

THE RESPIRATORY SYSTEM - STRUCTURE AND FUNCTION



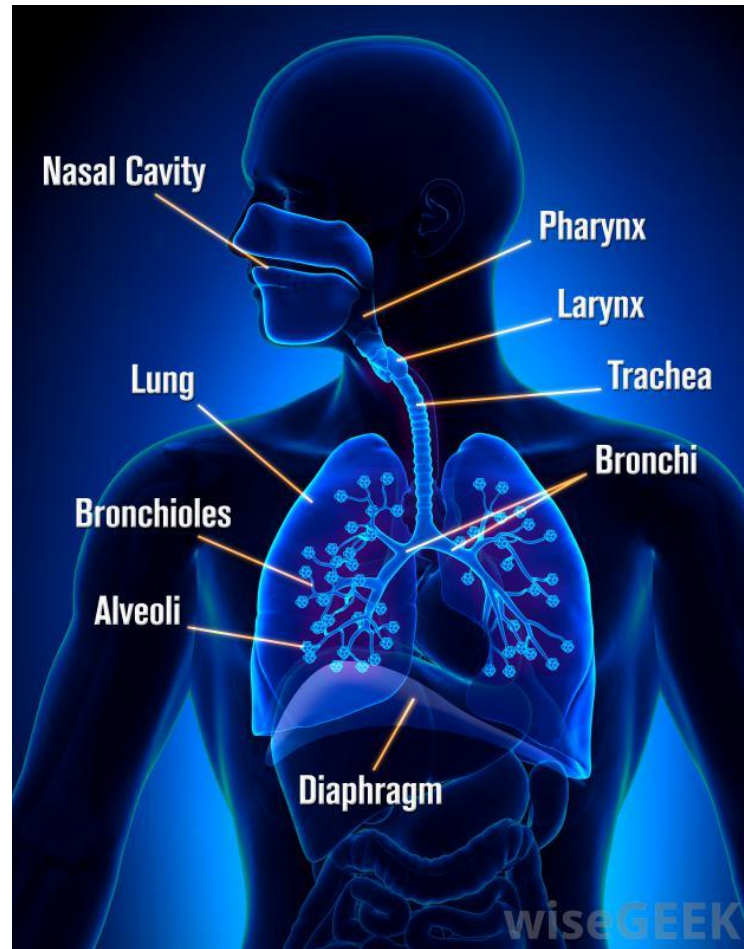
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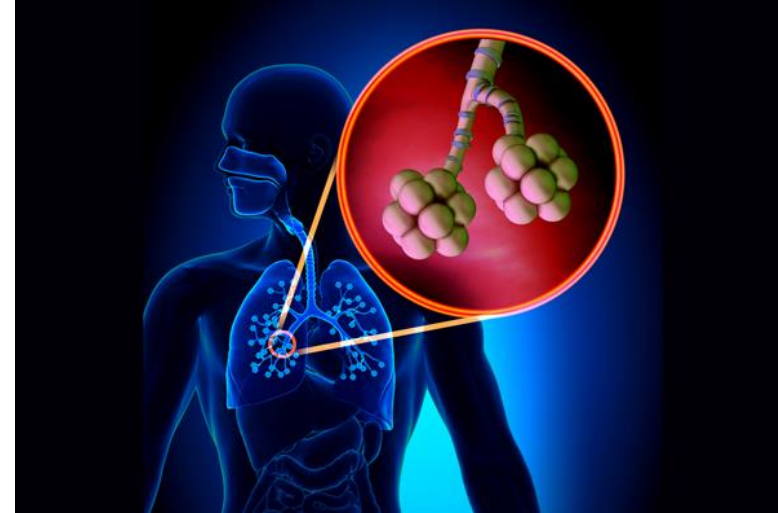
RESPIRATORY SYSTEM

- The respiratory system is the system in the human body that enables us to breathe.

The act of breathing includes: inhaling and exhaling air in the body; the absorption of oxygen from the air in order to produce energy; the discharge of carbon dioxide, which is the byproduct of the process.



THE PARTS OF THE RESPIRATORY SYSTEM



- The respiratory system is divided into two parts:

Upper respiratory tract:

This includes the nose, mouth, and the beginning of the trachea (the section that takes air in and lets it out).

Lower respiratory tract:

This includes the trachea, the bronchi, bronchioles and the lungs (the act of breathing takes place in this part of the system).

The organs of the lower respiratory tract are located in the chest cavity. They are delineated and protected by the ribcage, the chest bone (sternum), and the muscles between the ribs and the diaphragm (that constitute a muscular partition between the chest and the abdominal cavity).

- **The trachea** – the tube connecting the throat to the bronchi.
- **The bronchi** – the trachea divides into two bronchi (tubes). One leads to the left lung, the other to the right lung. Inside the lungs each of the bronchi divides into smaller bronchi.
- **The bronchioles** - the bronchi branches off into smaller tubes called bronchioles which end in the pulmonary alveolus.
- **Pulmonary alveoli** – tiny sacs (air sacs) delineated by a single-layer membrane with blood capillaries at the other end.
- The exchange of gases takes place through the membrane of the pulmonary alveolus, which always contains air: oxygen (O₂) is absorbed from the air into the blood capillaries and the action of the heart circulates it through all the tissues in the body. At the same time, carbon dioxide (CO₂) is transmitted from the blood capillaries into the alveoli and then expelled through the bronchi and the upper respiratory tract.
- The inner surface of the lungs where the exchange of gases takes place is very large, due to the structure of the air sacs of the alveoli.
- **The lungs** – a pair of organs found in all vertebrates.
- The structure of the lungs includes the bronchial tree – air tubes branching off from the bronchi into smaller and smaller air tubes, each one ending in a pulmonary alveolus.

DIFFERENT PARTS OF RESPIRATORY SYSTEM

NOSE AND NASAL CAVITY

The [nose and nasal cavity](#) form the main external opening for the respiratory system and are the first section of the body's airway—the respiratory tract through which air moves. The nose is a structure of the face made of cartilage, bone, muscle, and skin that supports and protects the anterior portion of the nasal cavity. The nasal cavity is a hollow space within the nose and [skull](#) that is lined with hairs and mucus membrane. The function of the nasal cavity is to warm, moisturize, and filter air entering the body before it reaches the lungs. Hairs and mucus lining the nasal cavity help to trap dust, mold, pollen and other environmental contaminants before they can reach the inner portions of the body. Air exiting the body through the nose returns moisture and heat to the nasal cavity before being exhaled into the environment.

MOUTH

The mouth, also known as the [oral cavity](#), is the secondary external opening for the respiratory tract. Most normal breathing takes place through the nasal cavity, but the oral cavity can be used to supplement or replace the nasal cavity's functions when needed. Because the pathway of air entering the body from the mouth is shorter than the pathway for air entering from the nose, the mouth does not warm and moisturize the air entering the lungs as well as the nose performs this function. The mouth also lacks the hairs and sticky mucus that filter air passing through the nasal cavity. The one advantage of breathing through the mouth is that its shorter distance and larger diameter allows more air to quickly enter the body.

PHARYNX

The pharynx, also known as the throat, is a muscular funnel that extends from the posterior end of the nasal cavity to the superior end of the [esophagus](#) and larynx. The pharynx is divided into 3 regions: the nasopharynx, oropharynx, and laryngopharynx. The [nasopharynx](#) is the superior region of the pharynx found in the posterior of the nasal cavity.

DIFFERENT PARTS OF RESPIRATORY SYSTEM

Inhaled air from the nasal cavity passes into the nasopharynx and descends through the oropharynx, located in the posterior of the oral cavity. Air inhaled through the oral cavity enters the pharynx at the **oropharynx**. The inhaled air then descends into the **laryngopharynx**, where it is diverted into the opening of the larynx by the epiglottis. The **epiglottis** is a flap of elastic cartilage that acts as a switch between the trachea and the esophagus. Because the pharynx is also used to swallow food, the epiglottis ensures that air passes into the trachea by covering the opening to the esophagus. During the process of swallowing, the epiglottis moves to cover the trachea to ensure that food enters the esophagus and to prevent choking.

LARYNX

The **larynx**, also known as the voice box, is a short section of the airway that connects the laryngopharynx and the trachea. The larynx is located in the anterior portion of the neck, just inferior to the **hyoid bone** and superior to the trachea. Several cartilage structures make up the larynx and give it its structure. The epiglottis is one of the cartilage pieces of the larynx and serves as the cover of the larynx during swallowing. Inferior to the epiglottis is the **thyroid cartilage**, which is often referred to as the Adam's apple as it is most commonly enlarged

and visible in adult males. The **thyroid** holds open the anterior end of the larynx and protects the vocal folds. Inferior to the thyroid cartilage is the ring-shaped cricoid cartilage which holds the larynx open and supports its posterior end. In addition to cartilage, the larynx contains special structures known as vocal folds, which allow the body to produce the sounds of speech and singing. The vocal folds are folds of mucous membrane that vibrate to produce vocal sounds. The tension and vibration speed of the vocal folds can be changed to change the pitch that they produce.

DIFFERENT PARTS OF RESPIRATORY SYSTEM

TRACHEA

The trachea, or windpipe, is a 5-inch long tube made of C-shaped hyaline cartilage rings lined with pseudostratified ciliated columnar epithelium. The trachea connects the larynx to the bronchi and allows air to pass through the neck and into the thorax. The rings of cartilage making up the trachea allow it to remain open to air at all times. The open end of the cartilage rings faces posteriorly toward the esophagus, allowing the esophagus to expand into the space occupied by the trachea to accommodate masses of food moving through the esophagus. The main function of the trachea is to provide a clear airway for air to enter and exit the lungs. In addition, the epithelium lining the trachea produces mucus that traps dust and other contaminants and prevents it from reaching the lungs. Cilia on the surface of the epithelial cells move the mucus superiorly toward the pharynx where it can be swallowed and digested in the gastrointestinal tract.

BRONCHI AND BRONCHIOLES

At the inferior end of the trachea, the airway splits into left and right branches known as the primary bronchi. The left and right bronchi run into each lung before branching off into smaller secondary bronchi. The secondary bronchi carry air into the lobes of the lungs—2 in the left lung and 3 in the right lung. The secondary bronchi in turn split into many smaller tertiary bronchi within each lobe.

The **tertiary bronchi** split into many smaller bronchioles that spread throughout the lungs. Each bronchiole further splits into many smaller branches less than a millimeter in diameter called terminal bronchioles. Finally, the millions of tiny terminal bronchioles conduct air to the alveoli of the lungs.

As the airway splits into the tree-like branches of the bronchi and bronchioles, the structure of the walls of the airway begins to change. The primary bronchi contain many C-shaped cartilage rings that firmly hold the airway open and give the bronchi a cross-sectional shape like a flattened circle or a letter D. As the bronchi branch into secondary and tertiary bronchi, the cartilage becomes more widely spaced and more smooth muscle and elastin protein is found in the walls. The bronchioles differ from the structure of the bronchi in that they do not contain any cartilage at all. The presence of smooth muscles and elastin allow the smaller bronchi and bronchioles to be more flexible and contractile.

DIFFERENT PARTS OF RESPIRATORY SYSTEM

The main function of the bronchi and bronchioles is to carry air from the trachea into the lungs. Smooth muscle tissue in their walls helps to regulate airflow into the lungs. When greater volumes of air are required by the body, such as during exercise, the smooth muscle relaxes to dilate the bronchi and bronchioles. The dilated airway provides less resistance to airflow and allows more air to pass into and out of the lungs. The smooth muscle fibers are able to contract during rest to prevent hyperventilation. The bronchi and bronchioles also use the mucus and cilia of their epithelial lining to trap and move dust and other contaminants away from the lungs.

FUNCTIONS OF THE RESPIRATORY SYSTEM

Through breathing, inhalation and exhalation, the respiratory system facilitates the exchange of gases between the air and the blood and between the blood and the body's cells. The respiratory system also helps us to smell and create sound. The following are the five key functions of the respiratory system.

- ⦿ 1. Inhalation and Exhalation Are Pulmonary Ventilation—That's Breathing
- ⦿ 2. External Respiration Exchanges Gases Between the Lungs and the Bloodstream
- ⦿ 3. External Respiration Exchanges Gases Between the Lungs and the Bloodstream
- ⦿ 4. Air Vibrating the Vocal Cords Creates Sound
- ⦿ 5. Olfaction, or Smelling, Is a Chemical Sensation

DIFFERENT PARTS OF RESPIRATORY SYSTEM

LUNGS

The lungs are a pair of large, spongy organs found in the thorax lateral to the heart and superior to the diaphragm. Each lung is surrounded by a pleural membrane that provides the lung with space to expand as well as a negative pressure space relative to the body's exterior. The negative pressure allows the lungs to passively fill with air as they relax. The left and right lungs are slightly different in size and shape due to the heart pointing to the left side of the body. The left lung is therefore slightly smaller than the right lung and is made up of 2 lobes while the right lung has 3 lobes.

The interior of the lungs is made up of spongy tissues containing many capillaries and around 30 million tiny sacs known as alveoli. The alveoli are cup-shaped structures found at the end of the terminal bronchioles and surrounded by capillaries. The alveoli are lined with thin simple squamous epithelium that allows air entering the alveoli to exchange its gases with the blood passing through the capillaries.

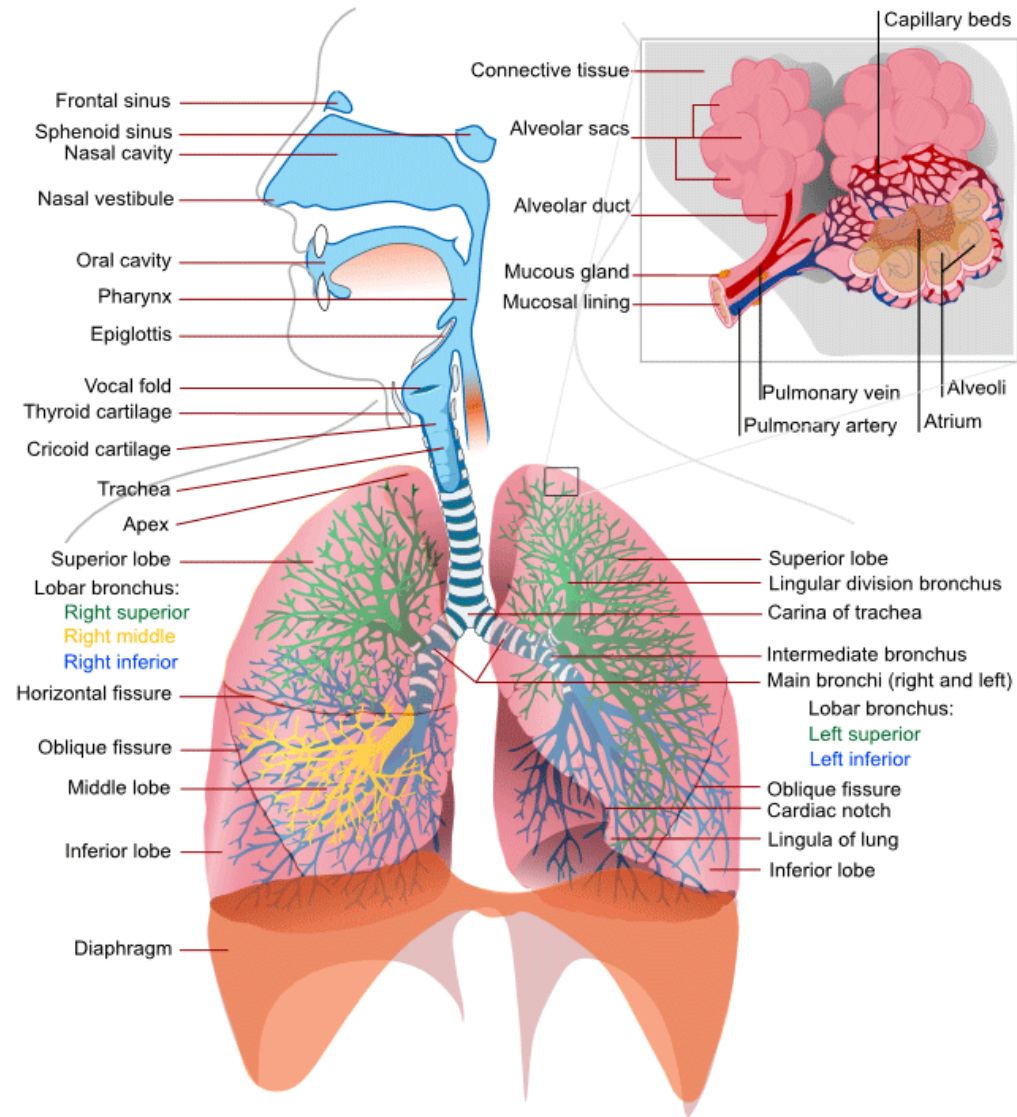


DIFFERENT PARTS OF RESPIRATORY SYSTEM

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blood passing through the capillaries.



THE ACT OF BREATHING

- The act of breathing has two stages – inhalation and exhalation
- ◉ Inhalation – the intake of air into the lungs through expansion of chest volume.
- ◉ Exhalation – the expulsion of air from the lungs through contraction of chest volume.

- ◉ **Inhalation and exhalation involves muscles:**

- ◉ **Rib muscles** = the muscles between the ribs in the chest.

- ◉ **Diaphragm muscle**

- ◉

Muscle movement – the **diaphragm and rib muscles** are constantly contracting and relaxing (approximately 16 times per minute), thus causing the chest cavity to increase and decrease.

During inhalation – the muscles contract:

Contraction of the diaphragm muscle – causes the diaphragm to flatten, thus enlarging the chest cavity.

Contraction of the rib muscles – causes the ribs to rise, thus increasing the chest volume.

The chest cavity expands, thus reducing air pressure and causing air to be passively drawn into the lungs. Air passes from the high pressure outside the lungs to the low pressure inside the lungs.

During exhalation – the muscles relax:

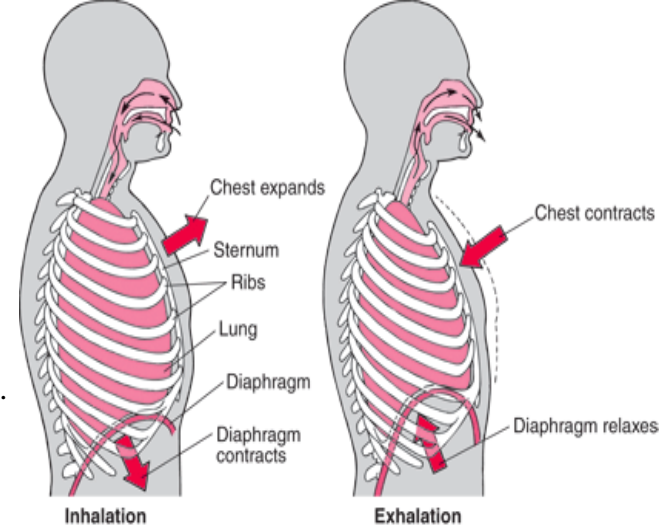
The muscles are no longer contracting, they are relaxed.

The diaphragm curves and rises, the ribs descend – and chest volume decreases.

The chest cavity contracts thus increasing air pressure and causing the air in the lungs to be expelled through the upper respiratory tract. Exhalation, too, is passive. Air passes from the high pressure in the lungs to the low pressure in the upper respiratory tract.

Inhalation and exhalation are involuntary and therefore their control requires an effort.

- ◉



MEASUREMENTS OF LUNG FUNCTION

1. **Air volume** (in liters) – lung capacity

- ⦿ **Maximum lung volume** is known as TLC (total lung capacity). It can be obtained by maximum strenuous inhalation.
 - ⦿ The maximum lung volume of a healthy adult is up to 5-6 liters. In children the maximum lung volume is up to 2-3 liters, depending on age. In infants it is up to 600-1000 milliliters.
 - ⦿ Note! Differences in lung volume can only be caused by gender, age, and height.
 - ⦿ **Essential air volume** is the maximum volume utilized by the lungs for inhalation, also known as VC (vital capacity).
 - ⦿ The differential between total lung capacity and residual volume is the **maximal volume utilized by the lungs in order to breath. It is known as vital capacity(VC)**. In an adult, the VC is between 3.5 and 4.5 liters.
 - ⦿ **Tidal Volume** or VT is the volume of air displaced between normal inspiration and expiration. In a healthy adult the tidal volume is approximately 500 milliliters.
- ## 2. **Rate of airflow** through the respiratory airways (into and out of the lungs). This measures the effectiveness of airflow.
- ## 3. **Efficiency of diffusion** of oxygen from the pulmonary alveoli into the blood (not dealt with in this unit).

RESPIRATORY RATE

- Children in the upper classes of elementary school breathe about 20 times per minute.

Every breath causes an inhalation of approximately 7 milliliters of air volume per kilogram of body weight.

A child who weighs 30 kilos inhales approximately 210 milliliters of air volume (210X30). In other words, in the duration of a minute some 4200 milliliters of air volume enters and be expelled from the lungs.

Athletes breathe slightly deeper and slower. With every breath they inhale approximately 10 milliliters of air per kilogram. Thus an athletic child who weighs 30 kilos will only breathe 15 times in the duration space of a minute. Each inhalation will require some 300 milliliters of air volume. In the space of a minute 4500 milliliters of air volume will enter and be expelled from the his lungs. We can deduce from this that athletes ventilate their airways in a much more efficient way.

When we are under strain we breathe faster and more deeply. Since the lungs contain a reserve of air, we do not become tired because lack of air (oxygen) is causing respiratory restriction, but because of strain and tiredness in our respiratory and heart muscles.

When we are under emotional stress (before an exam, in distress, or feeling very frightened) we breathe faster, but our breathing is shallower. For example, under stress we inhale 30 times per minute but at a rate of only 4 milliliters per kilo. In other words, overall only 3600 milliliters per minute are passing through our airways, so we feel “short of breath.”

During severe asthma attacks, the breathing of asthma patients is shallower and at a higher rate. Their breathing is thus not very efficient.

- The cells of the human body require a constant stream of oxygen to stay alive. The respiratory system provides oxygen to the body’s cells while removing carbon dioxide, a waste product that can be lethal if allowed to accumulate. There are 3 major parts of the respiratory system: the airway, the lungs, and the muscles of respiration. The airway, which includes the nose, mouth, pharynx, larynx, trachea, bronchi, and bronchioles, carries air between the lungs and the body’s exterior.
- CONTINUED FROM ABOVE... act as the functional units of the respiratory system by passing oxygen into the body and carbon dioxide out of the body. Finally, the muscles of respiration, including the diaphragm and intercostal muscles, work together to act as a pump, pushing air into and out of the lungs during breathing.
- Anatomy of the Respiratory System

MUSCLES OF RESPIRATION

- ◉ Surrounding the lungs are sets of muscles that are able to cause air to be inhaled or exhaled from the lungs. The principal muscle of respiration in the human body is the diaphragm, a thin sheet of skeletal muscle that forms the floor of the thorax. When the diaphragm contracts, it moves inferiorly a few inches into the abdominal cavity, expanding the space within the thoracic cavity and pulling air into the lungs. Relaxation of the diaphragm allows air to flow back out the lungs during exhalation.
- ◉ Between the ribs are many small intercostal muscles that assist the diaphragm with expanding and compressing the lungs. These muscles are divided into 2 groups: the internal intercostal muscles and the external intercostal muscles. The internal intercostal muscles are the deeper set of muscles and depress the ribs to compress the thoracic cavity and force air to be exhaled from the lungs. The external intercostals are found superficial to the internal intercostals and function to elevate the ribs, expanding the volume of the thoracic cavity and causing air to be inhaled into the lungs.

PHYSIOLOGY OF THE RESPIRATORY SYSTEM

◉ PULMONARY VENTILATION

- ◉ Pulmonary ventilation is the process of moving air into and out of the lungs to facilitate gas exchange. The respiratory system uses both a negative pressure system and the contraction of muscles to achieve pulmonary ventilation. The negative pressure system of the respiratory system involves the establishment of a negative pressure gradient between the alveoli and the external atmosphere. The pleural membrane seals the lungs and maintains the lungs at a pressure slightly below that of the atmosphere when the lungs are at rest. This results in air following the pressure gradient and passively filling the lungs at rest. As the lungs fill with air, the pressure within the lungs rises until it matches the atmospheric pressure. At this point, more air can be inhaled by the contraction of the diaphragm and the external intercostal muscles, increasing the volume of the thorax and reducing the pressure of the lungs below that of the atmosphere again.
- ◉ To exhale air, the diaphragm and external intercostal muscles relax while the internal intercostal muscles contract to reduce the volume of the thorax and increase the pressure within the thoracic cavity. The pressure gradient is now reversed, resulting in the exhalation of air until the pressures inside the lungs and outside of the body are equal. At this point, the elastic nature of the lungs causes them to recoil back to their resting volume, restoring the negative pressure gradient present during inhalation.

PHYSIOLOGY OF THE RESPIRATORY SYSTEM

External Respiration

- External respiration is the exchange of gases between the air filling the alveoli and the blood in the capillaries surrounding the walls of the alveoli. Air entering the lungs from the atmosphere has a higher partial pressure of oxygen and a lower partial pressure of carbon dioxide than does the blood in the capillaries. The difference in partial pressures causes the gases to diffuse passively along their pressure gradients from high to low pressure through the simple squamous epithelium lining of the alveoli. The net result of external respiration is the movement of oxygen from the air into the blood and the movement of carbon dioxide from the blood into the air. The oxygen can then be transported to the body's tissues while carbon dioxide is released into the atmosphere during exhalation.

Internal Respiration

- Internal respiration is the exchange of gases between the blood in capillaries and the tissues of the body. Capillary blood has a higher partial pressure of oxygen and a lower partial pressure of carbon dioxide than the tissues through which it passes. The difference in partial pressures leads to the diffusion of gases along their pressure gradients from high to low pressure through the endothelium lining of the capillaries. The net result of internal respiration is the diffusion of oxygen into the tissues and the diffusion of carbon dioxide into the blood.

Transportation of Gases

- The 2 major respiratory gases, oxygen and carbon dioxide, are transported through the body in the blood. Blood plasma has the ability to transport some dissolved oxygen and carbon dioxide, but most of the gases transported in the blood are bonded to transport molecules. Hemoglobin is an important transport molecule found in red blood cells that carries almost 99% of the oxygen in the blood. Hemoglobin can also carry a small amount of carbon dioxide from the tissues back to the lungs. However, the vast majority of carbon dioxide is carried in the plasma as bicarbonate ion. When the partial pressure of carbon dioxide is high in the tissues, the enzyme carbonic anhydrase catalyzes a reaction between carbon dioxide and water to form carbonic acid. Carbonic acid then dissociates into hydrogen ion and bicarbonate ion. When the partial pressure of carbon dioxide is low in the lungs, the reactions reverse and carbon dioxide

Homeostatic Control of Respiration

- Under normal resting conditions, the body maintains a quiet breathing rate and depth called eupnea. Eupnea is maintained until the body's demand for oxygen and production of carbon dioxide rises due to greater exertion. Autonomic chemoreceptors in the body monitor the partial pressures of oxygen and carbon dioxide in the blood and send signals to the respiratory center of the brain stem. The respiratory center then adjusts the rate and depth of breathing to return the blood to its normal levels of gas partial pressures.

EFFECTS OF EXERCISE ON HUMAN RESPIRATORY SYSTEM

◉ **SHORT-TERM EFFECTS OF EXERCISE**

- ◉ In respiratory system would be increased breathing rate by about three times the normal rate, increased amount of air taken in or out with each breathe by five times the normal rate, increased blood supply to and through the lungs and increased oxygen up take. Breathing rate returns to normal in 10 - 20 minutes being in rest mode.
- ◉ Would be increased use of oxygen (because muscles will require more oxygen in order to work) for heart to supply enough oxygen it has to increase its rate and stroke volume, so cardiac output will be high enough for all systems to get oxygen. Because body systems takes oxygen and gives carbon dioxide, lungs will have to work harder in order to remove carbon dioxide from blood and replace it with oxygen, so it will make breathing rate higher than normal.

◉ **LONG-TERM EFFECTS OF EXERCISE**

- ◉ Would be increase capacity and effectiveness of lungs, faster gaseous exchange from carbon dioxide to oxygen. Body will be more efficient using at using oxygen.
- ◉ For the lungs, you will have increased functional capacity during exercise, increased diffusion of respiratory gases (waste carbon dioxide exhaled from the body) and increased vital capacity (the maximum amount of air a person can expel from the lungs) which will decrease the debt of oxygen in blood while exercising. It also can prevent from lung disease and be more resistant to dust and mites. By exposing body to regular exercise (especially cardio exercises that includes running) you can increase cleaning process of lungs if you have been a smoker or working in dusty places.
- ◉ A very important muscle for lungs is diaphragm which makes the air to be sucked in to the lungs. By exercising you increase the strength of diaphragm. Also increase in the number of capillaries that is surrounding the alveoli that makes the gaseous exchange process faster and more effective.

THANK YOU