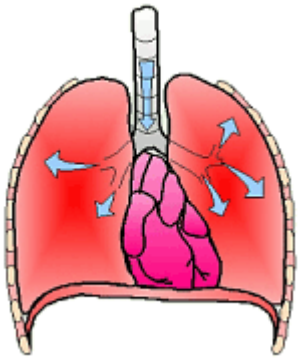
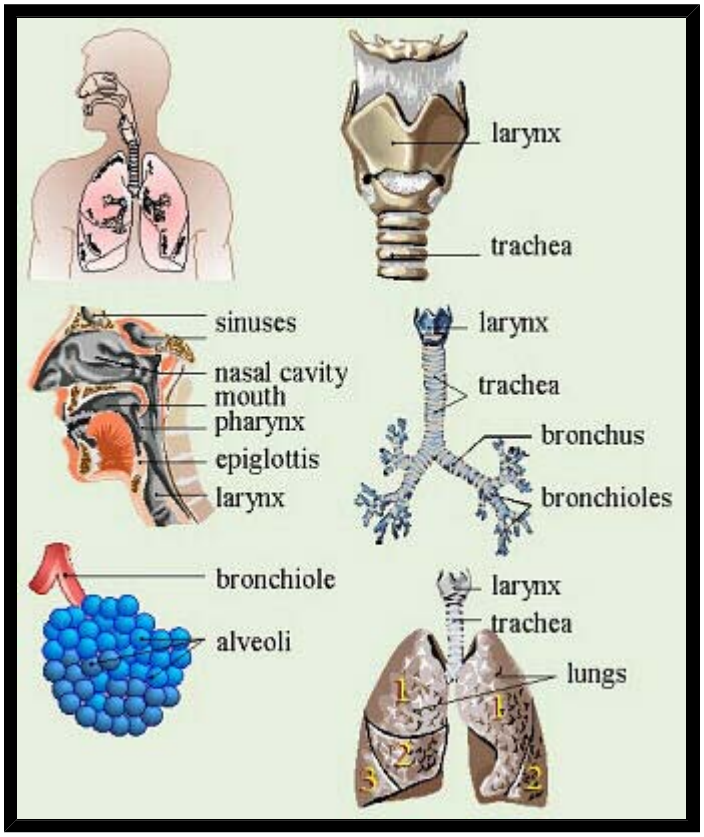
Respiratory System



Each cell in an animal's body must receive O_2 and give off CO_2. This is easier for smaller organisms. In the vertebrates, the blood carries O_2 and CO_2 to and from the cells, but these gases must also be exchanged with the outside air or water. In insects, the tracheal system takes air directly to the organs and O_2 is usually not carried in the blood. Mammals and some other vertebrates have have lungs to exchange air. However, the lungs are ventilated differently in different groups of vertebrates. For example, a frog opens its nostrils and expands the floor of its mouth to draw air into its mouth. Then it closes its nostrils and uses the floor of its mouth to *push* O_2 into its lungs. Mammals are unique in possessing a **diaphragm** to *pull* O_2 into the lungs. As the diaphragm contracts and the rib cage rises, a negative pressure is created in the chest cavity causing the lungs to expand and air to be drawn in.
(clipart edited from Corel Presentations 8)



1. Air first passes into the **nostrils** where it is filtered by the **nasal hairs** and warmed and humidified in the **nasal cavity and sinuses**.
2. From there, the air passes through the **pharynx**, which is shared with the digestive tract. Many students have trouble with the pronunciation of this word. It is pronounced "fair--inks," and you need to learn how to correctly pronounce it.
3. Air next passes through the **larynx**, (pronounced as above, but with an "l") also called the Adam's apple, voice box, or vocal cords. The vocal cords are under tension, and a change in tension causes a change in pitch as air passes over them and they vibrate. An inflammation of the larynx is called **laryngitis**.

The larynx is situated at the top end of the **trachea**, through which the air passes next. The trachea has rings of cartilage, like the rings in a vacuum cleaner hose, for support. The lining of the trachea is **pseudostratified**

ciliated columnar epithelium which brushes debris up and out. This epithelial tissue is destroyed by smoking, but can regenerate if the person stops smoking.

5. The trachea divides at its bottom end into two **bronchi** (sing. = bronchus), one to each lung. Recall that the mucus in the bronchi serves to trap and coat dust particles so they don't scratch or infect the delicate tissues in the lungs.
6. The bronchi divide in the **lungs** into smaller branches called **bronchioles**. In humans, the lungs are not symmetrical because the heart, while located in the center of the chest (thorax), leans slightly to the left. Thus the right lung has three lobes (sections) and the left lung has two.
7. The tiniest bronchioles branch to the **alveoli** (sing. = alveolus) which are tiny, multi-lobed air sacs made of simple squamous cells. Having this thin wall enables air exchange with the equally-thin-walled capillaries of the circulatory system. In order to function properly, the alveoli must always stay moist. Special cells in the alveoli secrete a substance called a **surfactant** which reduces the surface tension of water, thereby enabling it to better coat the cells of the alveoli to keep them moist and keep them from sticking to each other when the person exhales. The ability to secrete this chemical doesn't develop until around the eighth or ninth month of pregnancy, so there frequently is a problem in premature babies with the lack of surfactant causing the alveoli to stick together when the baby exhales. Then, when the baby inhales again, the stuck alveolar cells tear away from their neighbors. Scar tissue forms at these sites, thus the damage is permanent, and the person's lungs lose some of their elasticity and ability to expand fully. A current "hot" area of research is searching for a suitable replacement surfactant that could be placed into the lungs of premature babies to prevent this damage.

The usual volume of air inhaled/exhaled in one breath is called the **tidal volume**. The average tidal volume for an adult human is around 500 mL of air. The maximum volume that can be exhaled during forced breathing (as in the "breathing machines" people are given after surgery) is called the **vital capacity**. For young adult male humans, this amounts to around 4 to 5 L of air, and the average for females is slightly lower.

As mentioned when we were discussing muscles, the diaphragm is unique in that control of its operation can be either voluntary or involuntary. Normally, control is involuntary, and we don't have to think about breathing. The breathing center in the medulla of the brainstem responds to O_2 and CO_2 content in the blood when adjusting the breathing rate.

We also have the ability, somewhat, to control breathing voluntarily, and a classic example of this is holding one's breath while swimming.

Related to this, I have heard that it is physiologically impossible for a person to hold his/her breath until (s)he suffocates. Generally, as CO_2 builds up, a point is reached where the person just can't hold his/her breath any longer. If the person would pass out, control would immediately return to involuntary, and (s)he would automatically start

breathing normally. Parents, do not give in to a child who tries to do this to control you! I have seen advice that says to "ignore" and not react to this type of behavior. One thing that might not occur to you when you are upset with a child's behavior is that it would be pretty difficult for the child to hold his/her breath while being gently, lovingly tickled or if enticed into a conversation about some other, interesting topic.

To get air to all the cells of the body, in mammals, **hemoglobin** in the RBCs carries O_2 to everywhere in the body. However, hemoglobin has a greater affinity for carbon monoxide (CO), and does not readily release it. Thus a victim of CO poisoning, is usually put on supplemental oxygen to make sure the remaiming hemoglobin gets all it can carry. Also, because of this, it takes a long time to recover from CO poisoning. Some other organisms have **hemocyanin** in their blood (this has Cu rather than Fe in a porphyrin ring). This is typical of many insects with greenish or bluish blood. Most insects, however, do not depend on their blood to take oxygen to their tissues, but rather, their **tracheal system** allows air to go *directly* to the body organs.

Knowing CPR (**cardiopulmonary resuscitation**), or at least mouth-to-mouth can prepare you to save someone's life, and the **Heimlich maneuver** (developed by a doctor here in Cincinnati) can help save someone's life if (s)he is choking. If you have never had CPR training, you might wish to check with the Red Cross for their class schedule.

Diseases and disorders of the respiratory tract include:

Hiccups
: are spasms of the diaphragm thought to be caused by not enough CO_2 in the body.

  Thus, hiccups are frequently cured by breathing into a paper bag.

Rhinitis
: is an inflammation of the mucus membrane in the nose, due to a common cold, allergies, etc.

Pharyngitis
: is a sore throat, which could be due to a viral infection such as the common cold or flu or a bacteria infection such as *Streptococcus pyogenes*.

Laryngitis
: is an inflammation of the vocal cords in which the person partially or totally loses his/her voice.

Bronchitis
: is an inflammation of the bronchi, causing them to over-secrete mucus, which in turn, causes coughing to get it up.

Pneumonia and **tuberculosis**
: infect the lungs.

Empyema
: is an infection, similar to pneumonia, in the chest cavity outside of the lungs.

Pleurisy

is an infection of the pleural membranes lining the inside of the chest cavity and coating the lungs. Normally these membranes are very slippery, aiding in breathing, but when they become infected, they don't slide over each other as well, and breathing becomes painful.

Asthma

is an allergic reaction that causes constriction of the bronchiole muscles, thereby reducing the air passages, thus the amount of air that can get to the alveoli. Interestingly, many of the treatments for asthma are similar to treatments used for **hypoglycemia**. That and the fact that diabetics rarely also have asthma have led some authors to suggest that asthma may be related to hypoglycemia, and that a hypoglycemia diet may aid in alleviation of asthma symptoms.

Emphysema

is a progressive loss of elasticity in the lungs due to rupture of some alveolar walls, coalescing of alveoli, and formation of scar tissue.

Lung cancer

has been shown to be more common in people who smoke cigarettes and/or who are constantly forced to inhale someone else's side stream smoke. A number of pamphlets from the American Cancer Society and biology textbooks have featured pictures that show what smoking can do to a person's lungs. Typically, there is a photograph of a robust, healthy, pink lung next to a photograph of a shrivled, diseased, blackened lung from a smoker. Similarly, people who work around substances like asbestos fibers, coal dust, flour dust, or dry, crumbled, dusty bird droppings for much of their lives, frequently show signs of lung diseases caused by these substances.

carterjs@uc.edu

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