CHAPTER XXII

THE LUNGS

327. Oxidation. — Life is a process of oxidation. The body is an engine. The living cells are the machinery, and both they and the blood are the fuel. The fires are lighted at birth, and burn without cessation until death.

328. Respiration. — In every fire a free draft of air must be supplied and the burned products must be carried off. So in the body air must enter continually, and the oxidized products pass out again. The red blood cells are set apart for the special work of carrying oxygen to the rest of the cells of the body, while the lungs are arrangements in which the red blood cells can obtain oxygen from the air. The passage of air into and out of the lungs is *breathing*. Breathing and oxidation together constitute *respiration*.

329. Respiratory organs. — An air tube leads from the surface of the body to the lungs. The parts of the tube from the surface to the lungs are the *nose*, *pharynx*, *larynx*, *trachea*, and *bronchi*. These parts taken together form the *respiratory tract*. They, together with the lungs and red blood cells, form the *respiratory system*.

330. The nose. — The nose is a double tube lined with mucous membrane. Each tube has a smooth bottom and inner wall, but its outer wall is thrown into three curved folds extending lengthwise so as almost to form partitions across the tubes. The folds warm the air and strain out dust as it passes over their surfaces. From each side of

the nose a tube extends to the eye to drain away tears, and another opening extends into the *antrum* or cavity in the upper jawbone. In the nose there are special nerves of the sense of smell. (See p. 324.)

331. The pharynx. — The pharynx is the muscular bag just back of the mouth, through which both food and air pass. Air should always enter it from the nose. Just in front of the pharynx upon each side is a fleshy body, looking like an almond, and called the *tonsil*. Sometimes the tonsils become very large in children and close the opening into the nose, making it necessary to breathe through the mouth.

332. Adenoid vegetations. — In the upper part of the pharynx, just behind the opening of the nose, there often grows a collection of soft, grapelike bodies, called *adenoid vegetations*. They close the opening to the nose and compel a person to breathe through the mouth. They begin to form during early childhood while the bones are growing. The unnatural breathing and open mouth deform the upper jaw so that it becomes narrow and pointed. The trouble is a serious one. While it does not cause inconvenience in itself, yet it compels mouth breathing; it renders the child very susceptible to taking cold; and is the most common cause of deafness, for it stops the Eustachian tube leading to the ear. Often they are associated with large tonsils.

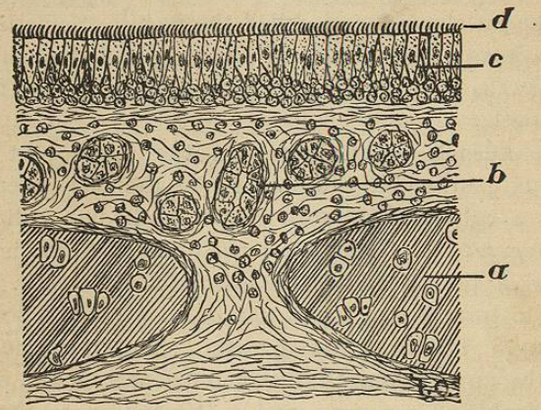
When a child becomes grown, the adenoid vegetations often shrink, and so cure themselves, but the deformed jaw lasts through life. They can easily be broken down and removed with the finger, as they should be in every case.

333. Mouth breathing. — The mouth contains no means for warming the air, or for screening out dust and disease germs, as the nose has. So a mouth breather is very likely to take cold. When he

makes an extra exertion and becomes short of breath, the air irritates the throat and brings on a cough.

With many, mouth breathing is a habit which can easily be broken by attention to the breathing. In others, it is due to a cold, or to adenoid vegetations, or to enlarged tonsils.

334. The larynx. — In the front side of the lower part of the pharynx is the opening of a box called the *larynx*, through which air passes. The larynx is a box of cartilage. Across its upper end are stretched two thin elastic bands, the vocal cords, which can be tightened and brought near together at will. Air passing between them produces a sound called the *voice*.



A slice from the trachea (× 200).

a cartilage. *b* glands in the mucous membrane.
c lining of epithelial cells.
d cilia upon the surface of the epithelium.

335. The trachea. — From the bottom of the larynx there extends downward a tube called the *windpipe* or *trachea*. The trachea is about four and one half inches in length and three quarters of an inch in diameter. It is composed of a framework of twenty hoops of cartilage, bound together with tough connective tissue and lined with mucous membrane.

336. The bronchi. — Within the chest the trachea divides into two tubes, the *bronchi*. Each bronchus divides again and again, until the finest divisions are about $\frac{1}{15}$ inch in diameter. Like the trachea, each bronchus is composed of hoops of cartilage lined with mucous membrane.

337. Cilia. — The surface of the epithelium of the mucous membrane of most of the nose and larynx and the whole of the trachea and bronchi is covered with microscopic hairs, the *cilia*. Each cilium is slightly curved upward and waves continually in a rapid up and down motion which tends to force dust and mucus away from the lungs.

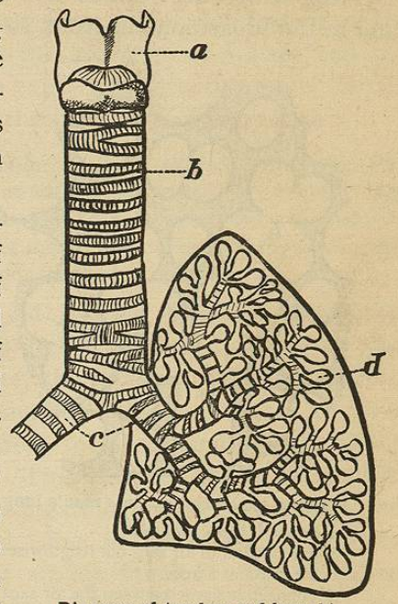


Diagram of trachea and bronchi.

a larynx. *b* trachea. *c* bronchi.
d air sacs of the lung.

338. The lungs. — The ends of the bronchi are studded with numerous cup-shaped depressions called *air sacs*, each about $\frac{1}{100}$ inch in diameter. Upon the inner surface of each air sac is a close network of capillary blood tubes. The collection of bronchi, air sacs, and blood tubes forms two spongy bodies called *lungs*. Between the air sacs is a thin layer of connective tissue. The lungs can be

stretched like rubber bags, when air is blown through the trachea, and will contract to their former size when the air has been let out.

339. The chest or thorax. — The lungs are covered by the ribs, which are hinged to the spinal column behind, and to the breastbone in front, so as to form a bony frame-

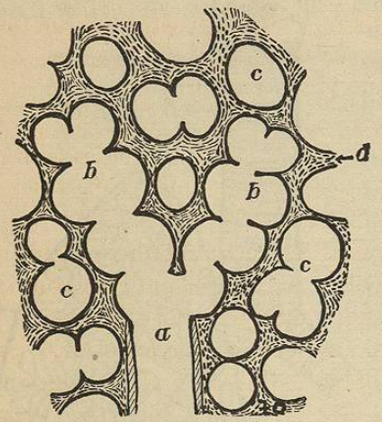


Diagram of the air sacs in a man's lung.

a smallest bronchial tube.
b a collection of air sacs cut lengthwise.
c air sacs cut across.
d connective tissue between the air sacs.

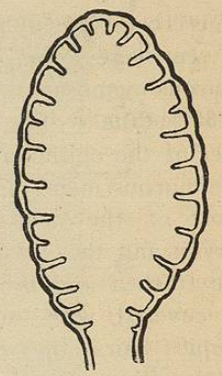


Diagram of a frog's lung.

work inclosing a cavity called the *chest* or *thorax*. The floor of the thorax is formed by a muscle called the *diaphragm*, which is attached to the lower border of the ribs, and arches upward. It is lined with a smooth and shining serous membrane like peritoneum, called the *pleura*. Each lung is covered with pleura also.

340. Inspiration and expiration. — Muscles connect and cover the ribs. They raise the ribs and expand the chest. The diaphragm flattens its arch and makes the chest

deeper. Thus the size of the chest can be increased in all directions. When the chest expands, air rushes in to distend the lungs. The entrance of air into the lungs is called *inspiration*. At the end of inspiration the muscles relax. Then the weight of the parts and the elasticity of the distended lung forces out the air. In addition, the muscles of the abdomen and arms can be made to contract so as to expel the air with greater force. Driving out the air from the lungs is called *expiration*.

341. Amount of expansion. — In an ordinary inspiration the chest becomes from one half an inch to one inch larger around. By taking a very deep breath most people can expand the chest two or three inches. An expansion of four or five inches is exceptional. By breathing exercises the expansion can be increased.

342. Amount of air used in each breath. — After the fullest possible inspiration, the lungs contain about 330 cubic inches of air. After the fullest possible expiration, the lungs still contain about 100 cubic inches of air. So it is possible, by strong effort, to inhale and exhale about 230 cubic inches of air. This is called the *vital capacity* of the lungs, and is the breathing power which can be used in violent exercise. But in quiet breathing only about 30 cubic inches of air are inhaled. This is called *tidal* air. By an effort about 100 cubic inches of air can be inhaled in addition to the tidal air. This is called the *complemental* air. By a forced expiration, the lungs can expel about 100 cubic inches of air more than in quiet breathing. This is called the *reserve* or *supplemental* air. There still will be left 100 cubic inches of air, called *residual* air.

343. Action of the cilia. — The motion of the cilia creates an air current in the smaller bronchi, which mixes the incoming fresh air with that already in the lungs, so that

while all the air is not changed with each inspiration, yet there is a free mingling of the fresh with the impure air. The cilia also intercept particles of dust which the nose and pharynx have failed to remove.

344. Rate of breathing. — In health an inspiration occurs with every four heart beats, or about eighteen times each minute, but in exercise its rate may be increased to sixty or seventy times a minute. A baby breathes about forty times a minute. The rate slowly diminishes until, at eighteen years of age, it is the same as in a man.

An inspiration takes about five sixths as long as expiration, but the regularity and force of both inspiration and expiration can be varied indefinitely. Respiration usually goes on without a person's knowledge or thought, yet it is somewhat under the control of the will in talking, blowing, and other actions.

345. Modifications of breathing. — *Coughing* is a forcible expiration in which the closed vocal cords are suddenly blown open with force.

Sneezing is a sudden expiration in which air is driven mainly through the nose.

Blowing is a long forcible expiration in which air is forced in a steady stream through a small opening in the lips.

Laughing and *crying* are each a succession of short expirations. They sound so much alike that it is often impossible to tell which a child is doing.

Sobbing is a succession of short inspirations.

Hiccoughing is a single inspiration caused by a sudden contraction of the diaphragm.

Snoring is a sound produced during inspiration by air passing over the soft palate. It is usually due to air passing through both the nose and the mouth at the same time.

Gaping or *yawning* is a long and deep inspiration and expiration through the open mouth, while the muscles of the throat are strongly contracted.

Sighing is a deep inspiration followed by a sudden relaxation of the muscles so that the escaping air makes a sound.

Choking is a sudden stoppage of the larynx or trachea. When a person is choked, he should lie down upon his face with his head lowest. Slapping his back will aid in jarring the substance loose. If this does not dislodge it, he should be hung head downwards while his back is pounded vigorously. In that position the substance may fall out, while if he sits upright, it may fall in deeper unless it is coughed out.

Suffocation, or *smothering*, is a cessation of breathing caused by shutting off the air either partly or wholly.

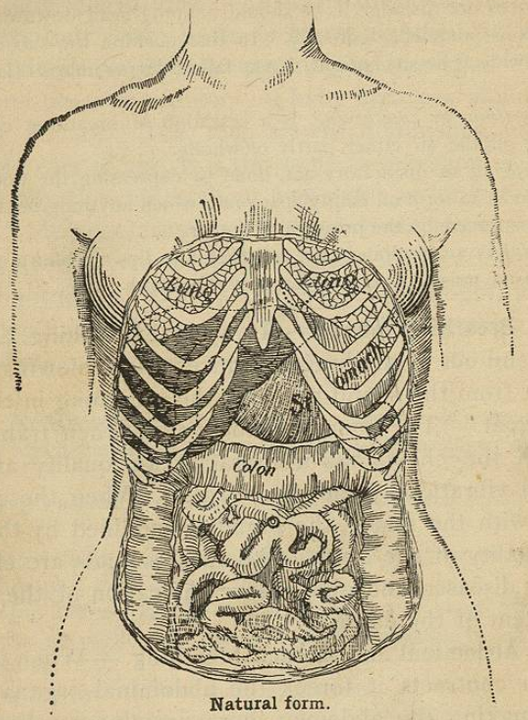
Sucking is an inspiratory act, done by depressing the floor of the mouth so as to form an empty space into which anything held between the lips is forced by the pressure of the air.

Spitting is an expiratory act in which the lips are blown open with an explosive noise. It can be done by the mouth alone.

346. Breathing sounds. — In natural breathing, air rushing in and out of the lungs produces a low, blowing sound, distinct from the sound made by the breathing in the nose and throat. The sound of the voice, when transmitted through the chest, has a characteristic quality and produces a vibration of the chest walls. When the chest is struck with the finger, the sound is modified by the resonant quality of the lungs. All these sounds are changed in lung diseases, and give a sure indication of the nature and extent of the disease.

347. Abdominal and thoracic breathing. — When the diaphragm contracts, it forces the abdominal organs downward, making the abdomen more prominent. Breathing by the free use of the diaphragm is called *abdominal* breathing. When the diaphragm remains comparatively quiet, the ribs are compelled to move more freely. Breathing mainly by use of the ribs is called *thoracic* breathing. In men abdominal breathing is greatest, while in women thoracic breathing seems more prominent.

Distention of the stomach and intestine by a full meal, or by gas, interferes with the downward movements of the diaphragm, and compels a greater extent of thoracic breathing.

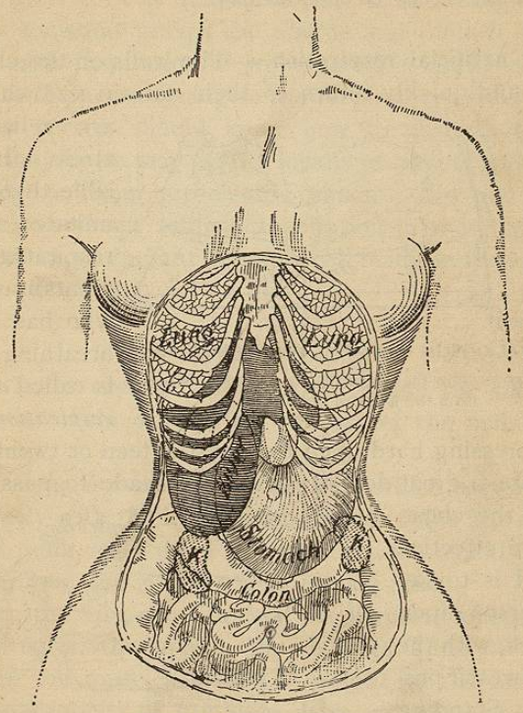


Natural form.

348. Effect of tight lacing. — A person whose waist is laced tightly with corsets cannot breathe in the proper amount of air, but is short of breath and easily fatigued.

Tight corsets also compress the liver and other abdominal organs. In extreme cases the liver becomes divided almost into two parts by the pressure.

349. The respiratory center. — The movements of the chest and diaphragm in breathing are controlled by a small part of the brain situated just above the spinal cord, and called the *respiratory center*. When it is destroyed,



Results of unhealthful dress.

respiration ceases at once, and no power can arouse it again.

Stimulation of the nerves of the body which go to the respiratory center may cause it to send out orders for the respiratory muscles to act. Thus, suddenly throwing cold water on the chest will cause a

contraction of the muscles of breathing which lasts for a few seconds, so that a person cannot catch his breath.

A substance sucked into the trachea irritates the nerves which go to the respiratory center. The center sends back an order to the respiratory muscles to expel the substance by a forcible blast of air. Thus the substance is coughed or sneezed up.

350. Artificial respiration. — The walls of the chest are elastic and quickly return to their natural size when they are relieved of stress. It is possible, therefore, to imitate natural respiratory movements upon a man who has stopped breathing. This is called *artificial respiration.*

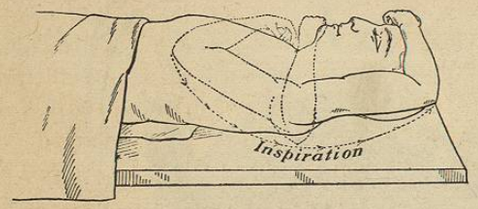


Diagram of artificial respiration, showing inspiration. The arrows show that the arms are moved outward from the sides of the chest.

By pressing hard upon the chest fifteen or twenty times a minute, a great deal of air will be made to pass in and out of the chest. A more effective method is to lay the person upon his back, with the head lowest if possible. Standing at his head, draw each arm outward and upward, in a semicircle, away from his body, until they are stretched above his head almost in a line with his body. This raises the chest and

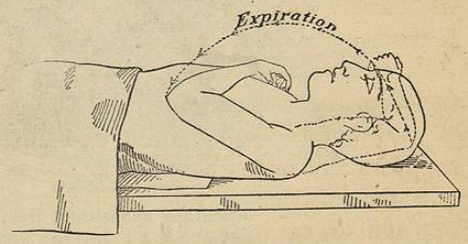


Diagram of artificial respiration, showing expiration. The arrows show that the arms are carried directly forward until they are pressed hard against the chest.

produces an inspiration. Then carry the arms directly forward and down and press them forcibly against the side of the chest. This produces an expiration. These movements should be repeated about fifteen or twenty times a minute, or at the rate of natural breathing.

If an assistant grasps the tongue and pulls it forward during each inspiration, it will open the larynx and also stimulate the nerves going to the respiratory center.

Every person should know how to perform artificial respiration, for it may be the means of saving a life from drowning or from an electric shock. No one should hesitate to attempt artificial respiration in these cases, for even crude and ignorant attempts will result in the entrance of some air and may save a life.

SUMMARY

1. The lungs are two organs from which the red blood cells obtain oxygen for the use of the cells of the body.
2. Each lung is made of tiny air sacs which communicate freely with the air through the windpipe and nose.
3. Each lung rests upon a curved muscle called the *diaphragm*, and is covered by curved ribs.
4. When the ribs are lifted or the diaphragm depressed, air enters the lungs. This is inspiration.
5. When the muscles relax, the weight of the parts and the elasticity of the lungs drive out some of the air. This is expiration.
6. Inspiration and expiration occur alternately about eighteen times a minute.
7. The movements of the ribs and diaphragm in breathing are controlled by a small part of the brain just above the spinal cord.

8. Artificial respiration can be performed by alternately pulling the arms above the head and compressing them against the chest about twenty times a minute.

DEMONSTRATIONS

81. Each pupil can notice the different movements of his own breathing. At will he can change from abdominal breathing to thoracic breathing, or can use all of the muscles of the chest in taking a very deep inspiration. A tape measure passed around the body just under the armpits will show how the chest increases in size with each inspiration and diminishes with expiration.

82. A small animal should be killed and its chest opened so as to show the lungs and heart in place. Notice the shining pleura, and that at the back part of the chest it leaves the chest wall and covers the lungs. Notice the position of the ribs and diaphragm, and the arrangement and direction of their muscle fibers. (See demonstration 35.)

83. In a recently killed cat or dog the diaphragm can be made to contract by irritation of the nerve called the *phrenic* nerve, which conveys orders for motion from the respiratory center to the diaphragm. There are two nerves, one of which enters the diaphragm near the middle of each side of the arch. Remove the lungs carefully. Then the site of the nerve can be recognized by a slight roughness in the otherwise smooth pleural covering. Pricking or pinching this point will cause a contraction of the diaphragm. (See demonstration 35.)

84. Kill a frog by placing it in a tight jar with a few drops of chloroform. Open its chest and abdomen. Insert a small pointed glass tube into its trachea. The slitlike opening can be found upon the back of the tongue. Blow through the tube to inflate the lungs, and at once tie a string tightly around their base. Remove the lungs and let them dry. Notice the partitions like the cells in a honeycomb, extending a little way into the central cavity. Explain that a man's lung is like a collection of tiny frog's lungs. (See illustration on page 196.)

85. Examine a prepared microscopic specimen of a lung and of the trachea and bronchi. Notice the ciliated epithelium in the trachea and bronchi. Notice that the walls of the air sacs form an irregular network inclosing the large spaces of the air sacs. The specimen will probably show a small bronchus. Notice its thick walls containing some muscular tissue and possibly some cartilage.

86. Show the class how to perform artificial respiration. Have a boy lie upon a desk and go through the movements of carrying his arms above his head and of pressing them against his side again. Do not perform the movements too rapidly and do not press the arms too far backward above the head.

87. The *pharynx* and *palate* are puzzling parts to understand, but are very simple when shown upon a small animal. With a sharp knife and fine saw, divide the head and neck of a small animal through the middle of the nose and backbone. Show that the hard palate and the soft palate divide the nose from the mouth. Show that the pharynx extends upward behind the nose and downward lower than the tongue. Show the position of the tonsils and where adenoid vegetations form.

88. *Cilia* can be shown with cells from a frog's mouth. Gently scrape its roof, removing a drop of slime with some of the epithelial cells. Examine it with the high power of the microscope. The cilia will appear as a fringe in rapid motion. (See demonstration 35.)

REVIEW TOPICS

1. Define *respiration* and state its object.
2. Describe the *nose*, *pharynx*, *larynx*, *trachea*, *bronchi*, *cilia*, *air sacs*, *lungs*, and *pleura*.
3. Describe *adenoid vegetations* and their effects.
4. Give the evil effects of *mouth breathing*.
5. Describe the chest, ribs, and diaphragm.
6. Describe *inspiration* and *expiration*.
7. Give the amount of air used in *ordinary* and in *forced* breathing.
8. Give the action of the *cilia*.
9. Give the *rate* of breathing, and its variation in laughing, sobbing, coughing, hiccoughing, sneezing, gaping, sighing, and snoring.
10. Describe the *sounds* produced by breathing.
11. Describe *abdominal* and *thoracic* breathing.
12. Give the effects of tight lacing.
13. Describe the respiratory center and its action.