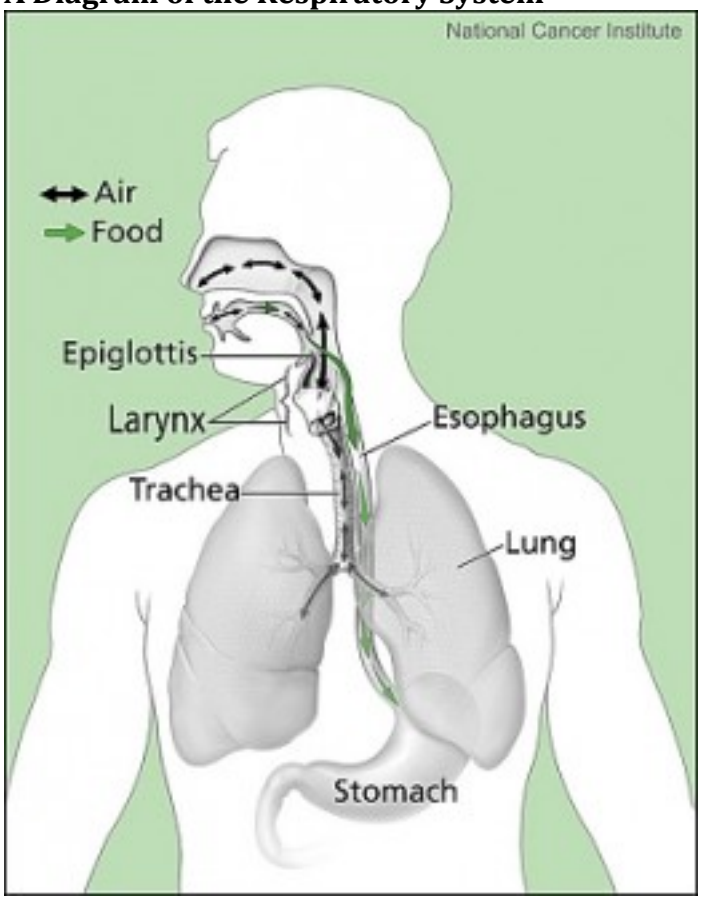
A Diagram of the Respiratory System



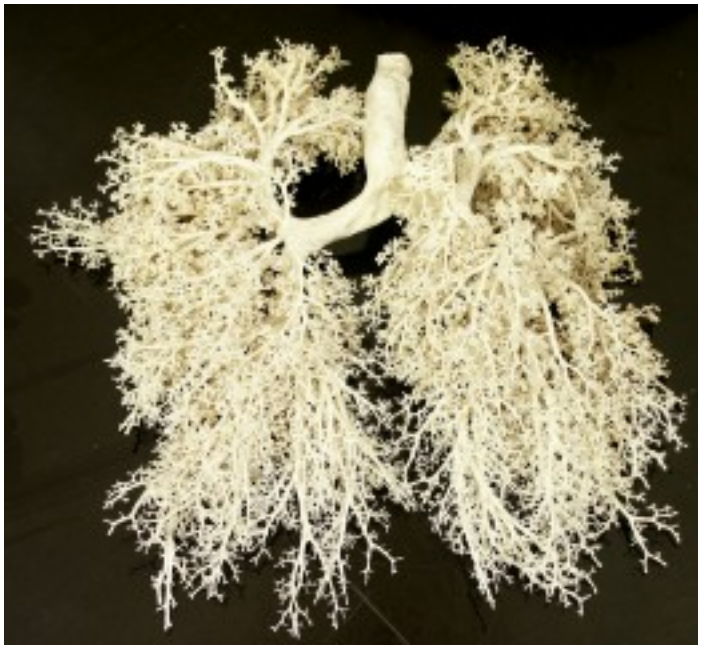
Source: Alan Hoofring, NCI, public domain image

The respiratory system is a network of tubes, sacs and muscles that obtains oxygen from the air and transports it to the bloodstream. The blood delivers the oxygen to all the cells in the body, which use it to produce energy from digested food. Carbon dioxide waste made by the cells is transported in the opposite direction, from the cells into the respiratory system to be exhaled. The respiratory system has some very interesting features to help it do its job efficiently.

We depend on our respiratory system for our survival, since all of our vital organs require oxygen in order to function. Brain cells will be damaged after only a few minutes without oxygen (except under very special conditions), and death will soon follow. Occasionally young children are able to recover from lack of oxygen for longer than a few minutes after their body has been chilled very rapidly. One situation in which this chilling may occur is when a child falls through ice into cold water.

The respiratory system carries out the first two stages of respiration. Respiration is a multi-step process involving breathing (ventilation), gas exchange between the lungs and the bloodstream (external respiration), gas exchange between the bloodstream and the body's cells (internal respiration), and the chemical reaction between oxygen and carbohydrates inside the mitochondria of cells (cellular respiration). Cellular respiration produces energy, carbon dioxide and water as products.

The Bronchial Tree



Plasticized human lungs
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Breathing and Gas Exchange (For High School Students)

Airways and Alveoli

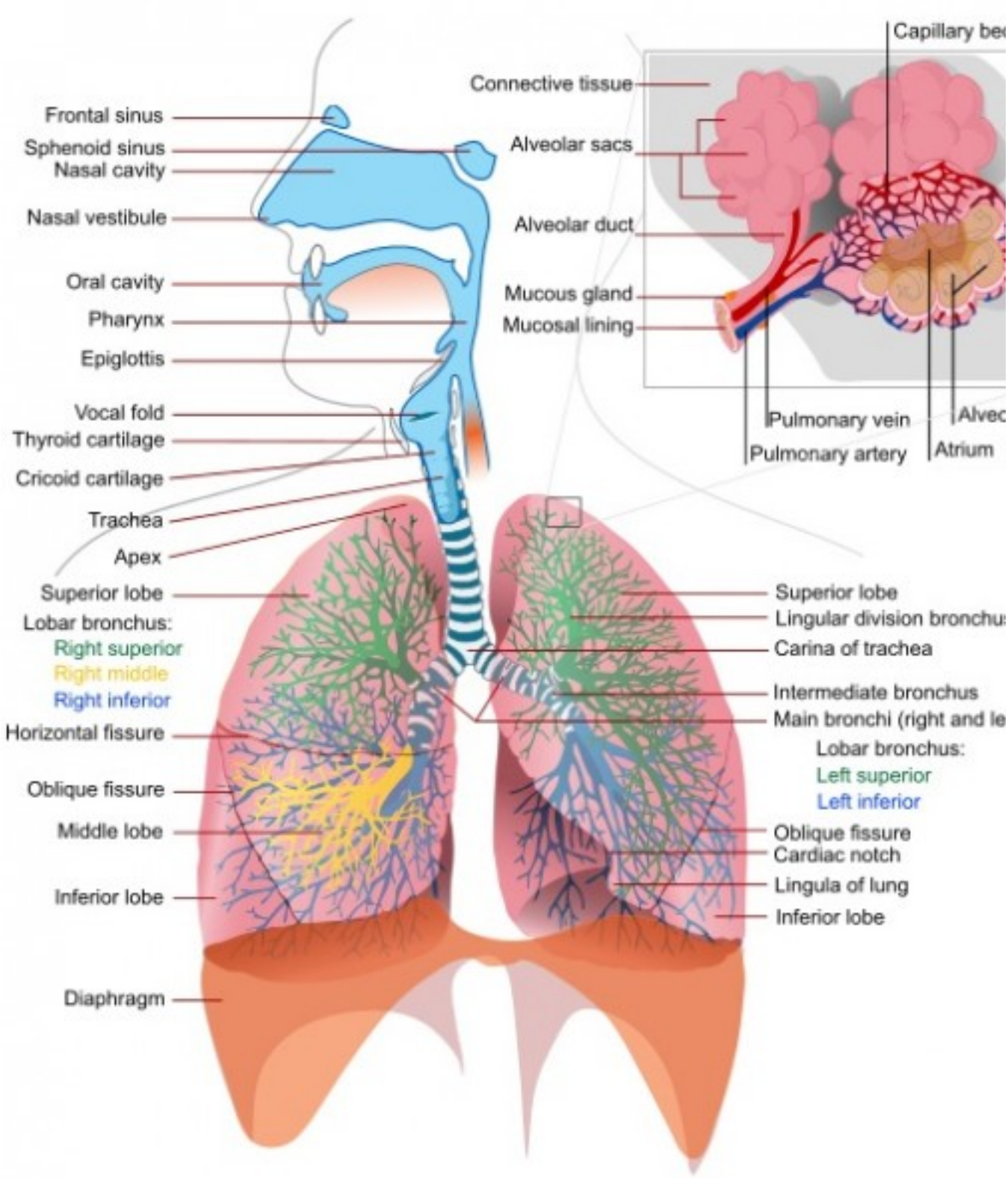
1. The respiratory system contains a total of about 1500 miles (2400 km) of airways. The airways begin with the trachea (windpipe), which branches into two bronchi, one going to each lung. The bronchi then divide into thousands of tiny bronchioles within the lungs.
2. An adult lung contains 300 million to 500 million tiny air sacs, known as alveoli, at the ends of the bronchioles.
3. The lungs are able to float on water since they contain so many air sacs.
4. If all the alveoli in both lungs were flattened out, they would have a total area of about 160 square meters – about 80% of the size of a singles tennis court and about 80 times greater than the surface area of an average-sized adult's skin.
5. The interior lining of an alveolus is covered by a thin layer of water, which enables oxygen to move through the wall of the alveolus and into the bloodstream efficiently.
6. Water molecules on the lining of an alveolus are attracted to each other, creating a force known as surface tension. When the alveoli become smaller during exhalation, the surface tension increases. This could cause the alveoli to collapse and prevent them from expanding again.
7. The lining of alveoli produces a substance called a surfactant. The surfactant reduces the surface tension of water, preventing the alveoli from collapsing.
8. The surface of an alveolus is covered with capillaries. Capillaries are narrow blood vessels with a thin wall that is just one cell thick. If all the capillaries in the lungs were placed end to end they would have a length of about 1600 km.

9. Like the wall of capillaries, the wall of an alveolus is also just one cell layer thick. This allows for quick absorption of oxygen from the alveoli into the capillaries and the quick release of carbon dioxide from the capillaries into the alveoli.
10. A red blood cell contains about 250 million hemoglobin molecules, which carry oxygen through the blood. Each hemoglobin molecule can carry four oxygen molecules. There are 4 million to 6 million red blood cells in each microliter (cubic millimeter) of blood.

Lung Anatomy and Function, from the Kahn Academy

The Lungs

11. The right lung is larger than the left lung. The heart is located between the lungs, with its pointed tip directed towards the left side of the body. The position of the heart allows for less space for the left lung than for the right lung.
12. An adult generally breathes between 12 and 18 times a minute when he or she is not exercising - or about 17,000 to 26,000 times in a twenty four hour period.
13. The total lung capacity (maximum amount of air that someone's lungs are capable of holding) is between 4 and 6 liters of air in an adult. Males usually have higher total lung capacities than females.
14. When we are relaxed we inhale and exhale about 500 mL of air per breath. This value is called the tidal volume. We inhale and exhale greater volumes of air in certain situations, such as when we are exercising or during forced breathing.
15. About 30% of the tidal volume of air never reaches the alveoli and stays in the airways. This air is called "dead air" because it is useless for oxygen extraction as it isn't in the alveoli.
16. Even after a very strong exhalation, about 1000 to 1200 mL of air remains in the lungs. This is known as residual volume.
17. Exhaled air contains water vapor from our bodies. Each day we lose about half a liter of water from our bodies by exhaling.



Lung Anatomy
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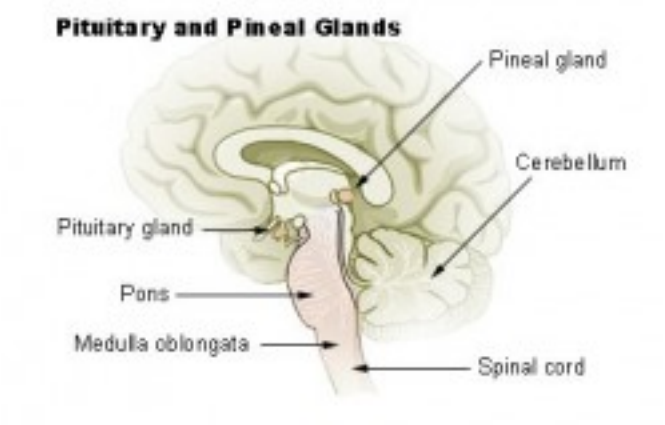

The medulla oblongata controls inhalation.
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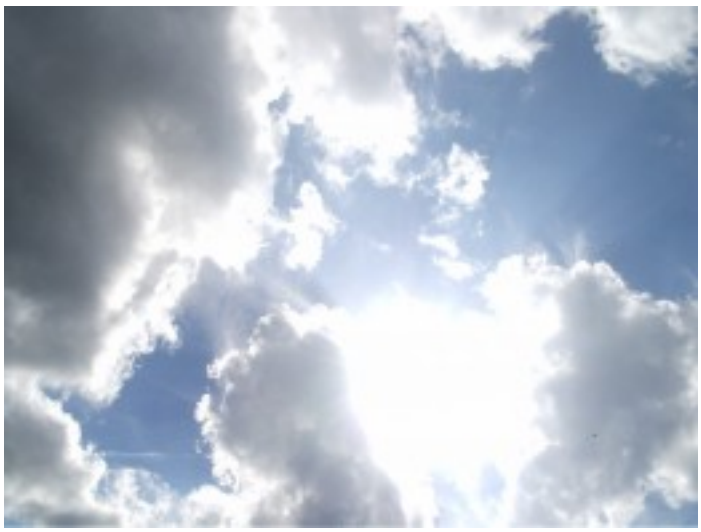
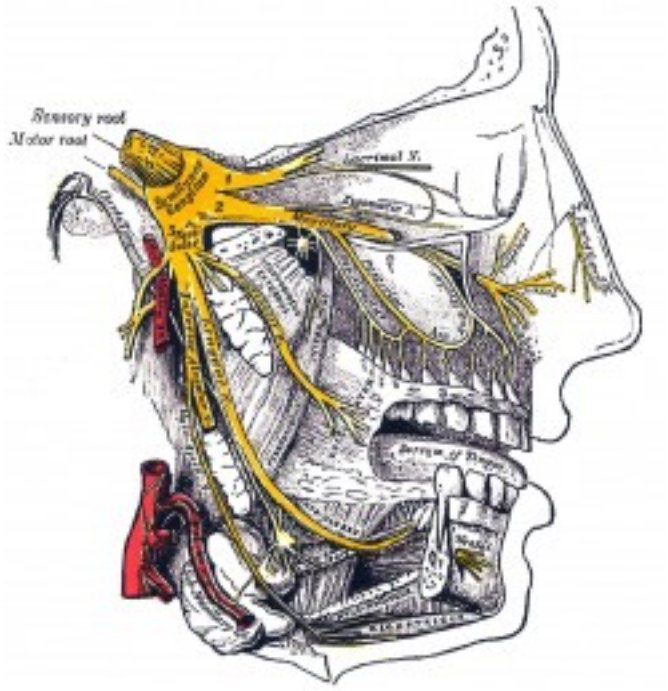
Mucus and Cilia in the Lungs

Inhalation and Exhalation

18. The diaphragm (the sheet-like muscle under the lungs) and the intercostal muscles between the ribs are both used for inhalation (also called inspiration), but the diaphragm plays a more important role than the intercostal muscles.
19. Inhaled air doesn't push the lungs open. Instead, during inhalation the diaphragm and intercostal muscles contract, increasing the volume of the chest cavity and pulling the lungs open. Air inside the lungs spreads out, causing the air pressure inside the lungs to be reduced. Air outside the body, which is under a higher pressure than the air in the expanded lungs, then moves into the nose and mouth and down the airways towards the lungs.
During exhalation (also called expiration) the diaphragm and intercostal muscles relax, causing the lungs to decrease in volume and air to be pushed out.
20. At the top of the trachea is an enlarged area called the larynx. The larynx is also called the voicebox, since it contains the vocal cords, which are also known as the vocal folds. The esophagus, which transports food to the stomach and joins the back of the throat like the trachea, is located just behind the trachea. When we swallow, a flap of tissue called the epiglottis moves downwards to cover the trachea to prevent the entry of swallowed materials, which could block the passage of air and cause choking.
21. Mucus is a vital substance made by the air passages. Mucus traps inhaled dirt and bacteria and also moistens the airways.
22. The cells lining the airways have hair-like extensions called cilia. The cilia beat in a coordinated fashion to create a current of mucus that is swept up to the back of the throat, where it is swallowed.
23. Smoking damages cilia, allowing mucus to build up and block the airways.
24. The medulla oblongata in the brainstem stimulates us to inhale without us having to make a conscious decision.
25. A high level of carbon dioxide in the blood is more important in triggering inhalation than a low level of oxygen.



A burst of sunlight can trigger a sneeze.
Source: dandipuffs, via morguefile.com. morgueFile free license



The branches of the trigeminal nerve (in yellow)
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Sneezing

26. The fastest recorded speed at which material released by a sneeze travels is approximately 102.5 miles an hour (165 kilometers an hour).
27. Sneezing can be due to other factors besides irritation in the nose. Some people sneeze when entering a bright environment after being in the dark. This type of sneeze is known as a photic sneeze, or a photic sneeze reflex. A reflex doesn't involve a conscious decision by the brain.
28. About 20% to 30% of people are thought to experience photic sneezes. A photic sneeze is also known as the ACHOO syndrome (Autosomal Dominant Compelling

Helio-Ophthalmic Outbust Syndrome). Some people sneeze once when exposed to light, but most people sneeze multiple times. There have been reports of photic sneeze outbursts involving forty sneezes. The trait seems to have a genetic basis.
29. The nerve that carries signals from the eyes to the brain is called the optic nerve. When the pupils of the eyes are adapted to a dark environment they are dilated. If someone moves from a dark environment to a very bright environment, the optic nerve sends an electrical signal to the brain, causing it to constrict the pupils in order to protect the inside of the eyeball from light damage.
The trigeminal nerve is stimulated when an irritant enters the nose. The nerve sends a message to the brain, which causes a sneeze. The trigeminal nerve lies close to the optic nerve. Scientists think that when photic sneeze sufferers enter a bright environment, some of the electrical signal traveling through the optic nerve to the brain escapes into the trigeminal nerve, causing the person to sneeze.
30. Some