

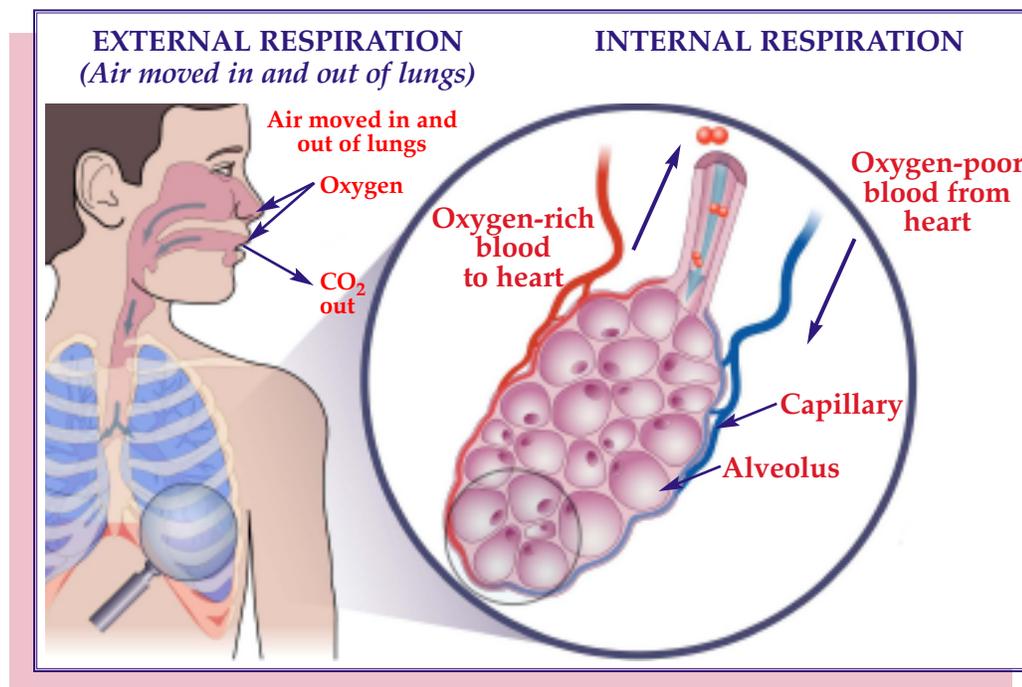
## Part I. Teacher Information

### Flash Animation Explanation

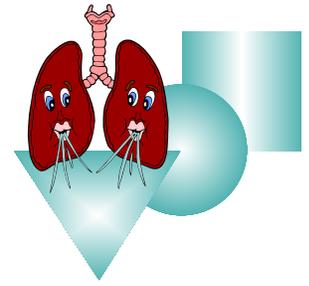
*Note: Students will infer as much of this information as possible from observing the flash animation and conducting the short lab activities.*

In the beginning of the animation *The Anatomy of Breathing*, students are shown the thoracic cavity of a young person. The **lungs** are superimposed onto the body in purple. Students should observe that the two lungs are not identical in size or shape. Each lung is divided into **lobes** and the right lung is slightly smaller. An indentation can be found where the heart rests against the right lung. The **diaphragm** appears in brown beneath the lungs. The diaphragm is a muscle that separates the thoracic cavity from the abdominal cavity and can contract to increase the volume of the chest cavity and relax to decrease the volume of the chest cavity. This action of the diaphragm is important in allowing us to **inhale** and **exhale**.

The cells of the human body require **oxygen** to burn fuel (glucose) much like a car requires it to burn gasoline. There are parts of the cell called mitochondria that use the oxygen to generate ATP (Adenosine triphosphate), which is the type of energy cells can use. This is called **internal respiration**. Internal respiration can only take place if **external respiration** occurs. External respiration begins as the body takes in air rich in oxygen through the nose and mouth. It travels down through the air tubes (the pharynx and larynx) and into the lungs through the trachea, the bronchial tubes, and into the alveolar spaces (Lab A addresses internal and external respiration). See Figure 1.



**Figure 1 Internal and External Respiration**

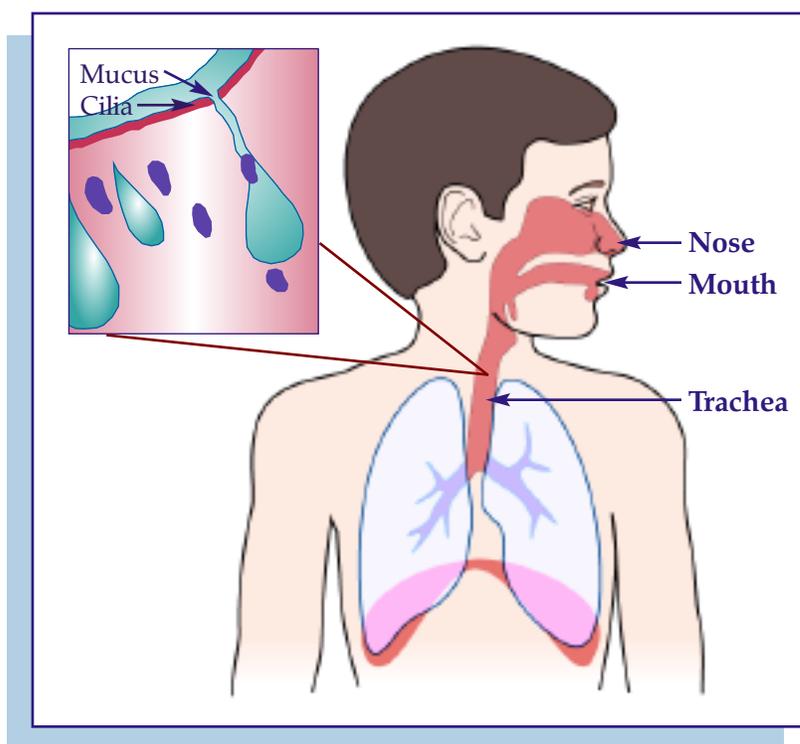


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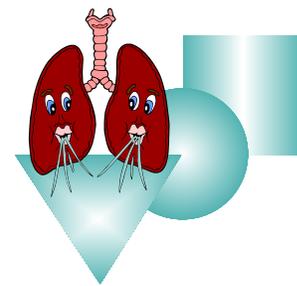


Breathing is controlled by the respiratory center in **brain stem**. The areas in the brain stem are called the medulla oblongata and the pons. The brain stem has some communication with the cerebral cortex, so that we can voluntarily control our breathing to some extent. It receives input from sensors that *monitor carbon dioxide and oxygen levels* in the blood. It sends nerve signals to the diaphragm and intercostal muscles, setting the rate and depth of breathing. Moving air in and out of the lungs is called **ventilation**, a primary function of the respiratory system. Lungs can be described as many lobules of sponge-like material that is protected by a clear, thin, shiny covering known as the **pleura**.

The **airway** is the next part to appear in pink in the flash animation; it is a series of branching tubes from the nose and mouth all the way to the bronchioles. The **trachea**, commonly called the windpipe, is labeled. Air enters the respiratory system through the nasal cavity. This air contains dust and dirt particles that could cause damage. The nose and **nasal cavity** provide a **filtration** service. Hairs in the nostrils keep larger particles from entering as air is inhaled. Dust particles are trapped by **mucus** and moved by **cilia** to the back of the throat for swallowing. Inhaled air is moistened and warmed as it passes through the nasal cavity. Air travels from the nasal cavity into the trachea. The **trachea** is a flexible tube that carries air into the larynx toward the lungs. The trachea is held open by C-shaped rings of cartilage embedded in its walls. The trachea also works to remove damaging dust particles. At its lower end, it divides into two main **bronchi**, one for each lung. (Lab B addresses the function of "air conditioning"). See Figure 2.



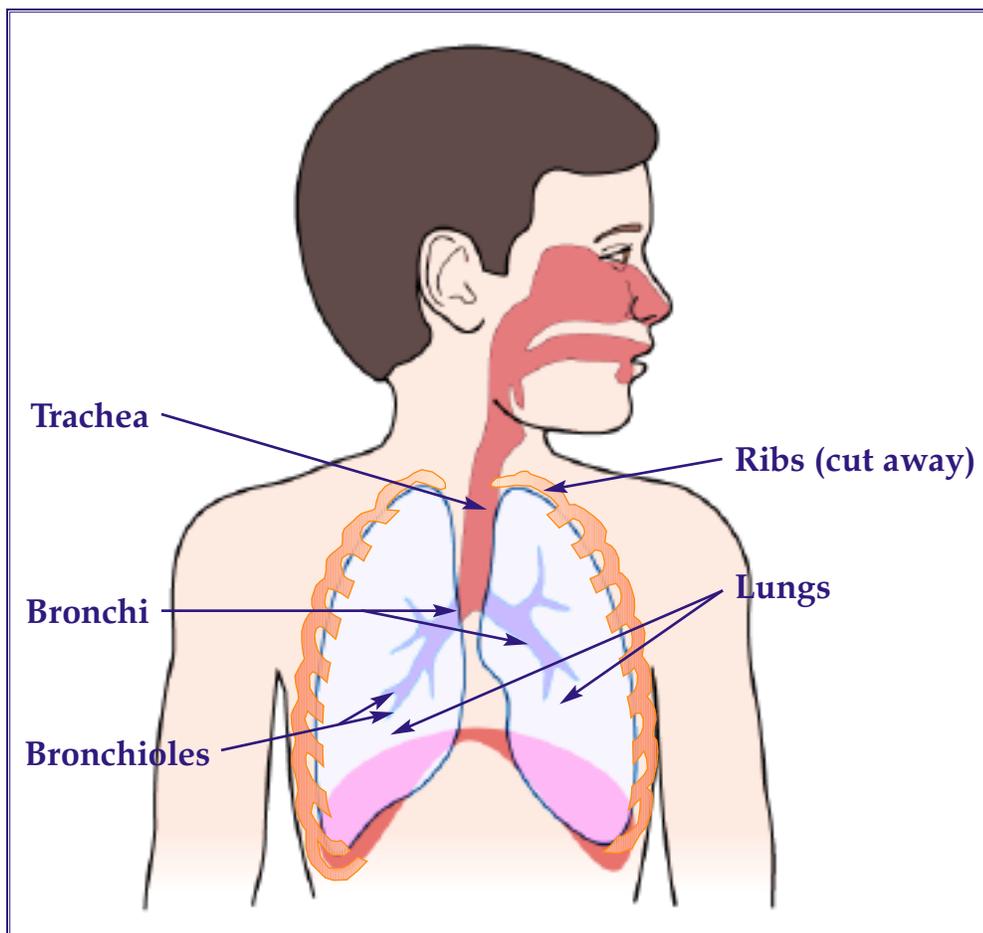
**Figure 2 Air Moistened and Filtered**



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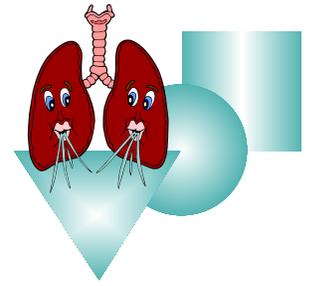


The trachea narrows and branches to form the bronchi and the bronchi enter the **hilum** of the lungs. The term **hilum** refers to a depression in an organ through which structures such as nerves or blood vessels enter. From the hilum, the bronchi split into **bronchioles** as the airways become smaller and smaller and branch out into the lungs. This **branching is important** because it allows more area of the lungs to be reached so more oxygen can be picked up by the blood. Students will also be interested in how food is kept from the airway. The **epiglottis** shuts off the trachea each time we swallow food. This sends food down the esophagus and allows air to travel down the trachea without interruption. (Lab G addresses **branching of the respiratory system to cover more area**). See Figure 3.



**Figure 3 Branching Airways**

The **ribs** cover and protect the lungs, airway, and diaphragm as well as the heart. Movement of the ribs increases or decreases the size of the rib cage, causing pressure changes needed for inhaling and exhaling. The bone in the center of the ribs is called the **sternum** and the shoulder bones across the tops of the ribs are called the **clavicles**.



# Activity Overview Continued



## Air Pressure Changes

In order to understand breathing, it is important to know that *air moves from areas of high pressure into areas with lower pressure*. It is also important to understand that if a *volume of air is increased*, the pressure exerted by the air molecules decreases because the molecules can spread out. If a *volume of air is decreased*, the pressure exerted by air molecules *increases* as they are pushed closer together. These principles are critical to the mechanism of inhaling and exhaling. There are three pressures we will consider; they are:

**Atmospheric pressure** – pressure exerted by air around us  
**Pressure** in bronchial tree and alveoli

**Intrathoracic pressure** – air pressure inside the rib cage

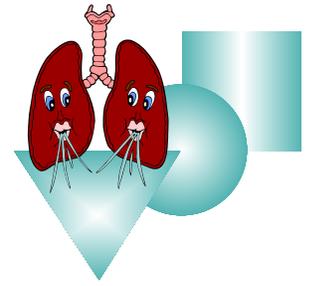
During the breathing cycle, air pressure in the lungs (bronchial tree and alveoli) and the air pressure inside the rib cage (thoracic cavity) change compared to the atmospheric pressure.

### Inhalation or inspiration:

Just before O<sub>2</sub> (oxygen) and other gases are taken into the airway, the diaphragm contracts and moves downward and the ribs move outward, **enlarging the volume** inside the rib cage. As the air molecules inside the rib cage spread out into the larger volume, *lower pressure* occurs in and around the lungs. Another way to look at this is that a **negative pressure** is generated compared with the atmospheric pressure (pressure exerted by gases in the atmosphere) outside the body. Because pressure is lower in the alveoli of the lungs than it is on the outside, air rushes into the lungs. Deeper inspirations require more forceful contractions of the diaphragm and external intercostals and the involvement of some neck and thoracic muscles.

### Exhalation or expiration:

Just before CO<sub>2</sub> (carbon dioxide) and other waste materials are breathed out of the airway, the diaphragm muscles relax and ribs move inward, **decreasing the rib cage volume**. As this is happening, the lungs recoil (snap back into shape) due to their elasticity. As a result of these two events, the air pressure in and around the lungs increases and becomes greater than the barometric pressure outside. Since air moves from high pressure areas to lower pressure areas, air leaves the lungs, where air pressure is now greater than the barometric pressure. Forced expiration, such as in heavy exercise, requires contraction of the internal intercostals and abdominal muscles (**Labs C & D address the effect of volume change on air pressure**). See Figure 4.

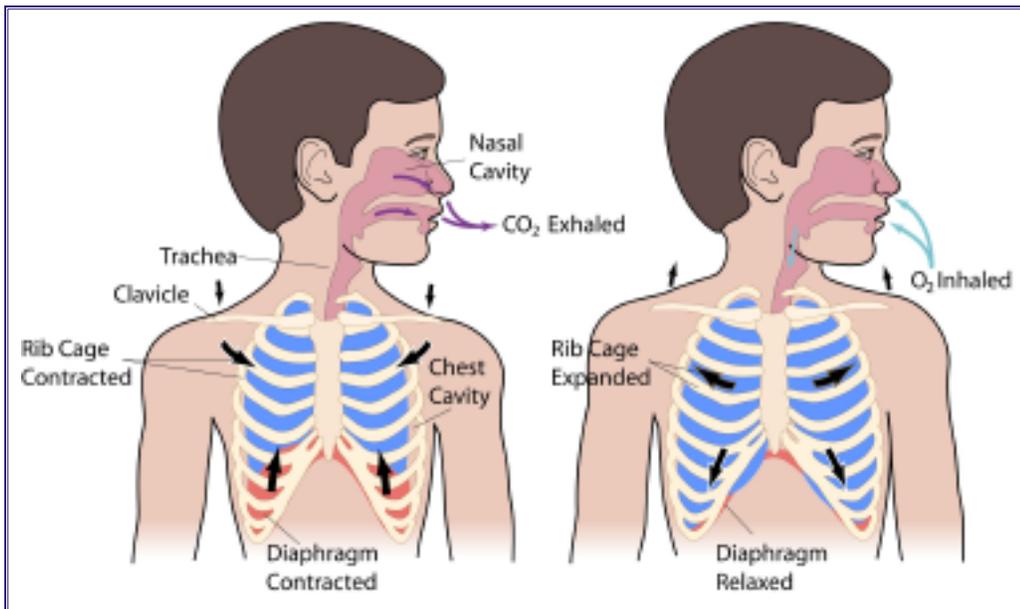


# Activity Overview Continued



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ACTIVITY 2A

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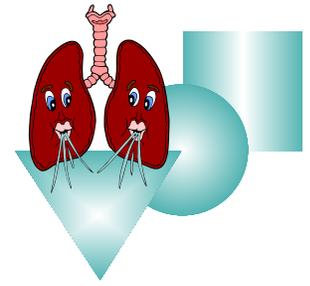


**Figure 4 Chest Cavity Volume Changes During Exhaling and Inhaling**

### Take a Closer Look

What is under the magnifying glass in the flash animation? Notice under “**Taking a Closer Look**”, the magnifying glass takes the observer from the bronchi, bronchiole, and into the alveoli where gas exchanges take place. Air breathed in is warmed, moistened, and filtered as it flows through these air ways. The respiratory zone starts where the bronchioles stop. This is where gas exchange begins. The bronchioles end with little grape-like sacs called alveoli. Each alveolus has a membrane that is one cell thin and covered with capillary nets. These tiny nets made up of many blood vessels allow for the movement (diffusion) of  $O_2$  into the blood stream and  $CO_2$  out of the blood stream.

As the **bronchial tree** branches out, alveoli are clustered in groups known as alveoli sacs (**Lab G**). De-oxygenated blood flows from the body loaded with  $CO_2$  left over from the breakdown of glucose. This blood enters lungs through the pulmonary arteries and moves into tiny capillaries. These capillaries are so small that red blood cells must move through in single file.  $CO_2$  moves out of the capillary and into the alveoli so it can be breathed out. Oxygen in the alveoli moves into the capillaries and is picked up by red blood cells. From the capillaries in the lungs, the oxygen-rich blood moves out of the lungs, back to the heart so it can be pumped out to all cells of the body. Water must be present in order for oxygen and carbon dioxide to move in and out of capillaries and alveoli. (**Lab E & F address gas exchange and diffusion through a membrane**). See *Figure 5*.

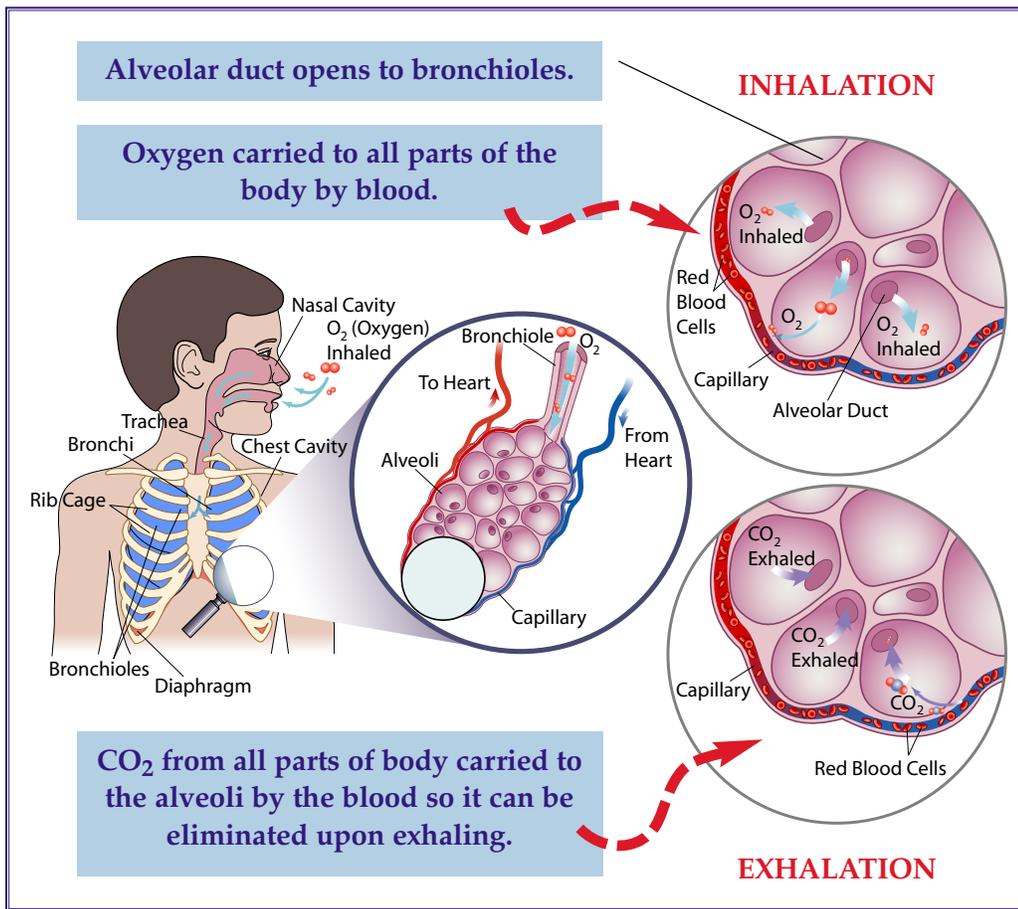


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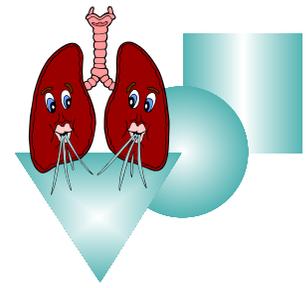
LESSON 2  
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**Figure 5 Oxygen/Carbon Dioxide Exchange**

Several things affect the rate at which this exchange takes place. The temperature of the body causes change in kinetic energy that can speed up or slow down the rate of exchange. The surface area for the lungs is tremendous — over *300 million alveoli*. Water molecules inside the alveoli along their inner wall attract other water molecules. Due to bonding of these water molecules, alveoli tend to collapse (think of a plastic bag that is wet on the inside). The body creates a substance known as surfactant to keep this from happening. *Surfactant* is a detergent-like molecule that lowers the attraction between water molecules. This lowers surface tension inside the alveoli, helping to keep them from collapsing. (Lab H addresses the issue of surface tension). See Figure 6.

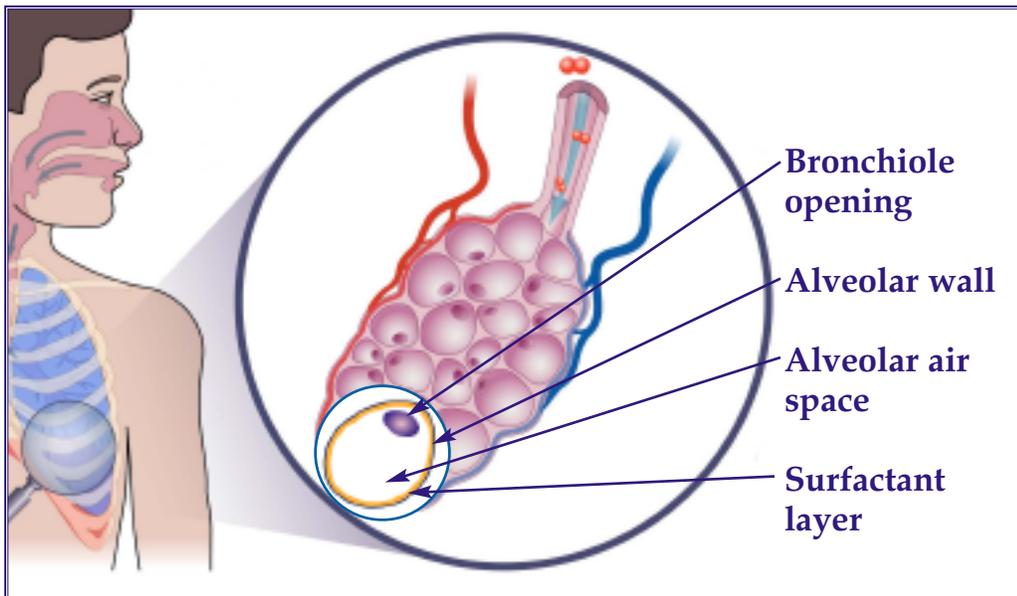


# Activity Overview Continued



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**Figure 6 Alveoli Expanded**

Any dust particles reaching the alveoli are engulfed by wandering white blood cells called alveolar **macrophages**. These “scavenger cells” are less active in heavy smokers.

## Part II. Teacher Information

### Under Construction: A Collection of Lab Stations for Pulmo Park

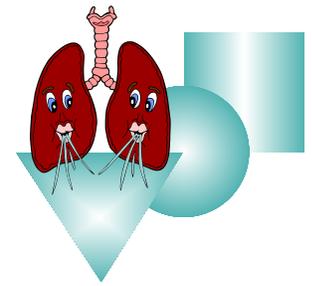
#### Teacher Directions:

Following are a collection of lab activities that can be arranged into 7-minute stations through which students rotate in groups of three. They will help students discover some of the important principles in the respiratory system. You may choose to use all of the labs or some of them. Divide students into groups and have them work collaboratively at each station as they rotate. The students may use their graphic organizer on “**The Anatomy of Breathing**” or visit the flash animation determine which lab best represents each lung function on “**Pulmo Park Builder’s Log.**” After the lab investigations, teachers will guide students through a discussion to determine the most logical lab representation for each lung function. Table 1 will help guide the student debate and discussion:

#### Answer Key for Builder’s Log

##### Visual Lab

- |                     |             |
|---------------------|-------------|
| 1. Gas Exchange     | A, E, and F |
| 2. Filtration       | B           |
| 3. Inhale/Exhale    | C and D     |
| 4. Branching Airway | G           |
| 5. Alveoli          | H           |



# Activity Overview Continued

