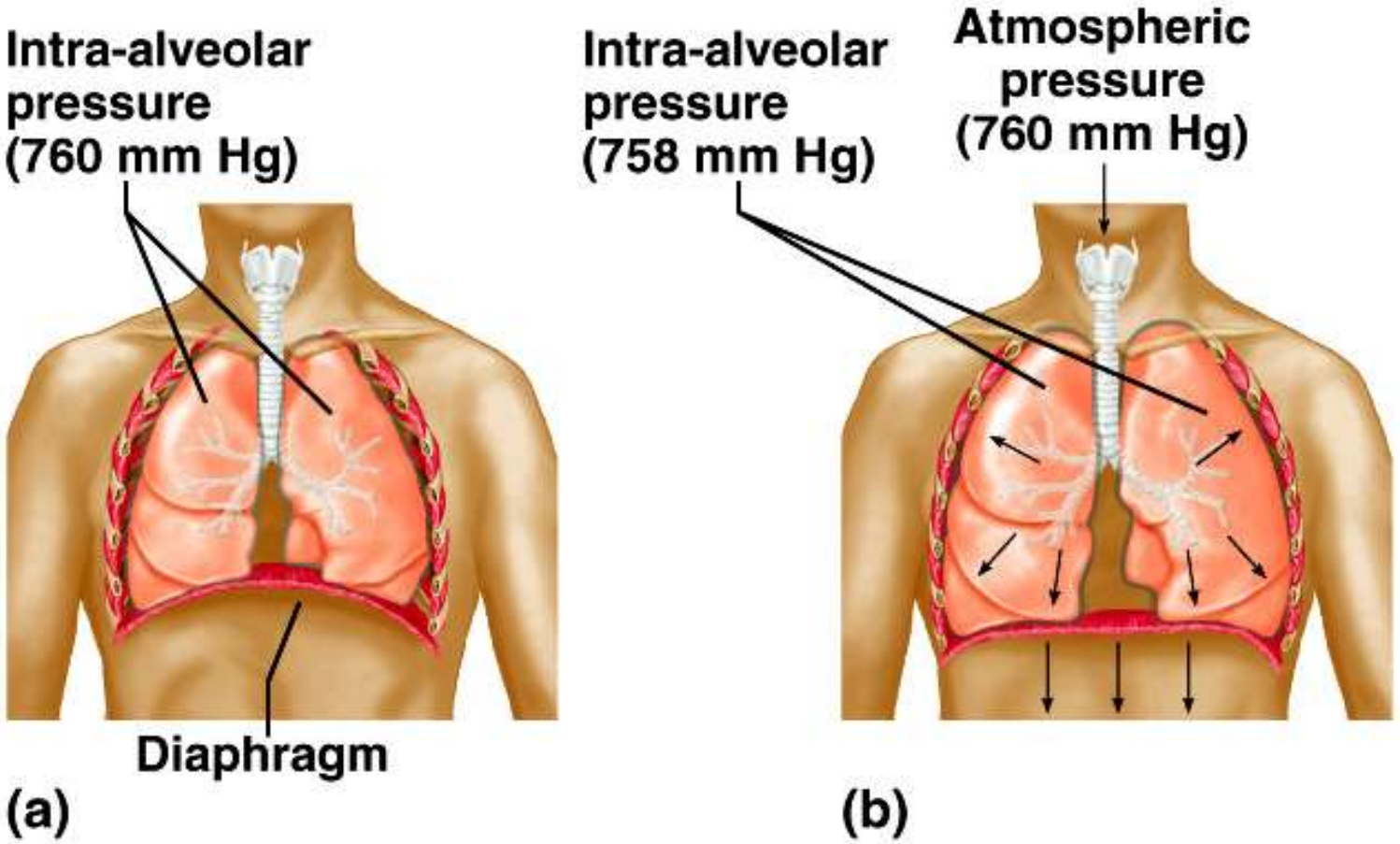
- Pulmonary ventilation
- External respiration
- Respiratory gas transport
- Internal respiration

Pulmonary Ventilation



- mechanical process
- Depends on volume changes in the thoracic cavity
- It is all about pressure outside, inside, and around the lungs
- Two phases
  - Inspiration
  - Expiration

Inspiration



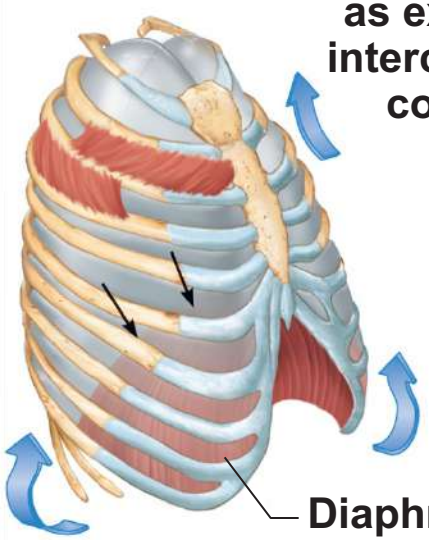
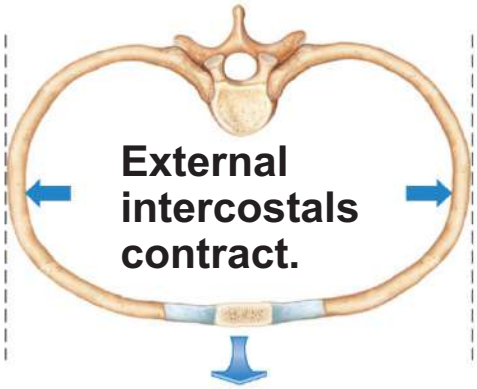
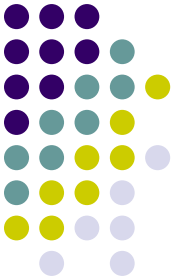
	Sequence of events	Changes in anterior-posterior and superior-inferior dimensions	Changes in lateral dimensions (superior view)
Inspiration	1 Inspiratory muscles contract (diaphragm descends; rib cage rises). ↓ 2 Thoracic cavity volume increases. ↓ 3 Lungs are stretched; intrapulmonary volume increases. ↓ 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).	Ribs are elevated and sternum flares as external intercostals contract.  Diaphragm moves inferiorly during contraction.	

Figure 22.13 (1 of 2)

Pressure Difference in Thoracic Cavity



- Differences in lung and pleural space pressures keep lungs from collapsing
- Atelectasis (lung collapse) is due to
  - Plugged bronchioles $\rightarrow$ collapse of alveoli
  - Wound that admits air into pleural cavity (pneumothorax)

Respiratory Volumes

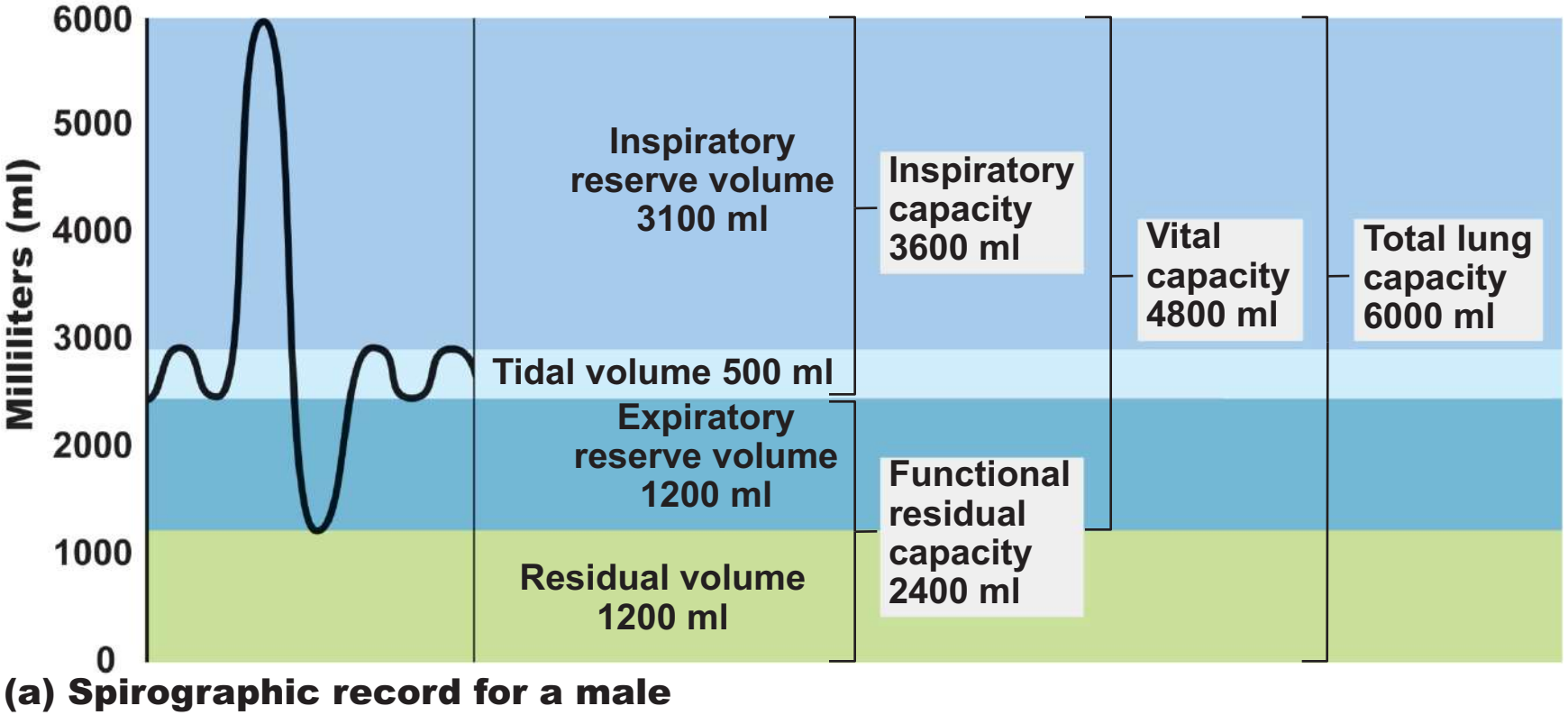
	Measurement	Adult male average value	Adult female average value	Description
Respiratory volumes	Tidal volume (TV)	500 ml	500 ml	Amount of air inhaled or exhaled with each breath under resting conditions
	Inspiratory reserve volume (IRV)	3100 ml	1900 ml	Amount of air that can be forcefully inhaled after a normal tidal volume inhalation
	Expiratory reserve volume (ERV)	1200 ml	700 ml	Amount of air that can be forcefully exhaled after a normal tidal volume exhalation
	Residual volume (RV)	1200 ml	1100 ml	Amount of air remaining in the lungs after a forced exhalation

Figure 22.16b

Respiratory capacities	Total lung capacity (TLC)	6000 ml	4200 ml	Maximum amount of air contained in lungs after a maximum inspiratory effort: TLC = TV + IRV + ERV + RV
	Vital capacity (VC)	4800 ml	3100 ml	Maximum amount of air that can be expired after a maximum inspiratory effort: VC = TV + IRV + ERV
	Inspiratory capacity (IC)	3600 ml	2400 ml	Maximum amount of air that can be inspired after a normal expiration: IC = TV + IRV
	Functional residual capacity (FRC)	2400 ml	1800 ml	Volume of air remaining in the lungs after a normal tidal volume expiration: FRC = ERV + RV

(b) Summary of respiratory volumes and capacities for males and females

Figure 22.16b



(a) Spirographic record for a male

Figure 22.16a

Alveolar Ventilation

- Alveolar ventilation rate (AVR): flow of gases into and out of the alveoli during a particular time

AVR	=	frequency	X	(TV – dead space)
(ml/min)		(breaths/min)		(ml/breath)

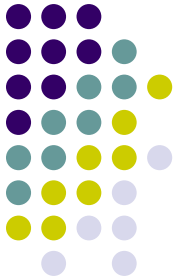
- Dead space is normally constant
- Rapid, shallow breathing decreases AVR

TABLE 22.2 Effects of Breathing Rate and Depth on Alveolar Ventilation of Three Hypothetical Patients

BREATHING PATTERN OF HYPOTHETICAL PATIENT	DEAD SPACE VOLUME (DSV)	TIDAL VOLUME (TV)	RESPIRATORY RATE*	MINUTE VENTILATION (MVR)	ALVEOLAR VENTILATION (AVR)	% EFFECTIVE VENTILATION (AVR/MVR)
I—Normal rate and depth	150 ml	500 ml	20/min	10,000 ml/min	7000 ml/min	70%
II—Slow, deep breathing	150 ml	1000 ml	10/min	10,000 ml/min	8500 ml/min	85%
III—Rapid, shallow breathing	150 ml	250 ml	40/min	10,000 ml/min	4000 ml/min	40%

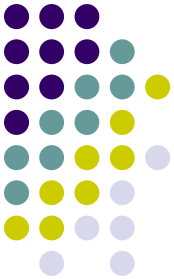
* Respiratory rate values are artificially adjusted to provide equivalent minute ventilation as a baseline for comparison of alveolar ventilation.

External Respiration

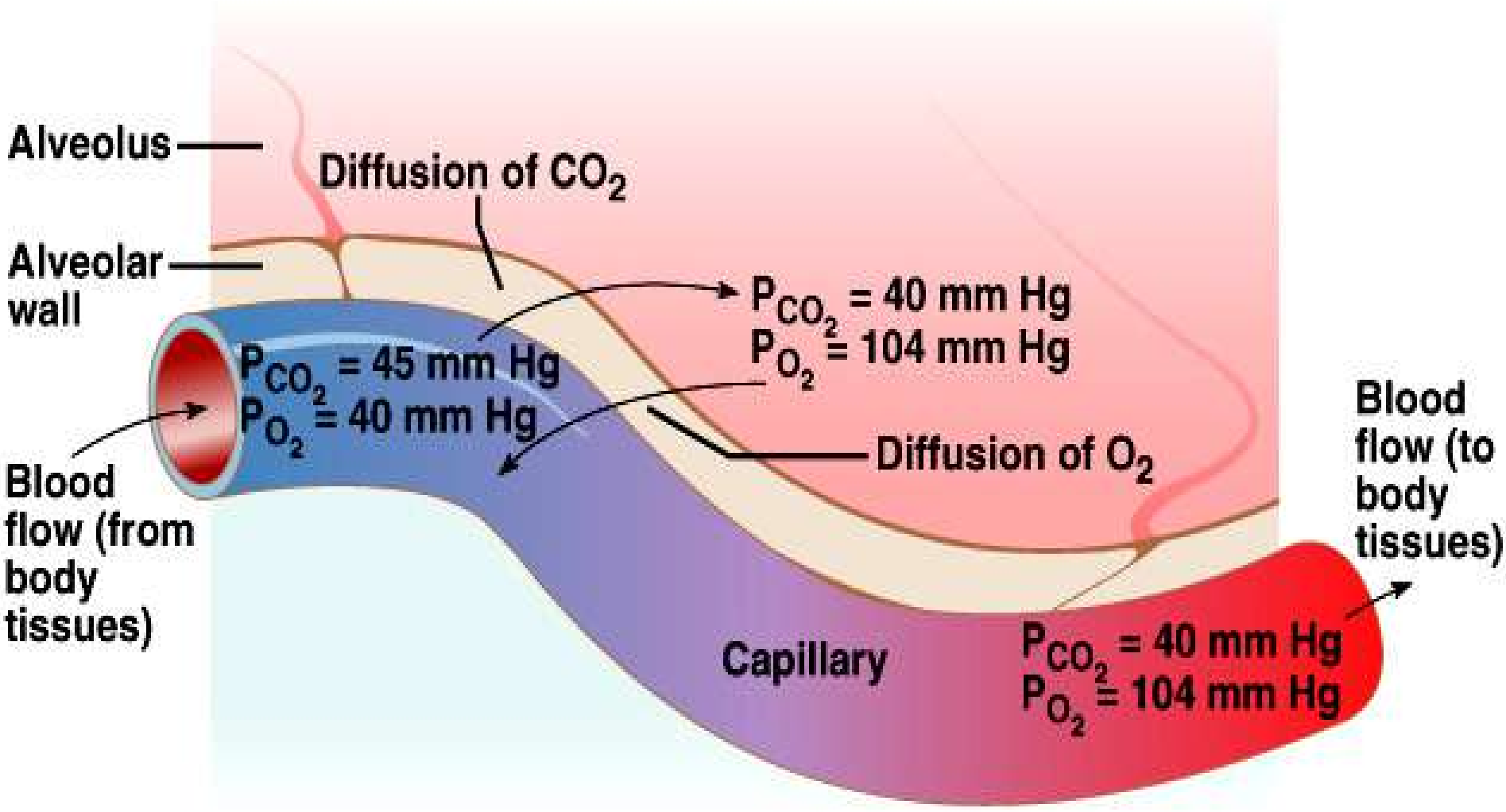


- Oxygen movement into the blood
- Carbon dioxide movement out of the blood
- Blood leaving the lungs is oxygen-rich and carbon dioxide-poor

Gas Transport in Blood



- Oxygen transport in the blood attached to hemoglobin (oxyhemoglobin [HbO2])
  - A small amount (1.5%) is carried dissolved in the plasma
- Carbon dioxide transport in the blood
  - transported in the plasma as bicarbonate ion (HCO3–) (70%) 10% free in plasma
  - A small amount is carried inside red blood cells on hemoglobin, but at different binding sites than those of oxygen (20%)



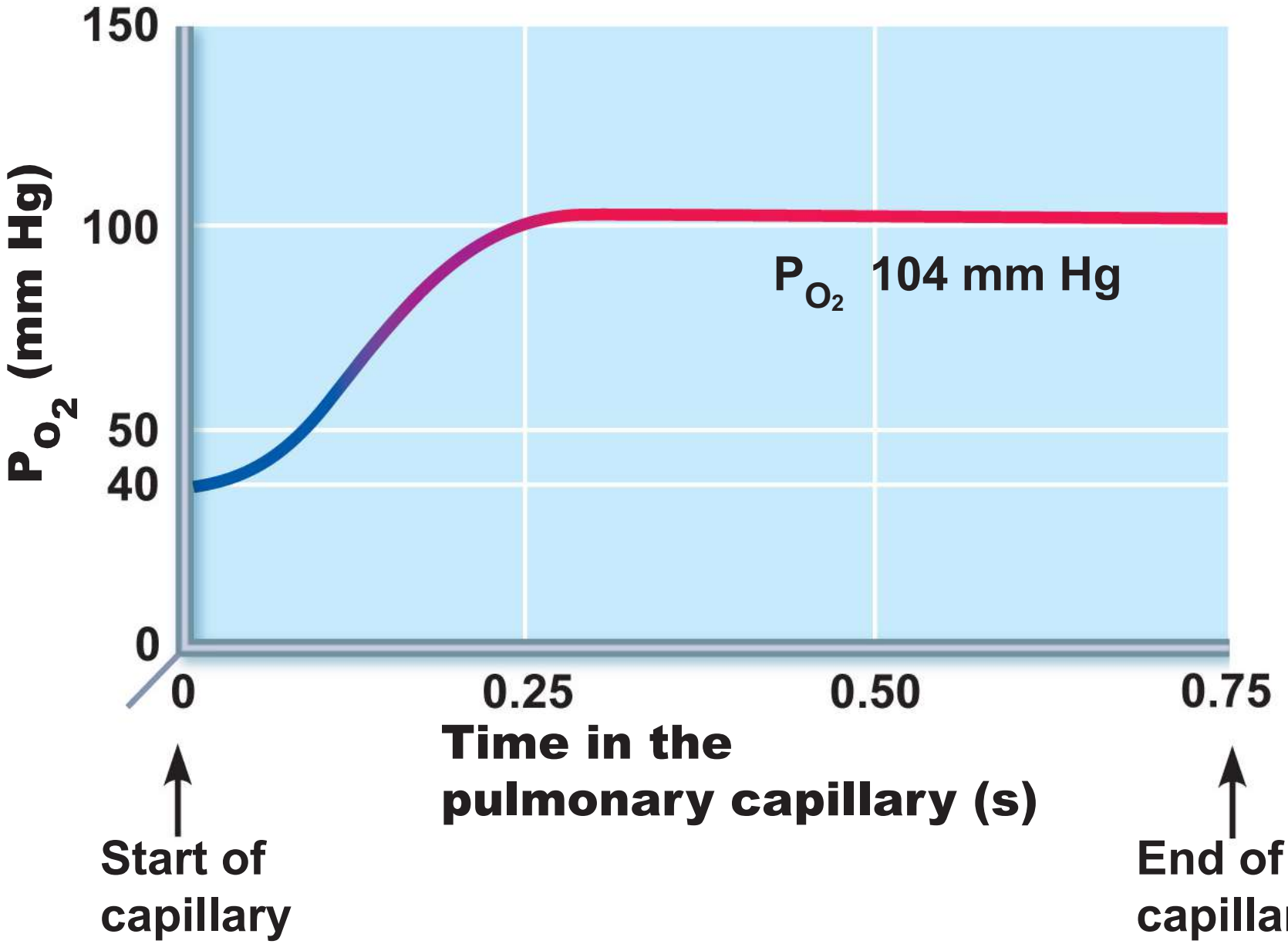

150
100
50
40
0
P_{O_2} (mm Hg)
P_{O_2} 104 mm Hg
0
0.25
0.50
0.75
Time in the pulmonary capillary (s)
Start of capillary
End of capillary

Figure 22.18

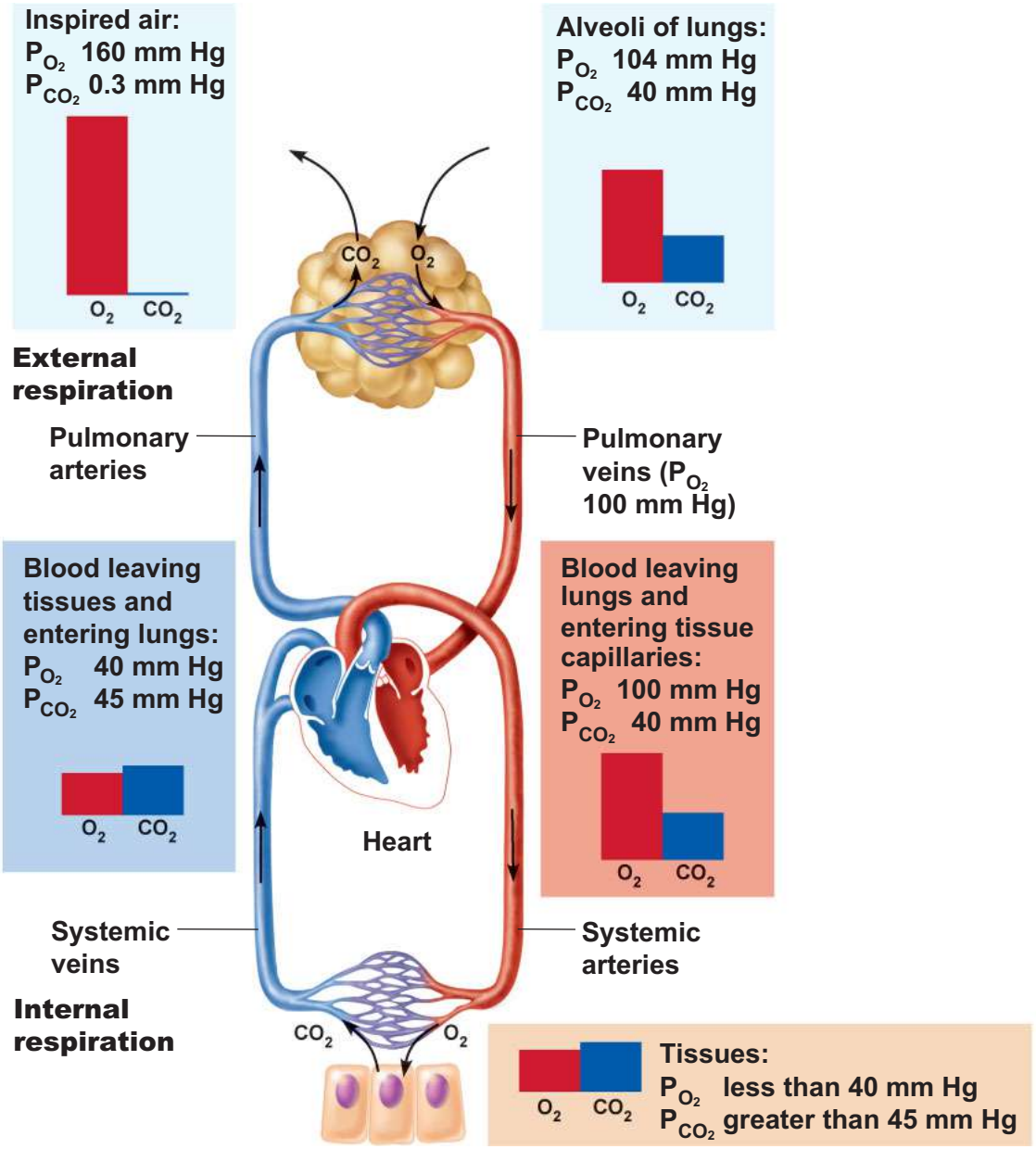
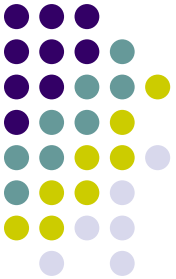

Inspired air:
P_{O_2} 160 mm Hg
P_{CO_2} 0.3 mm Hg
O_2 CO_2
External respiration
Alveoli of lungs:
P_{O_2} 104 mm Hg
P_{CO_2} 40 mm Hg
O_2 CO_2
CO_2 O_2
Pulmonary arteries
Pulmonary veins (P_{O_2} 100 mm Hg)
Blood leaving tissues and entering lungs:
P_{O_2} 40 mm Hg
P_{CO_2} 45 mm Hg
O_2 CO_2
Blood leaving lungs and entering tissue capillaries:
P_{O_2} 100 mm Hg
P_{CO_2} 40 mm Hg
O_2 CO_2
Heart
Systemic veins
Systemic arteries
Internal respiration
CO_2 O_2
O_2 CO_2
Tissues:
P_{O_2} less than 40 mm Hg
P_{CO_2} greater than 45 mm Hg

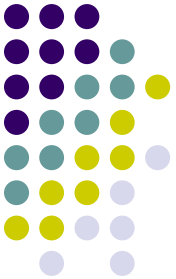
Figure 22.17

Factors that Increase Release of O_2 by Hemoglobin



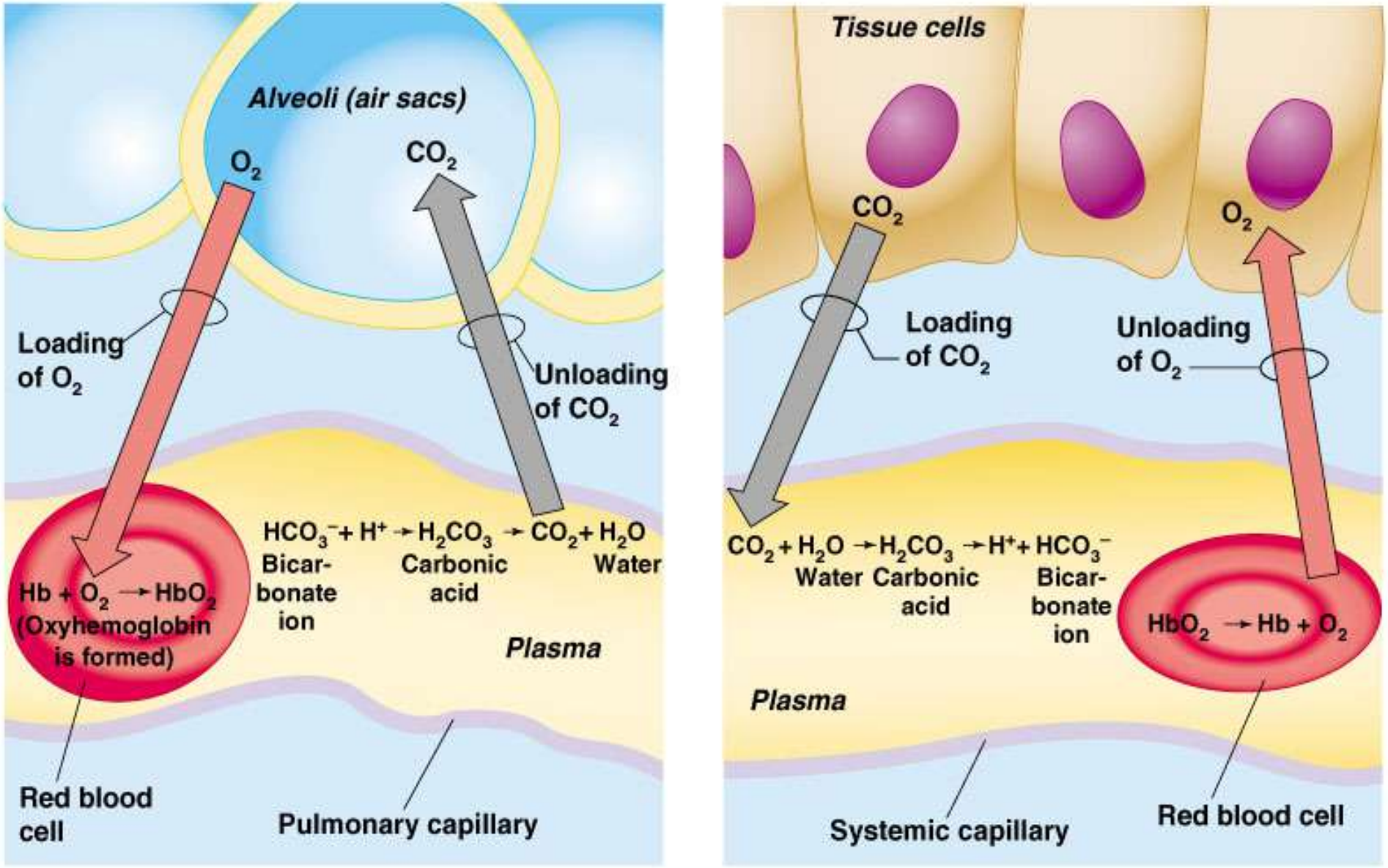
- As cells metabolize glucose
  - Pco_2 and H^+ increase in concentration in capillary blood
    - Declining pH weakens the hemoglobin-O_2 bond (Bohr effect)
  - Heat production increases
    - Increasing temperature directly and indirectly decreases Hb affinity for O_2

Internal respiration



- Exchange of gases between blood and body cells
- An opposite reaction to what occurs in the lungs
  - Carbon dioxide diffuses out of tissue to blood
  - Oxygen diffuses from blood into tissue

Internal respiration



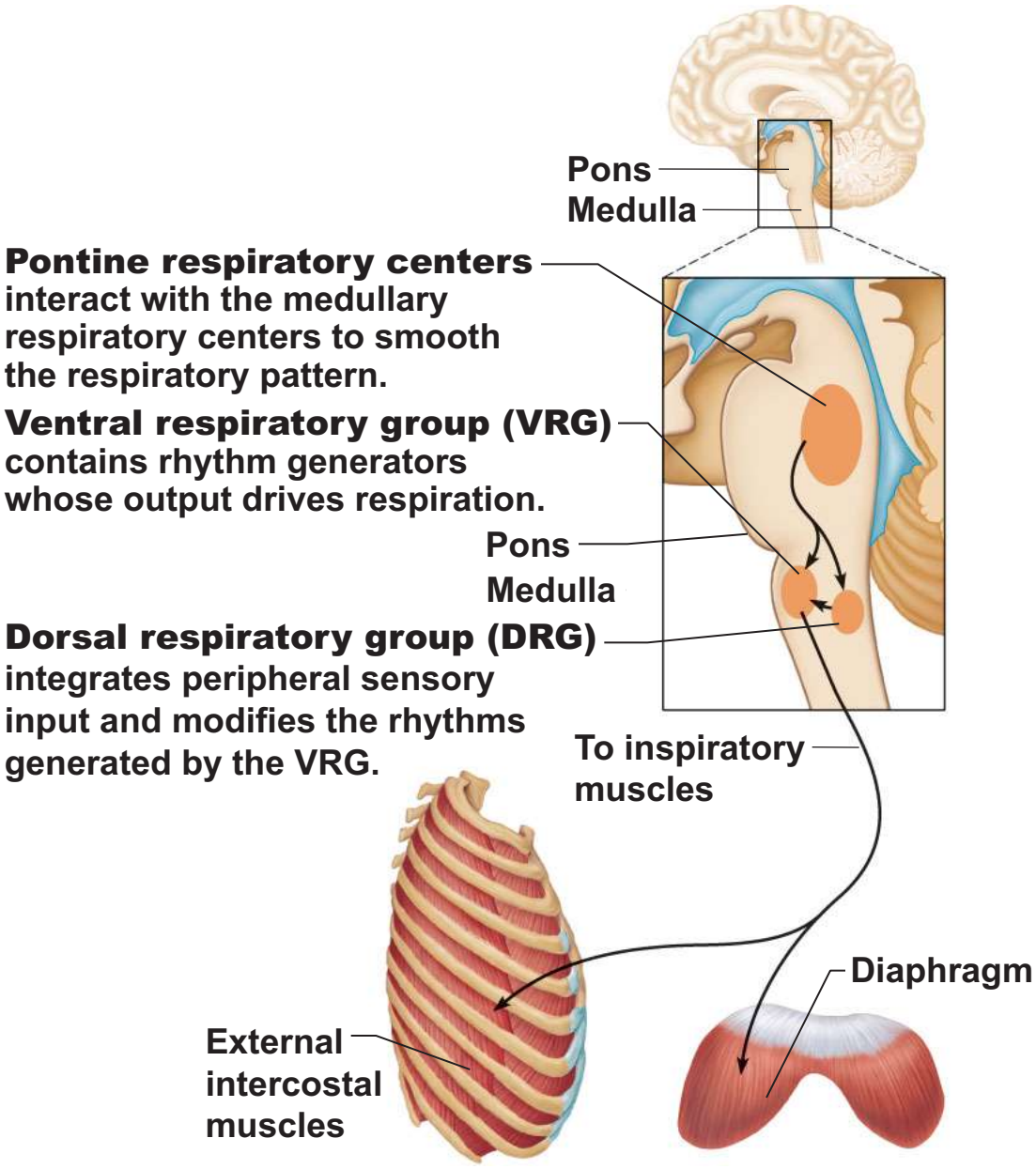

Pons
Medulla
Pontine respiratory centers interact with the medullary respiratory centers to smooth the respiratory pattern.
Ventral respiratory group (VRG) contains rhythm generators whose output drives respiration.
Pons
Medulla
Dorsal respiratory group (DRG) integrates peripheral sensory input and modifies the rhythms generated by the VRG.
To inspiratory muscles
Diaphragm
External intercostal muscles

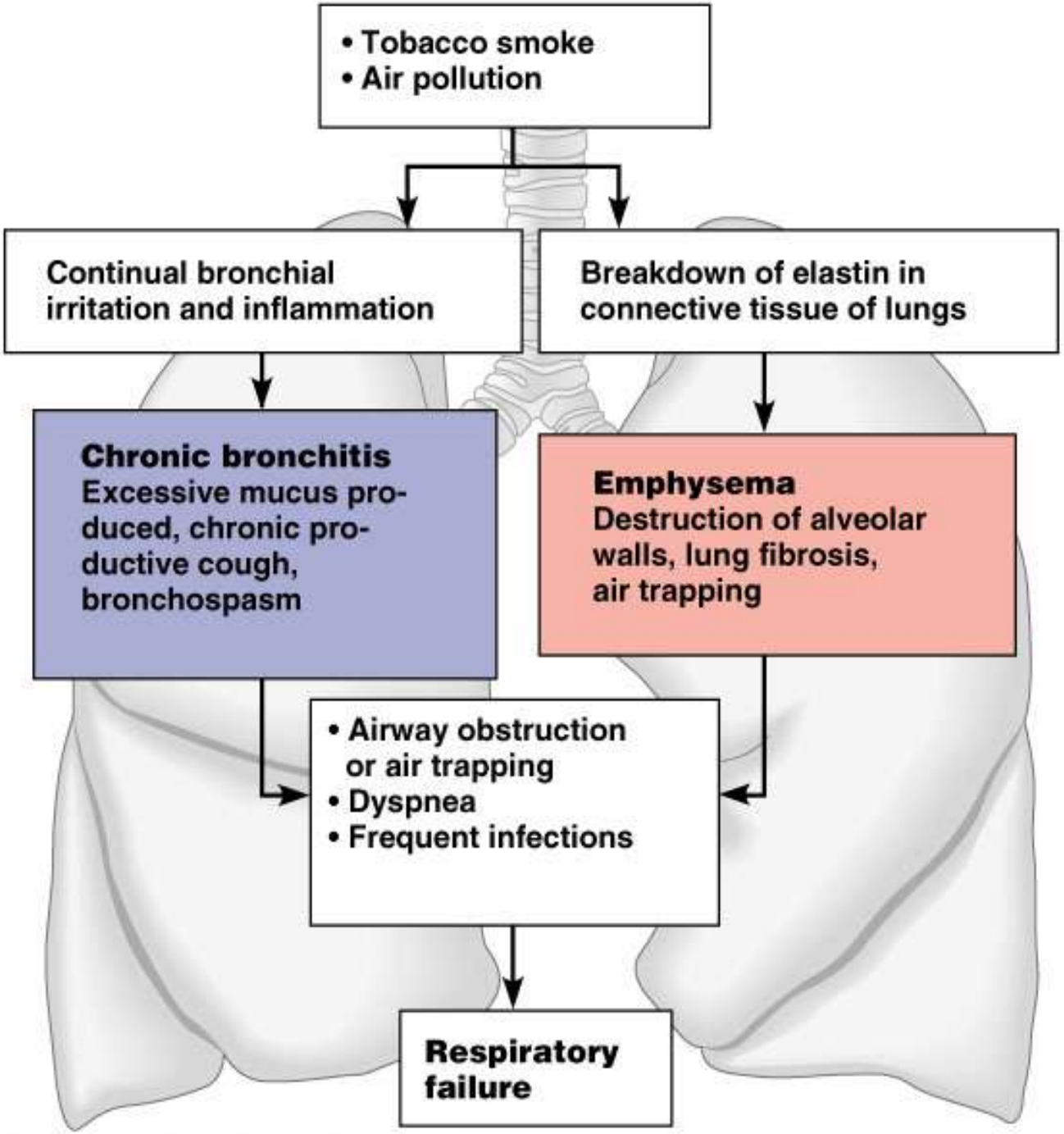
Figure 22.23

Factors affecting Breathing

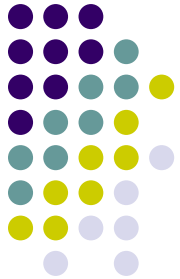
- **Physical factors**: Increased body temperature, Exercise, Talking, Coughing
- **Volition** (conscious control)
- **Emotional factors-** fight or flight
- **Chemical factors**
  - Carbon dioxide levels
    - Level of carbon dioxide in the blood is the **main** regulatory chemical for respiration
    - Increased carbon dioxide increases respiration
    - Changes in carbon dioxide act directly on the medulla oblongata

Disorders

COPD



Lung Cancer SIDS Asthma Etc.

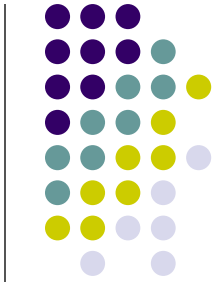


- **Lung Cancer:**
  - Accounts for 1/3 of all cancer deaths in the United States
  - Increased incidence associated with smoking (90%)
- **TB**- bacterial infection…1 year of antibiotics
- **SIDS**
  - Some cases are thought to be a problem of the neural respiratory control center
  - One third of cases appear to be due to heart rhythm abnormalities
- **Asthma**- Chronic inflamed hypersensitive bronchiole passages

That's Life

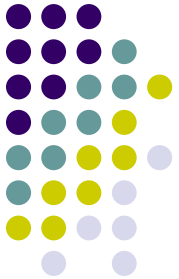
- reflect accumulation of environmental influences
- reflect the effects of aging in other organ systems
- cilia less active
- mucous thickens
- swallowing, gagging, and coughing reflexes slow
- macrophages in lungs lose efficiency
- increased susceptibility to respiratory infections
- "barrel chest" may develop
- bronchial walls thin and collapse
- dead space increases

The Death Stick



- **Cigarette affects**
- cilia disappear
- excess mucus produced
- lung congestion increases lung infections
- lining of bronchioles thicken
- bronchioles lose elasticity
- emphysema fifteen times more common
- lung cancer more common about 90% smoke other usually have jobs where air in full of impurities.
- much damage repaired when smoking stops
- And those who smoke say they need this!!!!

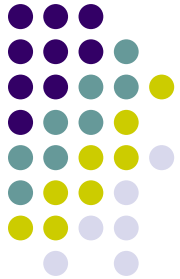
Cont…



- About half of all Americans who keep smoking will die because of the habit. Each year about 443,600 people in the United States die from illnesses related to tobacco use. 1 of 5 deaths in US. Smoking cigarettes kills more Americans than alcohol, car accidents, suicide, AIDS, homicide, and illegal drugs combined
- smokers are at increased risk for cancer of the larynx, oral cavity, esophagus, bladder, kidney, and pancreas.
- About 48 million people in the United States smoke an estimated total of 430 billion cigarettes each year
- the average cigarette contains around 4,000 chemicals, some of which are highly toxic and at least 60 of which cause cancer

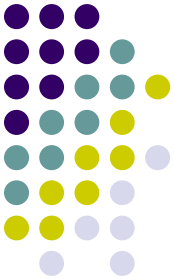
- Smoking causes a **fivefold** increase in the risk of dying from chronic bronchitis and emphysema, and a **twofold** increase in deaths from diseases of the heart and coronary arteries. Smoking also increases the risk of stroke by 50 percent—40 percent among men and 60 percent among women. Other research has shown that mothers who smoke give birth more frequently to premature or underweight babies

Why Smoke



- Recent findings may explain why cigarettes are addictive. An unknown component of tobacco smoke appears to destroy an important brain enzyme, monoamine oxidase B (MAO B). The enzyme is vital for breaking down excess amounts of dopamine, a neurotransmitter that triggers pleasure-seeking behavior. Smokers have decreased levels of MAO B and abnormally high levels of dopamine, which may encourage the smoker to seek the pleasure of more tobacco smoke.

Innocent Bystander



- the effect of tobacco smoke on nonsmokers who must share the same environment with a smoker. The United States Environmental Protection Agency (EPA) estimates that exposure to ETS, which contains all the toxic agents inhaled by a smoker, causes 3,400 cancer deaths and an estimated 46,000 deaths from heart disease per year in nonsmokers. Secondhand smoke can aggravate asthma, pneumonia, bronchitis, and impaired blood circulation.


Phototake NYC/Martin Rotker