The Respiratory System

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Respiratory System: Oxygen Delivery System

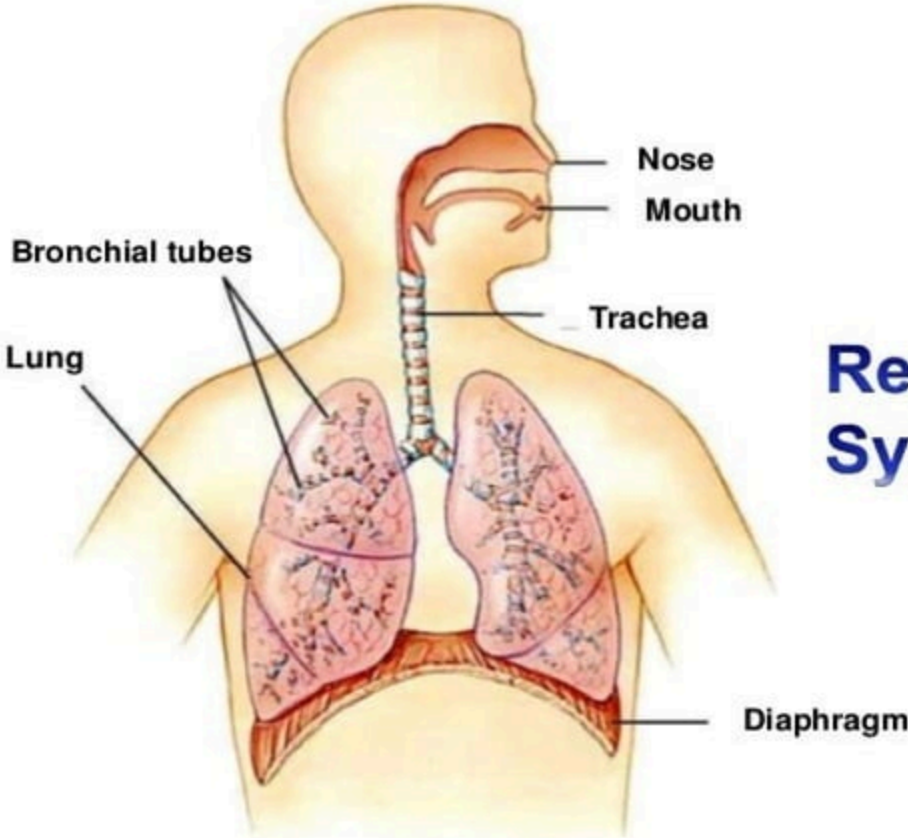
- *The respiratory system is the set of organs that allows a person to breathe and exchange oxygen and carbon dioxide throughout the body.*
- *The integrated system of organs involved in the intake and exchange of oxygen and carbon dioxide between the body and the environment and including the nasal passages, larynx, trachea, bronchial tubes, and lungs.*

The respiratory system performs two major tasks:

- Exchanging air between the body and the outside environment known as ***external respiration.***
- Bringing oxygen to the cells and removing carbon dioxide from them referred to as ***internal respiration.***



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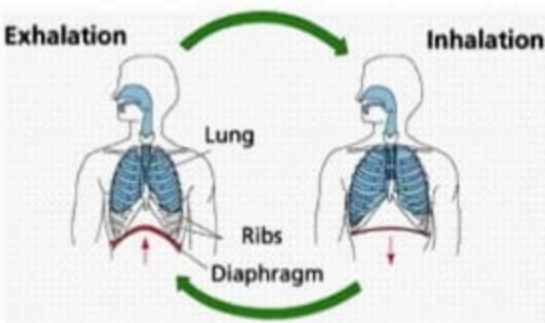
Respiratory System

Functions Of Respiratory System

1. Supplies the body with oxygen and disposes of carbon dioxide
2. Filters inspired air
3. Produces sound
4. Contains receptors for smell
5. Rids the body of some excess water and heat
6. Helps regulate blood pH

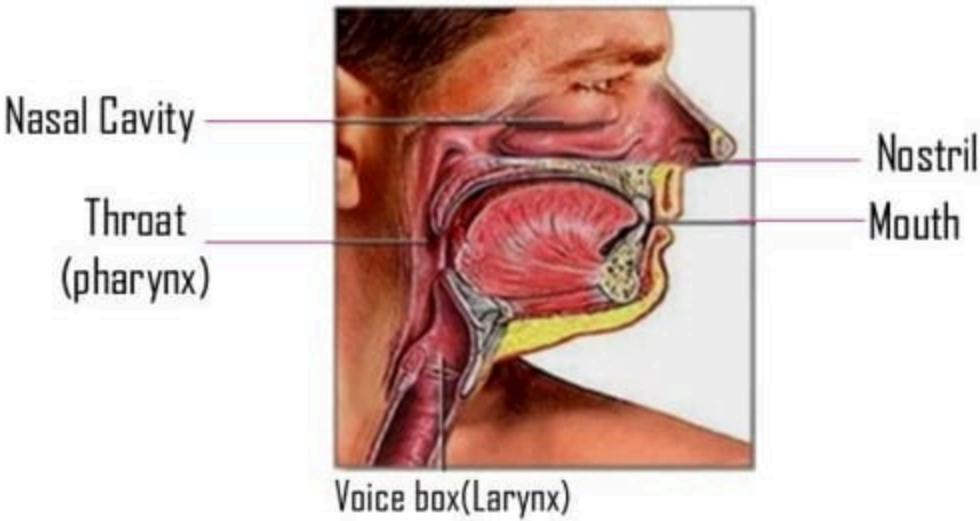
Breathing

- Breathing (pulmonary ventilation). consists of two cyclic phases:
  - **Inhalation**, also called inspiration - draws gases into the lungs.
  - **Exhalation,** also called expiration - forces gases out of the lungs.



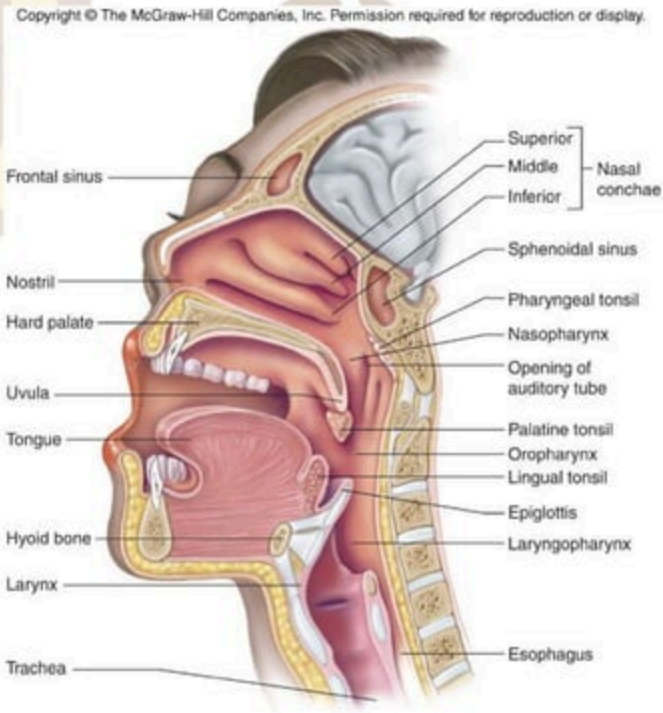
External Respiration

- Air from the outside environment enters the nose or mouth during **inspiration** (*inhalation*).
- Composed of the **nose** and nasal cavity, paranasal sinuses, pharynx (throat), larynx.
- All part of the conducting portion of the respiratory system.



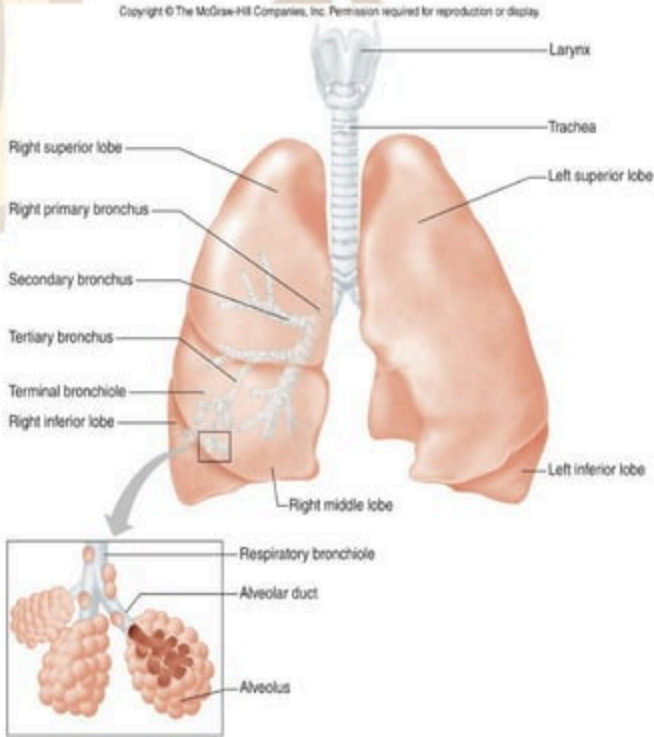
Divisions of the Respiratory System

- Upper respiratory tract (outside thorax)
  - Nose
  - Nasal Cavity
  - Sinuses
  - Pharynx
  - Larynx



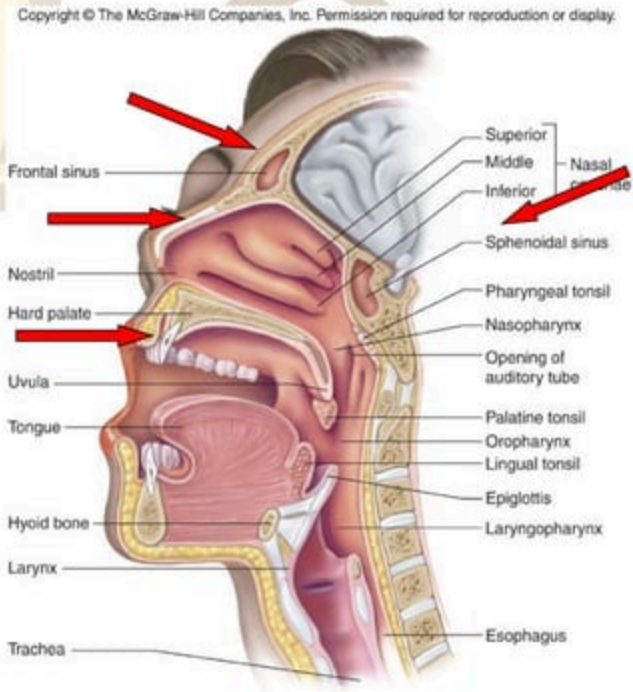
Divisions of the Respiratory System

- Lower respiratory tract (within thorax)
  - Trachea
  - Bronchial Tree
  - Lungs



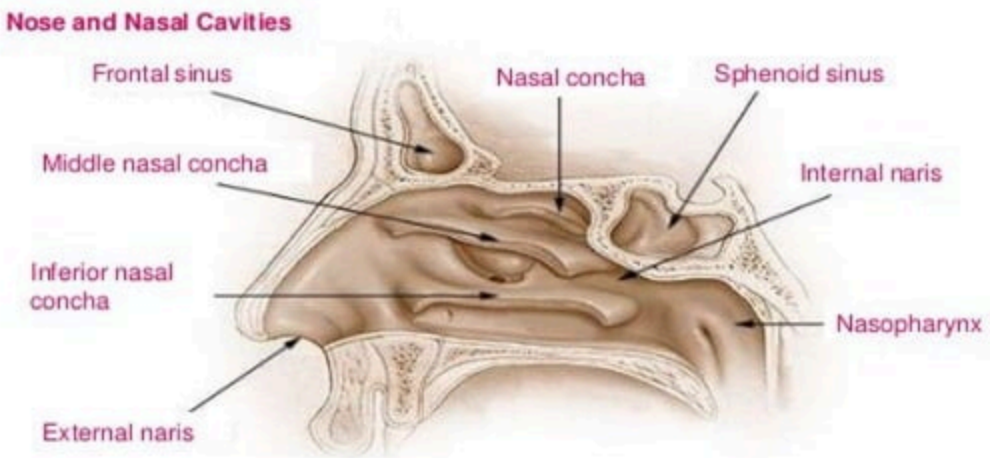
Structures of the Upper Respiratory Tract

- **Nose** - warms and moistens air
  - **Palantine bone** separates nasal cavity from mouth.
    - **Cleft palate** - Palantine bone does not form correctly, difficulty in swallowing and speaking.
  - **Septum** - separates right and left nostrils
    - rich blood supply = nose bleeds.
  - **Sinuses** - 4 air containing spaces – open or drain into nose - (lowers weight of skull).



Nose

- Also called external nares.
- Divided into two halves by the **nasal septum.**
- Contains the **paranasal sinuses** where air is warmed.
- Contains **cilia** which is responsible for filtering out foreign bodies.



- **Internal nares -** opening to exterior
- **External nares -** opening to pharynx
- **Nasal conchae -** folds in the mucous membrane that increase air turbulence and ensures that most air contacts the mucous membranes

Provides and airway for respiration

- Moistens and warms entering air
- Filters and cleans inspired air
- Resonating chamber for speech
  - detects odors in the air stream

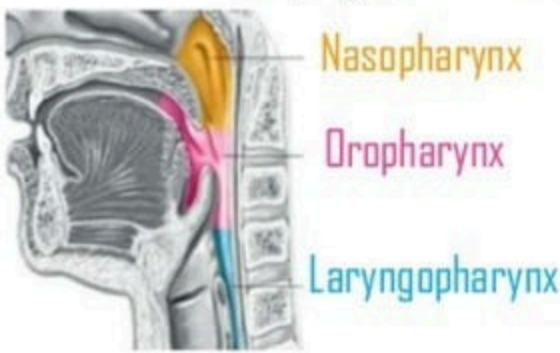
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Pharynx

- Common space used by both **the respiratory** and **digestive systems**.
- Commonly called **the throat**.
- Originates posterior to the nasal and oral cavities and extends inferiorly near the level of the bifurcation of the **larynx** and **esophagus**.
- Common **pathway** for both **air** and **food**.
- Walls are lined by a mucosa and contain skeletal muscles that are primarily used for swallowing.
- Flexible lateral walls are distensible in order to force swallowed food into the esophagus.

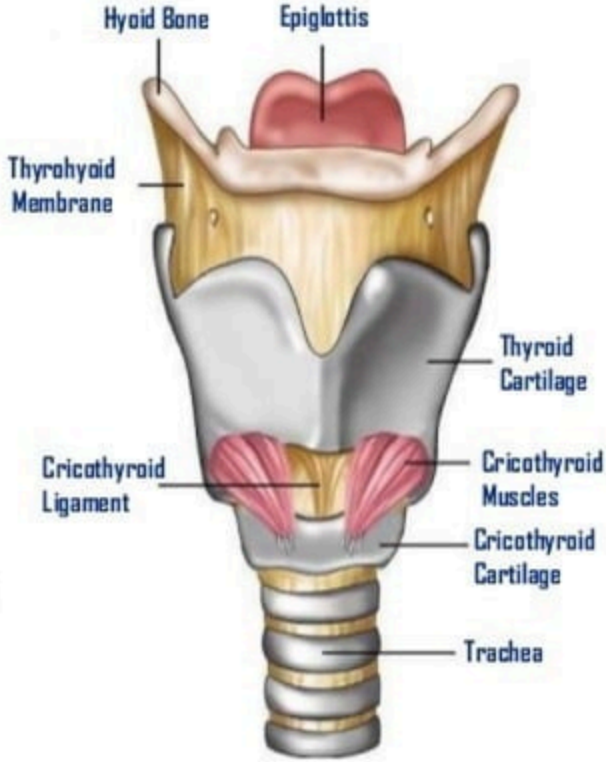
Three Sections of the Pharynx

- Nasopharynx
  - contains the *pharyngeal tonsils* (adenoids) which aid in the body's immune defense.
- Oropharynx
  - back portion of the mouth that contains the *palatine tonsils* which aid in the body's immune defense.
- Laryngopharynx
  - bottom section of the pharynx where the respiratory tract divides into the *esophagus* and the *larynx*.



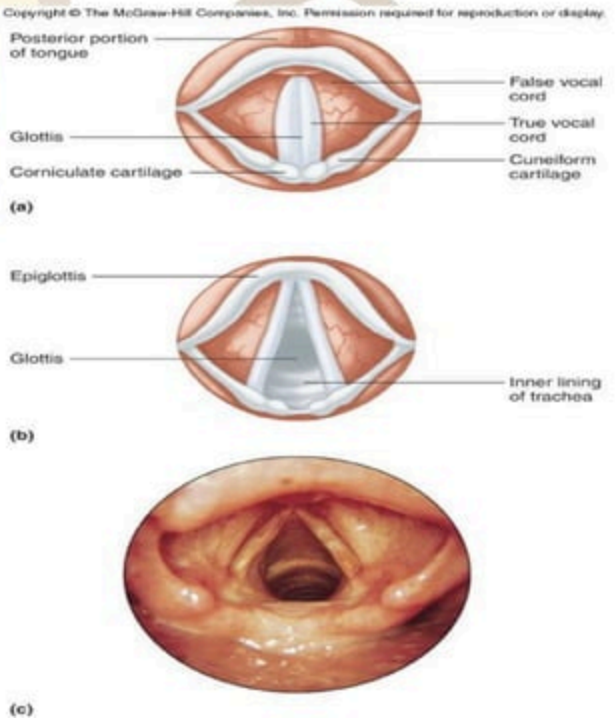
Larynx

- **Voice box** is a short, somewhat cylindrical airway ends in **the trachea**.
- Prevents swallowed materials from entering the lower respiratory tract.
- Conducts air into the lower respiratory tract.
- Produces sounds.
- Supported by a framework of nine pieces of cartilage (three individual pieces and three cartilage pairs) that are held in place by ligaments and muscles.



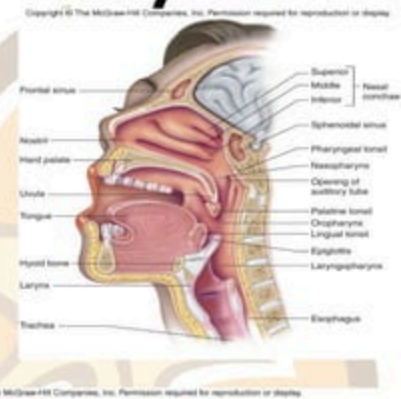
Structures of the Lower Respiratory Tract

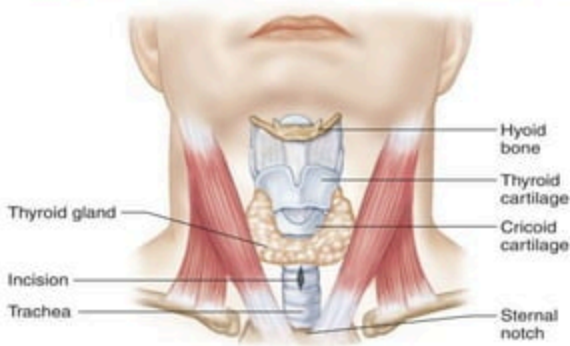
- **Larynx** - voice box
  - Root of tongue to upper end of trachea.
  - Made of cartilage
  - 2 pairs of folds
    - Vestibular - false vocal cords
    - True vocal cords



Structures of the Lower Respiratory Tract larynx cont…

- **Thyroid cartilage** - adam's apple - larger in males due to testosterone.
- **Epiglottis** - flap of skin (hatch) on trachea, moves when swallowing and speaking.
  - closes off trachea when swallowing food

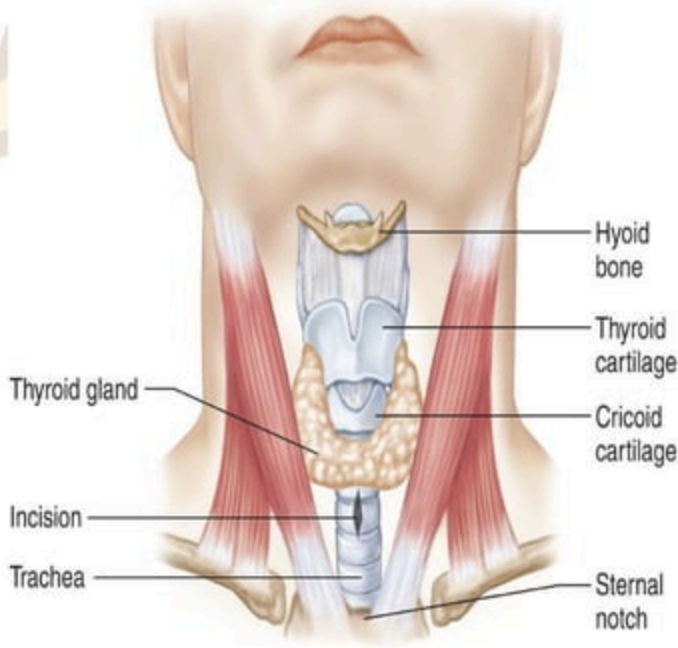




Structures of the Lower Respiratory Tract

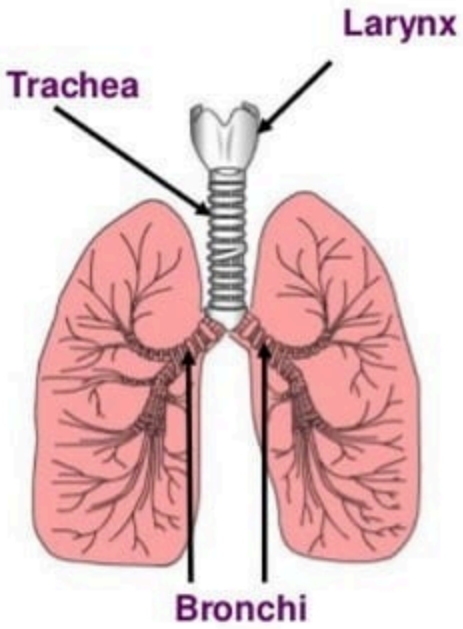
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- **Trachea (windpipe)**
  - Larynx to bronchi
  - Consists of smooth cartilage and C shaped rings of cartilage.
  - **Tracheostomy** - cutting of an opening in trachea to allow breathing.



Trachea

- A flexible tube also called *windpipe*.
- Extends through the mediastinum and lies anterior to the esophagus and inferior to the larynx.
- Cartilage rings reinforce and provide rigidity to the tracheal wall to ensure that the trachea remains open at all times.
- At the level of the sternal angle, the trachea bifurcates into two smaller tubes, called the right and left primary **bronchi**.
- Each primary bronchus projects laterally toward each lung.



TRACHEA

- Structures associated with the trachea:

✓ Superiorly : the larynx.

✓ Inferiorly :the right & left bronchi.

✓ Anteriorly :Isthmus of Thyroid gland & the arch of the aorta & the sternum.

✓ Posteriorly :the esophagus separates the trachea from the vertebral column.

✓ Laterally :the lungs

STRUCTURE OF THE TRACHEA

- It is composed of 3 layers of tissues & held by between 16-20 incomplete rings of hyaline cartilage.
- Rings are incomplete posteriorly.
- Connective tissues & involuntary muscle join the cartilages & form the posterior wall which is in contact with the esophagus.

Con..

- Three layers of tissue:

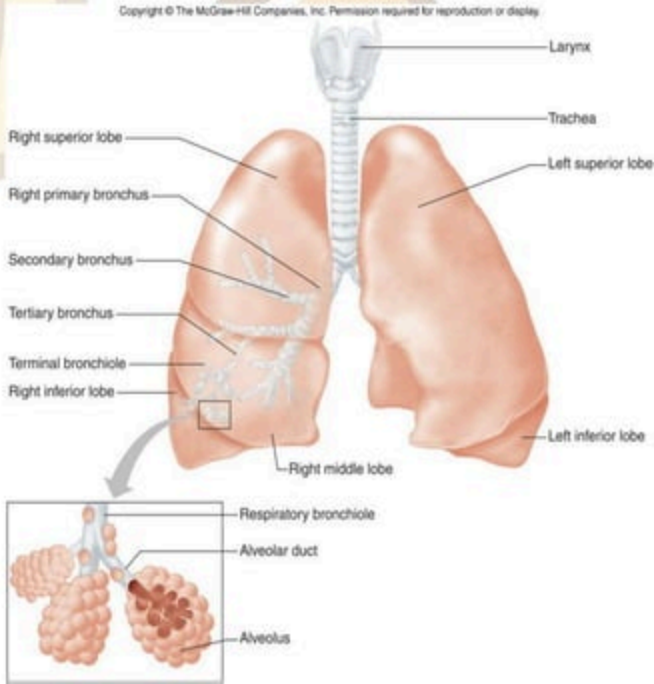
I. The outer layer: consists of fibrous & elastic tissue & encloses the cartilages.

II. The middle layer :consists of bands of smooth muscles in a helical manner. There is some areolar tissue.

III. The inner lining :consists of ciliated columnar epithelium, containing mucus secreting Goblet cells

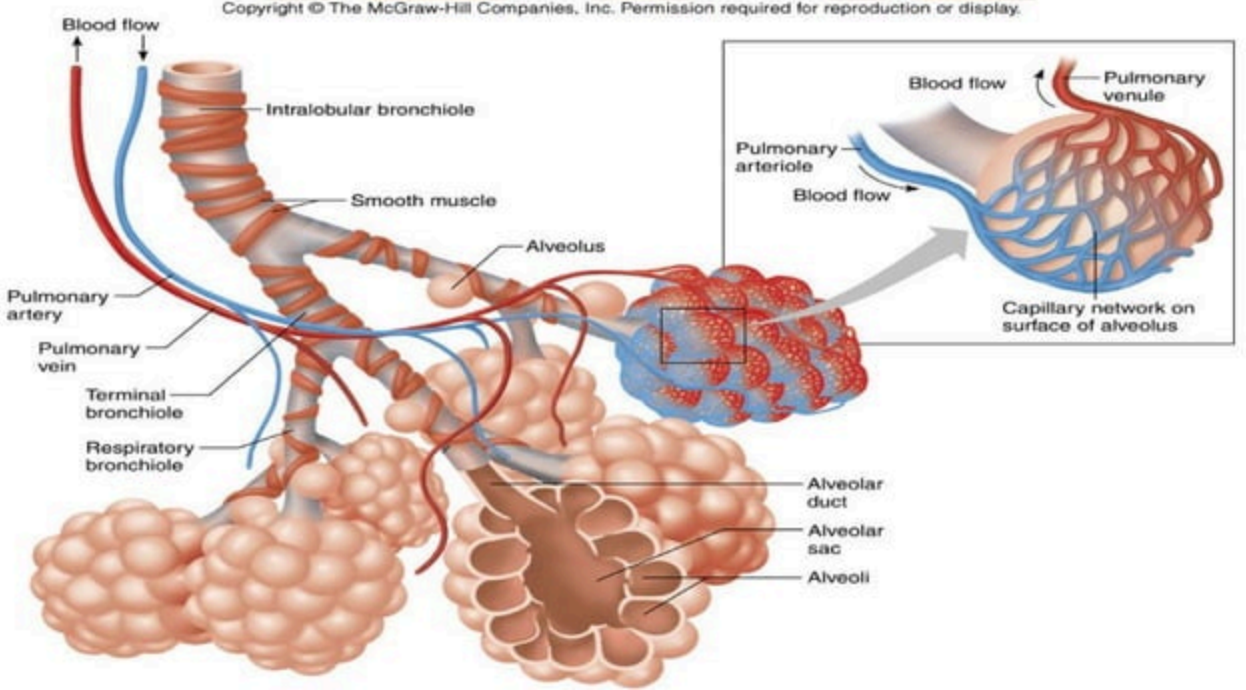
Structures of the Lower Respiratory Tract

- **Bronchi**
  - Tubes that branch off trachea and enter into lungs
  - Ciliated
  - Branches: Primary bronchi —secondary bronchi— tertiary bronchi— bronchioles
  - Bronchioles branch into microscopic alveolar ducts. Terminate into alveolar sacs
  - Gas exchange with blood occurs in sacs.



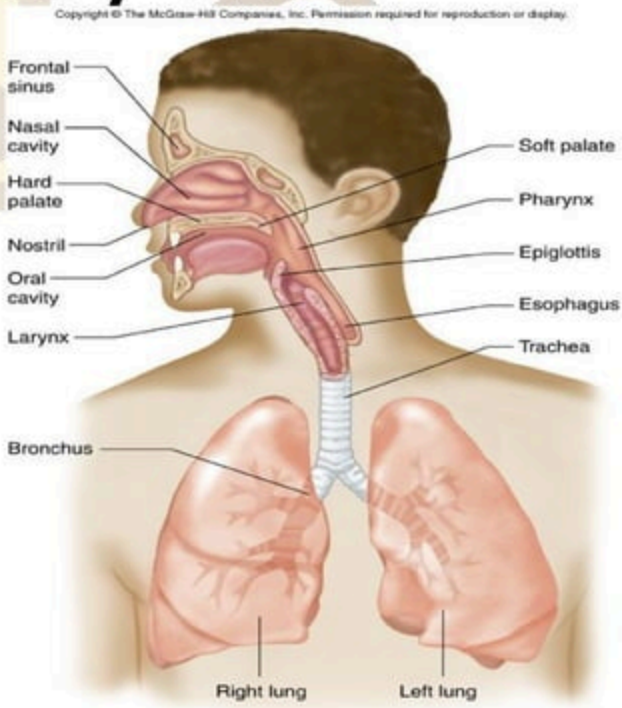
Structures of the Lower Respiratory Tract

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Structures of the Lower Respiratory Tract

- **Lungs**
  - Extend from diaphragm to clavicles
  - Divided into lobes by fissures.
  - Visceral pleura adheres to the lungs.
    - **Pleurisy** = inflammation of the pleural lining

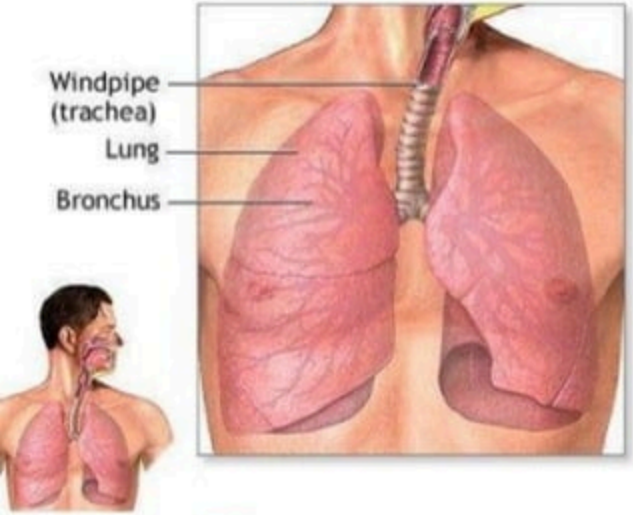


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Lungs

- Each lung has a conical shape. Its wide, concave base rests upon the muscular diaphragm.
- Its superior region called the **apex** projects superiorly to a point that is slightly superior and posterior to the clavicle.
- Both lungs are bordered by the thoracic wall anteriorly, laterally, and posteriorly, and supported by the rib cage.
- Toward the midline, the lungs are separated from each other by the **mediastinum**.
- The relatively broad, rounded surface in contact with the thoracic wall is called the **costal surface** of the lung.

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Lungs

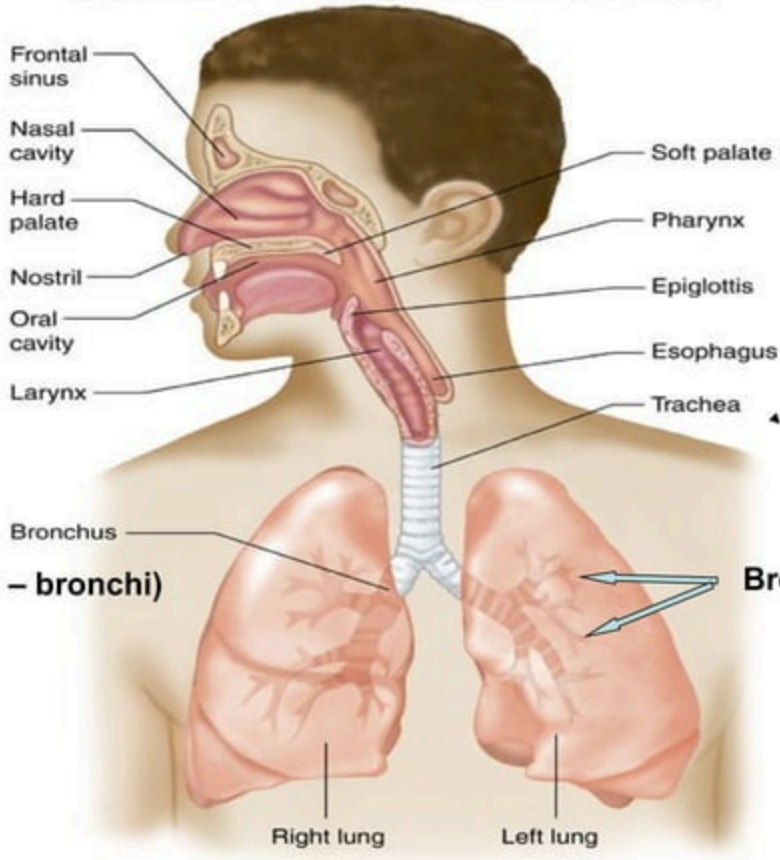
Left lung

- divided into 2 lobes by **oblique fissure**
- smaller than the right lung
- **cardiac notch** accommodates the heart

Right lung

- divided into 3 lobes by **oblique and horizontal fissure**
- located more superiorly in the body due to liver on right side

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(Plural – bronchi)

Bronchioles

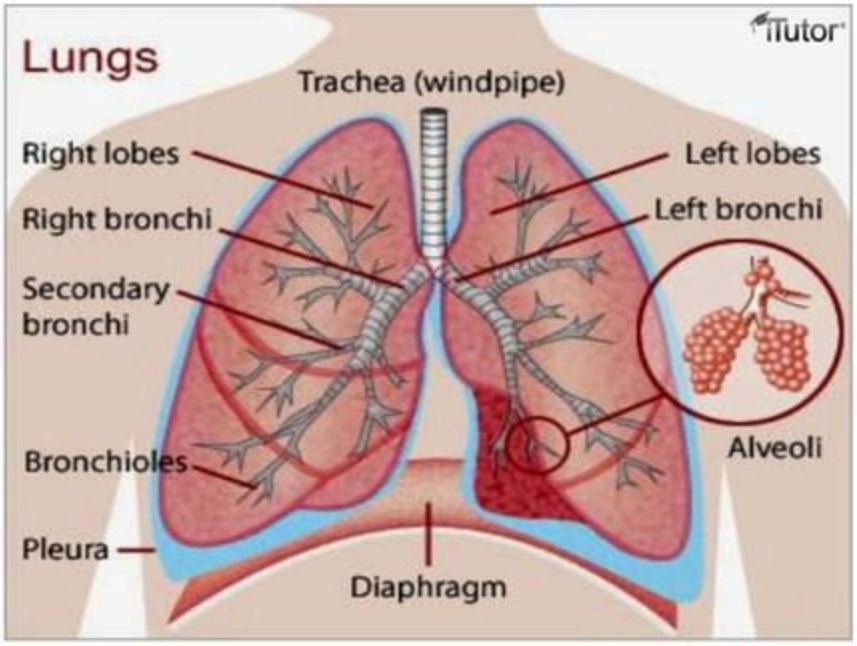
Pleura

- The outer surface of each lung and the adjacent internal thoracic wall are lined by a serous membrane called **pleura**.
- The outer surface of each lung is tightly covered by the **visceral pleura**.
- while the internal thoracic walls, the lateral surfaces of the mediastinum, and the superior surface of the diaphragm are lined by the **parietal pleura**.
- The parietal and visceral pleural layers are continuous at the **hilus** of each lung

Pleural Cavities

The potential space between the serous membrane layers is a **pleural cavity**.

- The pleural membranes produce a thin, serous **pleural fluid** that circulates in the pleural cavity and acts as a lubricant, ensuring minimal friction during breathing.
- **Pleural effusion** – pleuritis with too much fluid


Lungs
iTutor
Trachea (windpipe)
Right lobes
Left lobes
Right bronchi
Left bronchi
Secondary bronchi
Alveoli
Bronchioles
Pleura
Diaphragm

Inside the lungs..

- Bronchi & bronchioles:

❑ Two primary bronchi are formed when trachea divides at the level of 5th thoracic vertebra.

❑ The right bronchus:

- wider, shorter & more vertical than the left one.
- Approx 2.5 cm

❑ The left bronchus:

- About 5cm long
- Narrower.

BRONCHIAL TREE

The bronchi divide as follows:

Bronchi → bronchioles → terminal bronchioles → respiratory bronchioles → alveolar ducts → alveoli.

How Lungs work?

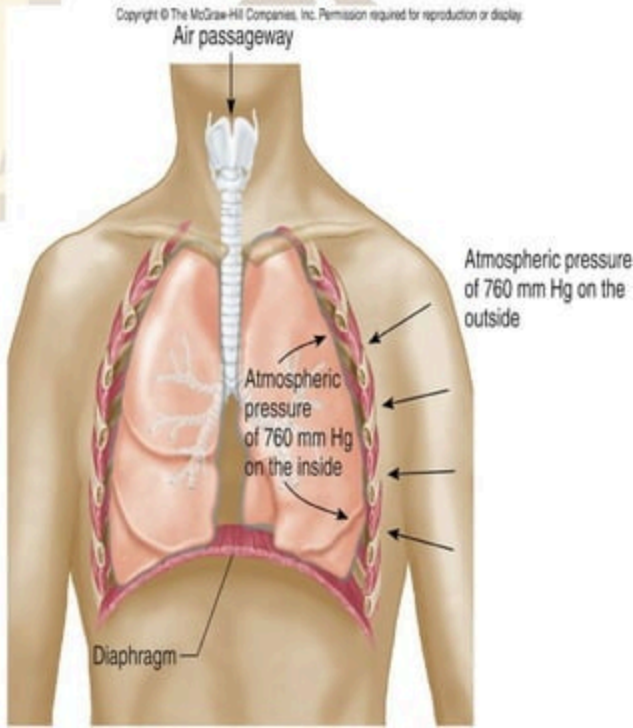
- Air enters your lungs through a system of pipes called the *bronchi*.
- The *alveoli* are where the important work of gas exchange takes place between the air and your blood. Covering each alveolus is a whole network of little blood vessel called ***capillaries***,
- It is important that the air in the alveoli and the blood in the capillaries are very close together, so that oxygen and carbon dioxide can move (or diffuse) between them.
- When you breathe in, air comes down the trachea and through the bronchi into the alveoli.
- This fresh air has lots of oxygen in it, and some of this oxygen will travel across the walls of the alveoli into your blood stream.
- Travelling in the opposite direction is carbon dioxide, which crosses from the blood in the capillaries into the air in the alveoli and is then breathed out.
- In this way, you bring in to your body the oxygen that you need to live, and get rid of the waste product carbon dioxide.

BLOOD SUPPLY

- The pulmonary trunk divided into the right and left pulmonary arteries, carrying deoxygenated blood to each lung.
- Within the lungs each pulmonary artery divides into many branches, which eventually end in dense capillary network around the alveoli.
- The walls of merge into a network of pulmonary venules.which in turn from two pulmonary veins carrying oxygenated blood from two pulmonary veins carrying oxygenated blood from each lung back to the left atrium of the heart.

Respiratory Physiology

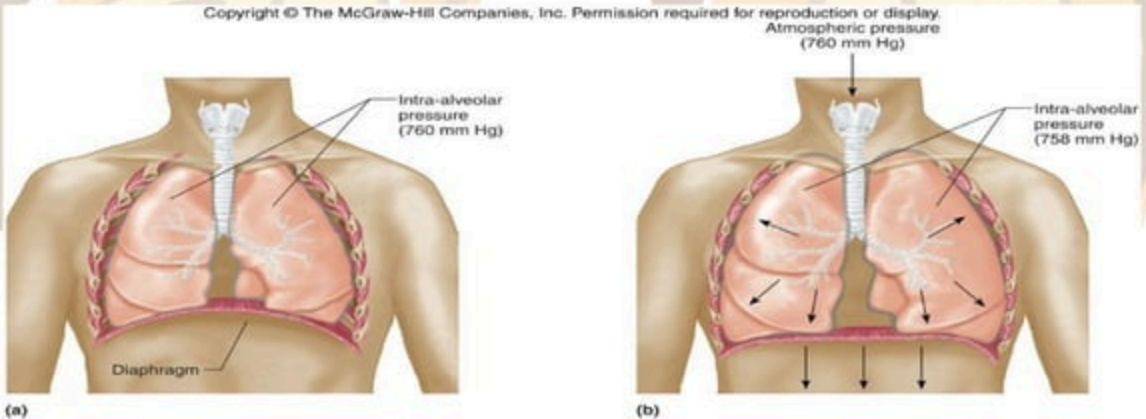
- **Pulmonary Ventilation** = breathing
  - **Mechanism**
    - Movement of gases through a pressure gradient - hi to low.
    - When atmospheric pressure (760 mmHg) is greater than lung pressure ---- air flows in = **inspiration**.
    - When lung pressure is greater than atmospheric pressure ---- air flows out = **expiration**.

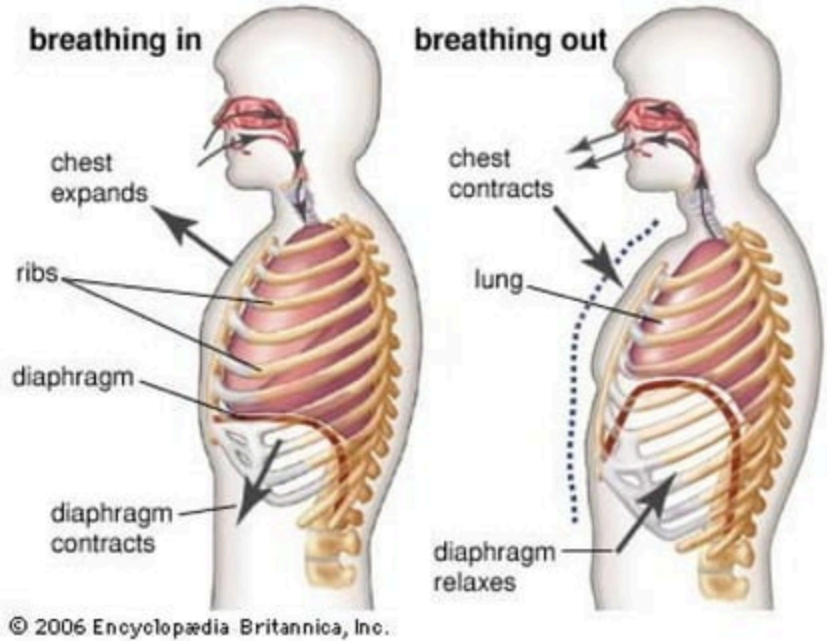


Respiratory Physiology

- **Pressure gradients are established by changes in thoracic cavity.**
  - increase size in thorax = a decrease in pressure --- air moves in.
  - Decrease size in thorax = increase in pressure --- air moves out.

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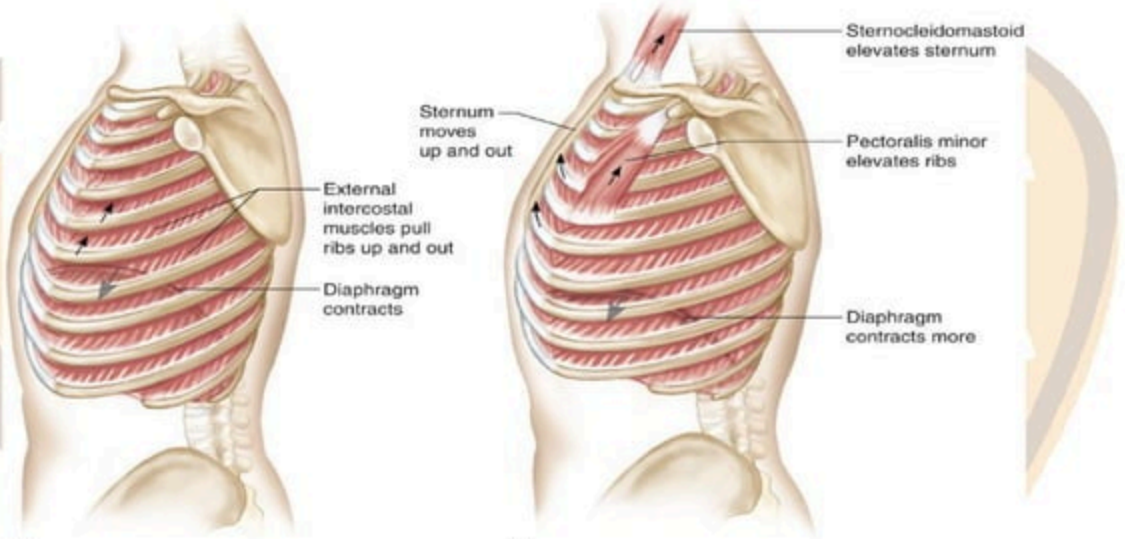


http://people.eku.edu/ritchisong/301notes6.htm

Inspiration

-contraction of diaphragm and intercostal muscles

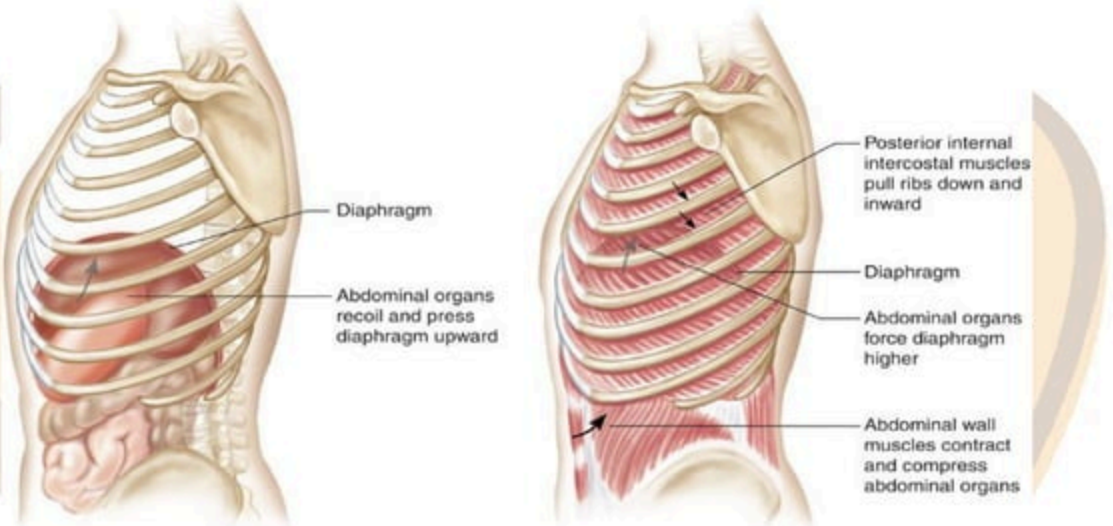
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Expiration

- relaxation of diaphragm and intercostal muscles

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Volumes of Air Exchange

- ***Tidal volume*** - amount of air exhaled normally after a typical inspiration. Normal - about 500 ml
- ***Expiratory Reserve volume*** - additional amount of air forcibly expired after tidal expiration (1000 - 1200 ml).
- ***Inspiratory Reserve volume*** - (deep breath) amount of air that can be forcibly inhaled over and above normal.
- ***Residual volume*** - amount of air that stays trapped in the alveoli (about 1.2 liters).

Volumes of Air Exchange

- ***Vital capacity*** - the largest volume of air an individual can move in and out of the lungs.
- Vital capacity = sum of IRV+TV+ERV
- Depends of many factors
  - size of thoracic cavity
  - posture
  - volume of blood in lungs → congestive heart failure, emphysema, disease, etc…

Volumes of Air Exchange

- **Eupnea** - normal quiet breathing, 12-17 breaths per minute.
- **Hyperpnea** - increase in breathing to meet an increased demand by body for oxygen.
- **Hyperventilation** - increase in pulmonary ventilation in excess of the need for oxygen.
  - Someone hysterical
  - exertion

  → Breathe into paper bag.
- **Hypoventilation** - decrease in pulmonary ventilation.
- **Apnea** - temporary cessation of breathing at the end of normal expiration.

Heimlich Maneuver

- Lifesaving technique that is used to open a windpipe that is suddenly obstructed.
- Air already in lungs used to expel object.



Heimlich Maneuver

- **Technique - Conscious victim**
  - Ask the victim if he/she can talk
  - Stand behind victim and wrap your arms around their waist.
  - Make a fist with one hand and grasp it with the other hand.
  - Place thumb side of fist below xiphoid process and above navel.
  - Thrust your fist in and upward - about 4 times.
- DO NOT press on ribs or sternum



Heimlich Maneuver

- **Technique - Unconscious victim**
  - Catch victim if they begin to fall - place on floor face up.
  - Straddle hips
  - Place one hand on top of other on the victims abdomen - above navel and below xiphoid process.
  - Forceful upward thrusts with heel of hand - several times if necessary.

Alveoli

- Structure of alveoli
  - Alveolar duct
  - Alveolar sac
  - Alveolus
- Gas exchange takes place within the alveoli in the respiratory membrane
- Squamous epithelial lining alveolar walls
- Covered with pulmonary capillaries on external surfaces

Respiratory Membrane (Air-Blood Barrier)

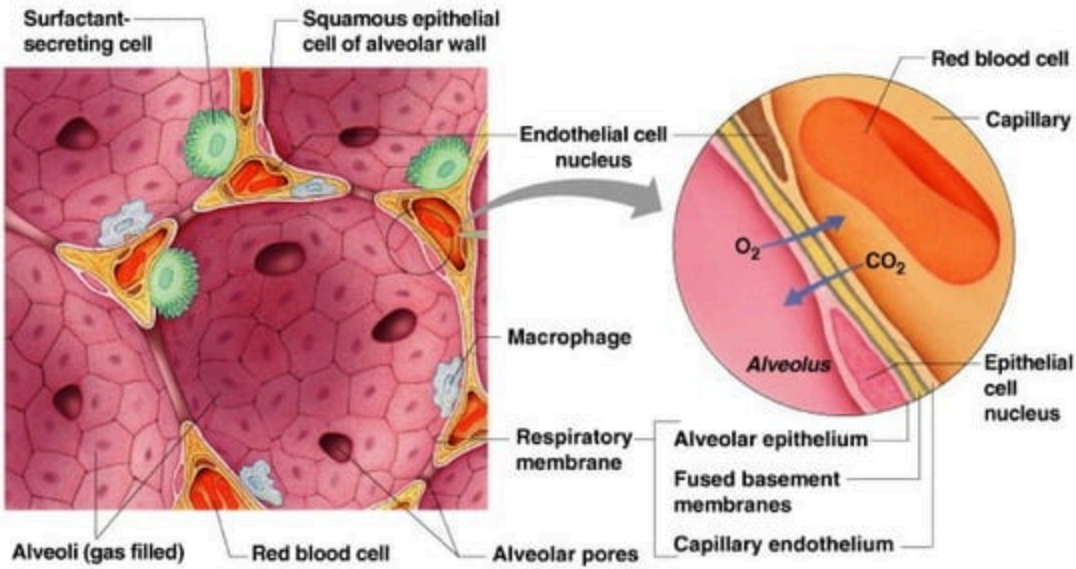


Figure 13.6

Gas Exchange

- Gas crosses the respiratory membrane by diffusion
  - Oxygen enters the blood
  - Carbon dioxide enters the alveoli
- Macrophages add protection
- **Surfactant coats gas-exposed alveolar surfaces**

Events of Respiration

- Pulmonary ventilation – moving air in and out of the lungs
- External respiration – gas exchange between pulmonary blood and alveoli

Events of Respiration

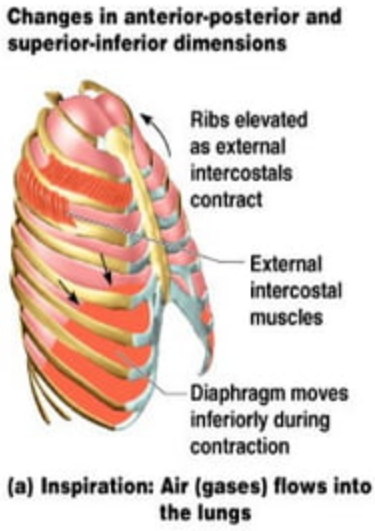
- Respiratory gas transport – transport of oxygen and carbon dioxide via the bloodstream
- Internal respiration – gas exchange between blood and tissue cells in systemic capillaries

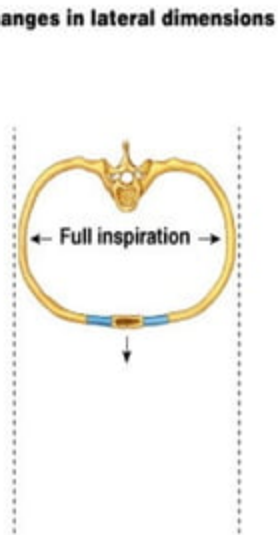
Mechanics of Breathing (Pulmonary Ventilation)

- Mechanical process
- Depends on volume changes in the thoracic cavity
- Volume changes lead to pressure changes, which lead to equalize pressure of flow of gases
- 2 phases
  - Inspiration – flow of air into lung
  - Expiration – air leaving lung

Inspiration

- Diaphragm and intercostal muscles contract
- The size of the thoracic cavity increases
- External air is pulled into the lungs due to an increase in intrapulmonary volume

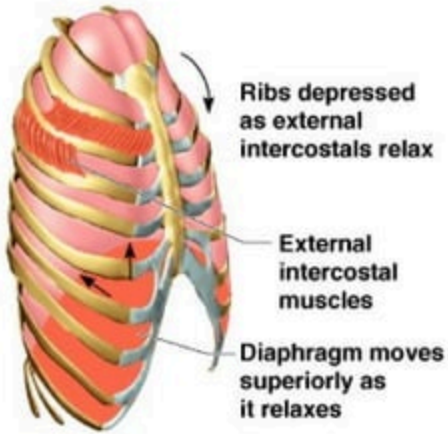




Expiration

- Passive process dependent up on natural lung elasticity
- As muscles relax, air is pushed out of the lungs
- Forced expiration can occur mostly by contracting internal intercostal muscles to depress the rib cage

Expiration



(b) Expiration: Air (gases) flows out of the lungs

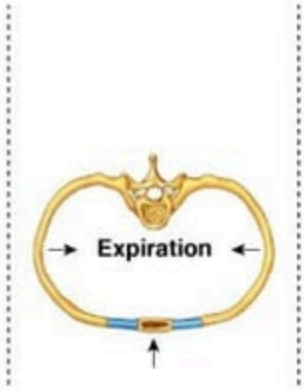


Figure 13.7b

Pressure Differences in the Thoracic Cavity

- Normal pressure within the pleural space is **always negative** (intrapleural pressure)
- Differences in lung and pleural space pressures keep lungs from collapsing

Nonrespiratory Air Movements

- Caused by reflexes or voluntary actions
- Examples
  - Cough and sneeze – clears lungs of debris
  - Laughing
  - Crying
  - Yawn
  - Hiccup

Respiratory Sounds

- Sounds are monitored with a stethoscope
- Bronchial sounds – produced by air rushing through trachea and bronchi
- Vesicular breathing sounds – soft sounds of air filling alveoli

External Respiration

- Oxygen movement into the blood
  - The alveoli always has more oxygen than the blood
  - Oxygen moves by diffusion towards the area of lower concentration
  - Pulmonary capillary blood gains oxygen

External Respiration

- Carbon dioxide movement out of the blood
  - Blood returning from tissues has higher concentrations of carbon dioxide than air in the alveoli
  - Pulmonary capillary blood gives up carbon dioxide
- Blood leaving the lungs is oxygen-rich and carbon dioxide-poor

Gas Transport in the Blood

- Oxygen transport in the blood
  - Inside red blood cells attached to hemoglobin (oxyhemoglobin [HbO_2])
  - A small amount is carried dissolved in the plasma
- Carbon dioxide transport in the blood
  - Most is transported in the plasma as bicarbonate ion (HCO_3–)
  - A small amount is carried inside red blood cells on hemoglobin, but at different binding sites than those of oxygen

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

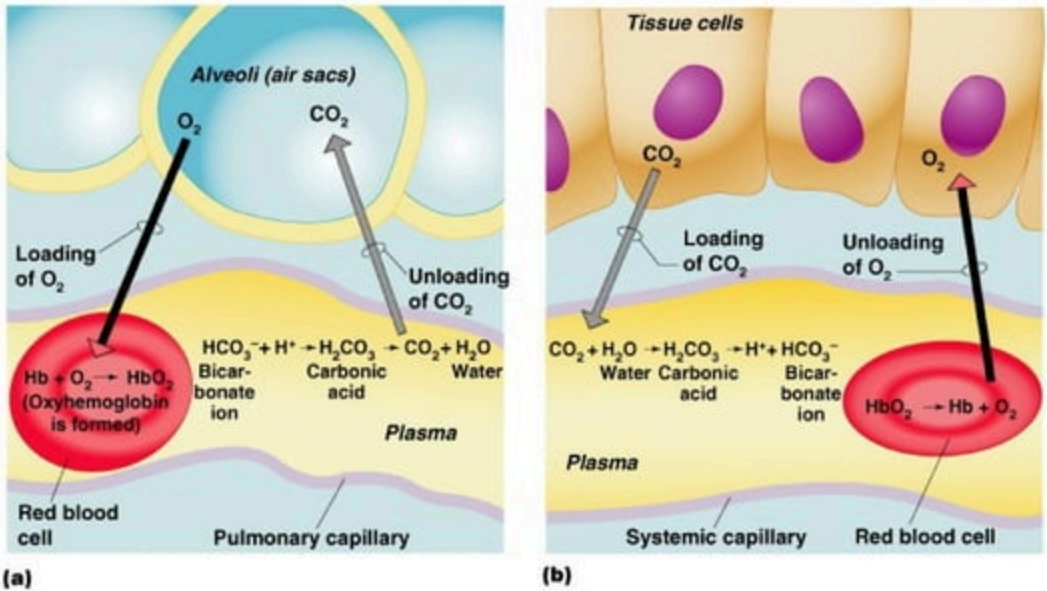


Figure 13.11

Neural Regulation of Respiration

- Activity of respiratory muscles is transmitted to the brain by the phrenic and intercostal nerves
- Neural centers that control rate & depth are located in the medulla
- The pons appears to smooth out respiratory rate
- Normal respiratory rate (eupnea) is 12–15 min.
- Hypernia is increased respiratory rate often due to extra oxygen needs

Factors Influencing Respiratory Rate and Depth

- Physical factors
  - Increased body temperature
  - Exercise
  - Talking
  - Coughing
- Volition (conscious control)
- Emotional factors

Factors Influencing Respiratory Rate and Depth

- 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

Factors Influencing Respiratory Rate and Depth

- Chemical factors (continued)
  - Oxygen levels
    - Changes in oxygen concentration in the blood are detected by **chemoreceptors** in the aorta and carotid artery
    - Information is sent to the medulla oblongata

Respiratory Rate Changes Throughout Life

Respiration rate:

- Newborns – 40 to 80 min.
- Infants – 30 min.
- Age 5 – 25 min.
- Adults – 12 to 18 min
- Rate often increases with old age