God's Wondrous Machine

Unit 2: The Breathtaking Respiratory System

VOCABULARY LEVELS

Choose the word list based on your skill level. Every student should be able to master Level 1 words. Add words from Levels 2 and 3 as needed. More proficient students should be able to learn all three levels.

Level 1 Vocabulary

- Allergy
- Inhale
- Stethoscope
- Alveoli
- Larynx
- Upper Respiratory Tract
- Asthma
- Lower Respiratory Tract
- Virus
- Bacteria
- Mucus
- Vocal Cords
- Bronchi
- Nares
- Carbon Dioxide
- Pharynx
- Cilia
- Exhale

Level 2 Vocabulary

Review and Know Level 1 Vocabulary

- Allergens
- Influenza
- Trachea
- Anosmia
- Iron Lung
- Ventilation
- Antiseptic
- Laryngitis
- Bronchioles
- Pandemic
- Cystic Fibrosis
- Physiologist
- Diffusion
- Pleura Sac
- Epidemic
- Polio
- Epiglottis
- Sinuses

Level 3 Vocabulary

Review and Know Level 1 and 2 Vocabulary

- Apneustic Center
- Chemoreceptors
- Cribriform Plate
- Epithelium
- Gestation
- Goblet Cells
- Nasal Turbinate
- Organogenesis
- Pneumotaxic Center
- Surfactant
- Tracheostomy

on the nose.

The surface area of the lungs is roughly the same size as a tennis court. God's amazing design of the lungs means that you use this large surface area for the diffusion of oxygen and carbon dioxide for breathing!

	Level 1 Vocabulary
	Level 2 Vocabulary
	Level 3 Vocabulary

See It, Say It, Know It!

Word [Pronunciation]	Definition
Allergens al·ler·gen (al´er-jen)	A foreign substance, such as mites in house dust or animal dander, that, when inhaled, causes the airways to narrow and produces symptoms of asthma
Allergy al·ler·gy (al´er-je)	An abnormally high, acquired sensitivity to certain substances, such as drugs, pollens, or microorganisms, that may include such symptoms as sneezing, itching, and skin rashes
Alveolus al-ve´o-lus Alveoli alve´oli (plural form)	Small air sacs or cavities in the lung that give the tissue a honey-comb appearance and expand its surface area for the exchange of oxygen and carbon dioxide
Anosmia an·os·mi·a	Loss of the sense of smell
Antiseptic an·ti·sep·tic	Capable of preventing infection by inhibiting the growth of bacteria
Apneustic Center app·new·stik sen·ter	The neurons in the brain stem controlling normal respiration
Asthma asth·ma	A common inflammatory disease of the lungs characterized by episodic airway obstruction caused by extensive narrowing of the bronchi and bronchioles. Common symptoms of asthma include wheezing, coughing, and shortness of breath.
Bacteria bac·te·ri·a	Organisms not able to be seen except under a microscope, found in rotting matter, in air, in soil, and in living bodies, some being the germs of disease
Bronchi bronc-i	The two branches of the trachea that extend into the lungs
Bronchioles bron·chi·ole	Any of the small, thin-walled tubes that branch from a bronchus and end in the alveolar sacs of the lung
Carbon Dioxide car·bon di·ox·ide	A colorless, odorless, incombustible gas, CO_2, formed during respiration, combustion, and organic decomposition and used in food refrigeration, carbonated beverages, inert atmospheres, fire extinguishers, and aerosols
Chemoreceptors che·mo·re·cep·tor	A sensory nerve stimulated by chemical means
Cilia cil·i·a	Short, hairlike, rhythmically beating organelles on the surface of certain cells that provide mobility, as in protozoans, or move fluids and particles along ducts in multicellular forms

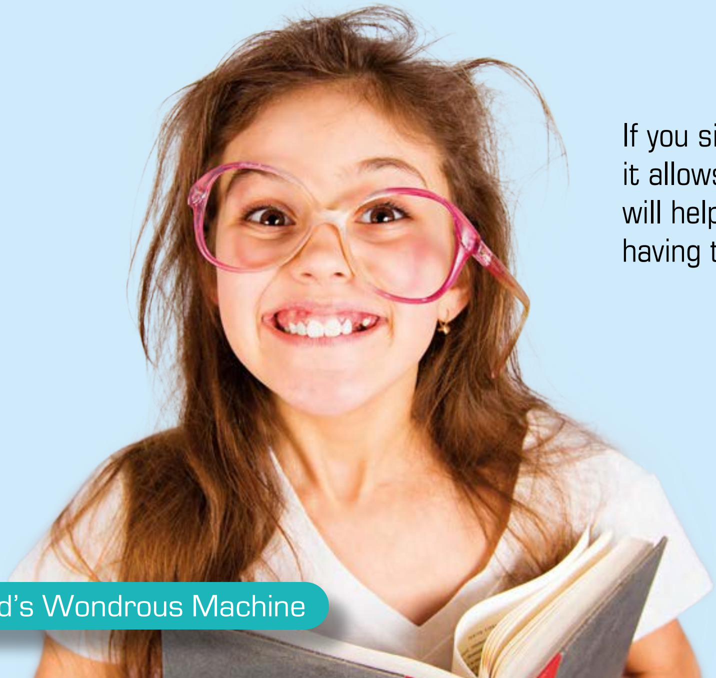
Word [Pronunciation]	Definition
Cribriform Plate crib-i-form plate	Located in the ethmoid bone of the skull in the nasal cavity where the nerve endings of the sense of smell are found
Cystic Fibrosis cys′tic fibro′sis	An inherited disorder of the exocrine glands, usually developing during early childhood and affecting mainly the pancreas, respiratory system, and sweat glands. It is marked by the production of abnormally thick mucus by the affected glands, usually resulting in chronic respiratory infections and impaired pancreatic function.
Diffusion dif·fu·sion	The movement of atoms or molecules from an area of higher concentration to an area of lower concentration. Atoms and small molecules can move across a cell membrane by diffusion.
Epidemic ep·i·dem·ic	An outbreak of a disease or illness that spreads rapidly among individuals in an area or population at the same time
Epiglottis ep·i·glot·tis	The thin elastic cartilaginous structure located at the root of the tongue that folds over the glottis to prevent food and liquid from entering the trachea during the act of swallowing
Epithelium ep·i·the·li·um	Any tissue layer covering body surfaces or lining the internal surfaces of body cavities, tubes, and hollow organs
Exhale ex·hale	To breathe out
Gestation ges·ta·tion	The period during which unborn young are “carried” inside the womb
Goblet Cells Gob-let cells	Cells in the respiratory tract that produce mucus
Influenza in·flu·en·za	A highly contagious and often epidemic viral disease characterized by fever, tiredness, muscular aches and pains, and inflammation of the respiratory passages
Inhale in·hale	To breathe in; inspire
Iron Lung i′ron lung	An airtight metal cylinder enclosing the entire body up to the neck and providing artificial respiration when the respiratory muscles are paralyzed, as by poliomyelitis
Laryngitis lar·yn·gi·tis	Inflammation of the larynx, often with accompanying sore throat, hoarseness or loss of voice, and dry cough

Level 1 Vocabulary	
Level 2 Vocabulary	
Level 3 Vocabulary	

Word [Pronunciation]	Definition
Larynx lar·ynx	The upper part of the trachea in most vertebrate animals, containing the vocal cords. The walls of the larynx are made of cartilage. Sound is produced by air passing through the larynx on the way to the lungs, causing the walls of the larynx to vibrate. The pitch of the sound that is produced can be altered by the pull of muscles, which changes the tension of the vocal cords. Also called voice box.
Lower Respiratory Tract lo·wer res·pir·a·tory tract	Consisting of all the structures in the respiratory tract lying below the larynx. The lower respiratory tract is composed of the trachea and lungs. The lungs include the bronchi, respiratory bronchioles, alveolar ducts, alveolar sacs, and alveoli.
Mucus mu·cus	The slimy, viscous substance secreted as a protective lubricant by mucous membranes. Mucus is composed chiefly of large glycoproteins called mucins and inorganic salts suspended in water.
Nares nar·is	An external opening in the nasal cavity of a vertebrate; a nostril
Nasal Turbinate Na-sal tur·bi·nate	Any of the scrolled spongy bones of the nasal passages in man and other vertebrates
Organogenesis or·gan·o·gen·e·sis	The development of bodily organs
Pandemic Pan·dem·ic	An epidemic that spreads over a very wide area, such as an entire country or continent
Pharynx phar·ynx	The passage that leads from the cavities of the nose and mouth to the larynx (voice box) and esophagus. Air passes through the pharynx on the way to the lungs, and food enters the esophagus from the pharynx.
Physiologist phys·i·ol·o·gist	Biologist specializing in physiology (the biological study of the functions of living organisms and their parts)
Pleura Sac pleu·ra sac	A membrane that encloses each lung and lines the chest cavity
Pneumotaxic Center pneu·mo·tax·ic sen·ter	A nerve center in the upper pons of the brain stem that rhythmically inhibits inspiration
Polio po·li·o	Poliomyelitis, an acute viral disease marked by inflammation of nerve cells of the brain stem and spinal cord that can affect the ability to walk and breathe

Word [Pronunciation]	Definition
Sinuses si·nus·es	A cavity or hollow space in a bone of the skull, especially one that connects with the nose
Stethoscope steth·o·scope	An instrument for listening to the sounds made within the body, typically consisting of a hollow disc that transmits the sound through hollow tubes to earpieces
Surfactant sur·fac·tant	Surfactant reduces the surface tension of fluid in the lungs and helps make the small air sacs in the lungs (alveoli) more stable.
Trachea tra·che·a	A thin-walled, cartilaginous tube descending from the larynx to the bronchi and carrying air to the lungs; also called windpipe
Tracheostomy tra·che·os·to·my	Surgical construction of an opening in the trachea, usually by making an incision in the front of the neck, for the insertion of a catheter or tube to facilitate breathing
Upper Respiratory Tract up·per res·puh·rah·tow·ree tract	Composed of the parts of the upper respiratory system: the nose, sinuses, pharynx, and larynx
Ventilation ven·ti·la·tion	The exchange of air between the lungs and the environment, including inhalation and exhalation
Virus vi·rus	Any of various extremely small, often disease-causing agents consisting of a particle (the virion), containing a segment of RNA or DNA within a protein coat known as a capsid. Viruses are not technically considered living organisms because they cannot carry out biological processes.
Vocal Cords vo′·cal cords	The two folded pairs of membranes in the larynx (voice box) that vibrate when air that is exhaled passes through them, producing sound

*Most pronunciation keys from: http://medical-dictionary.thefreedictionary.com



If you sit up straight while reading a book out loud, it allows you to use more of your lung capacity. This will help keep you from getting short of breath or having to gasp for air in the middle of a sentence!

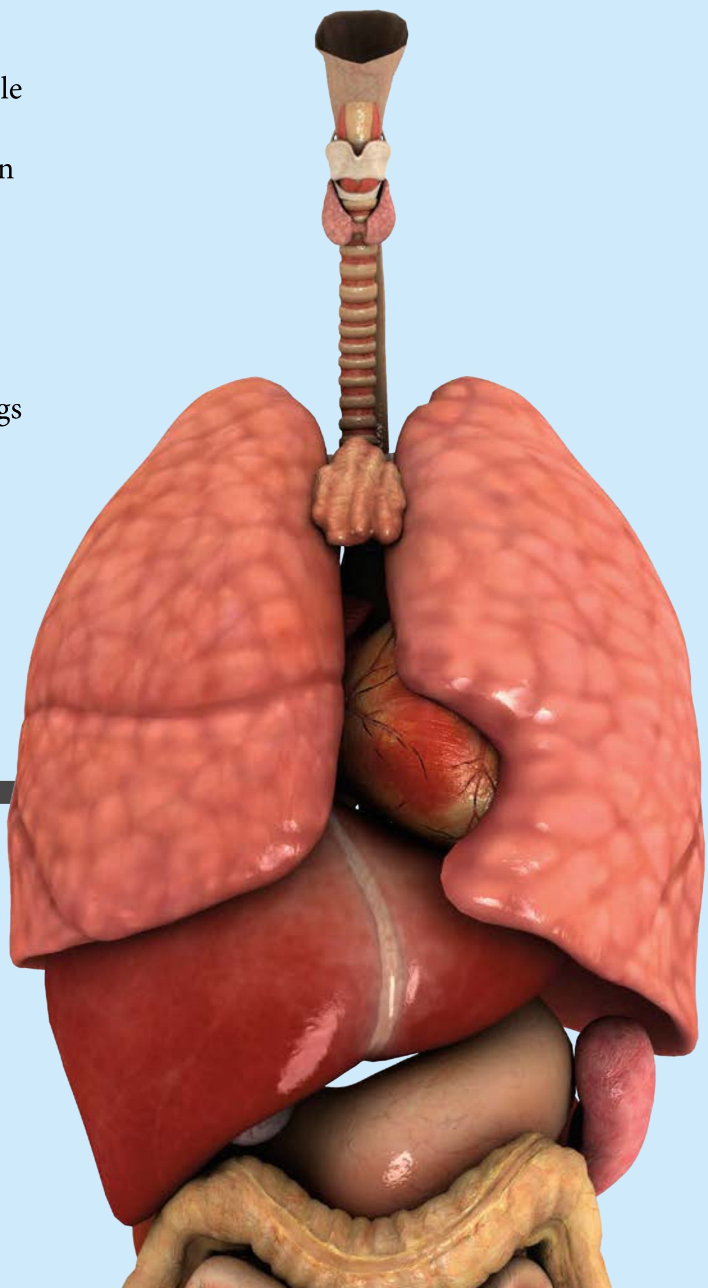
When you laugh, the muscles in your chest and your diaphragm contract, pushing air out of the lungs in a quick rush that makes your larynx vibrate to make the sound of laughter – ha ha! It has been observed that the average young child laughs nearly 300 times in a day. Adults, on average, laugh 15 to 100 times a day.

Laughter is good medicine! It helps to reduce pain and blood sugar levels. Proverbs 17:22 says, “A cheerful heart is good medicine, but a crushed spirit dries up the bones.”

1 Introduction: Why Do We Breathe?

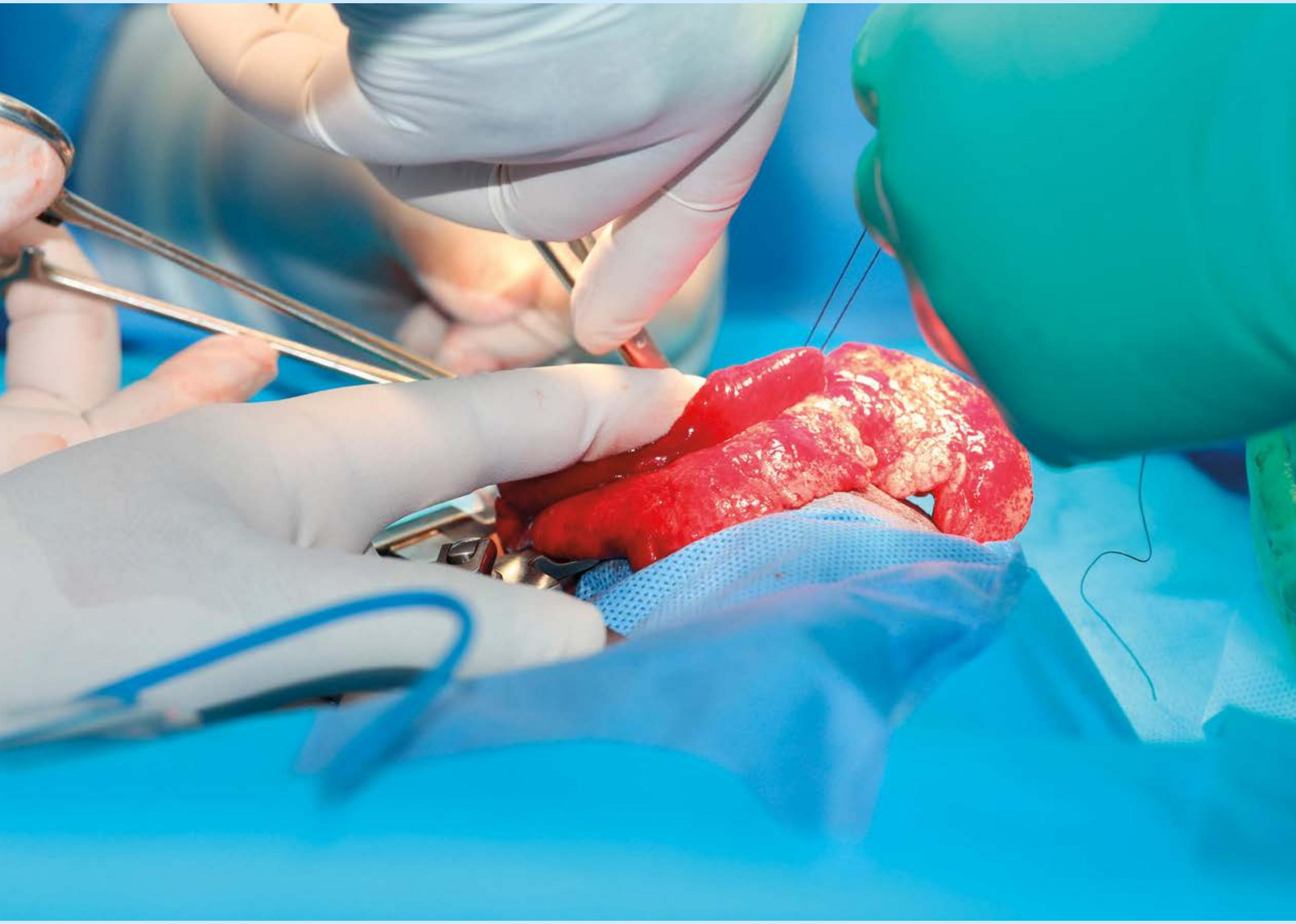
With a loud-piercing wail, each of us entered this world as a crying baby taking in our first breath of air. That breath ushers in a new independent life outside the mother's womb. Created from the dust on the ground and with the breath God breathed into his lungs, Adam took his first breath. This life-giving force originates from none other than God: the giver of life and breath. The respiratory system is yet another demonstration of God's provision, our human frailty, and our complete dependence on Him.

Why do we breathe? We breathe because we eat. Okay, that sounds a bit ridiculous. But it makes sense when we look at our bodies as an incredible engine. For an engine to carry out all of its processes, it needs energy. Oxygen is needed to burn and utilize the fuel we eat. The billions of cells in our bodies grab the oxygen we breathe from the red blood cells that travel by and utilize it to perform all of its complicated actions. The cells throw out the garbage from their day's work in the form of a gas called carbon dioxide. The lungs inhale oxygen and exhale carbon dioxide.



on the nose.

The capillaries in the lungs would extend 1,600 kilometers, almost 995 miles, if placed end to end. That is just slightly shorter than the distance between New York City and Tampa, Florida or almost equal to the distance between Chicago and Denver.



Sit back and breathe in. Come, as we embark on a captivating voyage through the wind tunnels of the body, and be prepared to be amazed. At the first stop on our journey, we will peer into the Bible and see what God's Word says about this life force. We will then take a look back in the pages of time and learn about discoveries that have helped shape our understanding of the respiratory system today. We will learn about the anatomy and physiology of this inverted tree-like structure called the lungs.

Discover remarkable things about your soft, spongy lungs. Did you know it is the only organ in your body that can actually float on water? The surface area of the alveoli (the small air sacs of the lungs) alone could cover the surface of an entire tennis court! Breeze in and witness this incredible expanse of God's Wondrous Machine. It will take your breath away!

2 Respiratory History Timeline: A Walk Back in Time

But isn't history just about a bunch of dead people? Why should it matter to me? How important is medical history for a particular system of the body? The dates and events are meaningless to our lives, right? Wrong. As you dive into "God's Wondrous Machine," you will see how these events have shaped what we understand to be true today. We encounter real problems in life. It is through those problems that we acquire new knowledge and original ways to solve those problems. History connects the past with the present and the future. When we study history, we can observe how things change over time and understand the situations and life circumstances that generate the necessity of innovation and invention. As you read, observe the frailty of our being and how God has given us each unique minds to help impact the world in which we live. You will see that the knowledge base that you now bring to the table far exceeds the knowledge of people from yesterday. We are confronted with new problems. The hope is that you will play a part in creating real solutions to the problems we encounter today to impact the advances of tomorrow.

Let's set sail through the pages of time and see how the various discoveries have provided a platform for future breakthroughs.

500 B.C.

Anaximenes, of ancient Greece, believed that all things were made of air. He called it *pneuma* which means "breath" in Greek. The Greeks believed everything was alive and breathing.

470 B.C.

Empedocles, the Greek philosopher, taught that all things were made of four elements — earth, air, fire, and water.

350 B.C.

Aristotle thought the heart was on fire. Breathing in cooled the fire and kept it from burning up the whole body.

1660

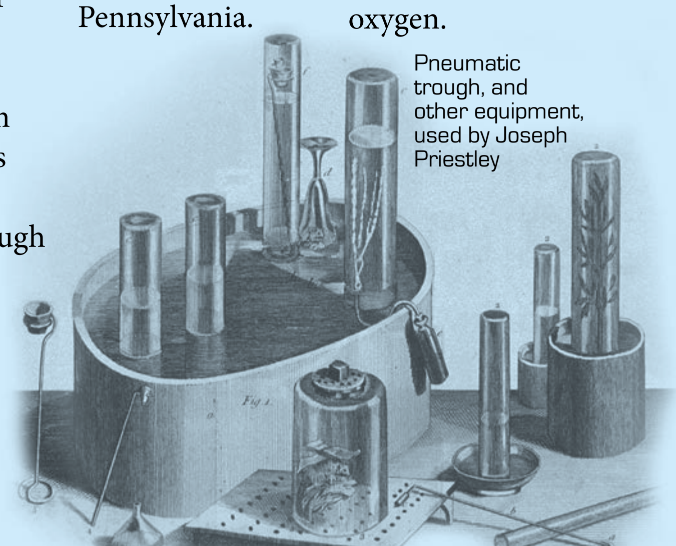
Marcello Malpighi, born in Crevalcore, Italy, March 10, 1628, showed that the lungs consist of many small air pockets and a complex system of blood vessels by observing capillaries through a microscope. He described the circulation of blood.

1765

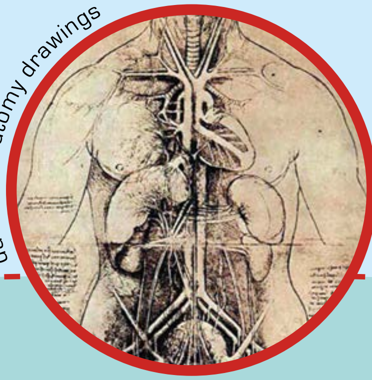
John Morgan founded the first medical school in America at the College of Pennsylvania.

1772-1774

Joseph Priestley discovered nitrous oxide and is credited with the discovery of oxygen.



Pneumatic trough, and other equipment, used by Joseph Priestley



da Vinci anatomy drawings

280-271 B.C.

Greek physician Erasistratus came very close to recognizing the circulation of the blood, especially by noting the relationship of the lungs to the circulating system.

A.D. 170

Galen taught that the secret of life was a spirit or *pneuma* that came from the air.

1500

Leonardo da Vinci, Italian painter and inventor, suggested that air was not made from one element but a combination of two gases.

1643

Evangelista Torricelli proved that air had weight and took up space.

1660

Robert Hooke, an Englishman, found that parts of the body act like pumps. Our ribs help pump air in and out of the lungs.

Re-enactment of the first operation under anesthesia

1779

Thomas Beddoes and Humphry Davy recognized nitrous oxide's anesthetizing effects, but did not think to use it to take away pain.

1779

Lavoisier proposed the name "oxygen" for the part of air that is breathed and responsible for combustion. He discovered that air was composed mainly of two components — oxygen and nitrogen.

1819

Treatise on Diagnosis by Listening to Sounds by physician Theophile René Laennec was written in which he demonstrated the use of a tube for investigating the lungs and heart sounds.

1845

Anesthetic inhaler invented. *Anesthetic* comes from the Greek word meaning "loss of feeling." Prior to the invention of anesthesia, patients were strapped down and held by strong individuals as the surgeon speedily worked.

1845

William Morton, an American doctor, used ether to extract a tooth from a patient. A sealed glass jar with an air valve containing several ether-soaked sponges was used, with a long rubber tube as a mouthpiece.

Early flexible stethoscopes

Jules Bordet

1847

Chloroform came into use. It was found that it was particularly useful in childbirth by James Young Simpson. This met a great deal of criticism — it was believed that it was always a woman's fate to suffer pain during childbirth. Queen Victoria popularized its use when she used it during the birth of her seventh child, Leopold.

1855

George Phillip Cammann, an American doctor, took Laennec's idea and developed the stethoscope we know today.

1882

Robert Koch discovers the bacterium that causes tuberculosis, the first definite association of a germ with a specific human disease.

1904

The National Association for the Study and Prevention of Tuberculosis was founded. This organization later became the American Lung Association.

1906

Jules Bordet discovered *Bordetella pertussis*, the bacterium that causes whooping cough.

Dr. Dorothy Andersen

Queen Victoria, with the Princess Royal

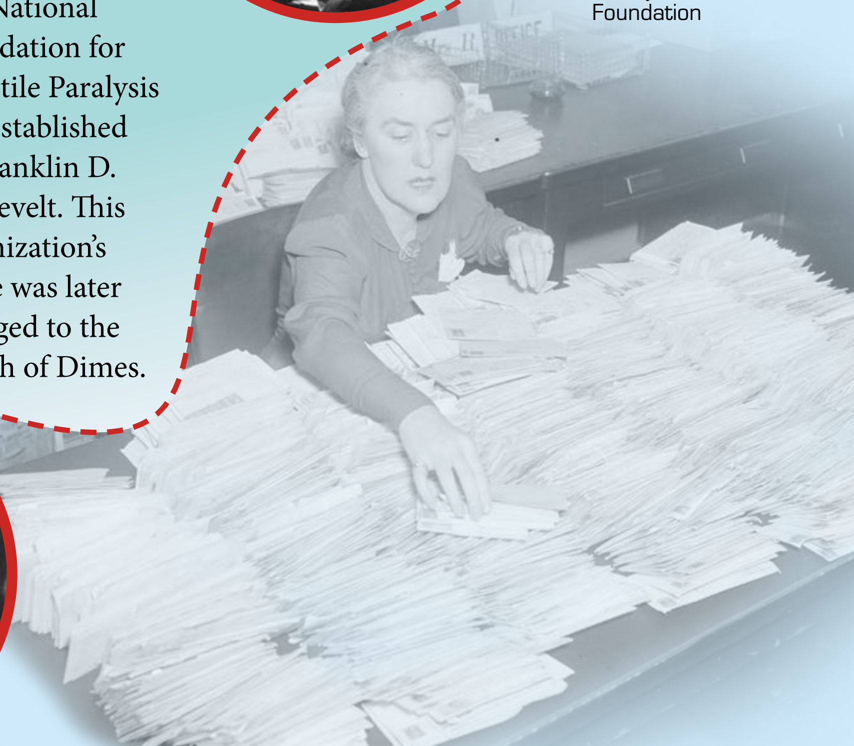
1938

Dr. Dorothy Andersen, a pathologist at Columbia-Presbyterian Babies and Children's Hospital in New York, was the first to document and observe the problems of cystic fibrosis, a genetic disease.

1953

Dr. Paul di Sant'Agnese developed an effective technique of diagnosing cystic fibrosis called the Sweat Test.


Franklin D. Roosevelt


Thousands send dimes to aid the Infantile Paralysis Foundation

1927

Phillip Drinker developed the “iron lung,” a mechanical metal device that encased a patient to help him breathe.

1938

Corneille Heymans of Belgium won the Nobel Prize for physiology or medicine for his discoveries in respiratory regulation.

1938

The National Foundation for Infantile Paralysis was established by Franklin D. Roosevelt. This organization’s name was later changed to the March of Dimes.


Dr. Jonas Salk

1955

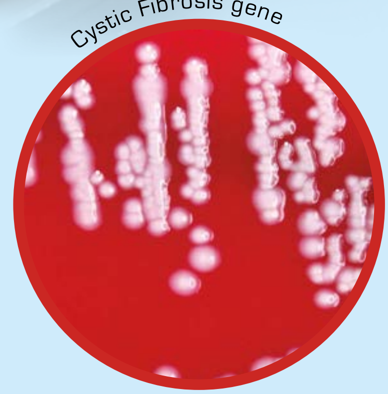
Dr. Jonas Salk, an American medical researcher, developed an injectable polio vaccine based upon a live weakened polio virus.

1957

Dr. Albert Sabin, a Polish American microbiologist, developed an oral (taken by mouth) vaccine that used a live weakened version of the polio virus.

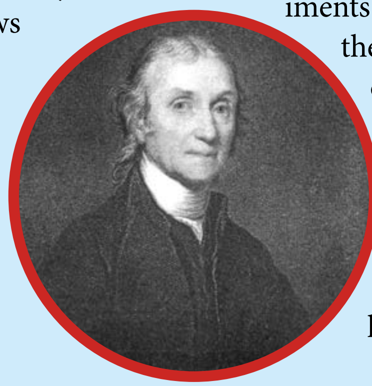
1989

The gene responsible for cystic fibrosis was identified, giving hopes of a cure one day by gene therapy.


Cystic Fibrosis gene

Joseph Priestley: The Dissenter Discovers Oxygen

Joseph Priestley (1733–1804) was born on March 13, 1733, in Fieldhead, England. Joseph's father died shortly after his birth. Joseph's mother was a devout religious woman who taught Joseph about God. As Joseph grew, he had a ravenous appetite for the Bible and learning. Faith and religion were central parts of daily life in England. England's official church was the Anglican Church, or the Church of England. It was a powerful organization and controlled many aspects of daily life. As Joseph matured in his faith, his views changed from the views held by the Anglican Church. Joseph became a dissenter. Dissenters were a diverse group that included Baptists, Lutherans, Methodists, Presbyterians, and Quakers that disagreed with the Church of England and broke away. Dissenters had limited rights in England. They could not attend the large universities, like Oxford and Cambridge. Nonetheless, Joseph pursued his passion for learning and God. He became an instructor at a local academy, a scientist, and was ordained as a Dissenting minister.



Priestley published six volumes of *Experiments and Observations on Different Kinds of Air* between 1772 and 1790. He detailed his experiments on gases or "airs." He is credited for the discovery of several gases: nitrogen dioxide, ammonia, nitrous oxide (laughing gas), nitrogen, and oxygen. The success that Priestley experienced as a scientist is credited to his keen mind and his ability to design ingenious contraptions to study gases he discovered.

The Breath of Life

Breathing is essential to life. Without the air that rushes into your lungs you would cease to exist. The Bible makes many references to breathing. Our Heavenly Father is the giver of life and through His breath He calls all creatures into existence. In Genesis 2:7 it says, "Then the Lord God formed a man from the dust of the ground and breathed into his nostrils the breath of life, and the man became a living being."

There is no evidence here of man being formed from an evolutionary process, but rather being formed from the actual loving hands of God. Job, through all his adversity, knew where his life force came from. In Job 33:4 he states, "The Spirit of God has made me; the breath of the Almighty gives me life." Remember, as Psalm 150:6 states, "Let everything that has breath praise the Lord. Praise the Lord."

Biblical References:			
2 Samuel 22:16	Job 4:9	John 20:22	Acts 17:25
Isaiah 11:4	Ezekiel 37:5–10	Isaiah 30:28	

I AM wonderfully made

The Haldanes and Their Bad Gas

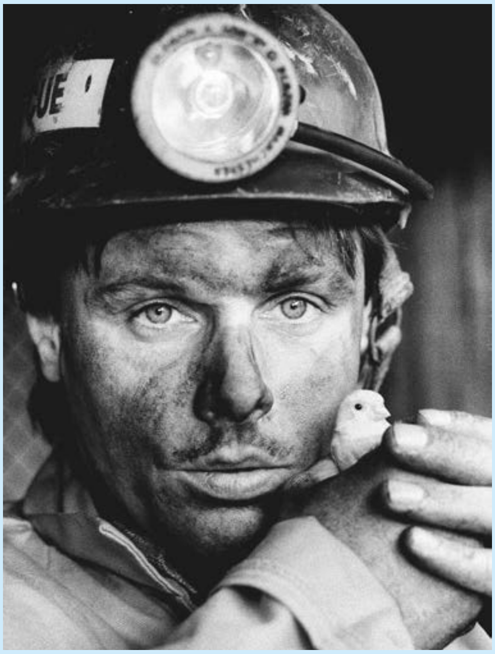
Today, scientific research is heavily managed and monitored. In the 1970s, the Food and Drug Administration (FDA) developed laws to protect human subjects taking part in clinical trials. Clinical trials are research studies that determine how well new medical approaches work in people.

Prior to this time, there was no standard on how things were tested on people. Many doctors and scientists would do unsafe practices on themselves or others in order to observe and learn new medical advances. There are two such scientists, father and son, who used themselves as human guinea pigs. (Guinea pigs have been commonly used in laboratory studies.) John and Jack Haldane utilized their bodies for scientific exploration. They made many contributions to our understanding of the respiratory system and the nature of gases.

John Haldane was a Scottish physiologist born in the late 1800s. A physiologist is a type of scientist that strives to understand how body systems work. Mr. Haldane demonstrated an insatiable thirst for knowledge. He would conduct experiments on himself. He would check the quality of air by locking himself in closed chambers and inhaling potentially deadly gases. He would then record the effects it had on his body and mind. John's son, Jack, was quick to get into the act. Jack began his own experimentation at three years of age when he gladly allowed his father to take a small amount of his blood for study. At the ripe old age of four years, Jack started breathing "bad air" in the underground railway and mines, and at 13 years he dove into the ocean in a leaky diving suit. Jack was a child scientist by his father's side.

On many occasions, the Haldanes felt the ill effects of their experiments. They suffered from headaches, vomiting, passing out, and on some occasions even turned blue. John was able to show that most of these ill effects were not due to a lack of oxygen but a build-up of carbon dioxide in their bloodstream.

They did many crazy things. It is not surprising that the family motto of the Haldane family was just one word — "suffer." They inhaled many mixtures of gases and studied the effects on their bodies. They were one of the first to identify that breathing was controlled by the blood-brain barrier that transported gases to a sensitive area of the brain. They were the experts on the hazards of breathing bad air. Their discoveries revolutionized and protected the jobs of miners, soldiers, deep sea divers, and submarine dwellers. They unlocked the mysteries of respiration and the gases that affect us.



John Haldane came up with the idea of using canaries as an early warning system. The miners carried a caged canary into the coal mine and if dangerous gases like carbon monoxide were present they would kill the canary before the miners felt the ill effects.