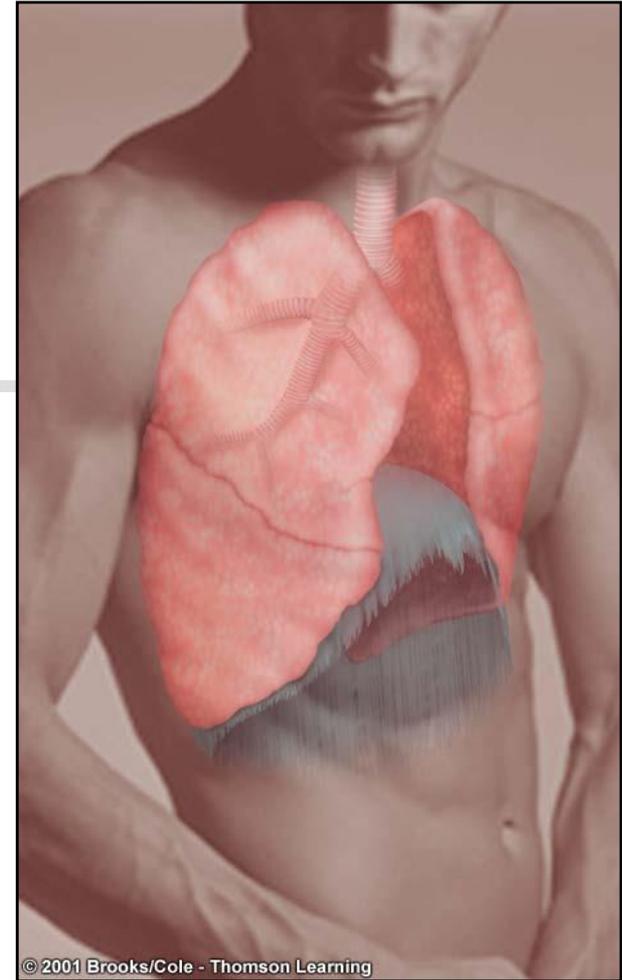
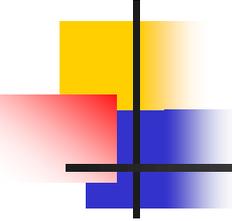


The Gas Exchange System

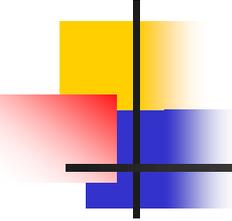
Also Called the
Respiratory System





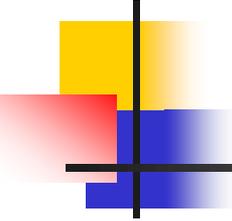
Main Points

- Main functions: Receiving oxygen and the elimination of carbon dioxide.
- This is achieved by the respiratory tract.
- This is a system of passageways that run from the nose & mouth to tiny chambers in the lungs.
- Oxygen diffuses from these tiny chambers into the blood.



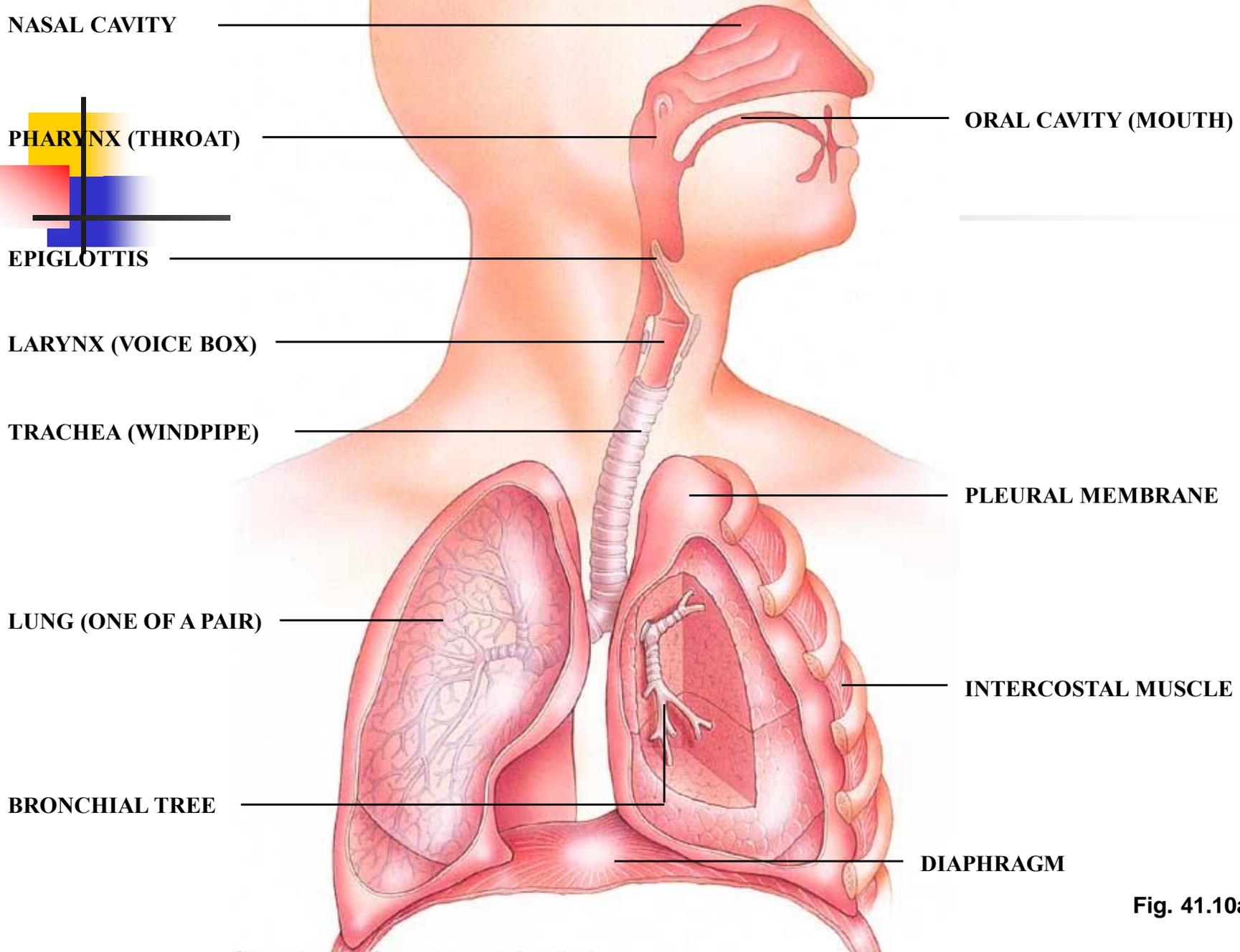
Main Points (2)

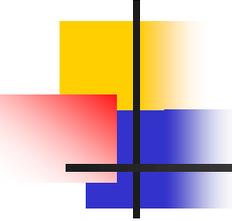
- Oxygen diffuses from these tiny chambers into the blood.
- Oxygen is then carried to all body cells.
- CO₂ from all body cells is carried by the blood to the lungs for removal.



Three Processes

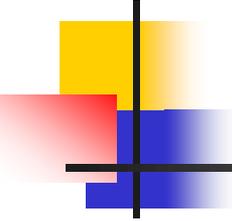
1. **Pulmonary Ventilation** or breathing: the mechanisms used to move air into and out of the lungs.
2. **External Respiration**: the exchange of gases between the lungs and the blood.
3. **Internal Respiration**: the exchange of gases between the blood and body tissues.





Part I; Follow an O₂ Molecule

- The O₂ molecule could pick the nose or the mouth for entry. Let's pick the nose (no pun intended.)
- The nose will **warm** and **filter** the incoming air. How...
- The molecule now passes into the **pharynx** a chamber that connects the nose with the mouth.



Follow an O₂ Molecule (2)

- The molecule now rushes past the **epiglottis**, a flap of tissue that covers the respiratory tract when we swallow.
- We are now inside the **larynx**, a bony and cartilaginous structure that contains the vocal cords.
- The larynx is protected by **circoïd cartilage**.

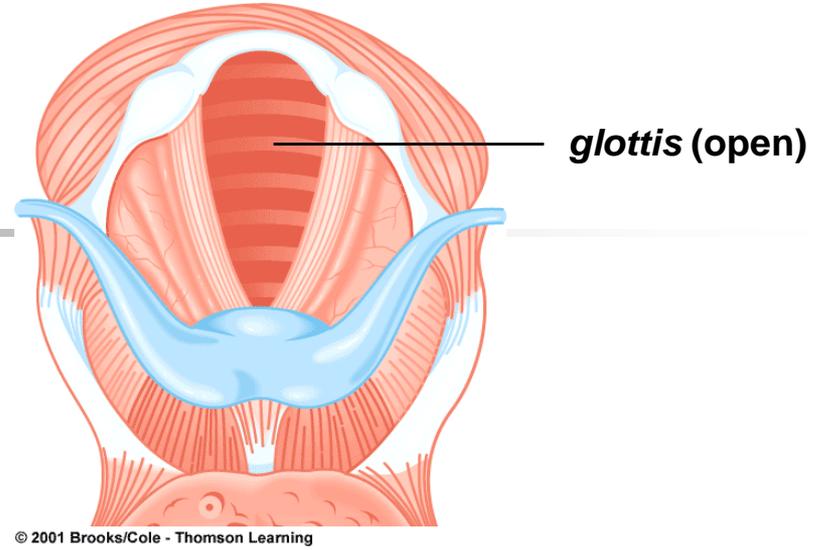
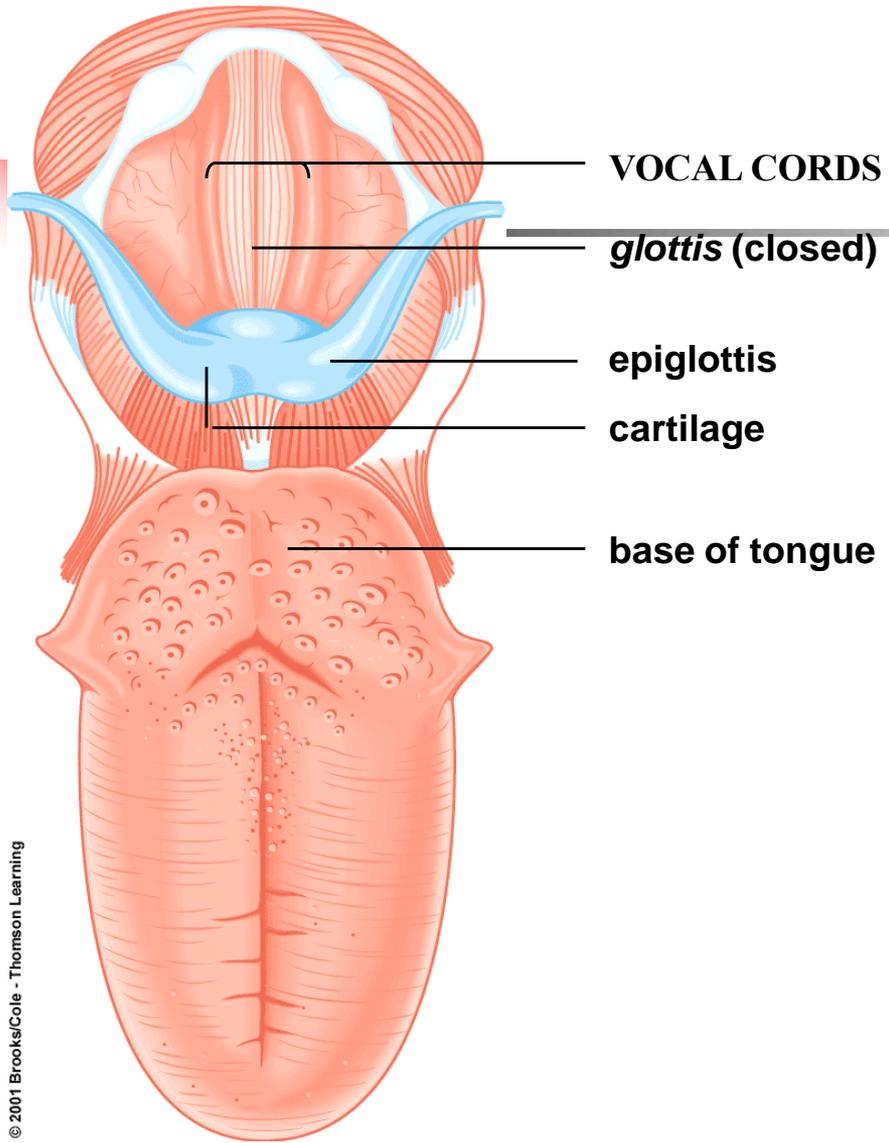
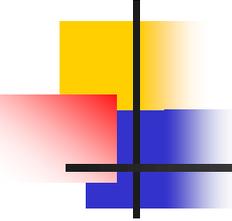
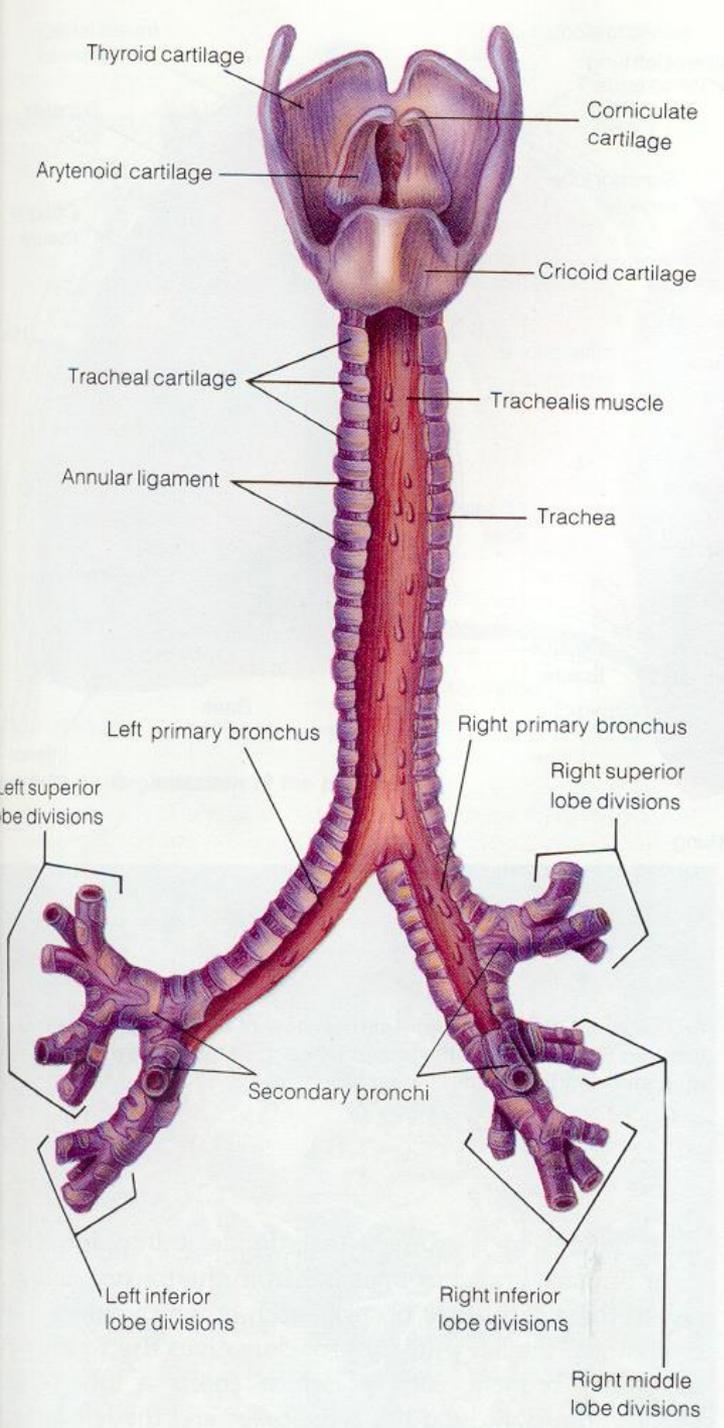


Fig. 41.11, p. 715



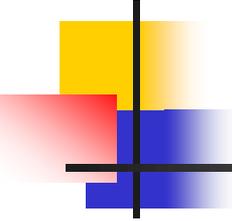
Follow an O₂ Molecule (3)

- Our molecule now races into the **trachea** or “wind pipe”. It is about 12 cm long.
- The trachea is always kept open by 16 to 20 **C-shaped bands of cartilage** in the tracheal wall.
- Our molecule now has a choice; go left or right into the **primary bronchi**.



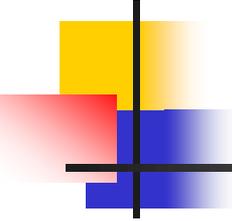
The inner surface of the trachea is lined with **pseudostratified ciliated columnar epithelium**.

They filter and move foreign matter up to the mouth to be swallowed or spit out.



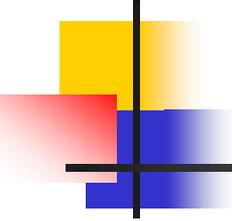
Follow an O₂ Molecule (4)

- Our molecule now sails into the lungs.
- The two lungs are not mirror images of one another, the left lung is slightly smaller than the right.
- The lungs are divided into lobes, with the right lung having 3 lobes and the left having 2.



Follow an O₂ Molecule (5)

- The molecule is now in the **pulmonary tree**.
- The primary bronchi now subdivide into smaller and smaller tubes called **bronchioles**.
- The bronchioles get smaller & smaller until they become **terminal bronchioles**.
- These branch further to become the **respiratory bronchioles**.



Follow an O₂ Molecule (6)

- Finally, our molecule of oxygen reaches the end of the line, as far as the respiratory tract is concerned; the **alveoli**.
- The alveoli are blind sacks used for gas exchange. They are the **functional unit** of the gas exchange system.
- The alveoli are composed mostly of **squamous epithelium**, 1 cell layer thick – Our oxygen molecule passes through this wall easily.

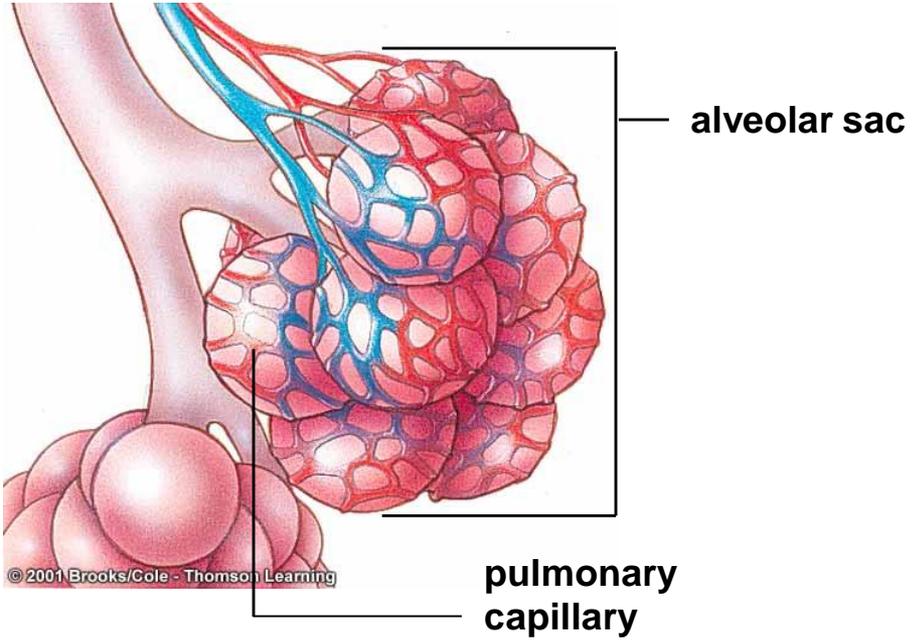
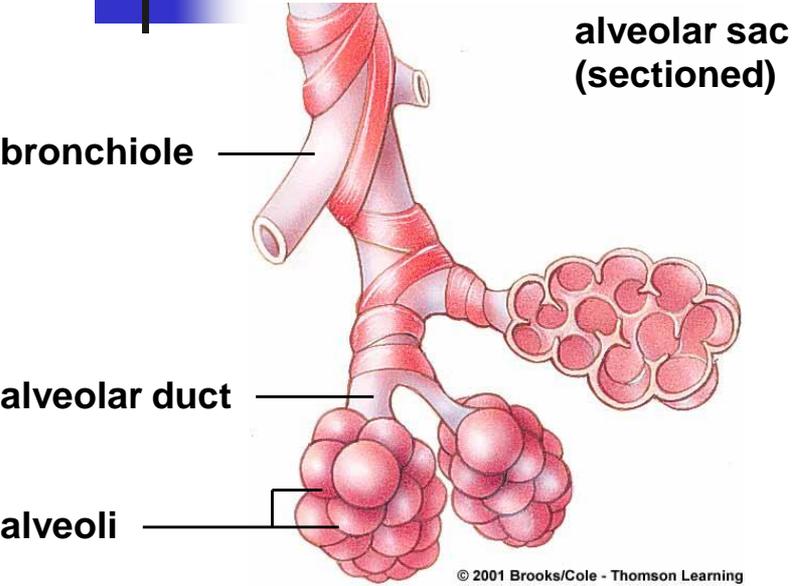
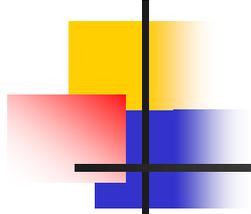
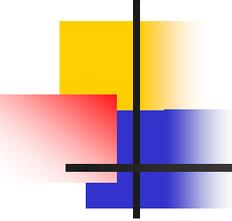
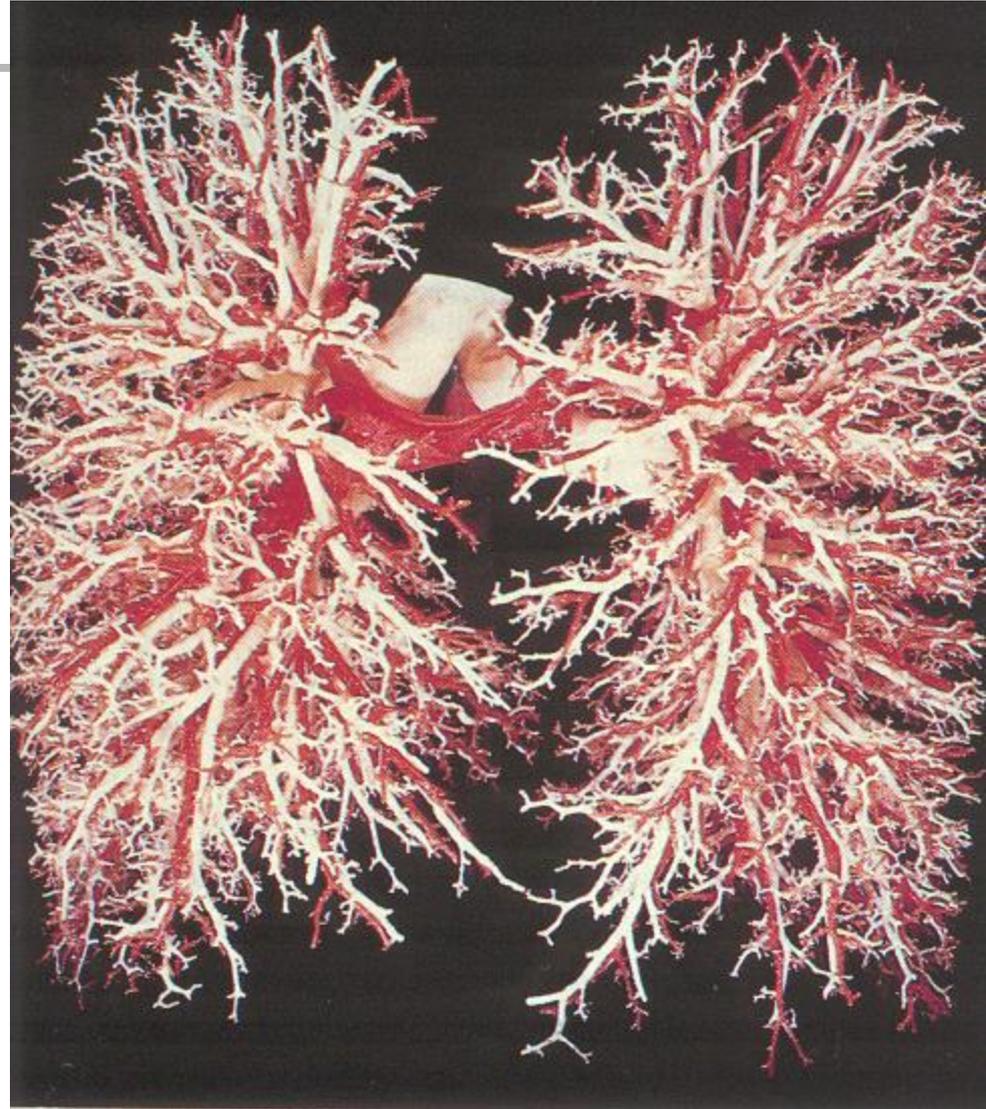


Fig. 41.10B, p. 714



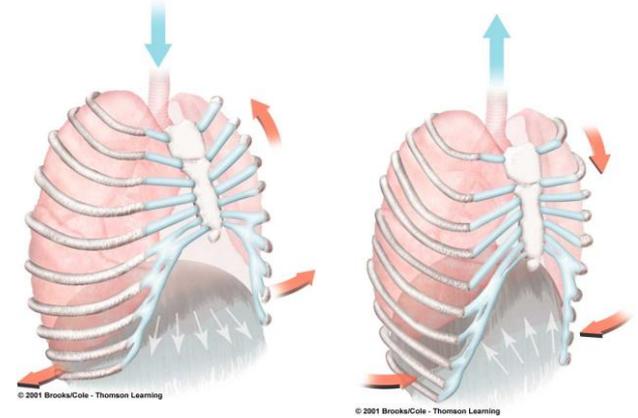
Notice how closely
the blood vessels
surround the tubes of
the lungs.



Part II; The Respiratory Cycle

■ Inhalation

- Active
- Contraction of diaphragm
- Pressure gradient
 - Increase in volume, decrease in pressure
- Negative intrapleural pressure

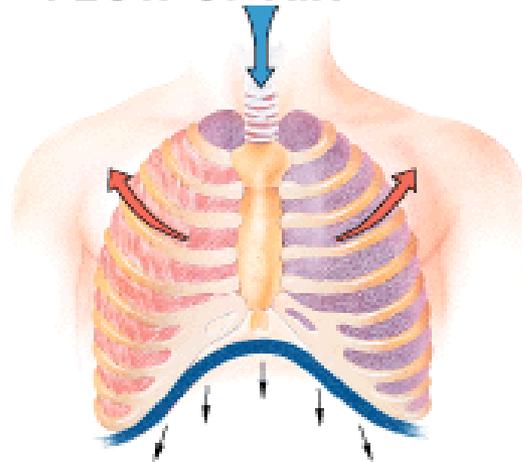


■ Exhalation

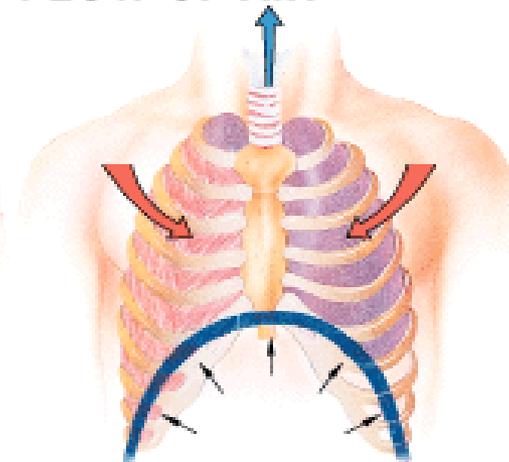
- Diaphragm relaxes
 - Volume decreases, pressure increases

The Respiratory Cycle and Pressure Changes

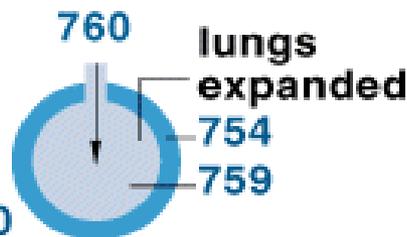
INWARD BULK FLOW OF AIR



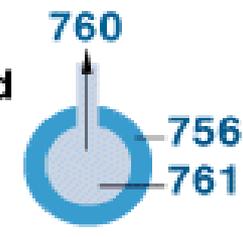
OUTWARD BULK FLOW OF AIR



c BEFORE INHALATION



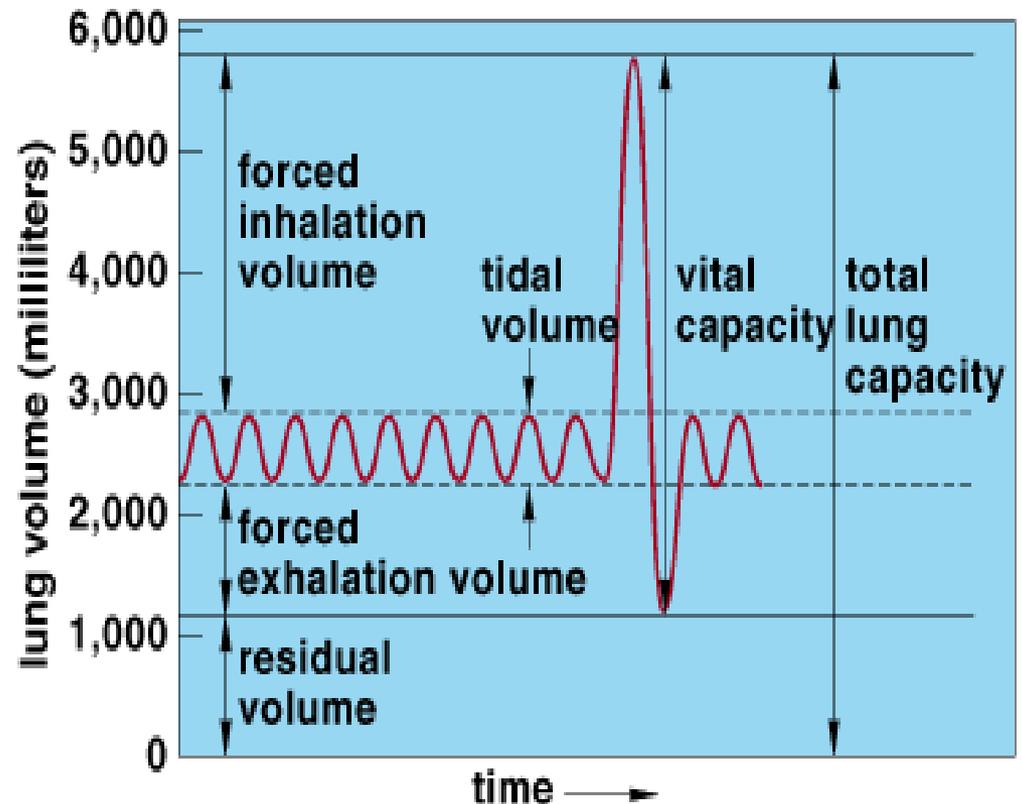
d DURING INHALATION

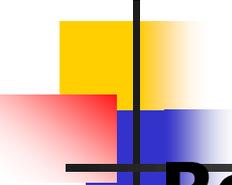


e DURING EXHALATION

Lung Volumes

- **5.7 L in males**
- **4.2 L in females**
- **Vital capacity**
- **Tidal volume**
 - **Normal breath**
 - **500 ml**
- **Residual volume**
- **Forced volumes**

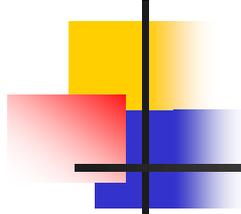




Gas Exchange and Transport

■ **Respiratory surface**

- **Epithelium of alveoli**
- **Endothelium of capillary**
- **98.5 % of oxygen bound to hemoglobin**
 - **Oxyhemoglobin**
- **Binding and release of oxygen**
 - **Temperature**
 - **pH**
 - **Partial pressures**



pore for
air flow
between
adjoining
alveoli

red blood
cell inside
pulmonary
capillary

alveolar
epithelium

capillary
endothelium

fused
basement
membranes
of both
epithelial
tissues

air space
inside
alveolus

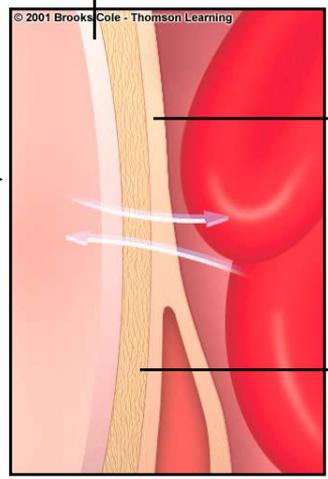
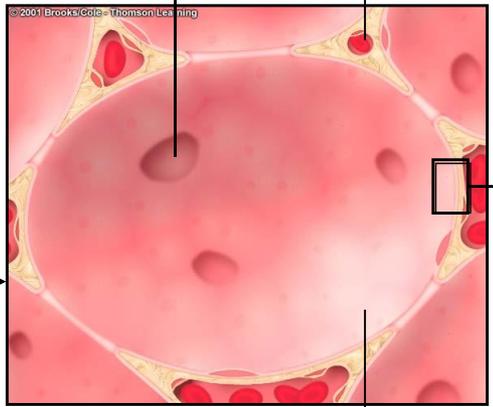
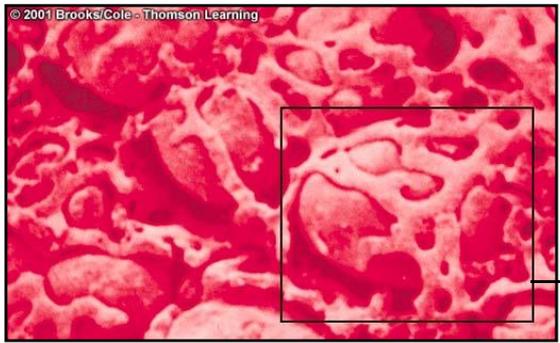
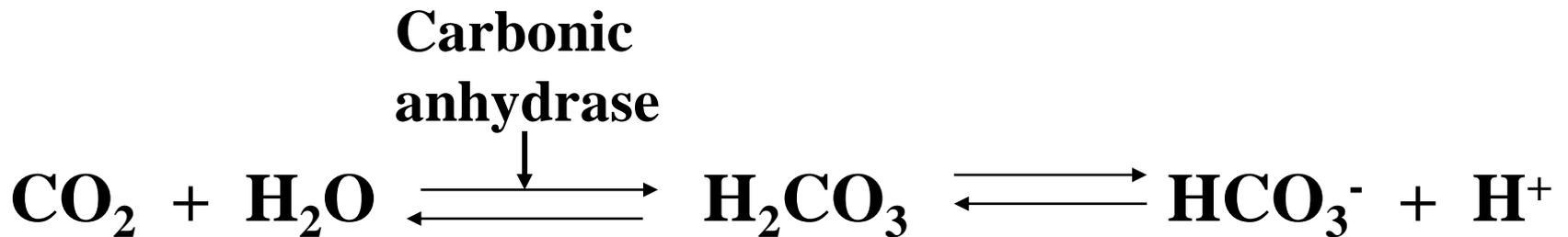
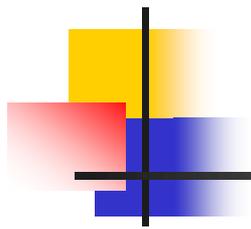


Fig. 41.14, p. 718

Carbon Dioxide Transport

- **10 % dissolved in blood**
- **30 % bound to Hb**
 - **Carbaminohemoglobin**
- **60 % as bicarbonate HCO_3^-**





DRY
INHAILED AIR

160 0.03

MOIST
EXHAILED AIR

120 27

pulmonary
arteries

40 45

pulmonary
veins

100 40

start of
systematic
veins

40 45

start of
systematic
capillaries

100 40

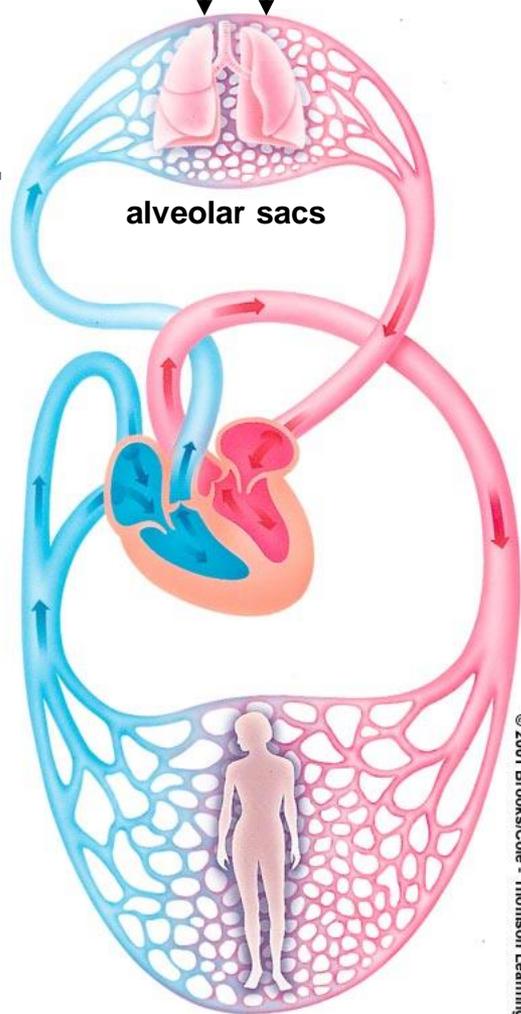
cells of body tissue

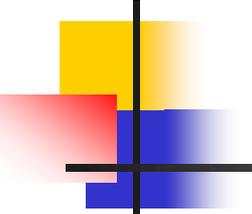
less than 40

more than 45

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Partial pressure
of oxygen (blue)
& carbon dioxide
(pink) in the
respiratory tract.





Diseases and Conditions

- **Bronchitis**
- **Pneumonia**
- **Emphysema**
 - **Alveoli break down**
 - **Cigarettes, marijuana**
 - **Second-hand smoke**
- **Lung cancer**
- **Cystic fibrosis**
- **Carbon Monoxide poisoning**
- **Nitrogen narcosis**
- **Decompression sickness**

Normal Lung

Emphysema Lung

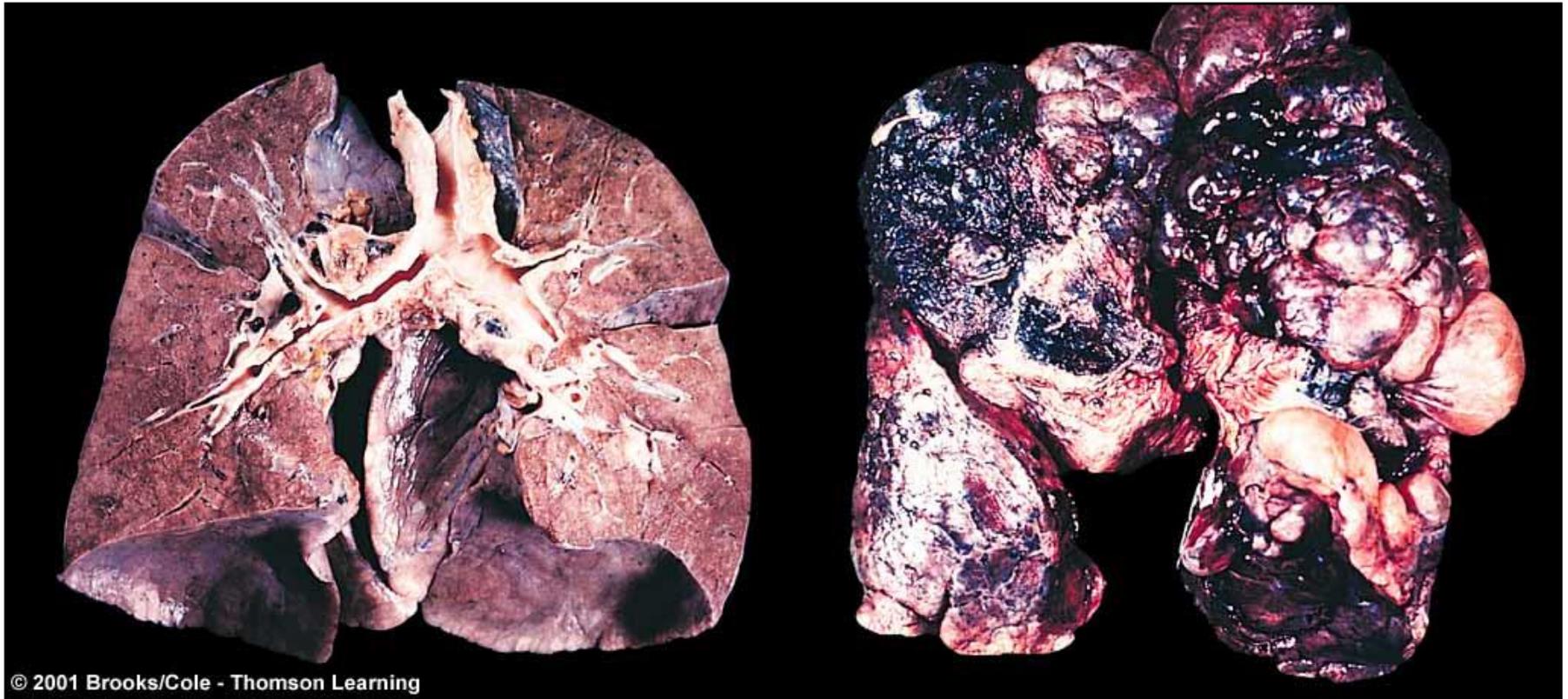
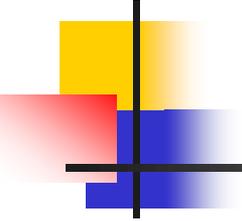
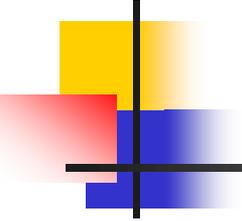


Fig. 41.17, p. 720



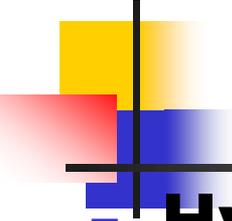
Control of Breathing

- **Medulla oblongata**
 - **Rhythmic breathing**
- **Pons**
 - **Apneustic center**
 - **Prolongs inhalation**
 - **Pneumotaxic center**
 - **Curtails inhalation**



Control of Breathing

- **H⁺ concentration (a by-product of CO₂)**
- **CO₂ levels - most critical**
- **Chemoreceptors**
 - **CSF**
 - **Aortic bodies**
 - **Carotid bodies**



Breathing at High Altitudes

- **Hypoxia**
- **Acclimatization**
 - **Breathing and cardiac output changes**
- **Erythropoietin**
 - **Stimulates erythrocyte production**

Binding Capacity Between Humans & Llamas

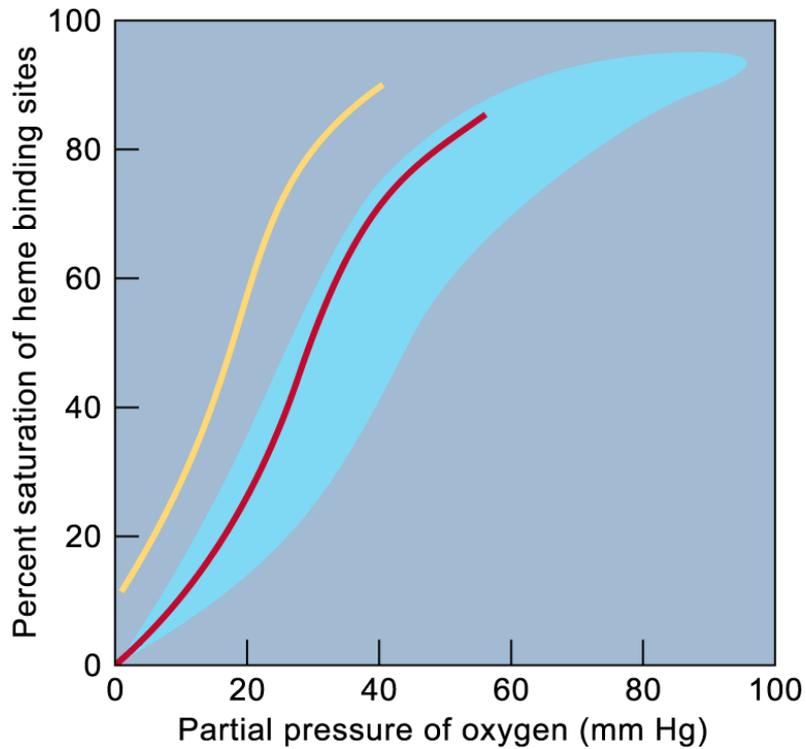


Fig. 41.19, p. 722