# BIOS 2015 … CHAPTER 13- Respiratory System Disorders

**Page** **Note**

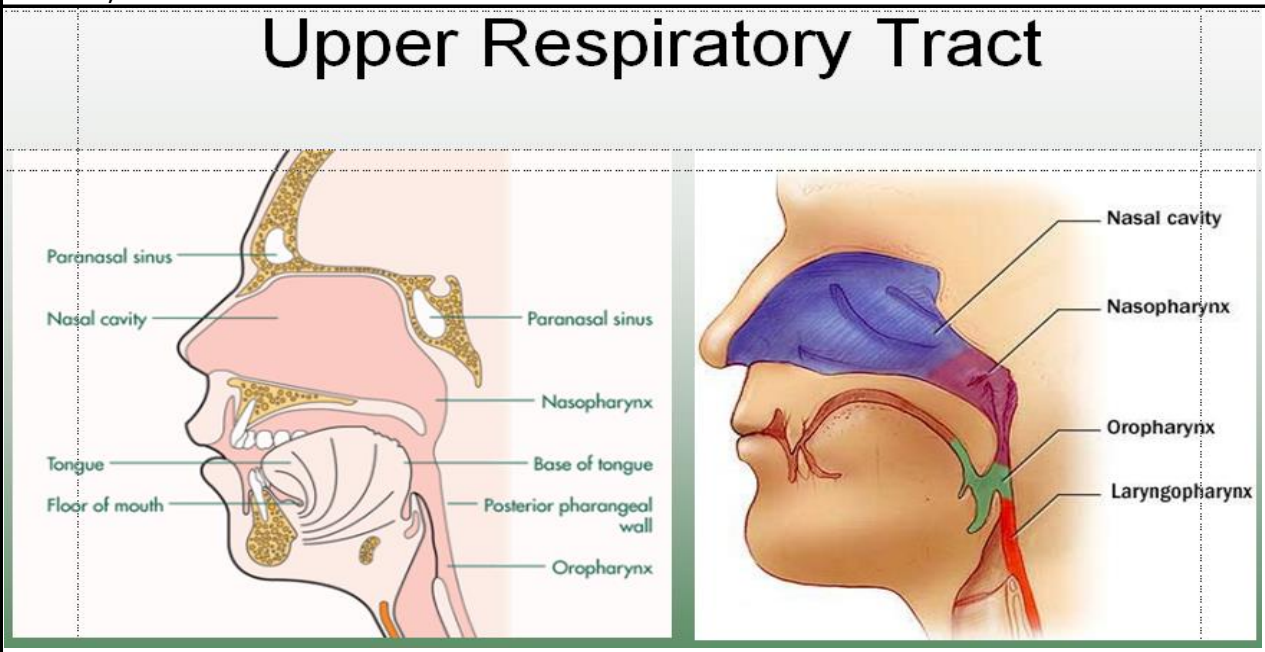
**Purpose:**

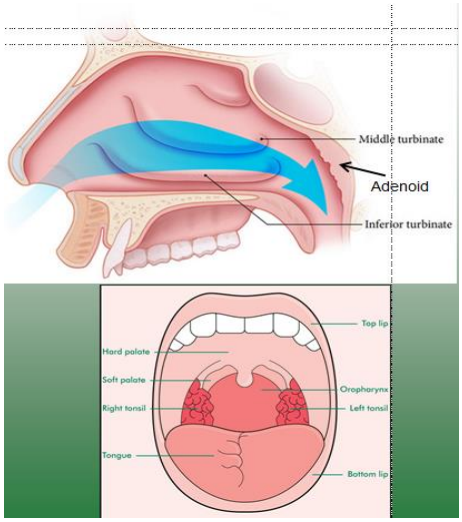
1. Transport of oxygen from air to blood
2. Removal of carbon dioxide from the blood

**Two anatomical areas**

Upper respiratory tract
- Contains resident flora

Lower respiratory tract
- Sterile, no flora.

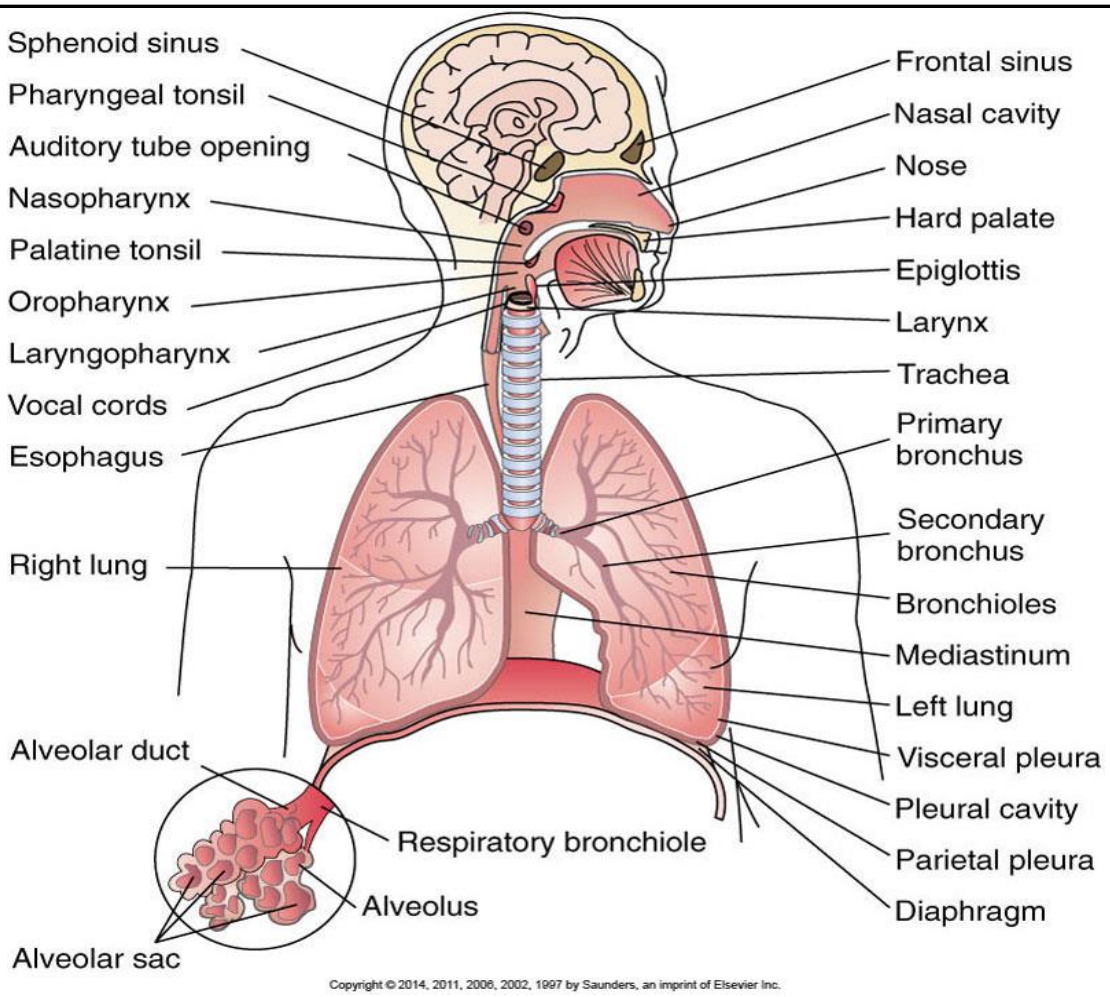



**Nasal cavity**
Warming and moistening of air
Foreign material trapped by mucous secretions

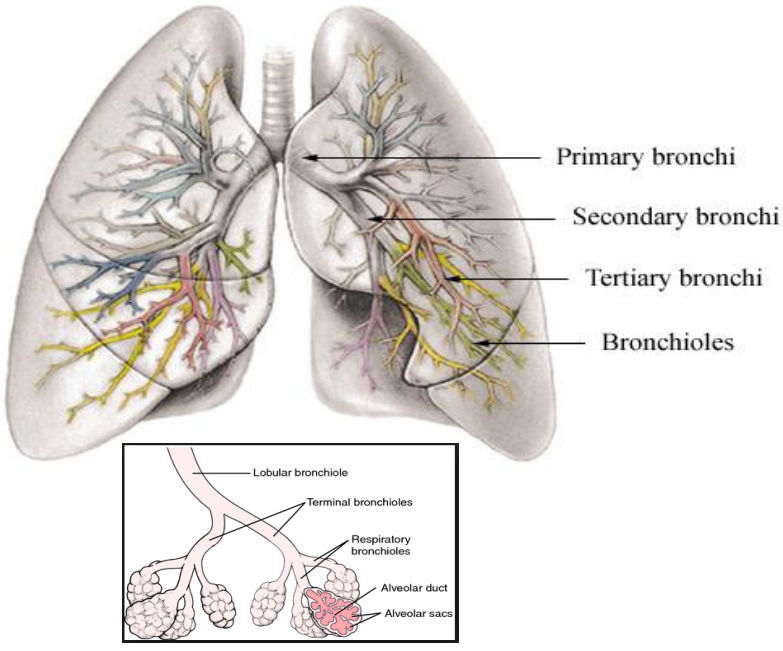
**Nasopharynx**
Pharyngeal tonsils (Adenoids) in posterior wall

**Palatine tonsils**
Lymphoid tissue in posterior portion of the oral cavity





## LOWER RESPIRATORY TRACT




Trachea branches into:
Right and left primary **bronchi**
Secondary bronchi
**Bronchioles**
**Terminal bronchioles**
**Respiratory bronchioles**
Alveolar ducts
**Alveoli**—lined by simple squamous epithelium and surfactant to reduce surface tension and maintain inflation
End point for inspired air
Site of gas exchange

**Know the progession: Bronchi > Bronchioles > Terminal Bronchioles > Respiraory Bronchioles > Alveoli**

**VENTILATION**

**Inspiration** creates low pressure in lungs and air moves into lungs
Intercostal muscles and diaphragm contract to expand the chest caviy and create low pressure.
**Expiration** creates high pressure in lungs and air moves out of lungs
Intercostal muscles and diaphragm relax and chest contracts to pre-expanded dimensions.

**Terms to know and understand:**

**Tidal volume** is the amount of air exchanged with quiet inspiration and expiration.

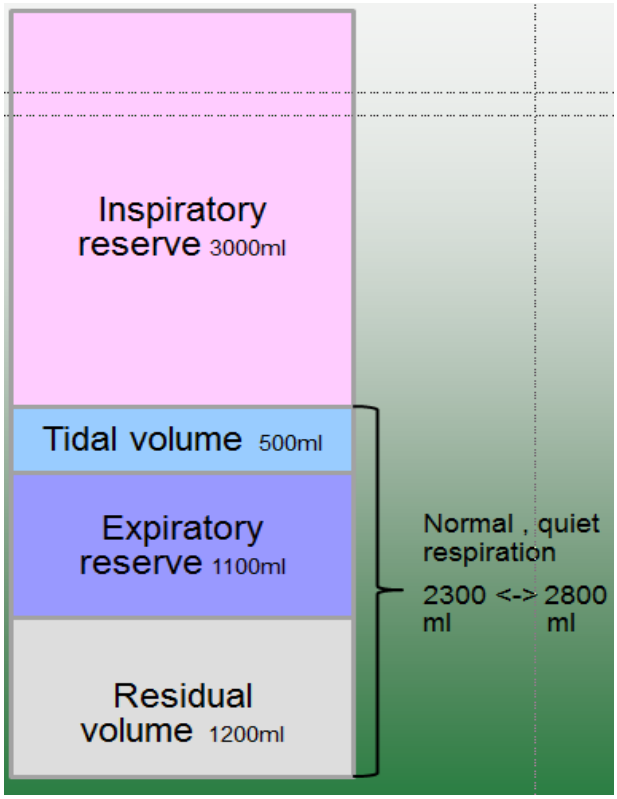
**Vital capacity**
Maximal amount of air that can be moved in and out of the lungs with a single forced inspiration and expiration

**Residual volume**
Volume of air remaining in lungs after maximum expiration

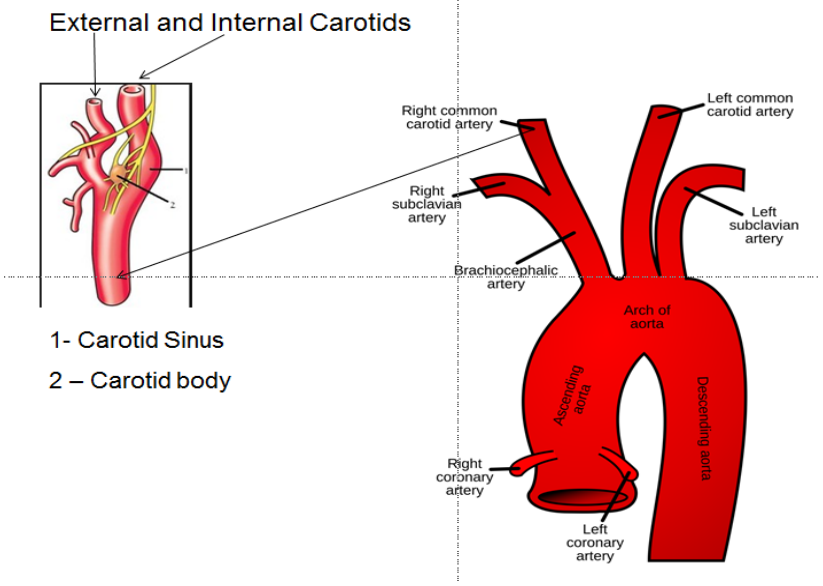
**Inspiratoy Reserve**
Maximal air that can be inhaled after quiet inspiration.

**Expiratoy Reserve**
Maximal air that can be exhaled after quiet expiration.

**Total lung capacity:**



## Review of Great Vessels




## Control of Ventilation

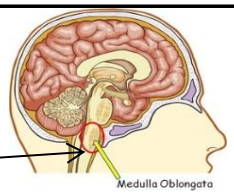
Primary control centers for breathing

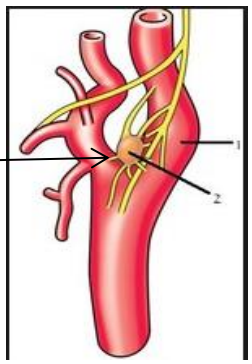
> Located in the medulla and pons

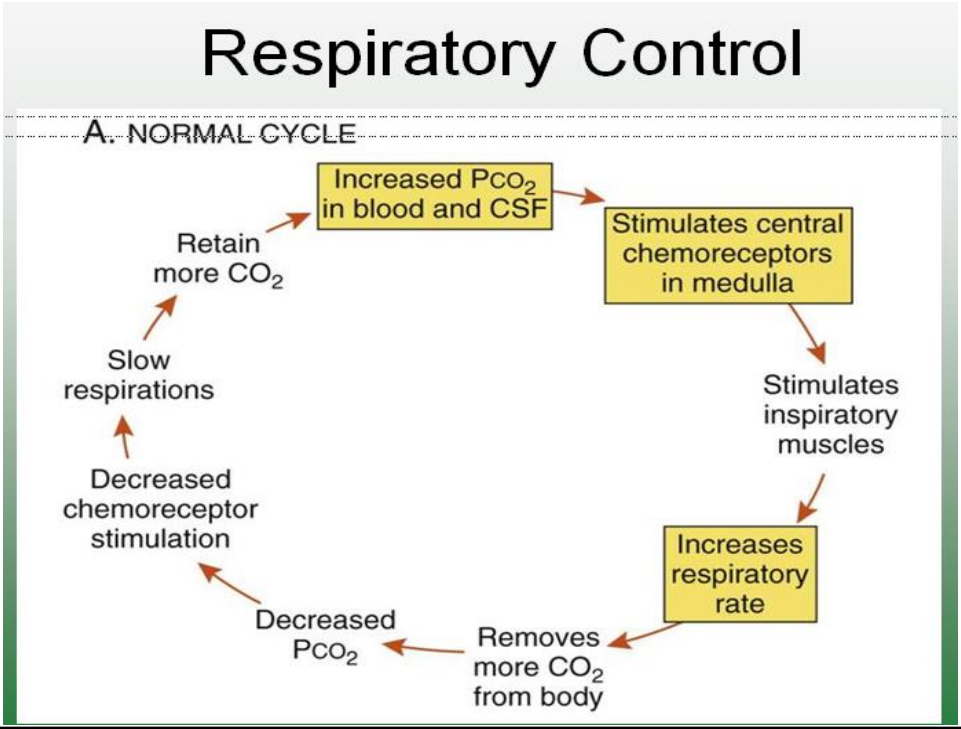
**Chemoreceptors** detect changes in **carbon dioxide level, hydrogen ion, and oxygen levels** in <u>blood or cerebrospinal fluid (CSF)</u>

> Central chemoreceptors are located in the medulla

> Peripheral chemoreceptors are located in the carotid bodies



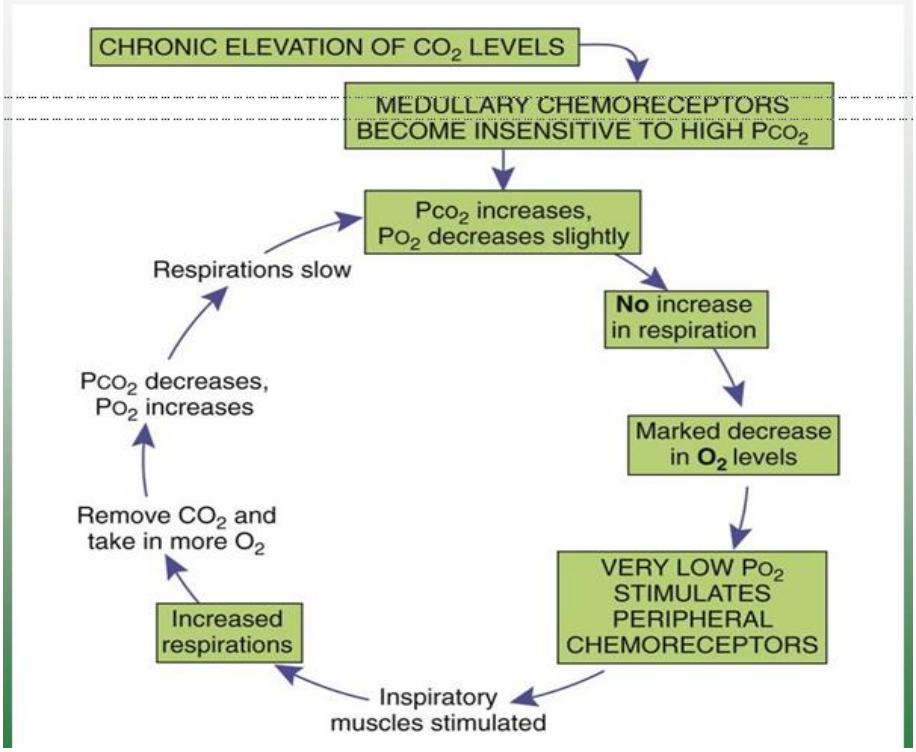






**Hypercapnia**
**Carbon dioxide** elevated in the blood.
Carbon dioxide easily diffuses into CSF.
Lowers pH and **stimulates respiratory center in medulla.**
Increased rate and depth of respirations (hyperventilation) to blow off CO2

**Hypoxemia**
Oxygen decreased in blood.
**Chemoreceptors in carotid body respond but oxygen must be significantly low**
**Usually high CO2 drives respiration before low O2.**

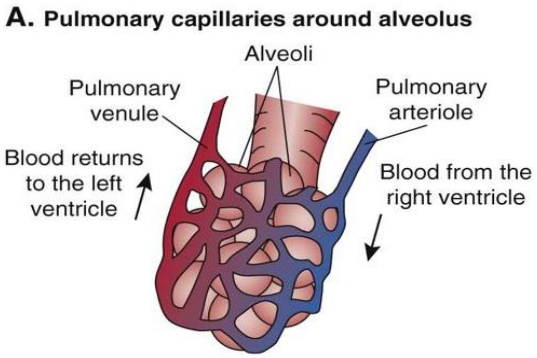
# Hypoxic Drive




Chronic Hypercapnea leads to medulla becoming tolerant and respiratory drive switchs from being driven by $CO_2$ to being sriven b $O_2$ sensed in the carotid bodies.

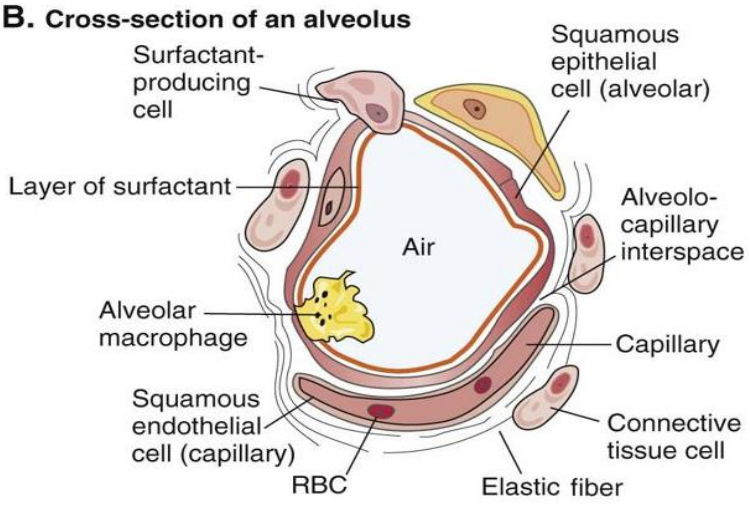
Gas exchange depends on the relative concentrations (partial pressures) of the gases.
$P_{O_2}$—partial pressure of oxygen
$P_{CO_2}$—partial pressure of carbon dioxide

Each gas in a mixture moves along its partial pressure gradient, independent of other gases




**Note the structures oxygen and carbon dioside must traverse in air - blood gas exchange.**

**Air > Surfactant > Alveolar squamous lining cell** (plasma membrane, cytoplasm, plasma membrane) **, interstitum, Endothelial cell** (plasma membrane, cytoplasm, plasma membrane) **, Erythrocyte** plasma membrane >>> bind to hemoglobin.



| | |
|---|---|
| | **Diagnostic Tests** |
| | **Spirometry**—pulmonary function test (PFT)<br>- Test pulmonary volumes and airflow times<br>**Arterial blood gas** determination ($pO_2$, $pCO_2$, pH, $HCO_3^-$).<br>- Checks oxygen, carbon dioxide, serum pH, bicarbonate.<br>**Oximetry**<br>- Measures O2 saturation of hemoglobin.<br>**Radiography**<br>- Helpful in evaluating tumors<br>- Evaluate infections<br>**Bronchoscopy**<br>- Perform biopsy.<br>- Check site of lesion or bleeding.<br>**Culture and sensitivity tests**<br>- Sputum testing for presence of pathogens<br>- Determine antimicrobial sensitivity of pathogen |
| | **Breathing patterns and characteristics** |
| | **Labored respiration or prolonged inspiration or expiration**<br>- Often associated with obstruction of airways<br><br>**<u>Audible sounds (without stehescope)</u>**<br>**Wheezing or whistling sounds**<br>- Indicate obstruction in small airways<br>**Stridor**<br>- High-pitched crowing noise<br>- Usually indicates upper airway obstruction<br><br>**<u>Sounds heard with a stethescope.</u>**<br>**Rales**<br>Light bubbly or crackling sounds, with serous secretions<br>**Rhonchi**<br>Deeper or harsher sounds from thicker mucus<br>**Absence** |
| | **Eupnea** - normal breating rate and depth. |
| | **Tachypnea** - fast rate, shallow depth. |
| | **Bradypnea** - slow rate, deeper depth. |
| | **Apnea** - cessation of breathing. |
| | **Kussmaul breathing** - rapid deep breathing, (seen in metabolic acidosis - attempting to blow off $CO_2$). |
| | **Dyspnea** - difficult breathing. |
| | **Othopnea** - dyspnea when lying down (seen with pulmonary congestion). |
| | **Paroxysmal nocturnal dyspnea -** Sudden acute dyspnea at night, Common in patients with left-sided congestive heart failure |
| | **Cyanosis**: Bluish coloring of skin and mucous membranes caused by large amounts of unoxygenated hemoglobin in blood. |

**Friction rub -** Soft sound produced as rough, inflamed, or scarred pleural move against each other

## Upper Respiratory Tract Infections (URI)

**Common Cold:**

- caused by 100's of different viruses.
- danger of secondary bacterial infection if viral infecion persists.

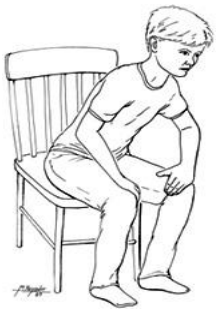
**Sinusitis** - usually bacterial.

**Laryngotracheobronchitis (croup)**

- Common viral infection, particularly in children
- Common causative organisms are Parainfluenza viruses and adenoviruses
- Infection usually self-limited

**Epiglottitis**

Acute infection common in children ages 3 to 7 years
Usually caused by **Haemophilus influenzae type B**
**Rapid onset; fever and sore throat**
**Child sits in tripod position**
**Drooling** and difficulty swallowing
Heightened anxiety
**Danger of significant obstruction from spasm if touched**



**Viral URI** - often influenza, Type A most prevalent (includes H1N1)

**Scarlet Fever**

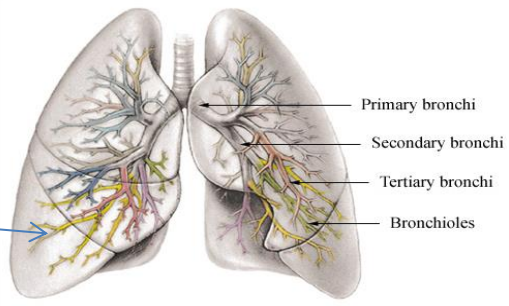
- Caused by group A β-hemolytic Streptococcus (S. pyogenes)

**Symptoms:**

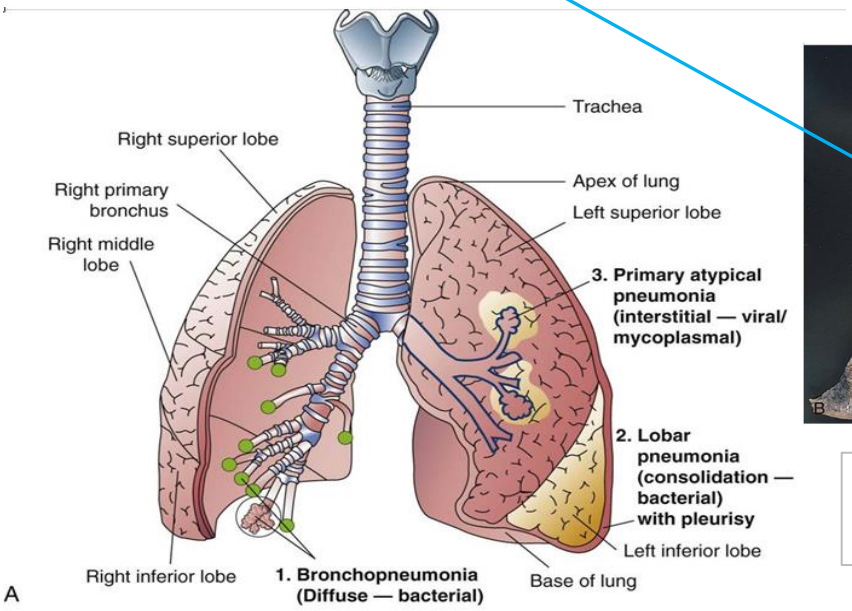
Typical "strawberry" tongue
Fever, sore throat
Chills, vomiting, abdominal pain, malais**e**

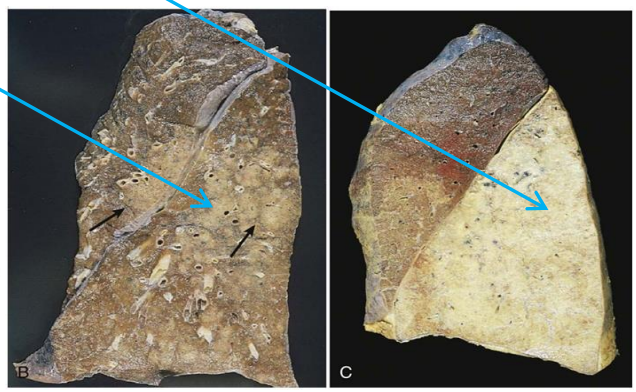
## Lower Respiratory Tract Infections

**Bronchiolitis:**
**Caused by the respiratory syncytial virus (RSV)**
Transmitted by oral droplet
Virus causes necrosis, inflammation in small bronchi and **bronchioles**
**Signs**
**Wheezing and dyspnea, rapid shallow respirations, cough, rales, chest retractions, fever, malaise**



**Pneumonia - two types: 1. Bronchopneumonia** (patchy) **and Lobar** (whole lobe invovled).




Darker color is normal lung.
Light tan area is pneumonia.

**Legionnaires' Disease**
Caused by **Legionella pneumophila**
Thrives in **warm, moist environments (airconditioner systems).**
Often nosocomial infection
**Difficult to identify—requires special culture**
Possibly fatal

**Primary Atypical Pneumonia**
**Mycoplasma pneumoniae**—bacterial
Common in older children and young adults
Infection varies greatly in severity.
**Infection is usually self-limiting.**

**Severe Acute Respiratory Syndrome (SARS)**
**-** Acute respiratory infection
Causative microbe: **SARS-associated coronavirus**
Transmission by respiratory droplets**—close contact (travelers).**

**SARS RISK FACTORS:**

**Travel to endemic or epidemic area**
**Close contact with such a traveler**

**Tuberculosis**

***Mycobacterium tuberculosis*** transmitted by oral droplets from persons with active infection

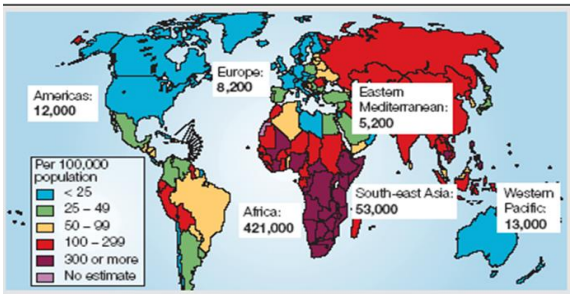
**Occurs more frequently with:**

People living in crowded conditions

Immunodeficiency, Malnutrition, Alcoholism

Conditions of war, Chronic disease, HIV infection

**Caution with immagrants from highly affected populations.**




## Tuberculosis (cont'd)

Usual caused by Mycobacterium tuberculosis

**Normal neutrophil response does not occur**

Cell-mediated immunity normally protection

Primarily affects lungs; other organs may also be invaded

### Primary infection

When organism first enters the lungs

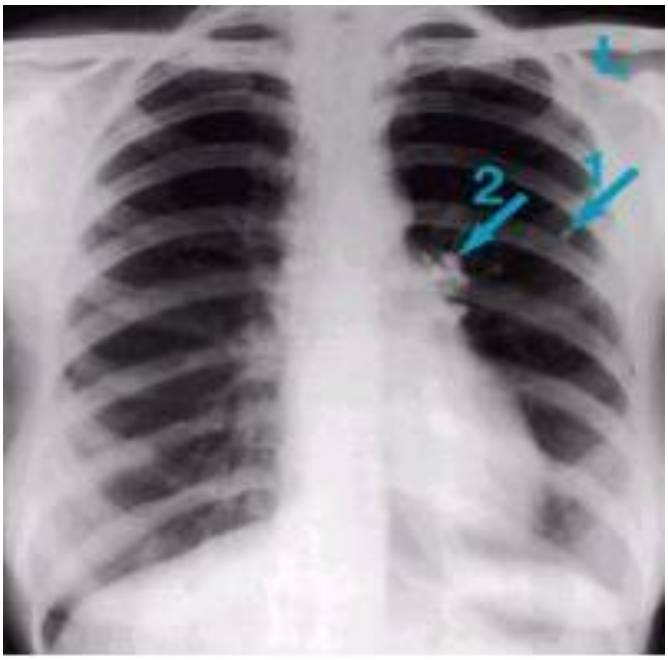
Engulfed by macrophages—local inflammation

**If cell-mediated immunity is inadequate:**
Mycobacteria reproduce and begin to destroy lung tissue. This form of disease is contagious!

**If cell-mediated immunity is adequate:**
Some bacilli migrate from the site of primary infection in the periphery of the lung (known as a Gohn lesion, seen as #1in Xray on right) to lymph nodes—granuloma froms, calcifying (seen as #2 in Xay on right).

Bacilli may remain viable in a dormant stage for years. Individual's resistance and immune responses high, bacilli remain walled off.

Primary or latent infection—individual has been exposed and infected, but does not have disease and



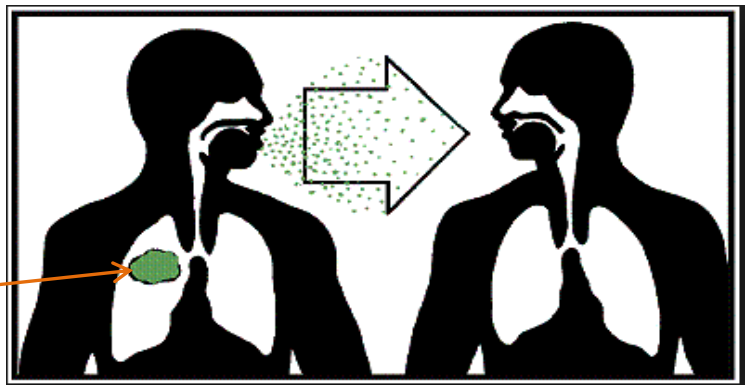

### Secondary or re-infection with TB

**Occurs when client's cell-mediated immunity is impaired** because of:
Stress, Malnutrition, HIV infection, Age

Mycobacteria begin to reproduce and infect lung.

**Often seen as apical cavitation**

**Active TB, which can be spread to others!**



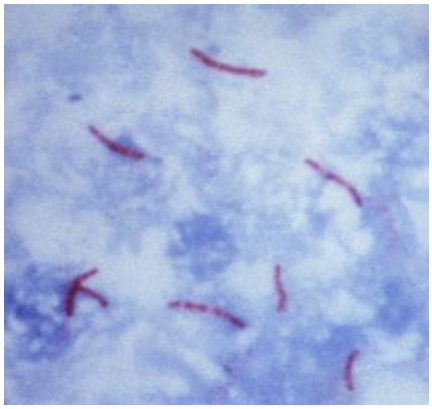
## Tuberculosis (cont'd)

**Miliary or extrapulmonary tuberculosis**
Rapidly progressive form more common in children < 5 years
**Early dissemination to other tissues**
**If lesions are not found in the lungs, this is not contagious.**
Common symptoms include weight loss, failure to thrive, and other infections such as measles

**Diagnostic tests**
**First exposure or primary infection**
- Indicated by positive tuberculin (skin) test results
- Blood test – Quantiferon.

**Active infections**
Acid-fast sputum test.
Chest radiograph
Sputum culture and sensitivity

**Treatment**
Long-term treatment with a combination of drugs
Length of treatment varies from 6 to 12 months.



**HISTOPLASMOSIS**
Fungal infection caused by the yeast - *Histoplasma capsulatum*

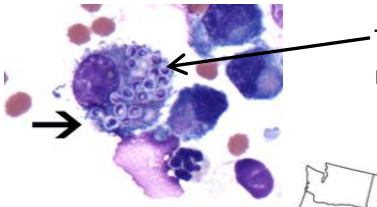
Spores can be inhaled on dust particles.

Common opportunistic infection

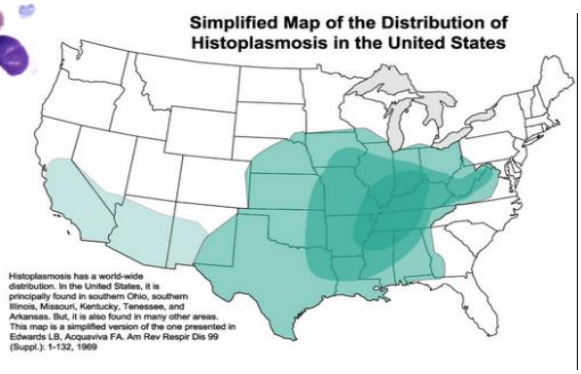
First stage often asymptomatic

Second stage - Granuloma formation and necrosis

**Suspect if from endemic region and has characteristic chest X-ray**



Tiny yeasts filling cytoplasm of a macrophage.




## Anthrax:

Bacterial infection by gram-positive bacilli
Inhalation anthrax
Flulike symptoms
Severe acute respiratory distress
Shock caused by release of toxins
**High fatality rates**

# OBSTRUCTIVE LUNG DISEASE

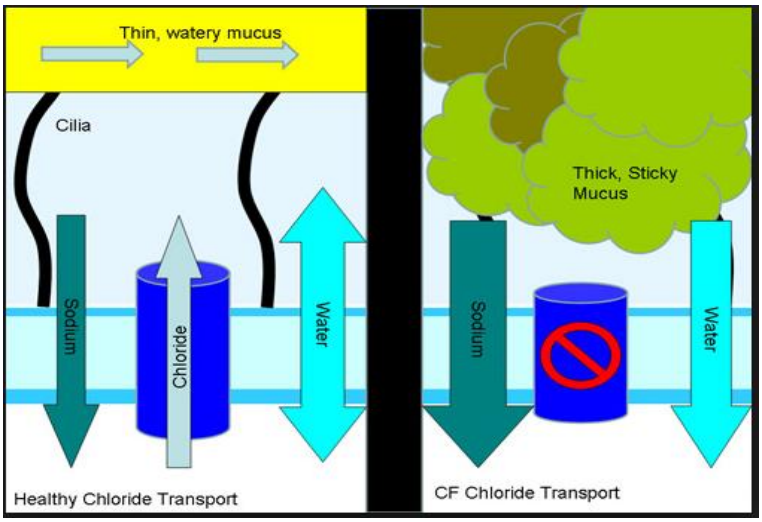
## Cystic Fibrosis

Inherited (genetic) disorder
Gene located on chromosome 7
- cystic fibrosis transmembrane conductance regulator (CFTR)

Tenacious mucus from exocrine glands

**Primary effects seen in lungs and pancreas**

**Lungs**
Mucus obstructs airflow in bronchioles and small bronchi.
Permanent damage to bronchial walls
**Infections are common.**
Commonly caused by
***Pseudomonas aeruginosa*** and
***Staphylococcus aureus***




**In sweat glands, the opposite occurs resulting in high levels of salt in the sweat**

**Digestive tract**
- **Meconium ileus** in newborns (mucoid stood impaction).
- **Blockage of pancreatic ducts** (and pancreatic juice that contains **lipase to digest fat**)
> leads to fatty stool – steatorrhea.
- **Obstruction of bile ducts** (and bile **that helps digest fat**).
- **Salivary glands** often mildly affected

**Reproductive tract (infertility).**
- Obstruction of vas deferens (male), blocks sperm transport from testes to semen.
- Obstruction of cervix (female), thick mucus blocks sperm entrance into uterus.

**Diagnosis**
Sweat chloride test (entry level test).
Genetic testing (definitive mutation analysis of CFTR)

**Treatment**
Interdisciplinary approach
Replacement therapy and well-balanced diet
High protein, low fat, and vitamin
Pancreatic enzymes and bile salts.
Chest physiotherapy
- Including postural drainage, percussion, and coughing

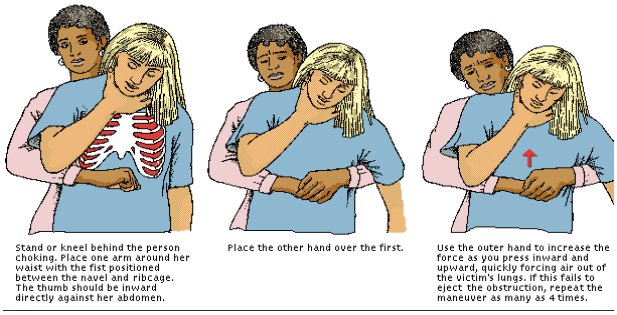
## Lung Cancer

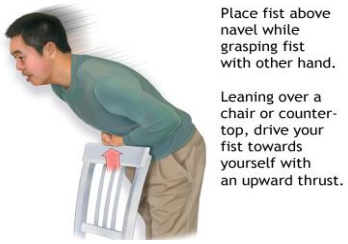
- About 90% of cases are related to smoking.
- **Bronchogenic carcinoma** is the most common type of primary malignant lung tumor
- Presents as a **chronic cough with bright red blood tinged sputum**, weight loss, fatigue
- Paraneoplastic syndrome - tumor secretes a hormone that produces a systemic effect.

**Aspiration**

- Passage of food, fluid, emesis, other foreign material into trachea and lungs
- Common problem in young children or individuals laying down when eating or drinking
- A complication of a **diminished gag reflex** (post anesthesia, sedating drugs, CNS damage-stroke).
- **Can lead to airway obstruction, chemical irritation (stomach acid), and aspiration pneumonia. Massive aspitation can be fatal.**

Treat obstruction with Heimlich maneuver (different for babies).






Sleep apnea - Pharyneal collapse and momentary cessation of breathing.

Treatment - Continuous positive airway pressure pump (CPAP machine)

**Asthma**

- Causes bronchial obstruction
- Occurs in persons with **hypersensitive or hyperresponsive airways**
- May occur in childhood or have an adult onset

**Extrinsic asthma**

**' - Acute episodes triggered by type I hypersensitivity (allergic) reactions**

**Intrinsic asthma**

' - Onset during adulthood

- **Hyperresponsive tissue in airway initiates attac**k.

Stimuli include:

- Respiratory infections, Stress, Exposure to cold, Inhalation of irritants, Exercise, Drugs

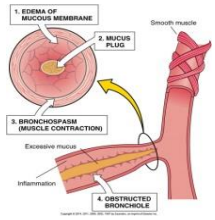
**Pathophysiological changes of bronchi and bronchioles**

'- **Inflammation** of the mucosa with edema

- **Bronchoconstriction, caused by contraction of smooth muscle**
- Increased secretion of **thick mucus**

**In airways:**

- Changes create obstructed airways, partial or total.



**Status asthmaticus**
**Persistent severe attack of asthma**
Does not respond to usual therapy
Medical emergency!
**May be fatal** because of severe hypoxia and acidosis

## Chronic Obstructive Pulmonary Disease (COPD)

Group of chronic respiratory disorders

Causes irreversible and progressive damage to lungs including scarring. Compromises expiration.

Debilitating conditions that may affect individual's ability to work

Examples include emphysema, chronic bronchitis, and chronic asthma

## Emphysema

**EMPHYSEMA**
Progressive difficulty with expiration.

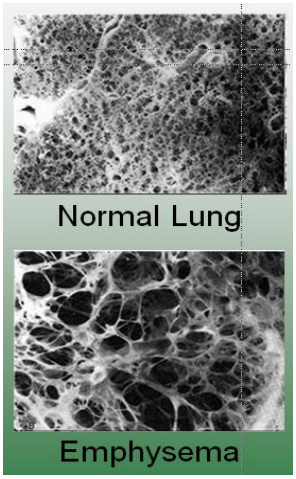
**Air trapping and increased residual volume with overinflation of the lungs.**

**Increased anterior-posterior diameter of thorax (barrel chest)**

**Flattened diaphragm (on radiographs)**

Hypercapnia becomes marked.

**Hypoxia becomes driving force of respiration**




## Chronic Bronchitis

I**nflammation, obstruction, repeated infection**, chronic coughing twice for 3 months or longer in 2 years
History of cigarette smoking or living in urban or industrial area
**Mucosa inflamed and swollen**
Hypertrophy and hyperplasia of mucous glands
Fibrosis and thickening of bronchial wall
Low oxygen levels
**Severe dyspnea and fatigue**
Pulmonary hypertension and cor pulmonale (right ventricular hypertrophy).

**Treatment**
Cessation of smoking and **reduction of exposure to irritants**
**Treatment of infection**
Vaccination for prophylaxis
Expectorants
**Bronchodilators**

## Bronchiectasis

Usually a **secondary condition**
**Irreversible abnormal dilation of the medium-sized bronchi (primarily)**
Arises from recurrent inflammation and infection
Leads to obstruction of airways, weakening of muscle and elastic fibers in bronchial walls, or both
**Stagnation leads to infections.**

## Restrictive Lung Disease

Group of disorders with impaired lung expansion and reduced total lung capacity
**First group**
**Abnormality of chest wall**—limits or impairs lung expansion
Kyphosis or scoliosis, poliomyelitis, amyotrophic lateral sclerosis, botulism, muscular dystrophy
**Second group**
**Diseases** affecting the supporting framework of lungs
Idiopathic **pulmonary fibrosis**, occupational diseases

## Pneumoconioses

Chronic restrictive diseases resulting from long-term exposure to irritating particles
Often named relative to the irritant.

| Disease | Agent | Occurrence |
|---|---|---|
| Coal workers disease or anthracosis | Coal dust | Coal mines |
| Silicosis | Silica | Stone-cutting, sand-blasting, mines |
| Asbestosis | Asbestos | Insulation, shipbuilding |
| Farmer's lung | Fungal spores | Hay |

**Know the above table**

**BONUS question on test:**
know how to spell the pneumoconiosis that comes from breathing volcanic ash.

Pneumonoultramicroscopicsilicovolcanoconiosis

Pneumono-ultra-microscopic-silico-volcano-coniosis

## Expansion Disorders

**Atelectasis** - collapsed lung
Mechanisms include airway obstruction or compression, fibroisis, and post anesthesia collapse.

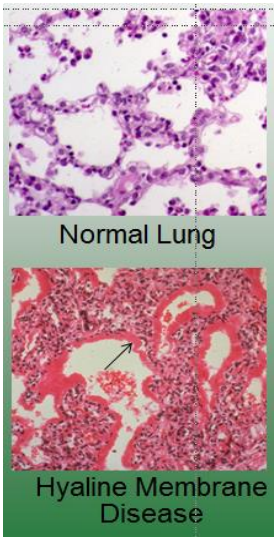
| | |
|---|---|
| | |
| | **Pneumothorax:** |
| | Air in pleural space compresses lung |
| | **Open Pneumothorax** - hole in chest wall allows air to be sucked into pleural space on inspiration. |
| | **Closed Pneumothorax** - leak in lung at pleural surface, like a ruptured bleb or tear in visceral pleura, leads to air filling pleural space. |
| | **Tension Pneumothorax** - very large pneumothorax that not only collapses the adjacent lung but also shifts the thoracic contents applying significant pressure on the tachea and opposite lung. |
| | |
| | **Infant Respiratory Distress Syndrome (Hyaline membrane disease)** |

Usually related to **premature birth**

**Lack of surfactant in alveoli**

Poorly developed alveoli are difficult to inflate.
Diffuse atelectasis results.
Decreased pulmonary blood flow—pulmonary vasoconstriction—severe hypoxia

Poor lung perfusion and lack of surfactant
Increased alveolar capillary permeability
**Fluid and protein are leaking into the interstitial area and alveoli, hyaline membrane formation**




| | |
|---|---|
| | **Adult Respiratory Distress Syndrome (ARDS)** |
| | |
| | - similar pathology to hyaline membrane disease but not due to low surfactant |
| | Due to: |
| | Multitude of predisposing conditions that damage alveolar capillaries and subsequently alveolar lining cells.<br>Often associated with multiple organ dysfunction or failure |
| | |
| | END OF NOTES |