

Chapter 1: The Lungs and Respiratory System

INTRODUCTION

Lung cancer affects a life-sustaining system of the body, the respiratory system. The respiratory system is responsible for one of the essential functions of life, breathing. Breathing enables us to take in oxygen and expel carbon dioxide. Every cell in the body depends on oxygen to function. If the supply of oxygen is impaired in any way, the entire body is affected.

An understanding of how the lungs and respiratory system work will help you understand how lung cancer affects the body. It may also be helpful as you talk with your health care providers, gather information about your illness, and communicate with your family and friends.

THE RESPIRATORY SYSTEM

Breathing

The respiratory system has one vital function, breathing. When you breathe in or *inhale*, your body receives oxygen. Oxygen is a gas in the air that is needed to sustain life. The human body cannot survive without oxygen for more than a few minutes. When you breathe out or *exhale*, you rid the body of carbon dioxide, a gas produced by normal body functions. Getting rid of carbon dioxide is necessary because excessive amounts of carbon dioxide are toxic. The lungs are the place in the body where essential oxygen is taken in, and toxic carbon dioxide is released. When the lungs have difficulty doing their job, other organs in the body have difficulty doing their jobs. Therefore, the health of the lungs has direct and immediate effects on the overall health of the body.

The respiratory system is made of up of those body parts that help us take in air and expel

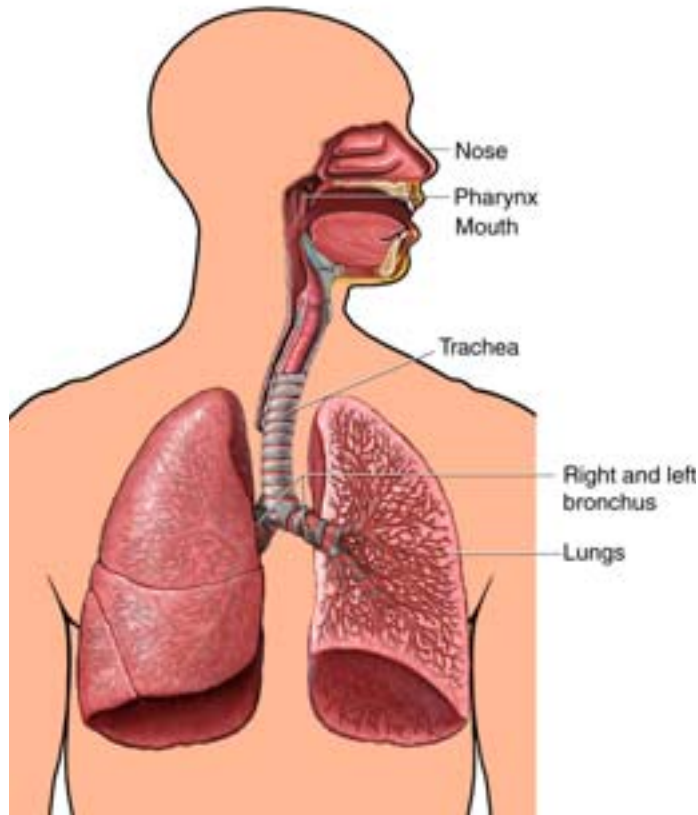


Figure 1: The Respiratory System

carbon dioxide. Take a breath in and you will quickly become aware of some of the body parts of the respiratory system. Air comes in through either the nose or the mouth. It passes to the throat (*pharynx*), and is pulled into the windpipe (*trachea*). The trachea splits in two between the lungs sending one branch to each lung (see Figure 1). These branches are called the right and left main bronchus. Before we discuss the path of air once it enters the lungs, let us first consider how we manage the act of breathing.

Air moves in and out of the body by the action of muscles. The diaphragm is a large muscle that sits below the lungs. It separates the lungs and other organs in the chest from the organs of the abdomen. When the diaphragm contracts or tenses, it moves down causing the lungs to expand and pull in air. When the diaphragm relaxes, it moves up, pushing against the lungs and causing them to expel air. There are also muscles between the ribs that help in this cycle of expanding and contracting the lungs, forcing air in and out. Put your hands on your chest and take a breath in. You will feel your chest expand. As you breathe out, you will feel your chest move inward. This movement is the result of the diaphragm and other muscles of the chest automatically contracting and relaxing with each breath in and out.

The lungs take up most of the space in the chest cavity, which extends from the collarbones to the diaphragm (see Figure 2). The organs of the chest are protected by the ribs. The area between the lungs in the middle of the chest is called the [mediastinum](#). It contains the heart, windpipe (trachea), food pipe ([esophagus](#)), blood vessels, and many lymph nodes. Examination of the lymph nodes in the mediastinum is an important part of the lung cancer staging process and is discussed in *Chapter 4: Lung Cancer Diagnosis and Staging*.

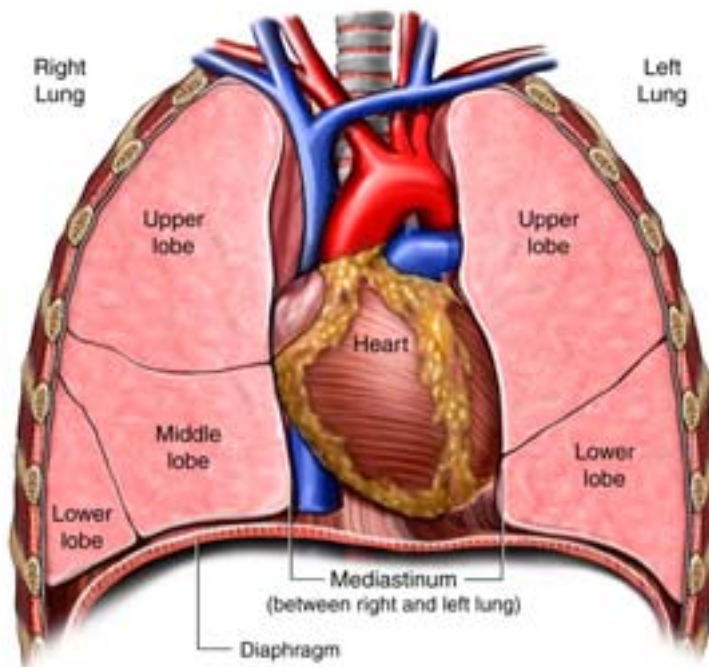


Figure 2: Organs of the Chest

The Lungs

You have two lungs, one on each side of the chest. The top, cone shaped part of the lung that fits under the collarbone is called the [apex](#). The broad, bottom part of the lung that rests on the diaphragm is called the [base](#). Unlike some other paired organs in the body, the two lungs are not identical (see Figure 2). The right lung is normally larger than the left. It is divided into three

sections or [lobes](#), the upper (also called superior), middle, and lower (also called inferior). The left lung has two lobes, the upper and lower. The left lung has an indentation called the cardiac notch to make room for the heart. Each lung lobe is divided into segments. Health care providers often use the names of lung segments to describe specific locations in the lungs.

The lungs contain elastic fibers that allow the lungs to expand and contract. Healthy lungs have a smooth, shiny surface because they are encased in a thin, moist covering called the [visceral pleura](#). There is also a pleural covering called the [parietal pleura](#) that

lines the inner surface of the chest cavity. The visceral and parietal pleura are normally slippery and glide easily against each other as you breathe.

The right and left main bronchi carry air in and out of the lungs. They are the beginning of a system of airways called the bronchial tree. The point at which the main bronchus enters the lung is called the hilum. The bronchial airway system is called a 'tree' for a very practical reason. The airways branch approximately 20 times in the lungs. At each

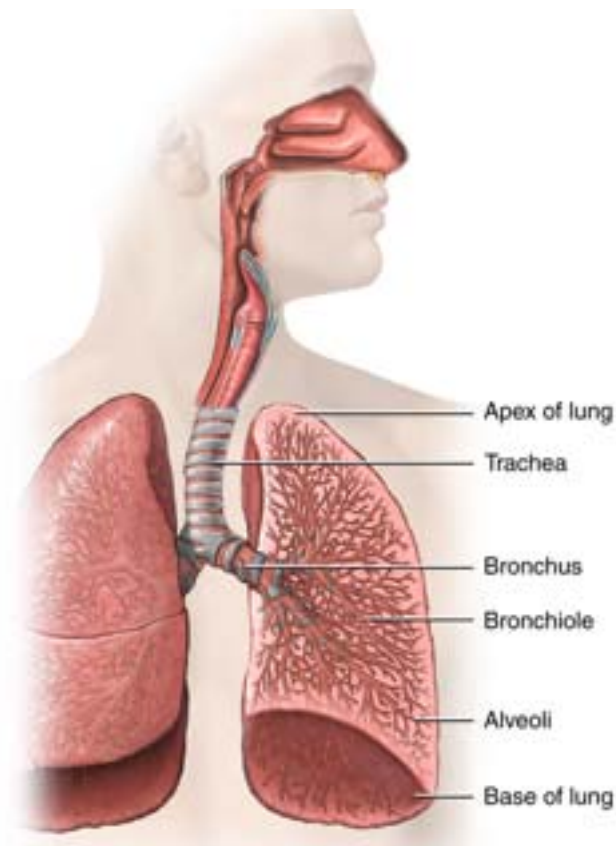


Figure 3: The Bronchial Tree

branch point, the airways become smaller and more numerous much like the branches of trees (see Figure 3). The main bronchi branch into lobar bronchi, one for each lobe of the lung. From here, the airways divide into segmental bronchi, one for each lung segment. Segmental bronchi branch several times into smaller airways called bronchioles. The final branches of the bronchial tree are called atria. The atria end in tiny, microscopic air sacs called alveoli. Alveoli resemble clusters of grapes under the microscope. Each lung contains about 300

million alveoli. The walls of the alveoli are extremely thin, which makes them fragile and susceptible to damage. Damage to the alveoli is irreversible.

Alveoli are surrounded by tiny blood vessels called capillaries. There are about one billion capillaries in the lungs, more than three for each air sac. The blood in the capillaries is separated from the air in the alveoli only by the extremely thin alveolar and capillary walls. This close proximity allows gases to be exchanged between the blood

and the lungs in a process called [respiration](#). Inhaled oxygen enters the blood from the alveoli. Carbon dioxide leaves the blood and enters the alveoli to be exhaled. The close relationship between the circulatory and respiratory systems will be discussed in the following section, *The Link Between the Respiratory and Circulatory Systems*.

The lungs are traversed by another important system of vessels called the [lymphatics](#). Each lung contains a network of lymphatic vessels that carry a mixture of fluid and proteins called [lymph](#). Lymph is carried from the lung tissues through a series of lymph nodes to filter the fluid before it is returned to the bloodstream. This network of lymph vessels and lymph nodes are an important part of the body's immune system. The work of the immune system and its role in lung cancer is discussed in *Chapter 2: Understanding Cancer*.

THE LINK BETWEEN THE RESPIRATORY AND CIRCULATORY SYSTEMS

The Respiratory Cycle

The respiratory and circulatory systems have closely related jobs. The work of these two systems is sometimes referred to together as the [cardiorespiratory system](#). The respiratory system is responsible for taking in oxygen and expelling carbon dioxide. However, it is dependent on the circulatory system to distribute the oxygen that has been taken in by the lungs to the body tissues. Similarly, the circulatory system picks up carbon dioxide from the tissues and delivers it to the lungs where it is exhaled.

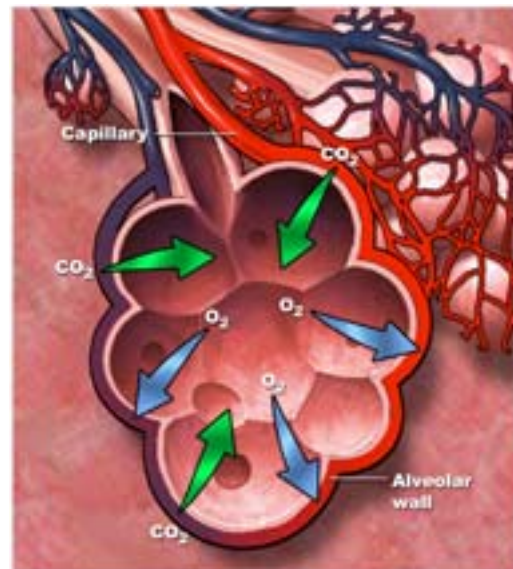


Figure 4: The Respiratory Cycle

Every cell of the body requires oxygen to perform its jobs. Carbon dioxide is released as these jobs are performed and must be eliminated to prevent excess amounts from

accumulating in the tissues. Continuous removal of carbon dioxide from the body is just as important for health as is a constant supply of oxygen.

In the respiratory cycle, oxygen is picked up by the capillaries surrounding the alveoli (see Figure 4). The oxygen-rich blood is carried to the heart, which pumps the blood into [arteries](#) that carry it to the tissues of the body. In the tissues, capillaries release oxygen and pick up carbon dioxide. This carbon dioxide-rich blood is carried by [veins](#) back to the heart, which pumps it to the lungs. Carbon dioxide is released from the blood into the alveoli and new oxygen is picked up, beginning the cycle again. A more detailed discussion of the circulatory system is presented in the next section, *The Circulatory System*.

The success of the respiratory cycle is dependent on the very thin walls of the alveoli. These walls normally allow for a quick and easy exchange of oxygen and carbon dioxide. Lung diseases like emphysema and cancer can damage the delicate alveoli and interfere with the vital exchange of gases resulting in abnormal levels of oxygen and carbon dioxide in the blood.

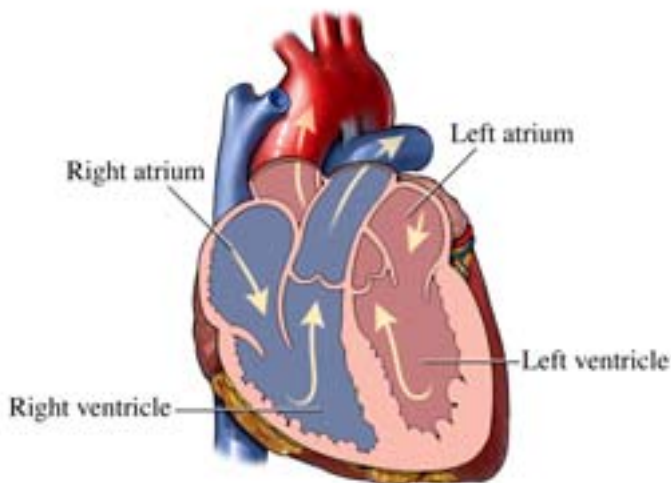


Figure 5: Chambers of the Heart. Arrows show the direction of blood flow through the heart.

The Circulatory System

Similar to the bronchial tree, the circulatory system is a branching network of blood vessels. The heart is at the center of the circulatory system. Its pumping action moves blood through the body. The heart has four compartments called chambers, two on the right and two on the left. The two chambers on the right work together as do the two

chambers on the left. The top chambers of the heart are called the [right atrium](#) and [left atrium](#). The bottom chambers are called the [right ventricle](#) and [left ventricle](#) (see Figure 5).

Carbon dioxide-rich, oxygen-poor blood is delivered from the tissues of the body by the veins to the right atrium of the heart. Blood flows from the right atrium to the right ventricle, and then leaves the heart through the [pulmonary artery](#) (PA). Before reaching the lungs, the PA divides into a right and left branch, one for each lung. Once in the lungs, the PA branches several times into smaller blood vessels called [arterioles](#). These arterioles run in the walls of the airway system's bronchioles. The arterioles continue to branch and become progressively smaller until they reach the level of the alveoli. At the alveoli, the blood vessels have become the tiny, microscopic capillaries that are capable of gas exchange.

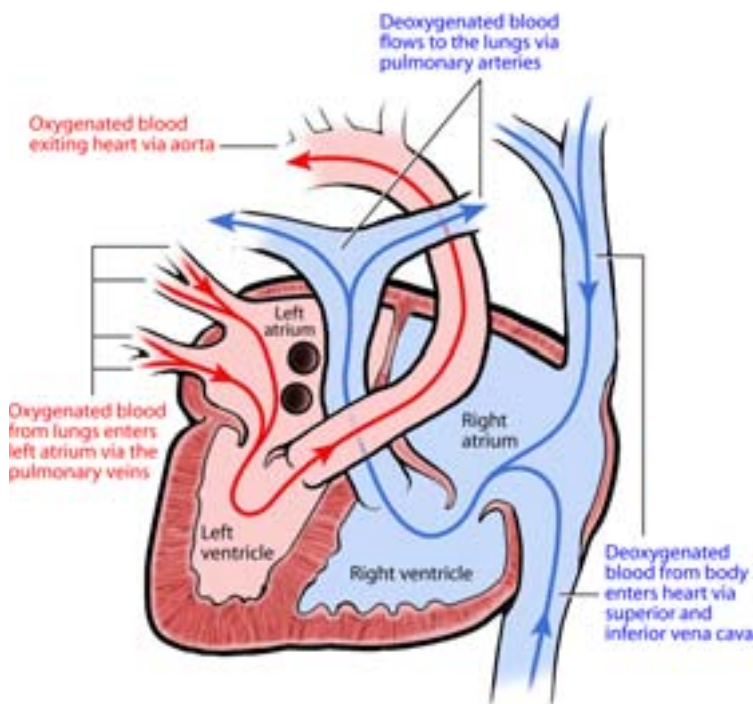


Figure 6: Blood Flow through the Heart

Blood passes through the alveolar capillaries releasing carbon dioxide and picking up oxygen. The oxygen-rich blood is delivered to the left atrium by the [pulmonary veins](#) (see Figure 6). Blood passes from the left atrium into the left ventricle, and is pumped out through the [aorta](#) to be distributed by a branching system of arteries, arterioles, and capillaries throughout the body.

Lung diseases, including lung cancers, can affect the function of the right side of the heart since blood is pumped from the right side of the heart to the lungs. Although right

heart abnormalities are not a common complication of lung cancer, they can occur. The left side of the heart is usually not affected by diseases of the lung. However, if the blood pressure in the lungs becomes very high, the left side of the heart can be affected.

RESPIRATION AND MAINTAINING CHEMICAL BALANCE

Respiration is one of the body's stabilizing or *homeostatic mechanisms*. The respiratory system helps maintain a constant internal environment that keeps all of the body cells functioning effectively. It does this by supplying adequate oxygen and removing excess carbon dioxide. Slight changes in the oxygen and/or carbon dioxide levels in the blood trigger processes that attempt to bring these levels back to normal. For example, if you exert yourself by running or climbing stairs, your heart rate and breathing will automatically increase. This is your body's response to an increased need for oxygen and an excess of carbon dioxide that must be eliminated. The harder your muscles work, the more oxygen they need and the more carbon dioxide they produce. By breathing faster, you increase your intake of oxygen and expel more carbon dioxide. A faster heart rate increases the speed of delivery of oxygen and the clearance of carbon dioxide. In other words, when you exert yourself, you breathe more quickly and your heart beats faster because the body is attempting to bring your oxygen and carbon dioxide levels back to normal.

Survival depends on the body's ability to respond to continuous changes in its environment. The body's ability to respond to changes in its internal and external environments requires constant communication and interaction between the various organ systems of the body. Changes in the body trigger complex responses. Various body systems often work together to return the internal environment to a normal state.

The kidneys help maintain normal levels of many substances in the body. In the preceding example, we discussed how a short-term increase in carbon dioxide from exercising causes rapid increases in heart and breathing rates. However, if the carbon

dioxide level is increased over a longer period and the increased efforts of the cardiac and respiratory systems are unable to clear it quickly enough, the accumulation of carbon dioxide can cause the internal body environment to become more acidic (the blood pH decreases). The pH of the blood is an indicator of the acidity or alkalinity of the body. The kidneys respond to a drop in blood pH. They attempt to assist the cardiac and respiratory systems by ridding the body of its excess acid through the urine. This demonstrates how different organ systems work together to try to keep the body in normal balance.

In addition to responding to the pH of the body, the kidneys also respond to prolonged decreases in body oxygen levels by increasing production of a hormone called [*erythropoietin*](#). Increased erythropoietin leads to an increase in the production of [*red blood cells*](#), the cells of the blood that carry oxygen. In this way, the kidneys try to help the body meet its oxygen needs by increasing the oxygen-carrying capability of the blood. [*Anemia*](#) is the condition of having an abnormally low number of red blood cells. There are many causes of anemia, and cancer is one of these causes. Anemia is also a common side effect of some forms of cancer therapy. The symptoms of anemia include feeling abnormally tired, shortness of breath, dizziness, and becoming easily fatigued (tiring quickly). Anemia associated with cancer or its treatment can overwhelm the body's homeostatic mechanisms. Therefore, if you have the symptoms of anemia, be sure to discuss them with your health care provider. He or she may be able to give you medications or treatments that will correct the problem and eliminate the symptoms.

Damage to lung tissues can reduce the respiratory system's ability to respond adequately to changes in oxygen and carbon dioxide levels in the body. This impaired capacity can lead to shortness of breath, [*dyspnea*](#) (uncomfortably difficult breathing), fatigue, dizziness, and other symptoms. Although these symptoms have other possible causes, they are common problems for people living with lung cancer. Breathing methods that are designed to help maximize the ability of the lungs to carry out the effective exchange of oxygen and carbon dioxide are described in *Chapter 10: Supportive Care for Symptoms of Lung Cancer and Its Treatment*.

SUMMARY

The lungs are vital organs; they are necessary to sustain life. The lungs take in needed oxygen and rid the body of excess carbon dioxide. The respiratory and circulatory systems work together to maintain normal oxygen and carbon dioxide levels in all the tissues of the body. When lung tissue is damaged or removed, the lungs become less effective at the vital exchange of these gases. The effects of this decreased function can be experienced throughout the body and cause a variety of symptoms.

GLOSSARY

NOTE TO THE READER

Many of the words listed in the *Glossary* have more than one definition. The definitions presented here are limited to how the words are used in the context of discussing lung cancer.

alveoli – tiny air sacs at the end of the airways in the lungs

anemia – a condition in which the number of red blood cells or the amount of hemoglobin in the blood is abnormally low

aorta – the large artery that carries oxygen-rich blood away from the heart where it will be distributed throughout the body by smaller blood vessels of the circulatory system

apex (of the lung) – the top part of the lung in the upper chest under the collar bone

arteriole – an intermediate-sized blood vessel that carries oxygen-rich blood to body tissues

artery – a large blood vessel that carries oxygen-rich blood to body tissues

atria (airway atria) – the smallest airways of the lungs; the atria lead to the alveoli

base (of the lung) – the broad, lower end of the lung that sits on the diaphragm

bronchial tree – the branching system of airways in the lungs

bronchiole – small airways of the lungs; part of the bronchial tree

capillary – the smallest blood vessels of the circulatory system

cardiorespiratory system – the joint work of the heart and lungs that brings oxygen to cells and rids them of excess carbon dioxide

dyspnea – difficult or painful breathing

erythropoietin – a hormone produced by the kidneys that stimulates red blood cell production

esophagus – the tube-like structure that carries food from the mouth to the stomach

exhale – to breathe out

hilum – the area of the lung where the mainstem bronchus and the large pulmonary arteries and veins enter and exit the lung

homeostatic mechanism – any of a number of processes that keep the substances of the body in normal balance

inhale – to breathe in

left atrium – the chamber of the human heart that receives oxygenated blood from the lungs

left ventricle – the chamber of the human heart that sends oxygenated blood from the lungs to the body

lobar bronchi – large airways that transport air to the individual lobes of the lungs

lobe (of the lung) – sections of the lungs; the right lung has three lobes and the left lung has two lobes

lymph – the fluid that circulates through the lymphatic vessels; made up of excess tissue fluid, proteins, and cells of the immune system

lymphatics/lymphatic vessels – thin walled structures that carry lymph fluid throughout the body

mediastinum – the area in the center of the chest between the lungs; contains the heart and the large blood vessels entering and leaving the heart, the trachea, the esophagus, and several lymph nodes; the lymph nodes of the mediastinum are often checked for cancer in the lung cancer staging process

parietal pleura – part of the sac enclosing the lung that is in contact with the inside of the chest wall

pharynx – the area behind the nose and mouth that leads to the trachea (for air) and the esophagus (for food); commonly thought of as the throat area

pulmonary artery – the large blood vessel that carries oxygen-poor blood from the right side of the heart to the lungs

pulmonary vein – the large blood vessel that carries oxygen-rich blood from the lungs to the left side of the heart

red blood cells – microscopic structures in the blood that carry oxygen and carbon dioxide between the body tissues and the lungs; the component of blood that gives it its characteristic red color

respiration – the process whereby cells take up oxygen and give off carbon dioxide; the breathing process

right atrium – the chamber of the human heart that first receives oxygen-poor blood from the body

right ventricle – the chamber of the human heart that sends oxygen-poor blood from the heart to the lungs

segmental bronchi – intermediate size airways that transport air in and out of the various segments of each lobe of the lung

trachea – the tube-like structure that carries air between the mouth and nose and the lungs

vein – a large vessel of the circulatory system that carries oxygen-poor blood from the tissues toward the heart

visceral pleura – part of the sac enclosing the lung that is in contact with the outer surface of the lung; the most common site of malignant mesotheliomas