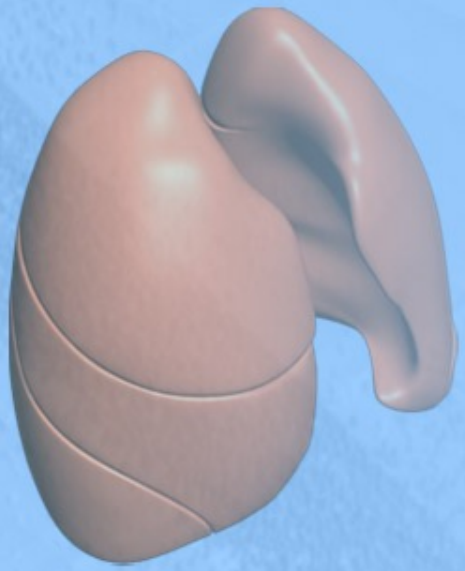
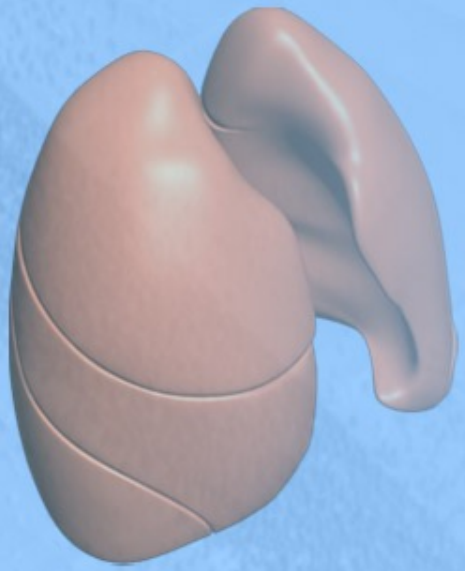
Pulmonary Disorders 1
Hypoxia

Dr. Gary Mumaugh



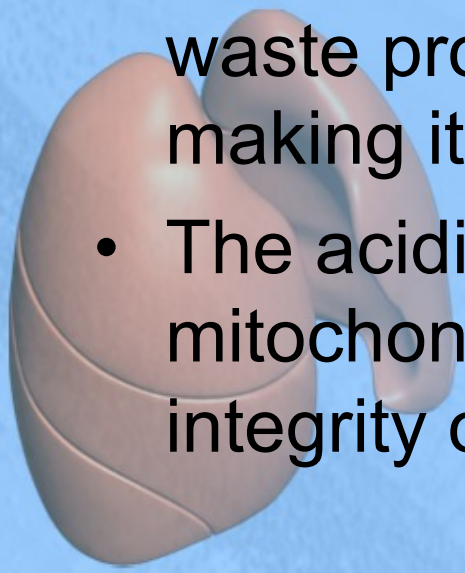
Hypoxia vs. Hypoxemia

- Hypoxia means deficiency of oxygen in the tissues
- Hypoxemia means low oxygen levels in the blood

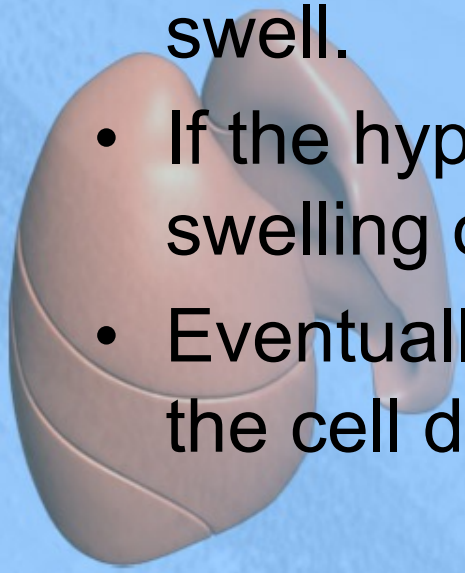


Hypoxic Injury

- When a cell is deprived of oxygen, it can no longer produce energy without oxygen.
- If the cell must live, it converts to making energy without oxygen – anaerobic.
- Anaerobic metabolism leads to lactic acid as a waste product and lowers the pH of the cell, making it acidic.
- The acidic environment damages the mitochondria and organelles and changes the integrity of the cell membrane.



- As the cell loses energy energy, it can't pump sodium out of the cell and sodium accumulates inside the cell.
- Because sodium is osmotic, it pulls massive amounts of water into the cell causing the cell to swell.
- If the hypoxia persists, the acidity of the cell and swelling of the cell causes an irreversible injury.
- Eventually the lysosome membrane ruptures and the cell dies.



Oxygen Pathway

External atmospheric air ☞☞☞

chest wall expansion ☞☞☞

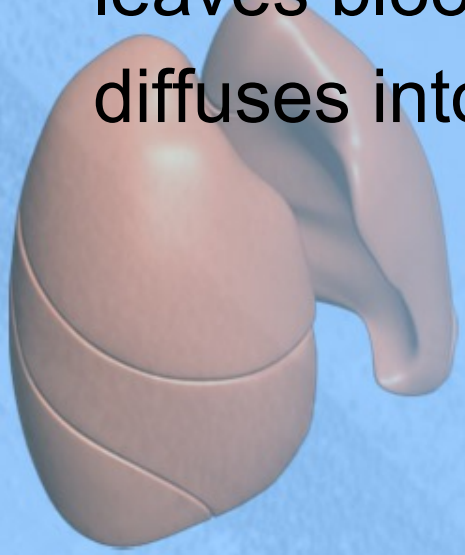
bronchial passages ☞☞☞

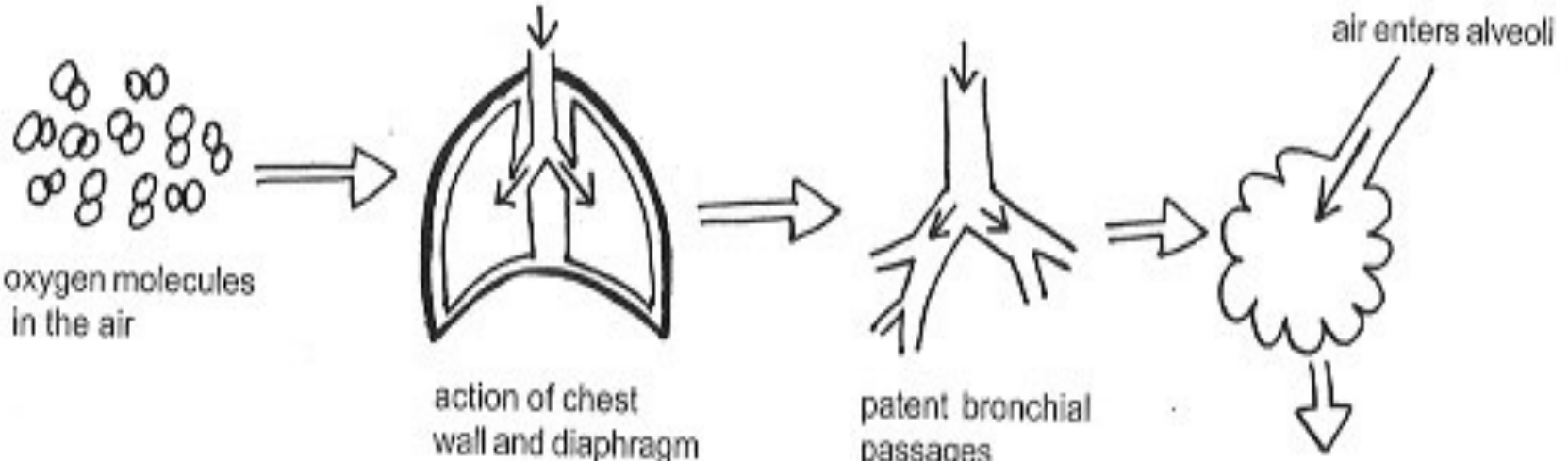
alveolus ☞☞☞

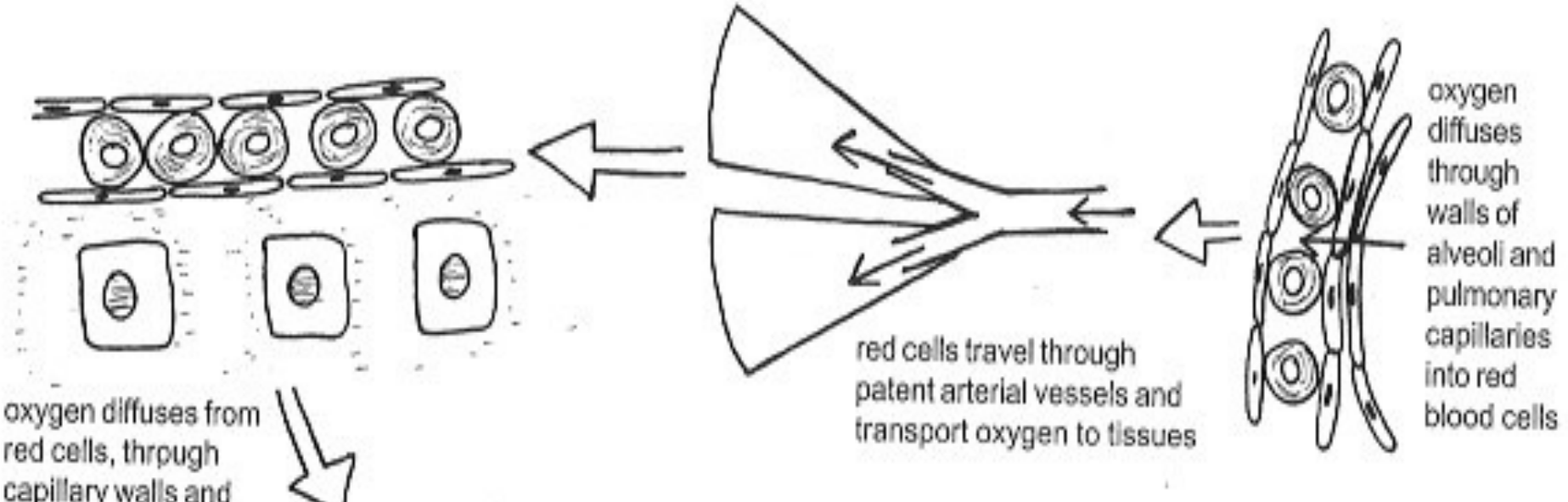
vascular transportation ☞☞☞

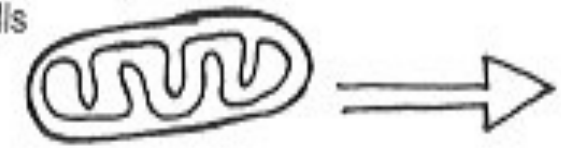
leaves blood into tissue fluids ☞☞☞

diffuses into cellular mitochondria









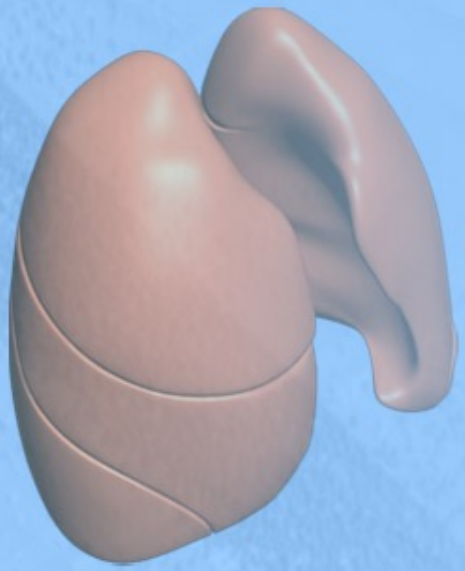
oxygen diffuses into mitochondria

glucose	+ oxygen	= carbon dioxide	+ water	+ energy
$C_6H_{12}O_6$	+ $6O_2$	= $6CO_2$	+ $6H_2O$	+ Energy

oxygen is finally used in the process of respiration

Major Classifications of Hypoxia

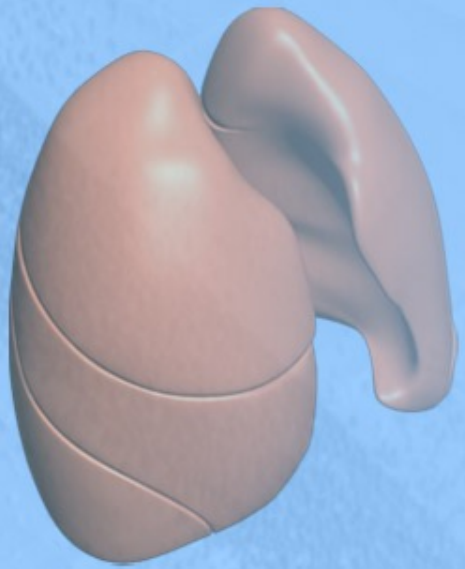
- Extrinsic Hypoxia
- Pulmonary Hypoxia
- Anemic Hypoxia
- Stagnant Hypoxia
- Histotoxic Hypoxia



Extrinsic Hypoxia

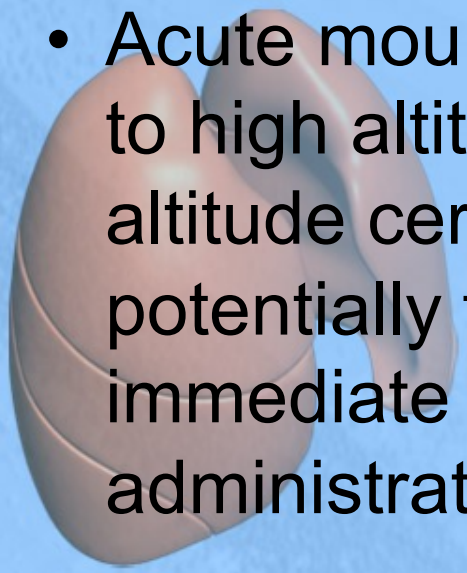
- This describes inadequate oxygenation of the lungs from reason that is OUTSIDE the lungs.
- The body tissues become hypoxic because there is not enough oxygen entering the lungs.

CAN YOU THINK OF ANY EXAMPLES?

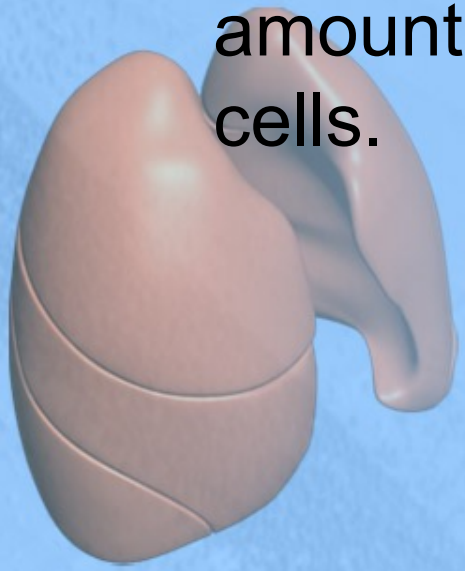


Altitude

- Oxygen levels lower dramatically at higher altitudes.
- Minor Acute Mountain Sickness (AMS) typically only occurs above 8,000 ft.
  - Climbers present with symptoms resembling a case of flu, carbon monoxide poisoning, or a hangover.
- Acute mountain sickness (AMS) can progress to high altitude pulmonary edema (HAPE) or high altitude cerebral edema (HACE), both of which are potentially fatal, and can only be cured by immediate descent to lower altitude or oxygen administration.

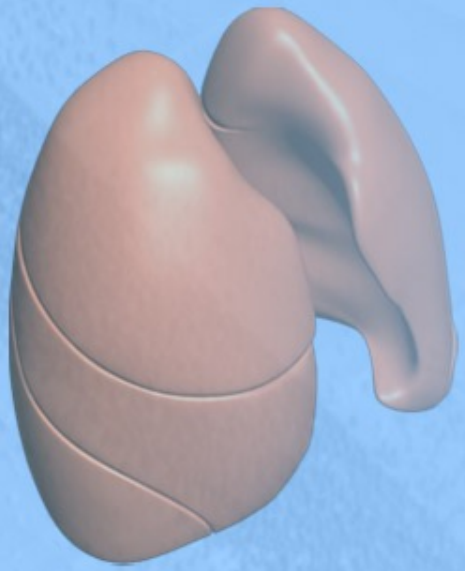


- Acclimatization occurs over several months which is an adaptation to high altitudes.
- The kidney will make more EPO to stimulate more RBC production and the number of mitochondria in cells will increase and the amount of myoglobin will increase in muscle cells.



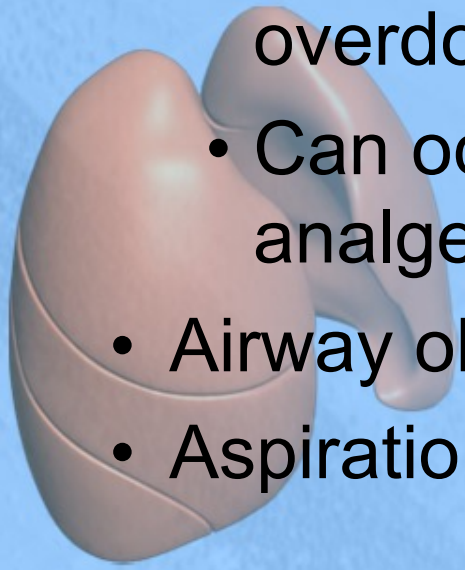
Lack of oxygen in the air even at sea level

This can be seen in certain occupations where the O2 and CO2 levels are altered such as farmers in silage pits and brewers of alcohol.



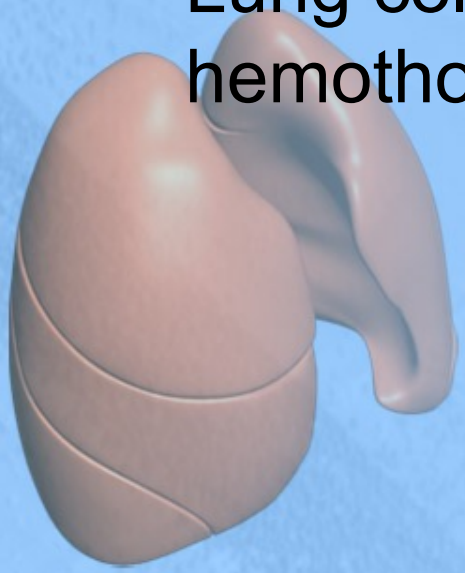
Problems causing hypoventilation

- Anything that interferes with normal chest ventilation and movement will cause extrinsic hypoxia.
  - Can be neurological, orthopedic, respiratory paralysis, chest injuries
  - Can be a side effect of medications as in opiate overdose
  - Can occur with muscle relaxants and analgesics
- Airway obstruction
- Aspiration



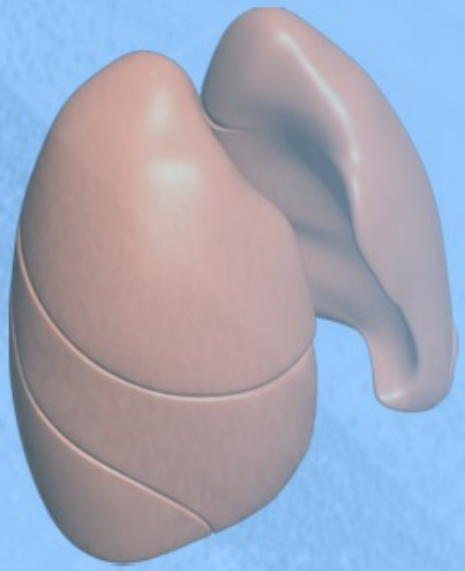
Pulmonary Hypoxia

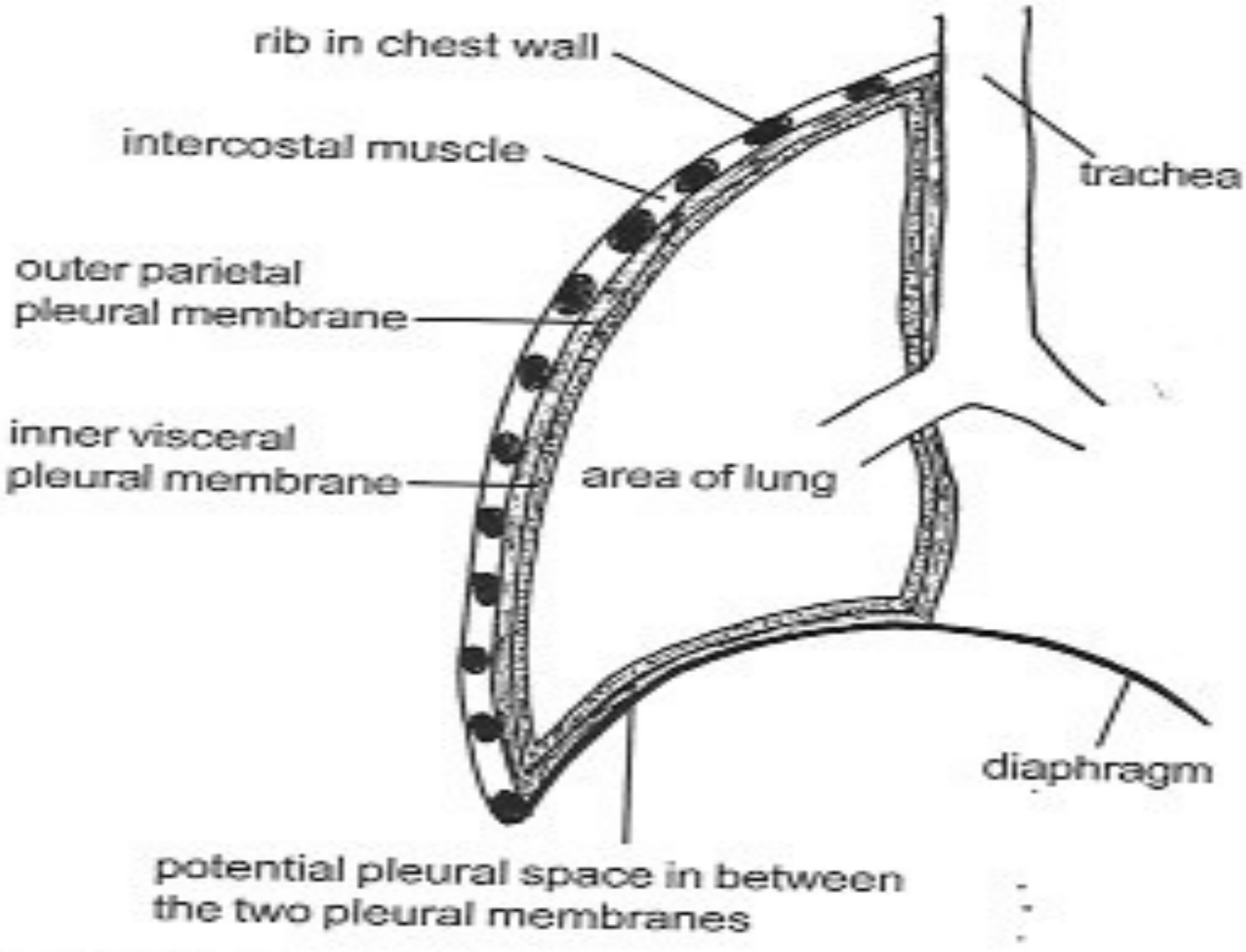
- Lung pathologies are obvious causes of hypoxia.
- Occurs as a result of airway resistance, alveolar issues or reduced membrane transport of oxygen.
  - Asthma, pneumonia, bronchiolitis, lung cancer, COPD and cystic fibrosis
  - Lung collapse secondary to pneumothorax, hemothorax or hydrothorax



Normal Pleura

- In normal lungs, the visceral pleura is sucked up onto the parietal pleura.
- This means that the lungs will fill up all the available space in the thoracic cavity.

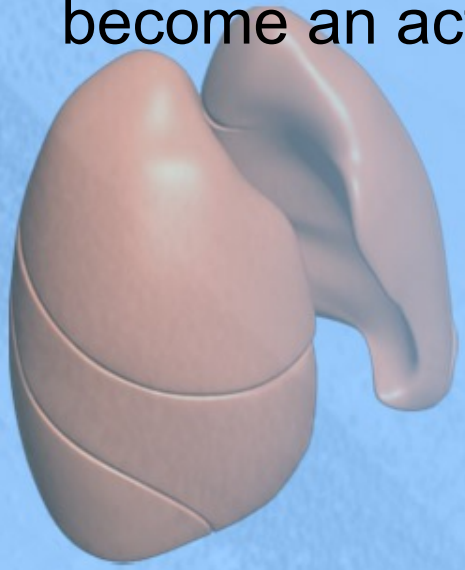


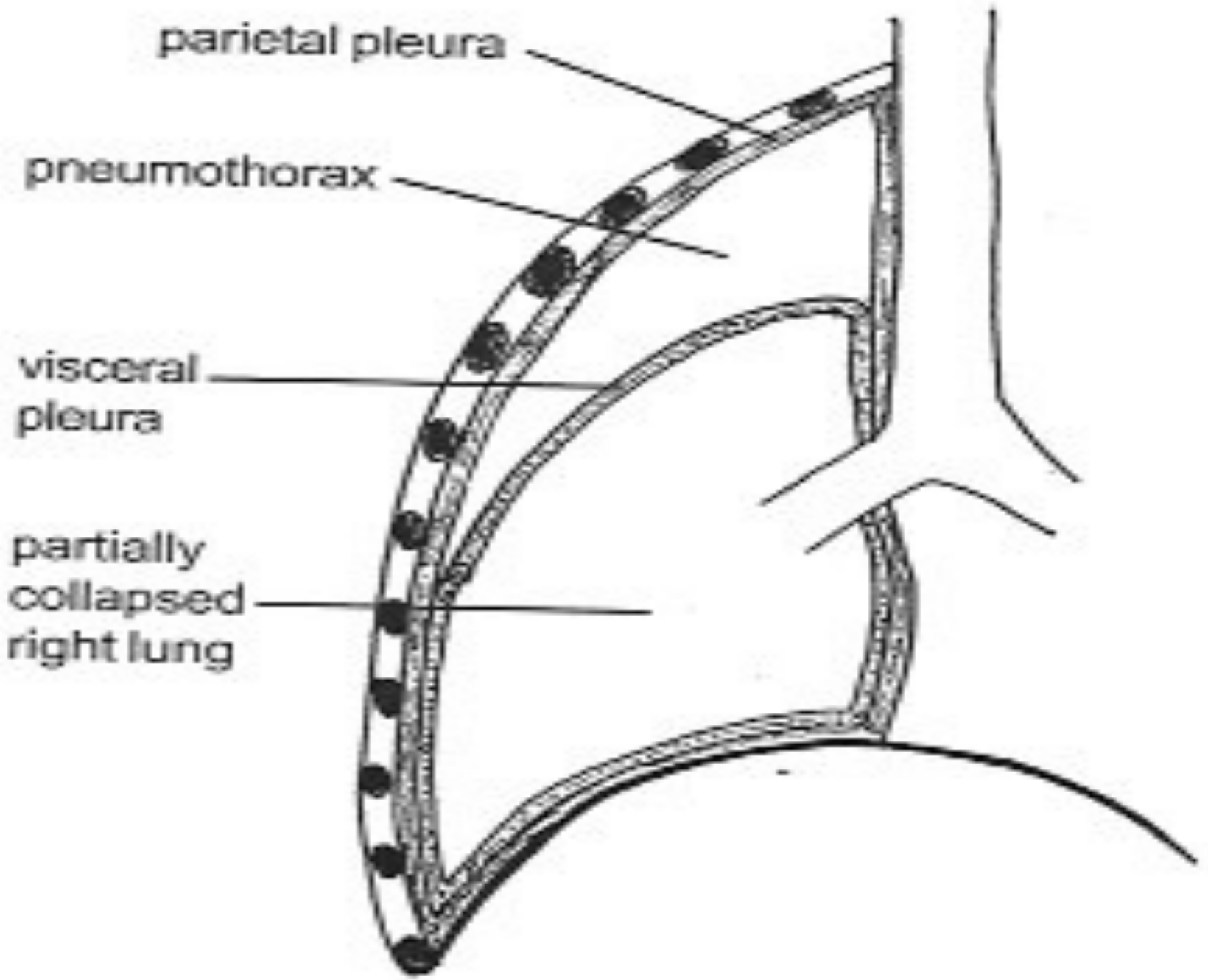

rib in chest wall
intercostal muscle
outer parietal pleural membrane
inner visceral pleural membrane
area of lung
trachea
diaphragm
potential pleural space in between the two pleural membranes

Pneumothorax

The parietal pleura will remain attached to the chest wall and the visceral pleura remains attached to the lung.

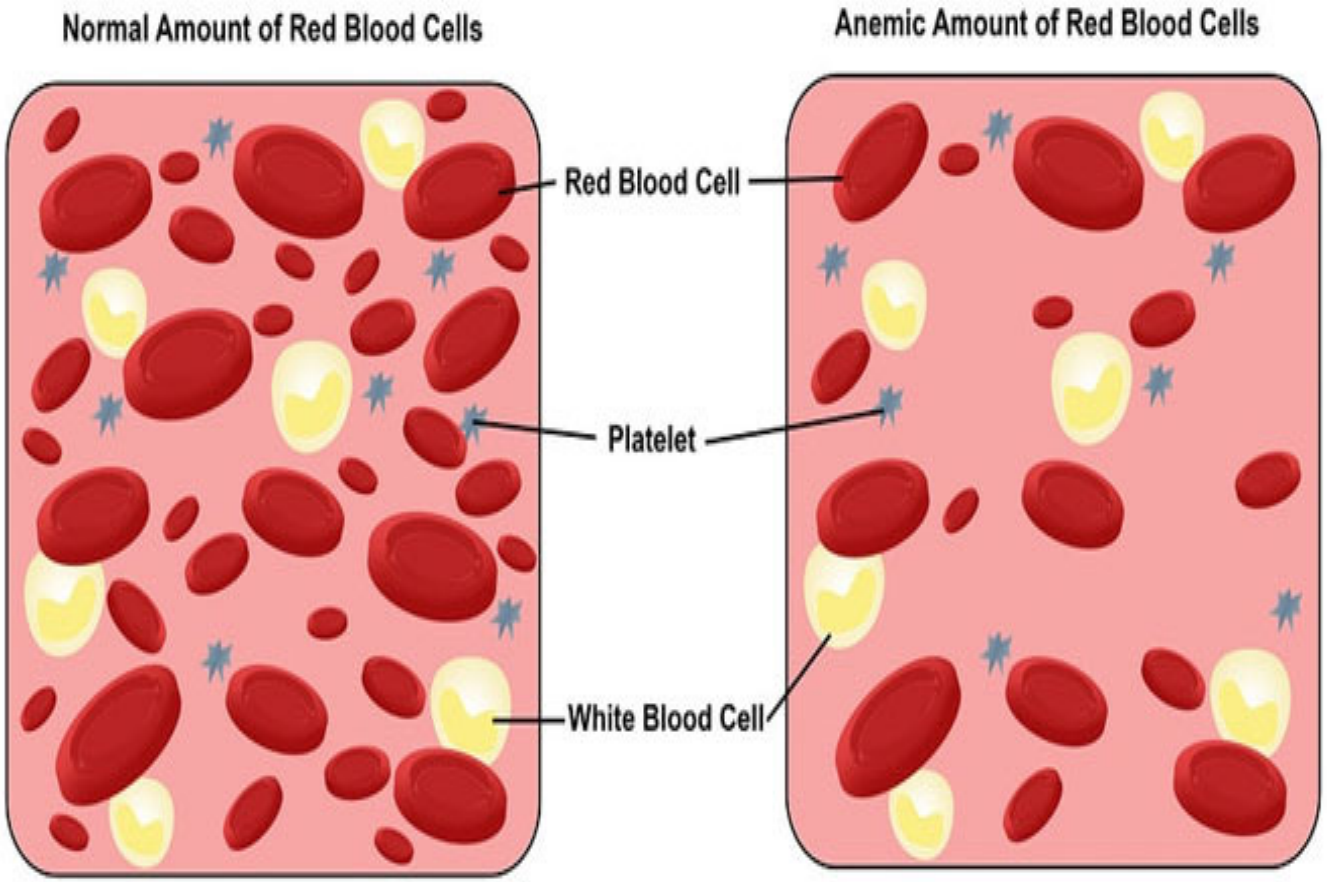
Because there is air (pneumothorax) or blood (hemothorax) or fluid (hydrothorax) in the space, the “potential space” has become an actual space and no suction occurs.




parietal pleura
pneumothorax
visceral pleura
partially collapsed right lung

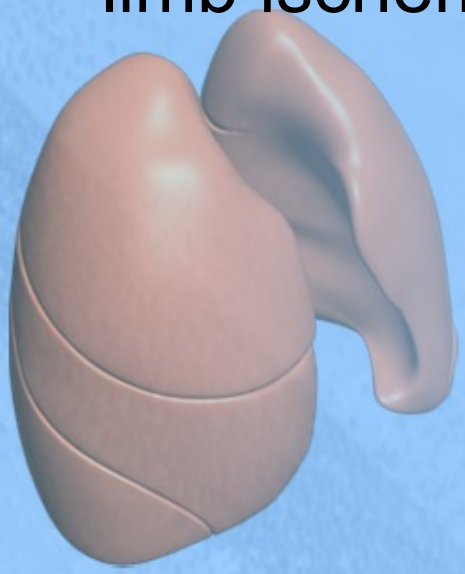
Anemic hypoxia can be caused by anything that can cause anemia or blood loss.

Low Oxygen Carrying Ability of the Blood Results in Anemic Hypoxia



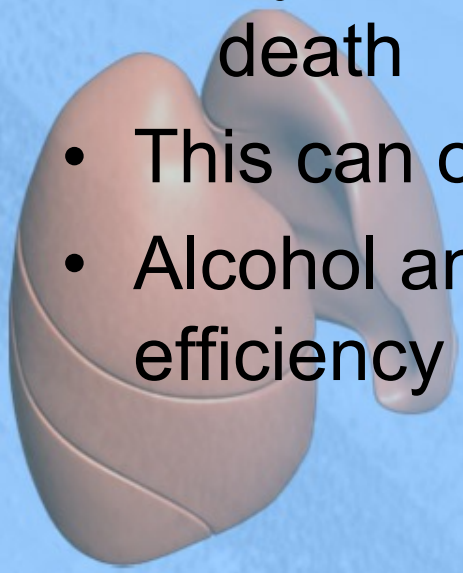
Stagnant Hypoxia

- Localized circulatory perfusion reduction will result is a stagnant hypoxia, which can occur as a result of any arterial disease of trauma.
- Localized hypoxia is referred to as ischemia
- Examples are intermittent claudication, TIA, acute limb ischemia, etc.



Histotoxic Hypoxia

- In some cases, the cells are unable to use the oxygen in cellular respiration
- This occurs in poisonings of cellular enzymes, such as with cyanide
  - Cyanide blocks enzymes and causes rapid death
- This can occur in sepsis
- Alcohol and carbon monoxide may reduce the efficiency of energy production in the mitochondria

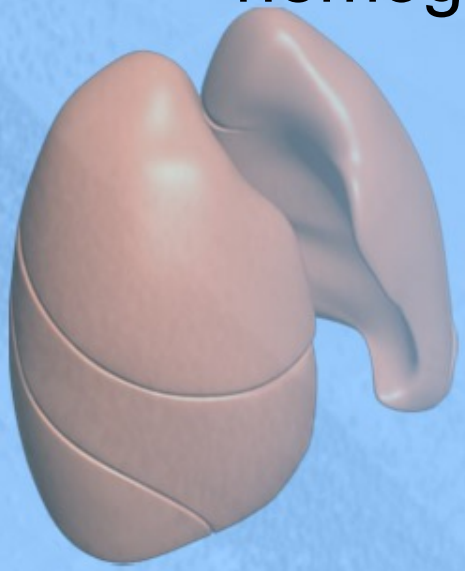


Response of the body to hypoxia

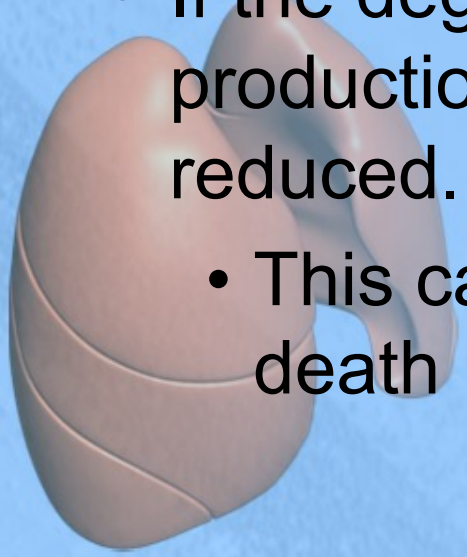
- **Oxygen flux is the flow of oxygen from the lungs to the tissues**
  - Cardiac output X

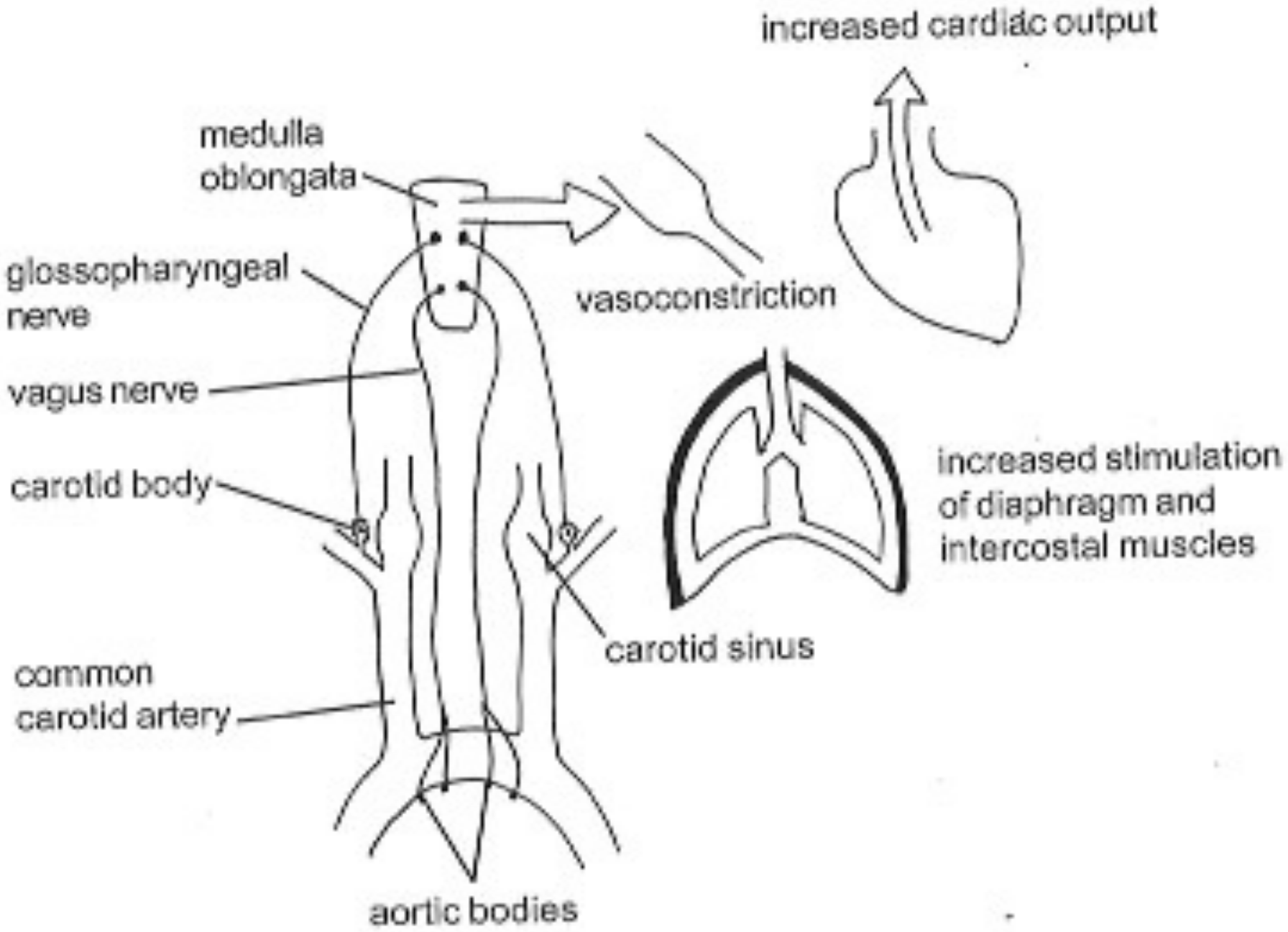
    arterial oxygen concentration X

    hemoglobin concentration

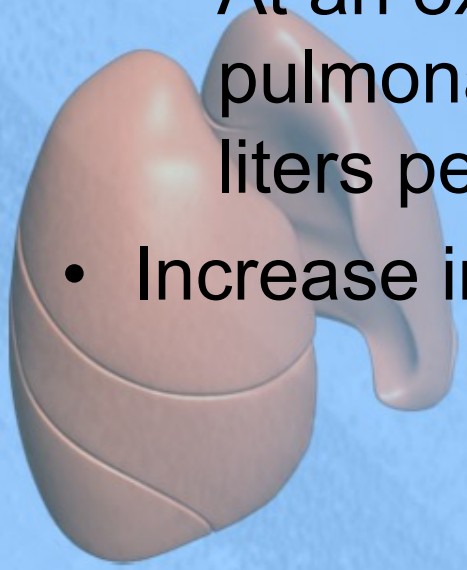


- Cardiovascular compensatory response
  - In hypoxia, the heart rate and stroke volume will increase
  - This increases oxygen flux increase
  - This is monitored by the chemoreceptors in the aortic bodies and carotids, which will increase blood pressure
  - If the degree of hypoxia continues, the energy production to the myocardium will eventually be reduced.
    - This can lead to decreased cardiac output and death



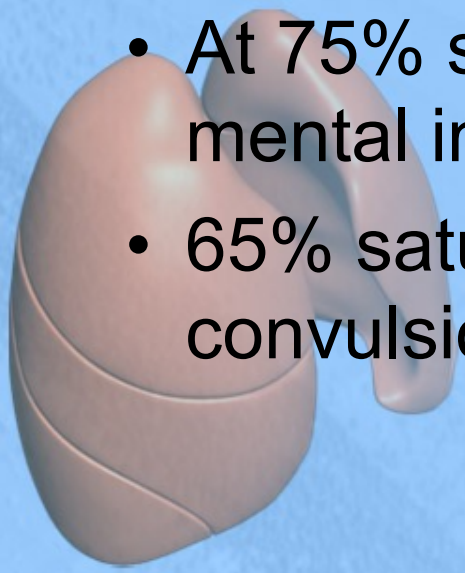

increased cardiac output
medulla oblongata
glossopharyngeal nerve
vagus nerve
carotid body
vasoconstriction
increased stimulation of diaphragm and intercostal muscles
carotid sinus
common carotid artery
aortic bodies

- Respiratory compensatory response
  - In hypoxia, there will be tachypnea with increased respiratory volumes
  - At an oxygen saturation rate of 90%, the pulmonary ventilation rate will increase to 15 liters per minute. (Normal is about 6 liters per minute)
  - At an oxygen saturation rate of 80%, the pulmonary ventilation rate will increase to 25 liters per minute.
- Increase in red blood cell response

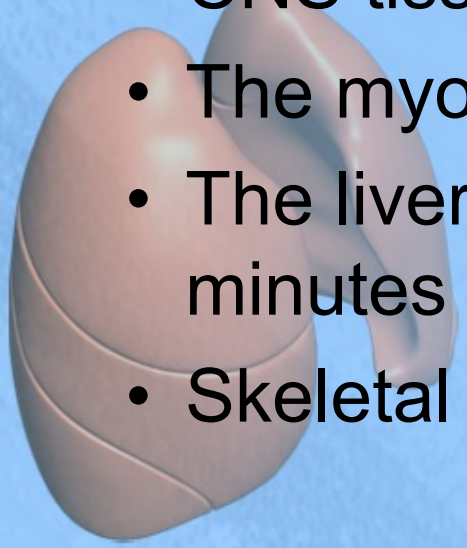


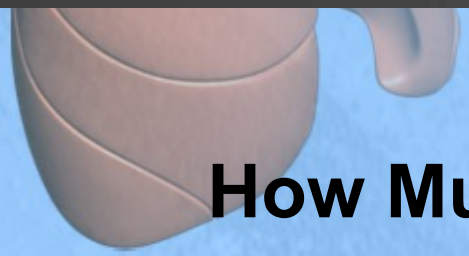
Other clinical features of hypoxia

- Cyanosis
  - Usually below an oxygen saturation rate of 85%
- CNS effects
  - At 85% saturation rate there is fatigue, headache, nausea, vomiting, dizziness and confusion
  - At 75% saturation rate there can become severe mental impairment.
  - 65% saturation rate will lead to coma, convulsions and eventually brain death.



- Cerebral edema
  - The hypoxia causes dilation of the cerebral capillaries which will led to increased permeability increasing volumes of tissue fluid.
  - The increased tissue fluid led to increased intracranial pressure
- Hypoxic damage to organs
  - CNS tissue can be damaged in one minute
  - The myocardium can be damaged in 5 minutes
  - The liver and kidneys can be damaged in 10 minutes
  - Skeletal muscles may survive up to 2 hours

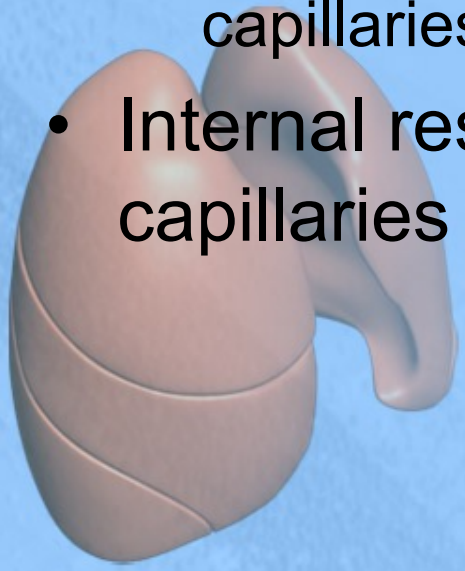




How Much Air to We Breath in Every Day?

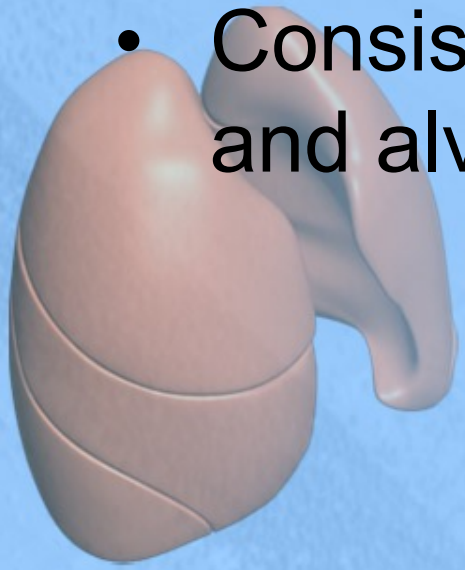
Respiratory Overview

- Respiratory and circulatory systems are closely related structurally and functionally
- External respiration – occurs at the alveoli of the lungs with the capillaries
  - This is where the O2 and CO2 exchange with the lung capillaries
- Internal respiration – takes place between the blood capillaries and the tissue cells.



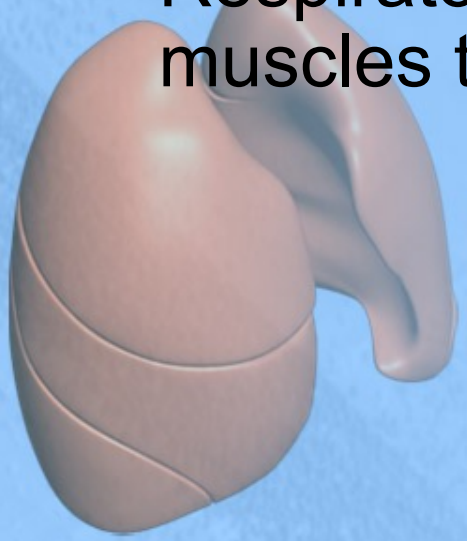
Respiratory System

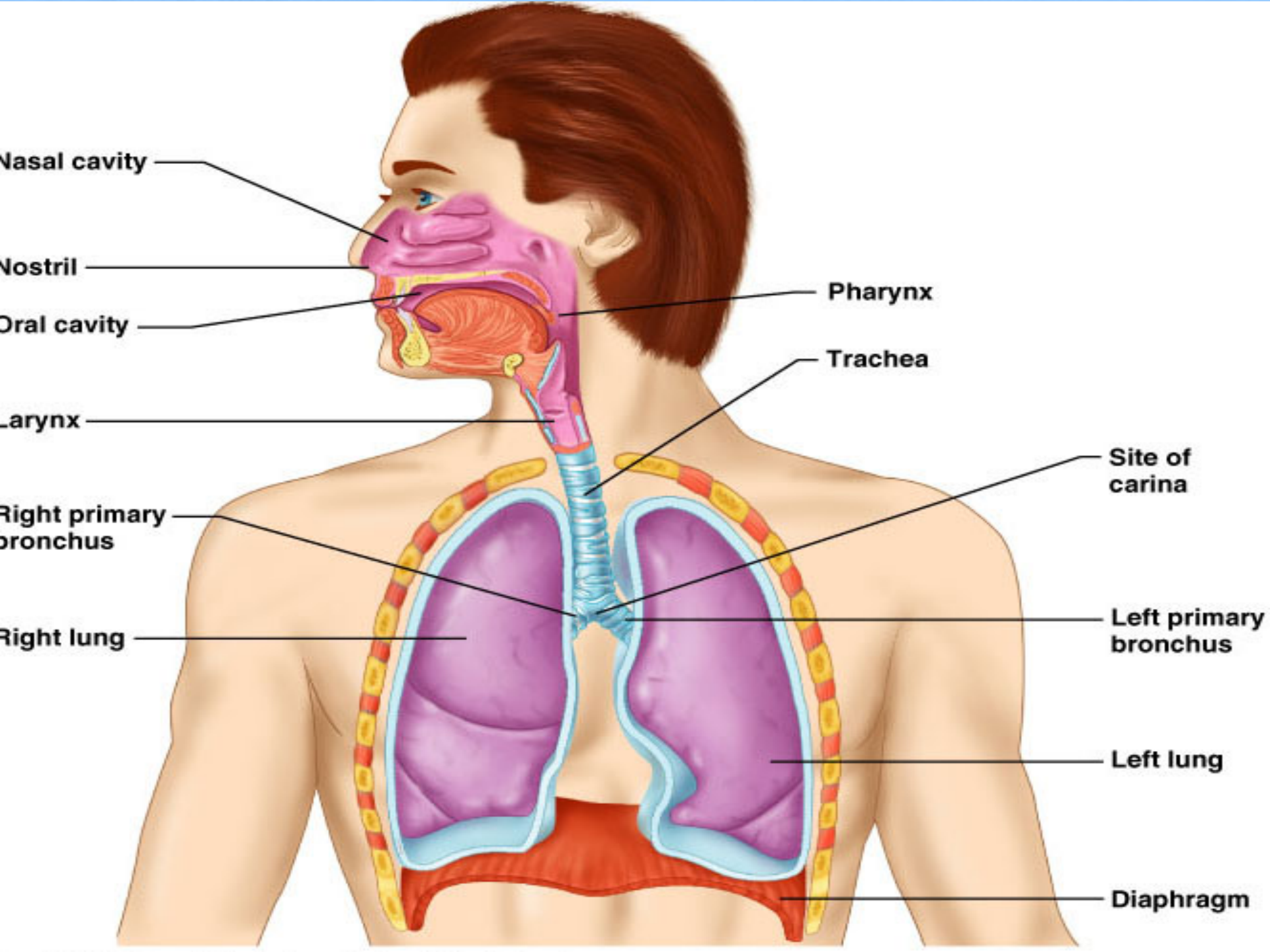
- Consists of the respiratory and conducting zones
- Respiratory zone
  - Site of gas exchange
  - Consists of bronchioles, alveolar ducts, and alveoli



Respiratory System

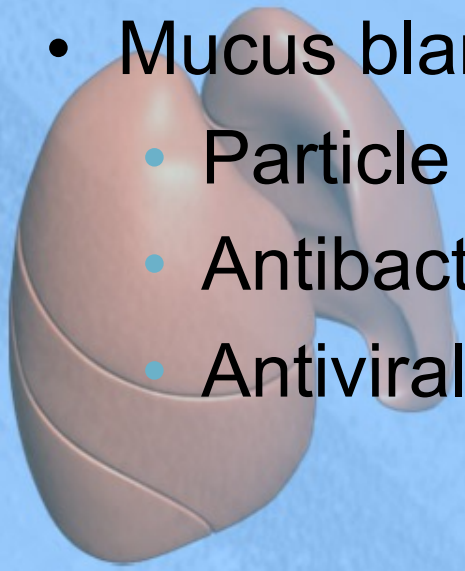
- Conducting zone
  - Provides rigid conduits for air to reach the sites of gas exchange
  - Includes all other respiratory structures (e.g., nose, nasal cavity, pharynx, trachea)
- Respiratory muscles – diaphragm and other muscles that promote ventilation




Nasal cavity
Nostril
Oral cavity
Larynx
Right primary bronchus
Right lung
Pharynx
Trachea
Site of carina
Left primary bronchus
Left lung
Diaphragm

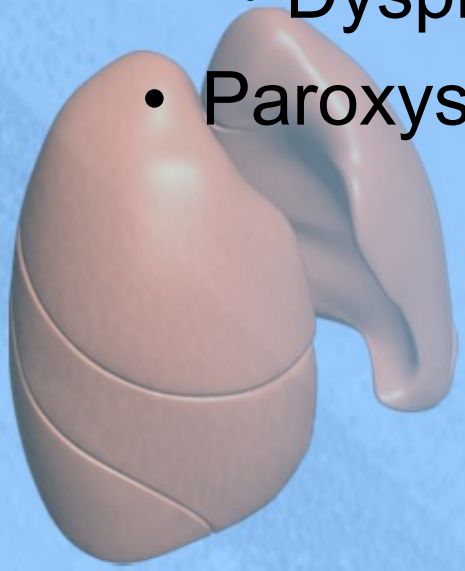
Respiratory Defense Mechanisms

- Warm and humidify incoming air
- Branching of bronchial tree increases its contact with airway mucus
- Cilia prevents particles form reaching distal airways
- Mucus blanket
  - Particle clearance (**macrophages**)
  - Antibacterial secretions (**lysosome**)
  - Antiviral secretions (**interferons**)



Signs and Symptoms of Pulmonary Disease

- Dyspnea
  - Subjective sensation of uncomfortable breathing
  - Orthopnea
    - Dyspnea when a person is lying down
  - Paroxysmal nocturnal dyspnea (PND)




Shortness of breath
Shallow breathing
Tense muscles
Getting anxious
Worse shortness of breath
Limiting your activities
Getting more anxious

Signs and Symptoms of Pulmonary Disease

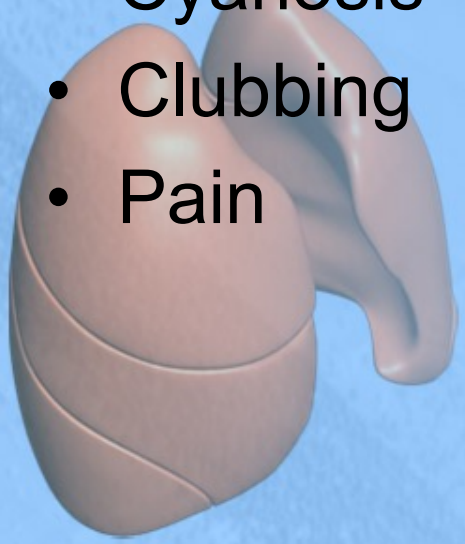
- **Cough**
  - Acute cough
  - Chronic cough
- Abnormal sputum
- Hemoptysis
- Abnormal breathing patterns:
  - Kussmaul respirations (hyperpnea)
    - Kussmaul Breathing
  - Cheyne-Stokes respirations
    - Cheyne-Stokes Breathing


Kussmaul Breathing Pattern
10 Year Old Male, Diabetic Ketoacidosis

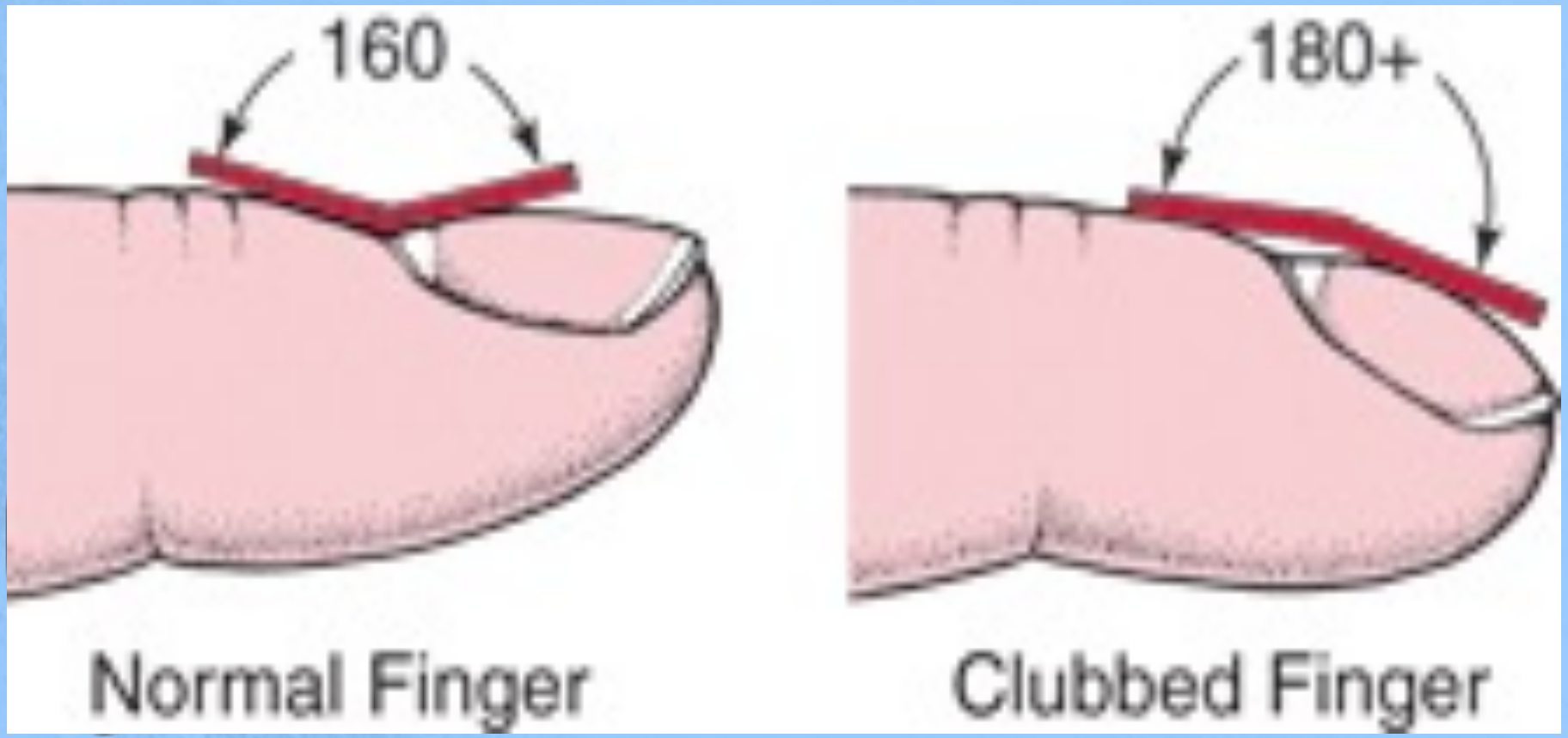

113
94
36
94
36

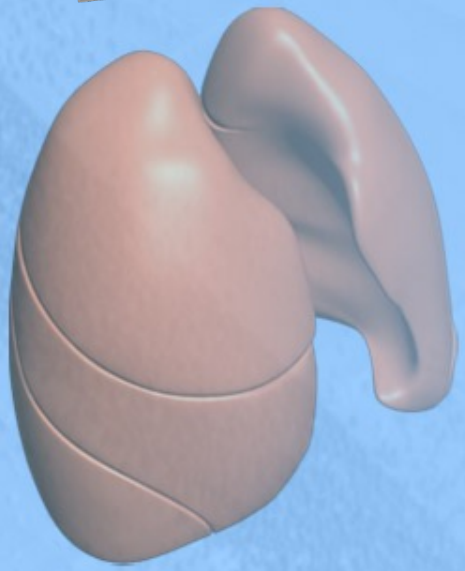
Signs and Symptoms of Pulmonary Disease

- Hypoventilation
  - Hypercapnia Increased CO_2 due to hyopventilation
- Hyperventilation
  - Hypocapnia Decreased CO_2 due to hyerpventilation
- Cyanosis
- Clubbing
- Pain

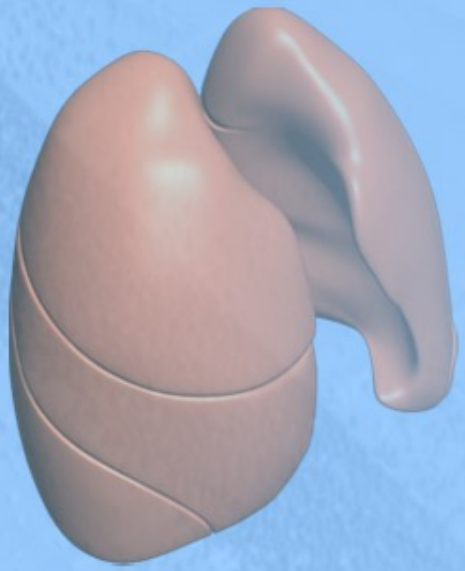


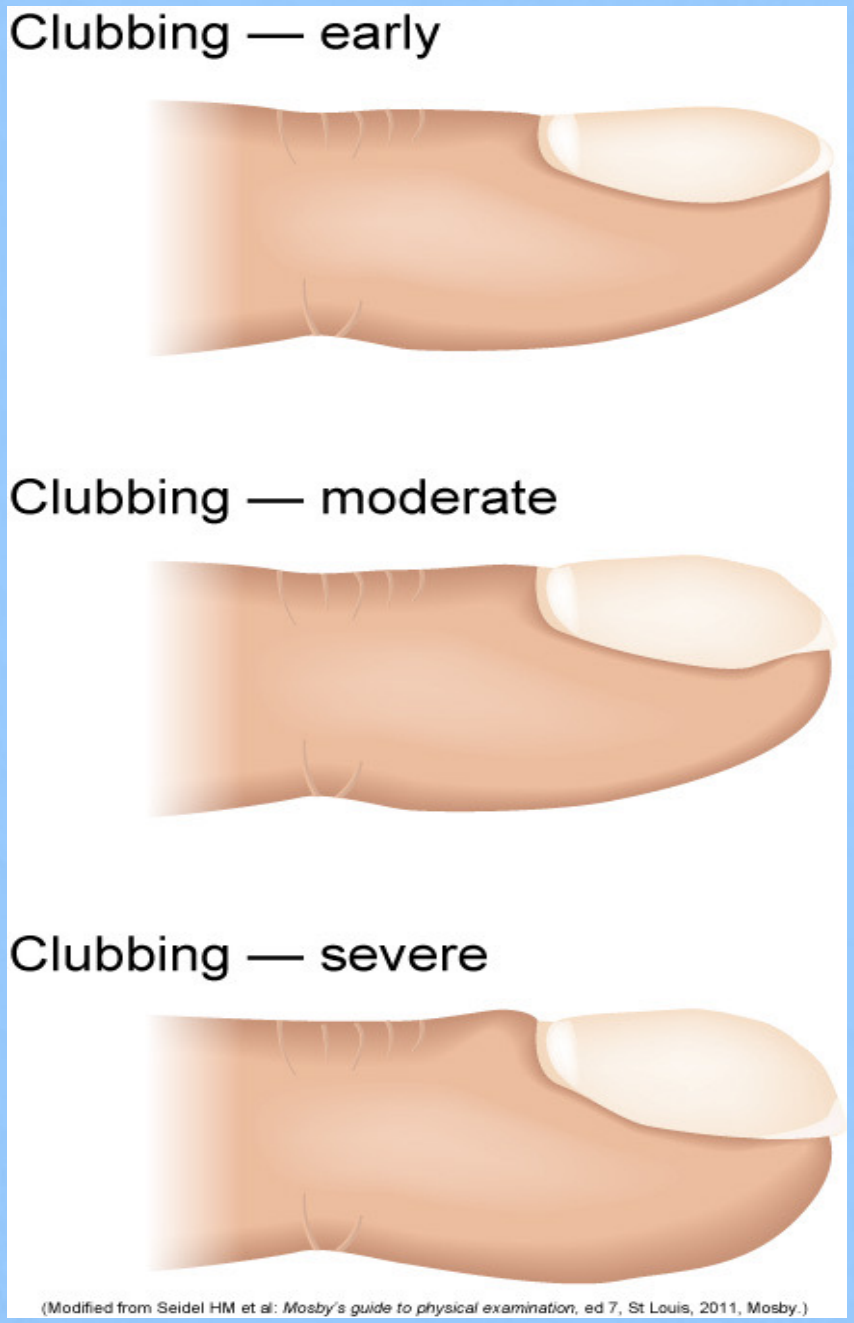
- Finger clubbing is characterized by enlarged fingertips and a loss of the normal angle at the nail bed.





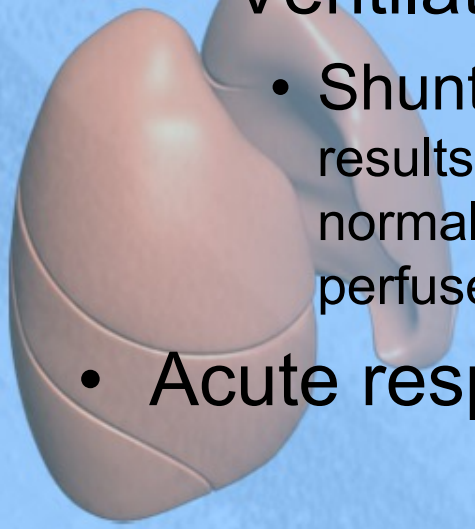
Clubbing




Clubbing — early
Clubbing — moderate
Clubbing — severe
(Modified from Seidel HM et al: *Mosby's guide to physical examination*, ed 7, St Louis, 2011, Mosby.)

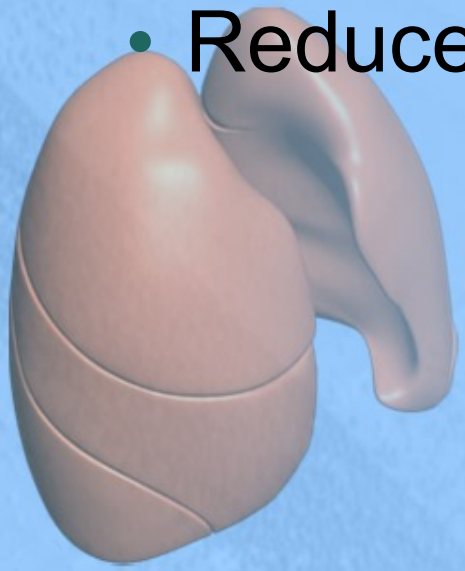
Conditions Caused by Pulmonary Disease or Injury

- Hypercapnia Increased CO_2 due to hyopventilation
- Hypoxemia Low blood oxygen
  - Hypoxemia versus hypoxia The body or a region of the body is deprived of adequate oxygen. Hypoxia may be classified as either *generalized*, affecting the whole body, or *local*.
  - Ventilation-perfusion abnormalities
    - Shunting A pulmonary shunt is a physiological condition which results when the alveoli of the lungs are perfused with blood as normal, but ventilation (the supply of air) fails to supply the perfused region.
- Acute respiratory failure



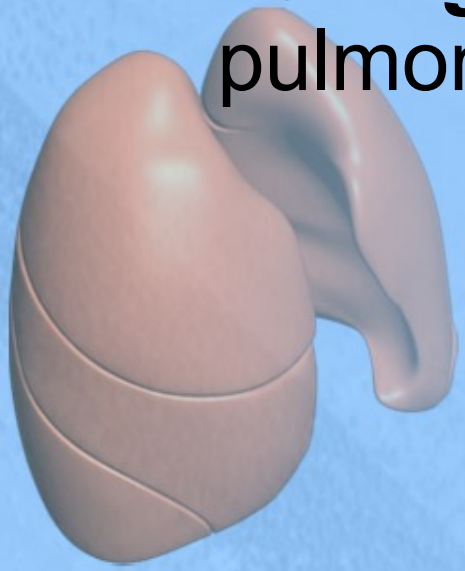
Hypoperfusion

- **Hypoperfusion:** inadequate blood flow to pulmonary capillaries
  - Heart Failure
  - Thromboembolism
  - Reduced Ventilation



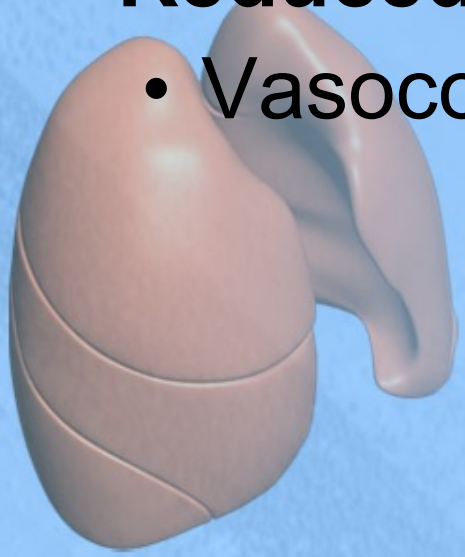
Hypoperfusion

- **Heart Failure**
  - **Failing left heart**- pulmonary hypertension, reduced blood flow at higher pressure
  - **Failing right heart**- reduced pulmonary blood flow



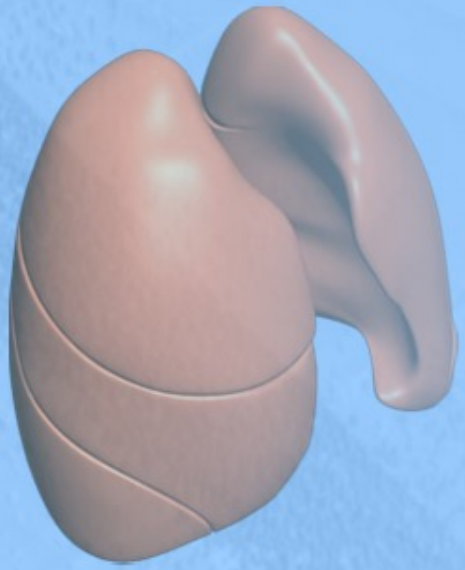
Hypoperfusion

- **Thromboembolism**- blockage of vessel
  - Blockage of vessel by embolus
  - Release of vasoconstrictors from activated platelets
- **Reduced Ventilation**
  - Vasoconstriction response in arterioles



Chest Wall Disorders

- Chest wall restriction
  - Compromised chest wall
    - Deformation, immobilization, and/or obesity
- Flail chest
  - Instability of a portion of the chest wall



FLAIL CHEST: PARADOXICAL BREATHING

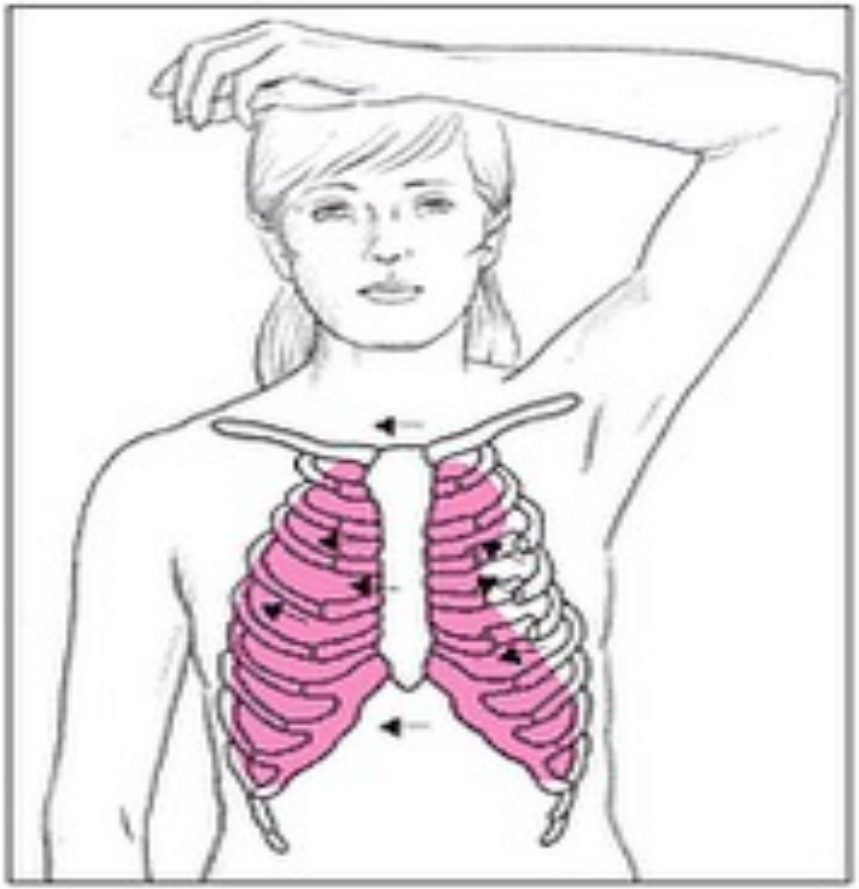
A patient with a blunt chest injury may develop flail chest, in which a portion of the chest "caves in." This results in paradoxical breathing, described below.

Inhalation

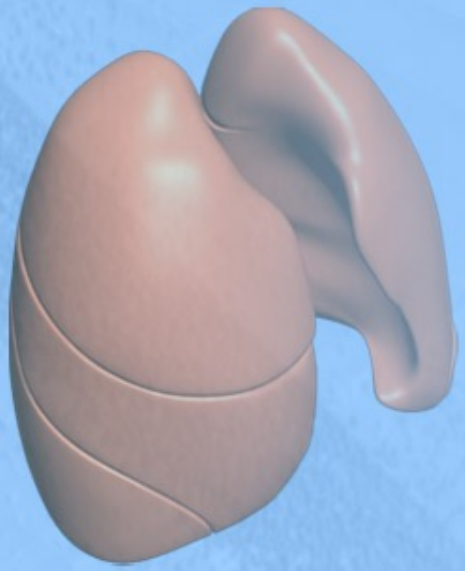
- Injured chest wall collapses in.
- Uninjured chest wall moves out.

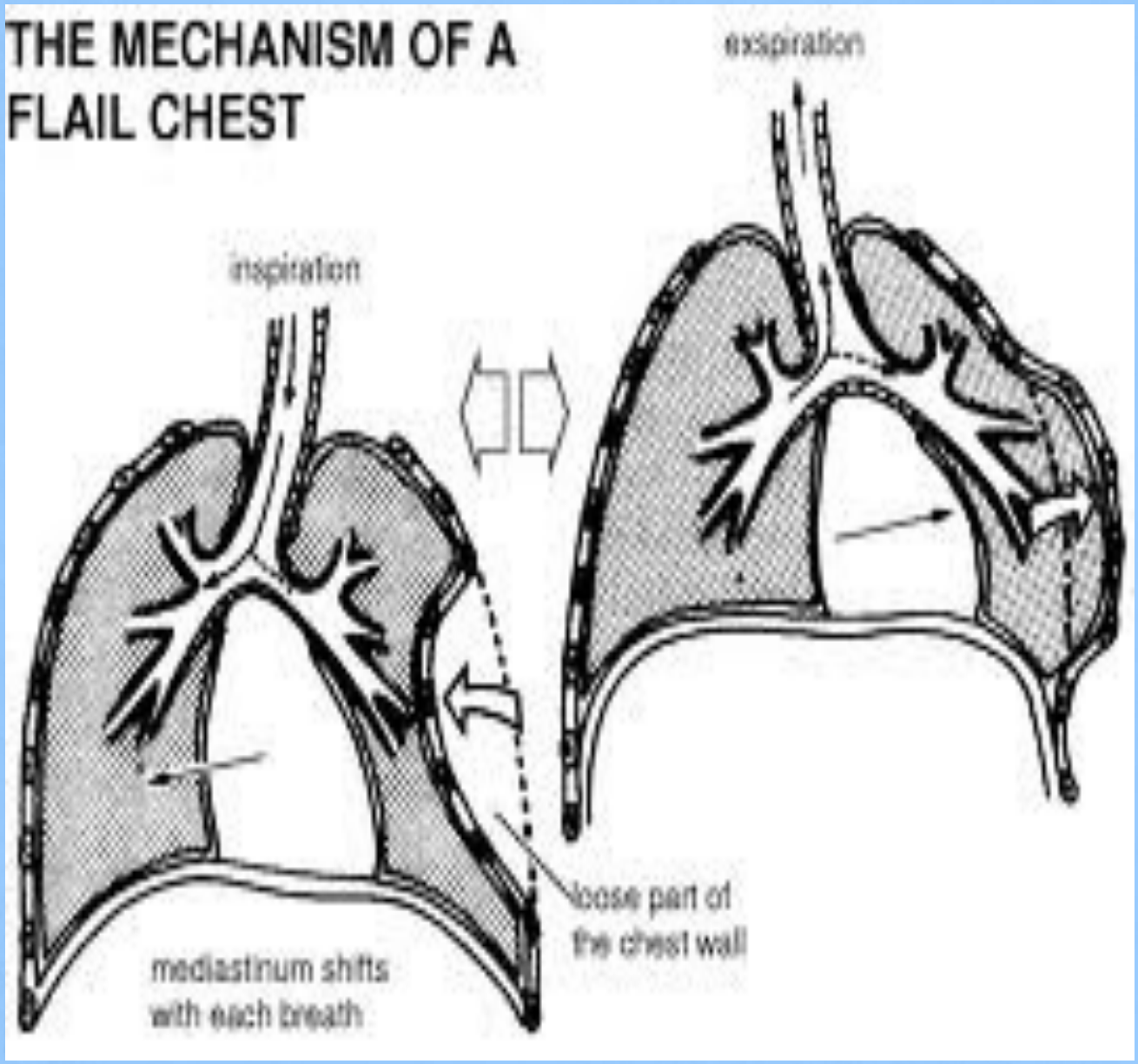
Exhalation

- Injured chest wall moves out.
- Uninjured chest wall moves in.



Flail Chest



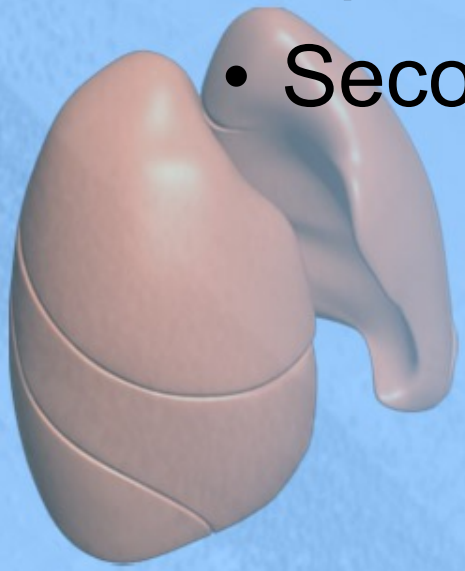

THE MECHANISM OF A FLAIL CHEST
inspiration
expiration
mediastinum shifts with each breath
loose part of the chest wall

Major Pulmonary Topics

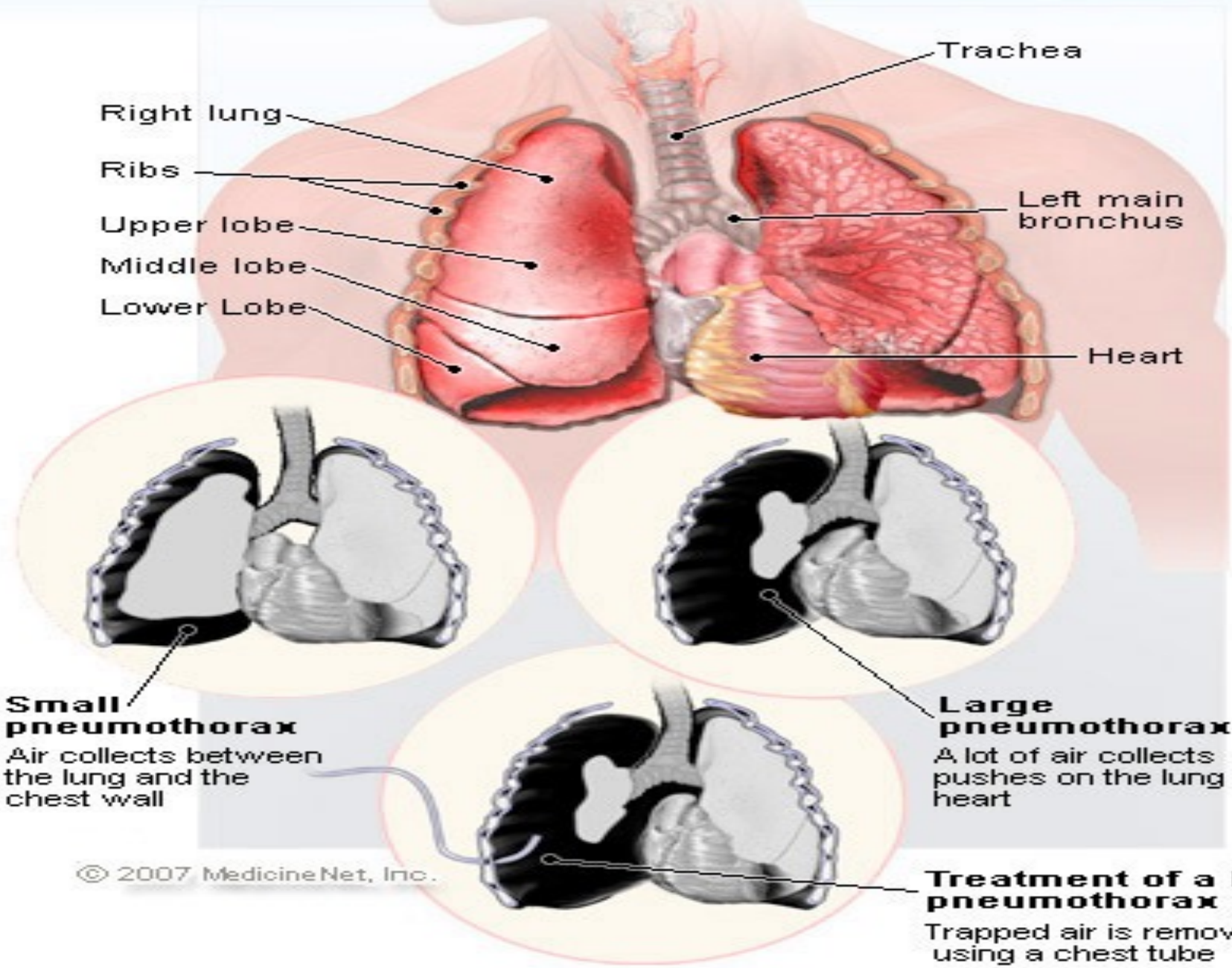
- Pleural Lesions
- Restrictive or Obstructive Lung Diseases
- Interstitial Lung Diseases
- Pulmonary Diseases of Vascular Origen
- Infections

Pleural Abnormalities

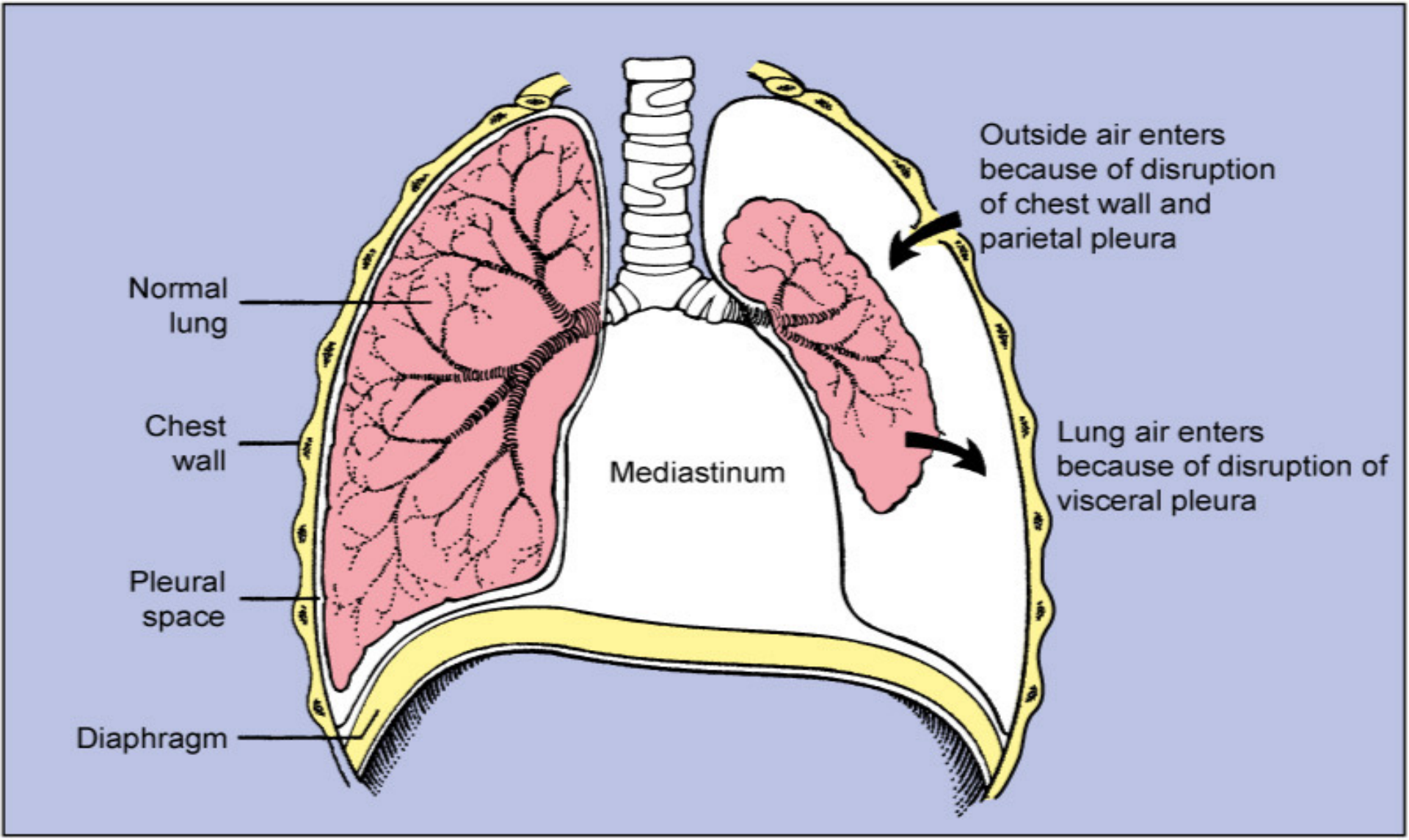
- **Pneumothorax**
  - Open pneumothorax
  - Tension pneumothorax
  - Spontaneous pneumothorax
  - Secondary pneumothorax



Pneumothorax

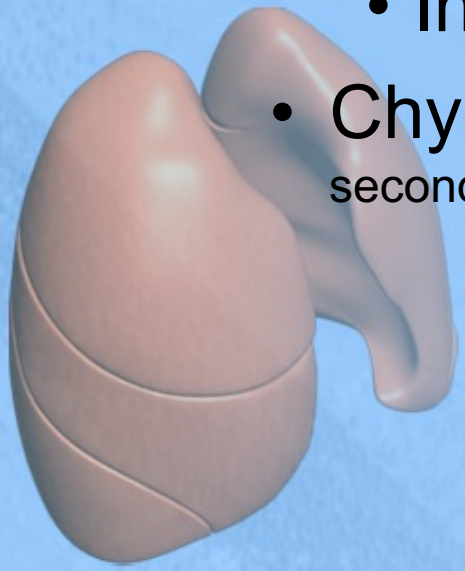


Pneumothorax

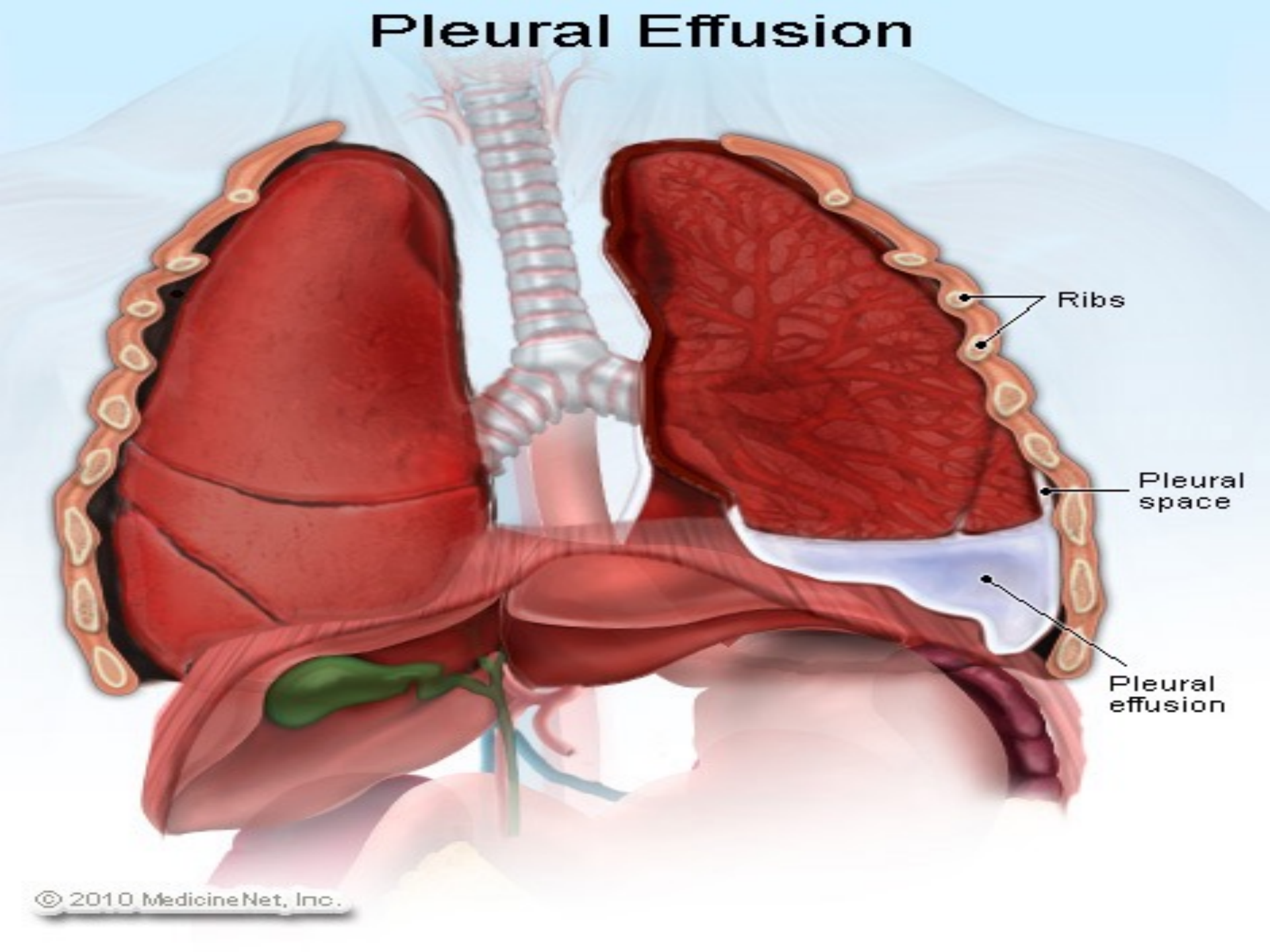


Pleural Abnormalities

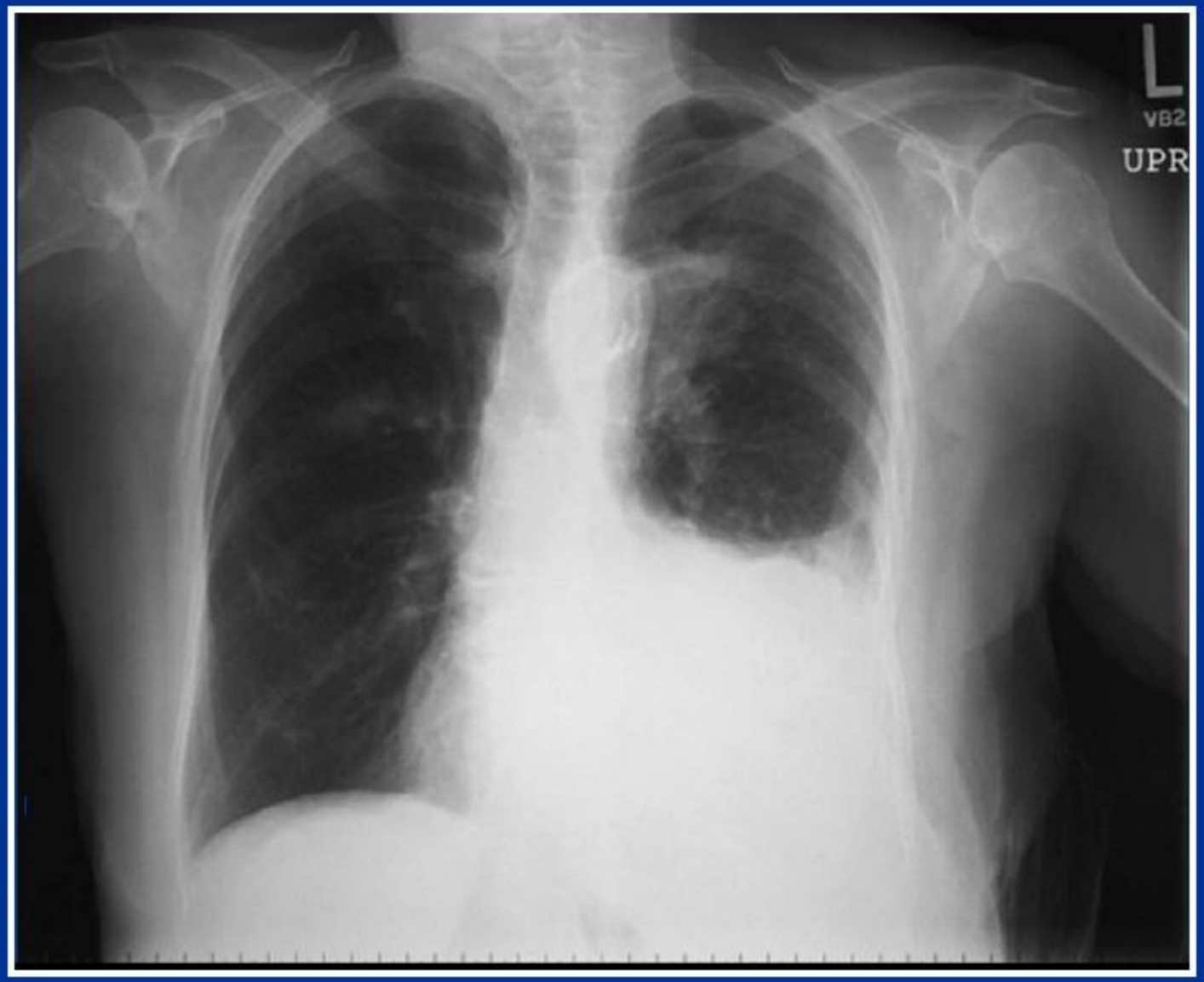
- **Pleural effusion**
  - Transudative effusion
  - Exudative effusion
  - Hemothorax
  - Empyema Collection of pus
    - Infected pleural effusion
  - Chylothorax The presence of lymphatic fluid in the pleural space secondary to leakage from the thoracic duct



Pleural Effusion



Chest X-Ray with Pleural Effusion on the Left



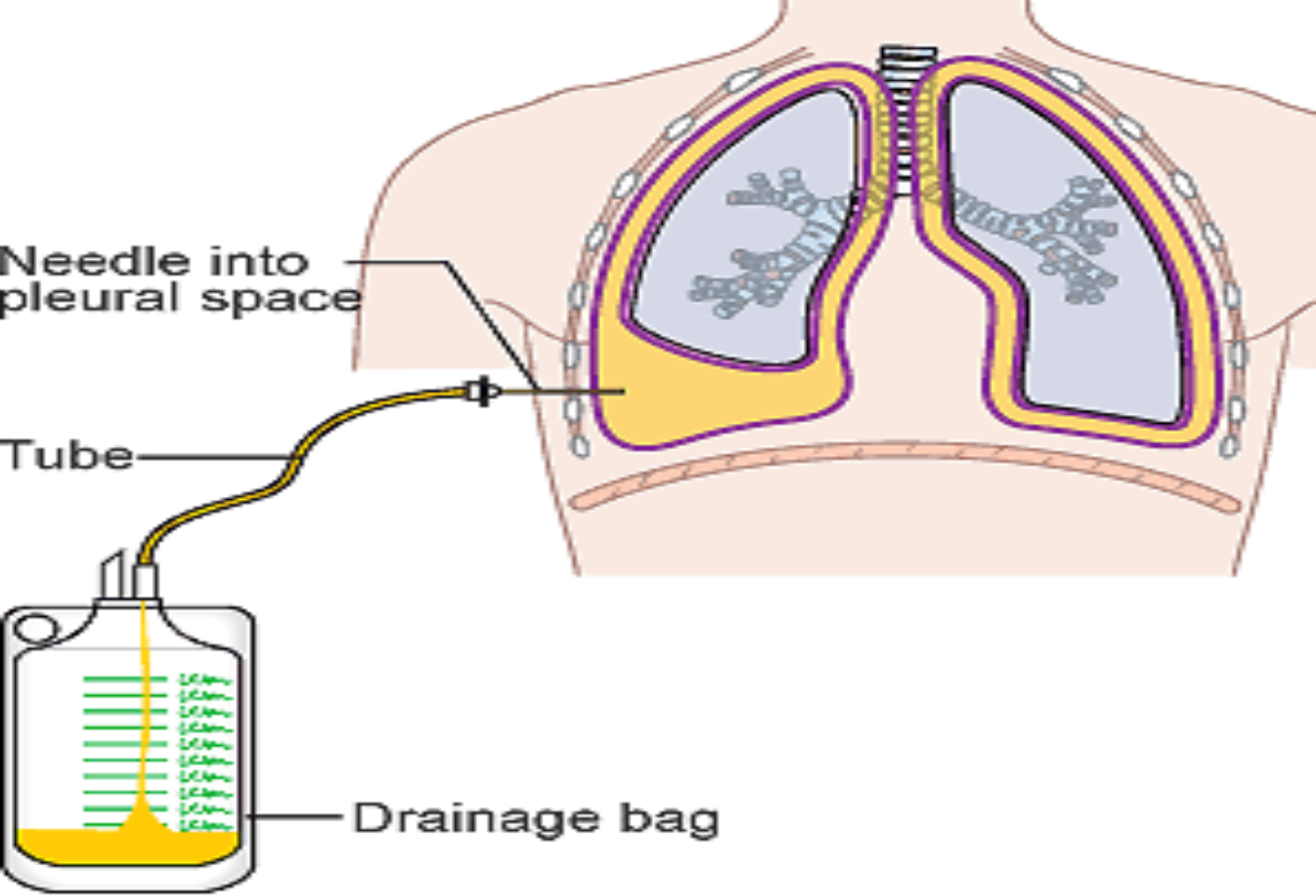


Diagram showing how a pleural effusion is drained