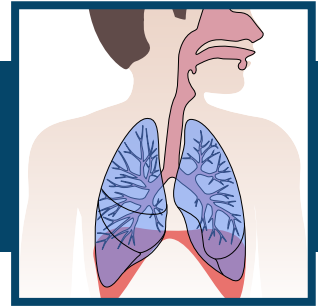


LESSON 1: MAPPING PULMO PARK

TEACHER BACKGROUND



TEXAS BIOMEDICAL
RESEARCH INSTITUTE
HEALTH STARTS WITH SCIENCE

Objectives:

The Student Will Be Able To:

1. Identify structures within the respiratory system and explain the function of each.
2. Describe how the respiratory system interact with or relate to other body systems.
3. Explain how the environment impacts the respiratory system.
4. Describe causes of common respiratory diseases and the impact these diseases have on the respiratory system.
5. Explain the mechanics and physiological processes of inhalation and exhalation.

Lesson Support Information

As an introduction to the “Mapping Pulmo Park”, students will explore the structure of the pulmonary system, exploring the functions of the lungs and how the health of our lungs is affected by interrelating factors.

Can you imagine that each day we breathe in about 20,000 times and by the time we’re 70 years old, we will have taken at least 600 million breaths? Breathing could not take place without the respiratory system and its vital parts. Chief among these parts are the lungs.

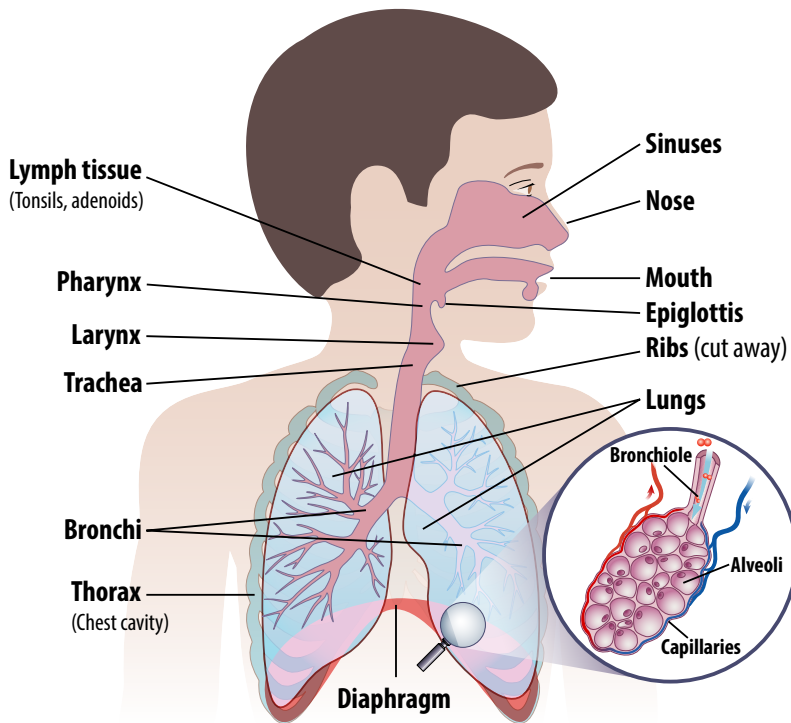
Respiratory Physiology: The Relationship Between Form and Function

The lungs are divided into lobes and work closely with the heart for pulmonary circulation at the **hilum**. The hilum is a depression or pit in an organ where structures such as blood vessels and nerves enter. The heart and lungs are attached to the **mediastinum** and are protected by the ribs. The ribs attach to the backbone and **sternum** which is located in the front center of the chest, forming a protective cage around the lungs. This protective cage is called the **thorax**. In addition to being protected by the thorax, the lungs are encased in a thin membrane called the **pleura**. The pleura acts as a cushion, further protecting the lung.

At the top of the respiratory system, the nostrils bring air into the nose, where it is warmed and humidified. The air then travels into the sinuses which are air pockets located inside the bones of the skull, located behind your cheekbones and forehead. The sinuses are lined with tiny hairs called cilia which protect the nasal passageways and other parts of the respiratory tract by filtering out dust, plant pollen, and other particles suspended in the air. **Mucus** is a slightly sticky substance produced by the body which coats the inside of the nasal passageways. The mucus also helps to filter the air by trapping particulates. If air is taken into the mouth, it bypasses the filtering mechanism within the nose and sinuses.

LESSON 1: MAPPING PULMO PARK

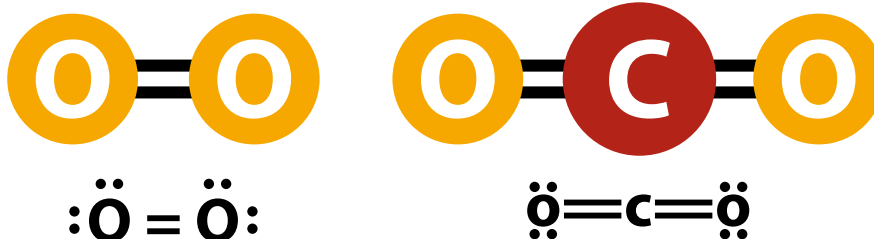
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The nasal cavity and mouth meet at the pharynx. The pharynx is commonly referred to as the throat. It is considered part of the digestive system as well as the respiratory system because it carries both food and air. Within the throat are lymph nodes. These small clusters of specialized cells include the tonsils and adenoids. Located in the back of the throat, these specialized cells filter out invaders, like bacteria and are part of the body's immune system.

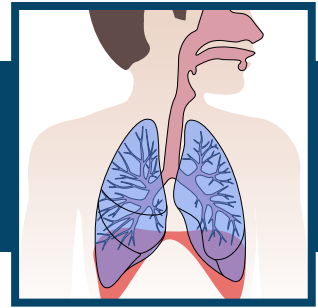
At the bottom of the pharynx, the pathway splits into two tubes. One tube, called the esophagus carries food to the stomach. The other tube is called the trachea which leads to the lungs. A small flap of tissue, called the epiglottis, covers the trachea when we swallow to keep food and liquid from going into the lungs. The walls of the trachea are strengthened by stiff rings of cartilage. The trachea is also lined with cilia which sweep fluids and foreign particles up and out of the trachea to keep the lungs clear.

In the upper section of the trachea is the larynx, or voice box. The larynx contains the vocal cords. The vocal cords are a pair of thin membranes which touch in the middle of the larynx. When they vibrate, the vocal cords produce sounds. Past the larynx, the trachea enters the chest cavity. Inside the chest cavity, the trachea branches into left and right tubes call bronchi, each leading into the lungs. Within the lungs, the bronchi branch into smaller tubes called bronchioles. Bronchioles lead into tiny air sacs called alveoli. The alveoli resemble clusters of grapes. Each lung houses about 300 to 400 million alveoli. Within the alveoli oxygen (O_2) diffuses into the body and carbon dioxide (CO_2) diffuses out of the body.



LESSON 1: MAPPING PULMO PARK

TEACHER BACKGROUND



Breathing Under Pressure

Breathing is a passive process resulting from a pressure difference between the lungs and the atmosphere. Inhaling (inspiration) expands the thoracic cavity which creates a negative pressure (a decrease in pressure) within the lungs. In other words, the pressure inside the lungs is less than the pressure outside of the body. Air naturally moves from an area of higher pressure into an area of lower pressure until the pressures are equalized. When the air pressure inside the lungs is equal to the air pressure outside the body, inspiration stops.

Because lungs have elastic properties, they expand during inspiration. But just like a stretched rubber band, there is a limit to how far the lungs can expand. When a stretched rubber band is released, it returns to the original size and shape. Just like the rubber band, when the lungs approach their expansion limit, their elastic properties pull them back. As the lungs contract, the air inside has less room, forcing the air molecules together. When gases are forced together, the pressure increases, resulting a higher pressure inside the lungs. The air inside the lungs moves out of the body into the now lower external pressure. As the air flows out of the body, this is called exhaling or exhalation.

Keep in mind the air pressure outside the body has not changed. Only the air pressure inside the lungs change. The changes in air pressure within the thoracic cavity is largely due to the movement of the diaphragm. This large, flat muscle separates the thoracic cavity from the abdominal cavity. As the diaphragm contracts and moves downward toward the abdomen. This expands the thoracic cavity and air flows into the lungs through the nose and/or mouth. When the diaphragm relaxes, it moves upward, forcing the thoracic cavity to get smaller which works with the contracting lungs to force lung gases closer together which increases the pressure in the lungs. The body takes advantage of pressure changes to passively move air in and out of the body. This greatly reduces the amount of energy the body uses to breathe.

The Mechanics of Respiration

With every breath, we take in oxygen-rich air through our nose and mouth. Air is a mixture of different gases. Approximately 20% of this mixture of gases is O_2 . When we inhale, air enters the lungs. Once in the lungs, the air moves through a series of smaller and smaller passages until the air enters the alveoli. The alveoli are surrounded by tiny, tubular blood vessels called capillaries. Oxygen diffuses (passes through) from the alveoli and enters the circulatory system (bloodstream) through the capillaries. Once in the bloodstream, O_2 binds to red blood cells and moves through the pulmonary veins which lead to the heart. The heart pumps the oxygen-rich blood to the body through a series of blood vessels, starting with large arteries which branch into smaller arterioles.

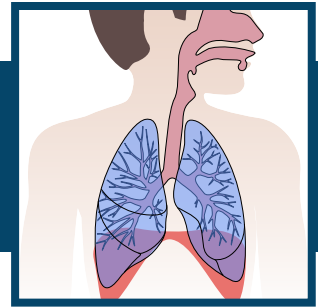
The arterioles branch into even smaller capillaries. Once in the capillaries, the oxygenated red blood cells come in close contact with the body's cells. The body cells are low in oxygen, but high in carbon dioxide (CO_2), a cellular waste product. Through diffusion, the O_2 and CO_2 trade places. The O_2 moves into the body's cells while the CO_2 moves into the red blood cells. Blood which carries carbon dioxide is called "oxygen-poor" blood. The capillaries move the

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LESSON 1: MAPPING PULMO PARK

TEACHER BACKGROUND

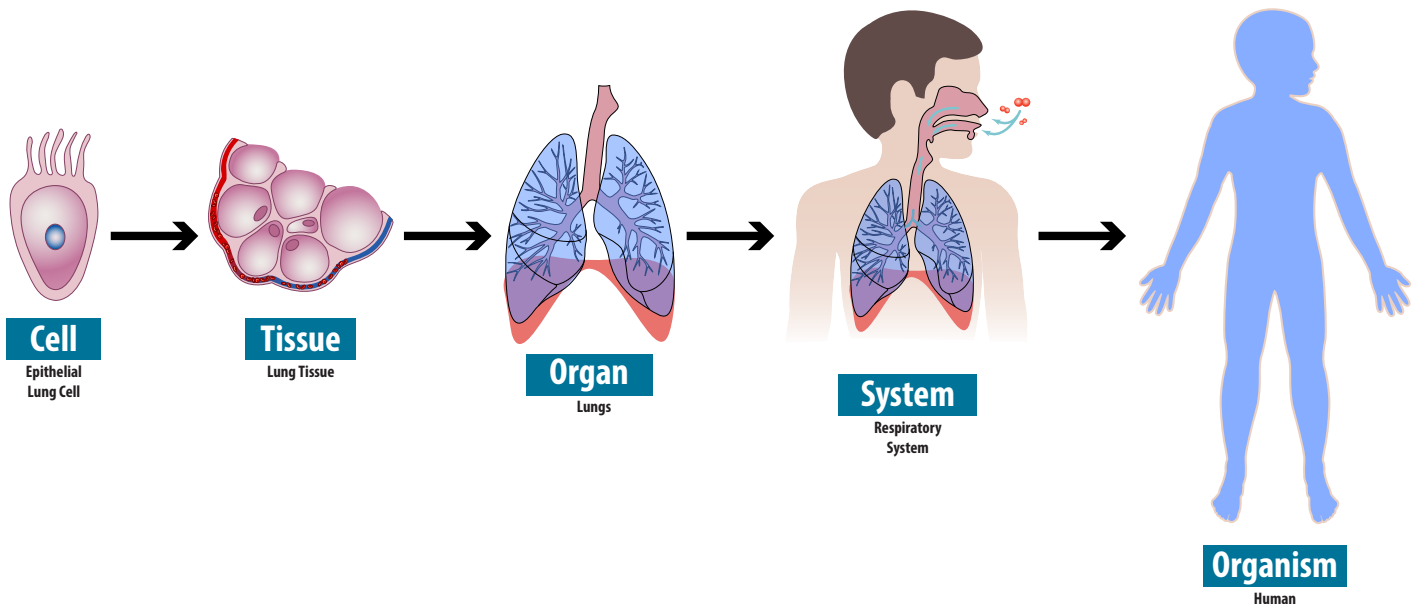


oxygen-poor red blood cells into larger venules. The venules connect to even larger veins which carry the oxygen-poor blood back to the heart. The heart pumps the oxygen-poor blood into the pulmonary arteries. The pulmonary arteries carry the oxygen-poor blood to the lungs, where the carbon dioxide diffuses into the lungs and is exhaled. And the process repeats.

Constructing a System

Living things are arranged according to levels of organization. The most basic level of organization is the cell. In a living thing made of more than one cell, cells can organize into tissues to do a specific job. For example, the circulatory system contains different types of cells and fluids. Together, these cells and fluids are called blood tissue. In more complex living things, tissues can organize into organs and work together to do a particular job. For example, blood tissue, muscle tissue, and nerve tissue form the heart, an organ that pumps blood to all parts of the body. Finally, in very complex living things, organs work together as systems to accomplish a particular job. Many systems working together to form a living organism.

Cell System Organization

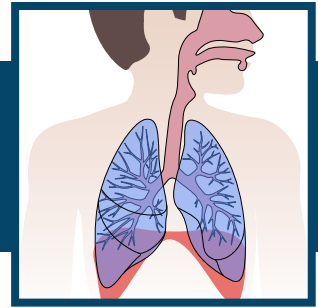


A system is defined as a group of independent but interrelated parts that work together as a whole for a common purpose. For example, the heart, blood, and blood vessels make up the circulatory system. The heart is an organ with its own job (function); to pump blood. The blood also has its own job, which is to carry nutrients, oxygen, and carbon to fight infections, etc. The blood vessels carry blood from one part of the body to the other. Each does its job well, but without the other parts, none can do the whole job of the circulatory system – it takes all working together. Similarly, the Respiratory System is made of its own parts working together to accomplish the job of respiration. In a wonderful display of cooperation, these two systems with their own structure (design) and functions (jobs), work

MIDDLE & HIGH SCHOOL LEVEL

LESSON 1: MAPPING PULMO PARK

TEACHER BACKGROUND



closely together to supply oxygen and to remove wastes from all parts of the body. If we didn't breathe, we couldn't live. It's one of the most important functions our bodies perform.

Pulmonary Health (*Student Lung Health Inventory Activity & PSA Extension*)

As reported by the World Health Organization, globally more than 1.5 million deaths annually from respiratory infections are attributable to the environment, including at least 42% of lower respiratory infections and 24% upper respiratory infections in developing countries. Respiratory infections are one of the biggest killers of children under the age of five. Most of these diseases are preventable because they are byproducts of a polluted environment. Even if the air we breathe is dirty or polluted, our respiratory and immune systems can defend against foreign matter and/or organisms that enter through the nose and mouth. Pollutants are trapped by hair or mucous, breathed out again, coughed up, swallowed, passed out through the intestines or destroyed in the digestive system. But when this system fails, things can go wrong in the respiratory system.

The lungs are prone to a range of disorders caused by pollutants in the air. Illnesses such as the common cold (caused by over 200 different viruses), influenza (commonly called the flu), and pneumonia (caused by viruses, bacteria, and fungus) contribute to respiratory issues. Of great concern is the virus which causes COVID-19. According to the Center for Disease Control (CDC), this virus is spread from person to person primarily through respiratory droplets. These droplets are produced by infected individuals and spread by sneezing, coughing, or even talking! These droplets are not visible but can be inhaled through the nose and mouth where the virus can move to infect the lungs. The COVID-19 virus is a "community spread" virus. This means it can easily spread within an area, or community, often without knowing how or when individuals were infected. The COVID-19 virus has resulted in a worldwide pandemic which means the disease has spread over a wide geographical area. In this case, COVID-19 has spread around the world. Wearing face masks is important to limit the spread of COVID-19. Face masks prevent the spread of the virus by reducing the number of virus-carrying droplets released into the air. Washing hands regularly throughout the day is also an important preventative measure. Our hands touch all types of surfaces which may have been exposed to droplets carrying COVID-19. Washing your hands for 20 seconds with warm water and soap removes the virus from your hands.

Another common lung illness is bronchitis in which the membranes lining the larger bronchial tubes become inflamed, and an excessive amount of mucus is produced. Bronchitis is caused by the same viruses that causes colds but can also be caused by bacteria. Bronchitis can be acute (short-term) or chronic (long-lasting). In an attempt to get rid of the excess mucus, the body generates a strong cough. Although rare, there have been documented cases of strong, prolonged coughing which have caused cracked ribs.

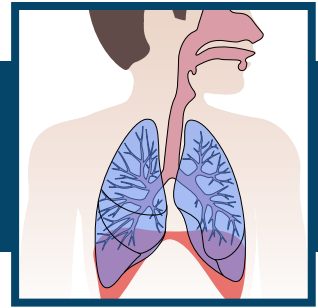
Sometimes family genetics or home environments make people more susceptible to lung issues, such as cystic fibrosis and asthma. Cystic fibrosis is a genetically inherited disease in which the body produces thick, sticky mucus.

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LESSON 1: MAPPING PULMO PARK

TEACHER BACKGROUND



The mucus clogs bronchioles and alveoli which decreases oxygen diffusion. The thick mucus traps bacteria leading to chronic lung infections and even respiratory failure. Asthma can be triggered by environmental factors, such as allergies and air pollutants. According to the CDC, nearly 25 million people in the United States have asthma. It is the number one reason students chronically miss school. Asthma flares involve contraction and swelling of the muscles around the tiny airways. The resulting narrowing of the airways prevents air from flowing properly, causing wheezing and difficulty breathing, sometimes to the point of being life-threatening.

Cigarette use can lead to lung diseases which can cause death, including chronic obstructive pulmonary disease (COPD) and lung cancer. COPD is a term that describes two lung diseases - chronic bronchitis and emphysema. Unlike acute bronchitis, chronic bronchitis can last for months or years. The constant inflammation of bronchial tubes generates more mucus which can lead to frequent lung infections and decreased airflow. Emphysema is associated with long term smoking. Smoking damages the alveoli which decreases oxygen diffusion. Although the body has capacity to heal, as we age, the body's ability to repair itself is reduced. Often, people who have emphysema need oxygen support for the rest of their lives. Cigarettes are a known carcinogen, meaning smoking has been scientifically proven to cause of cancer-related deaths in the United States. Lung cancer is caused by an abnormal growth of cells in the lungs. Symptoms include a persistent cough that may bring up blood, chest pain, hoarseness, and shortness of breath.

Although some respiratory diseases can't be prevented, many can be avoided by adopting healthy habits such as not smoking cigarettes and e-cigarettes, not abusing inhalants (huffing), and washing your hands frequently to reduce bacterial and virus transfer which cause respiratory illnesses.

Lesson References

Centers for Disease Control and Prevention (CDC). Retrieved August 26, 2021. <https://www.cdc.gov/tb/topic/basics/signsandsymptoms.htm>

The National Heart, Lung, and Blood Institute (NHLBI). (n.d.). How the Lungs Work. Retrieved August 28, 2020, from <https://www.nhlbi.nih.gov/health-topics/how-lungs-work>