The Breathtaking Respiratory System
# TABLE OF CONTENTS

How to Use This Book (All about Us!).................................................................................................................. 4
Using the Curriculum Guide ........................................................................................................................................ 5
About the Author ......................................................................................................................................................... 6
A Note from the Author ............................................................................................................................................... 7
Vocabulary Levels ....................................................................................................................................................... 8
See It, Say It, Know It!............................................................................................................................................... 9

1 Introduction: Why Do We Breathe ...............................................................................................................................14
2 Respiratory History Timeline: A Walk Back in Time ....................................................................................................... 16
   Joseph Priestley: The Dissenter Discovers Oxygen ................................................................................................. 20
   The Breath of Life..................................................................................................................................................... 20
   The Haldanes and Their Bad Gas............................................................................................................................. 21
3 The Structure of the Respiratory Tract .......................................................................................................................... 22
   Upper Respiratory Tract............................................................................................................................................ 22
   The Nose.................................................................................................................................................................. 24
   Parts of the Nose .................................................................................................................................................... 24
4 The Structure of the Lower Respiratory Tract ............................................................................................................... 30
5 Respiration — Ventilation Getting Into the Act .............................................................................................................. 36
6 The Development of the Lungs .................................................................................................................................. 40
7 Technology ............................................................................................................................................................... 44
8 Health and Illness ..................................................................................................................................................... 48
   Illnesses of the Lungs............................................................................................................................................. 53
9 The Story of Polio ...................................................................................................................................................... 62
10 Ponder This ............................................................................................................................................................. 68
    Conclusion .......................................................................................................................................................... 71
11 Fun Stuff ............................................................................................................................................................... 72
    Index ................................................................................................................................................................. 77
How to Use This Book (All about Us!)

About this God’s Wondrous Machine series:

Developed by a master’s-trained teacher and homeschooling mother who happens to be a pediatrician, this is the second book in an innovative anatomy curriculum that focuses on the human body’s respiratory system. It will create engaging opportunities for children to discover the wonders and workings of the human body.

Each book in this series delves into one of the major systems of the body; the first three of this nine-book series under development include the following:

The book series will be bursting with vibrantly colorful images, interesting historical and weird facts, anatomy, physiology, and modern innovations. You will engage your senses and have a multitude of choices for hands-on exploration. You will discover aspects of the human body from a doctor’s perspective. Each book will focus on a particular system of the body, discussing how it works and how it doesn’t at times. Common questions kids ask are answered to stimulate curiosity, and your senses will be engaged as the world of medicine is demystified.

This series gives many perspectives in science education by connecting to other fields of study (i.e., history, sociology, psychology, and theology), and it encourages the reader to appreciate God’s magnificent handiwork: your body.

God’s Wondrous Machine series recognizes that every learner is not the same. Whether used in a homeschool or classroom setting, the series’ hands-on activities are based on the educational theory of Multiple Intelligence by Howard Gardner (which states there are many types of intelligences and recognizes different learning styles: musical–rhythmic, visual–spatial, verbal–linguistic, logical–mathematical, bodily–kinesthetic, interpersonal, intrapersonal, and naturalistic). It is flexible enough for endless customization for the skills, interests, and abilities of each student.
Using the Curriculum Guide

This developing nine-book series will challenge the child in all facets of multiple intelligence. The parent/instructor is able to choose and customize hands-on activities that engage a multitude of learning styles and challenge the student to explore life's big issues. The program is specially designed for lower and upper elementary level students, including advanced learners with middle school proficiency!

You can use this book as an interesting:

- Unit Study
- Curriculum
- Supplemental Resource

An associated teacher guide is available. It contains perforated sheets for worksheets, and tests, in addition to a flexible educational calendar. This additional material allows for a multiple array of assessments for the instructor (i.e., project based, traditional testing, or portfolio assessment). It is designed to maximize the learning opportunities and retention of information from the book, as kids have fun learning about the mechanics and mysteries of themselves!

Did you know that your chest movement during respiration is not due to the air entering or leaving your lungs? This movement is due to your hardworking diaphragm. As the diaphragm contracts and moves downward, the space in your chest cavity increases in size. When you exhale, the opposite effect occurs.
Dr. Lainna Callentine has a passion for science. She spent many hours as a child turning over rocks and wading through streams chasing tadpoles. She is from a family of six children. Her parents grew up in the inner-city housing projects of Chicago, and her parents felt that education was a powerful tool. They instilled in her and her siblings a great love for learning.

Dr. Callentine wears many hats. She is a coach, teacher, pediatrician, and homeschool mother. She obtained her bachelor’s degree in human development and social policy from Northwestern University in the school of education while competing as a full-scholarship athlete. She began her professional career as an elementary school teacher. She obtained her master’s degree in education from Widener University. Then she went on to pursue her lifelong dream of becoming a doctor. Dr. Callentine obtained her medical degree from University of Illinois College of Medicine. She worked in one of the busiest emergency rooms in Illinois before answering the call to go home and homeschool her three children.

She founded Sciexperience and travels nationally as a speaker doing inspiring hands-on science workshops for all ages. She continues to utilize her medical training as a missionary doctor in a clinic for the uninsured in the suburbs of Chicago. She is a member of the Christian Medical and Dental Society and The Author’s Guild. She enjoys basketball, time with her husband and three kids, and the outdoors.

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LinkedIn: www.linkedin.com/pub/lainna-callentine-m-ed-m-d/50/744/a0b/
A Note from the Author

“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.”
— Genesis 2:7

Why do we breathe? Why do we have to inhale and exhale, multiple times a minute without fail? Why don’t we use gills or absorb oxygen through our skin as other animals do? It seems as if there are a number of other ways this could have been accomplished.

Breathing was designed for more than just the purpose of sustaining life, though it was certainly well designed for that. All creation was designed by God for a purpose, but not just a physical purpose. You were designed for a unique and special purpose. Breathing serves as a constant reminder of that first moment when God breathed into Adam and finished his creation. It is also a reminder of the nature of the Holy Spirit, often described as the Breath of God.

I continue to be amazed how creation declares the glory of God at every turn. The Breathtaking Respiratory System is no different. My prayer is that this will become evident to you with every new word and every weird or gross fact you learn. May your mind be open to discovering God’s handiwork and recognizing the majesty that is reflected in the respiratory system. It will truly take your breath away.

In His Service,

Dr. Lainna Callentine

While humans and goldfish each breathe oxygen, you get oxygen from the air when it is filtered through the lungs. Breathing more often than a person, goldfish get dissolved oxygen from the water when it is passed through its gills. God designed people and all of the animals in His creation in unique ways, and there is a lot we can learn from these differences!
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
• Cribiform Plate
• Epithelium
• Gestation
• Goblet Cells
• Nasal Turbinate
• Organogenesis
• Pneumotaxic Center
• Surfactant
• Tracheostomy

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!
### See It, Say It, Know It!

<table>
<thead>
<tr>
<th>Word [Pronunciation]</th>
<th>Definition</th>
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<tbody>
<tr>
<td><strong>Allergens</strong></td>
<td>al·ler·gen (al´er-jen)</td>
</tr>
<tr>
<td><strong>Allergy</strong></td>
<td>al·ler·gy (al´er-je)</td>
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<tr>
<td><strong>Alveolus</strong></td>
<td>al-ve´o-lus</td>
</tr>
<tr>
<td><strong>Alveoli</strong></td>
<td>alve´oli (plural form)</td>
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<tr>
<td><strong>Anosmia</strong></td>
<td>an-os-mi-a</td>
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<tr>
<td><strong>Antiseptic</strong></td>
<td>an-ti-sep-tic</td>
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<td><strong>Apneustic Center</strong></td>
<td>app-new-stik sen-ter</td>
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<td><strong>Asthma</strong></td>
<td>asth·ma</td>
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<tr>
<td><strong>Bacteria</strong></td>
<td>bac·te·ri·a</td>
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<tr>
<td><strong>Bronchi</strong></td>
<td>bronc-i</td>
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<tr>
<td><strong>Bronchioles</strong></td>
<td>bron-chi-ole</td>
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<tr>
<td><strong>Carbon Dioxide</strong></td>
<td>car·bon di·ox·ide</td>
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<tr>
<td><strong>Chemoreceptors</strong></td>
<td>che-mo-re-cep-tor</td>
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<tr>
<td><strong>Cilia</strong></td>
<td>cil-i-a</td>
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<tr>
<td>Word [Pronunciation]</td>
<td>Definition</td>
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<tr>
<td>Cribriform Plate</td>
<td>Located in the ethmoid bone of the skull in the nasal cavity where the nerve endings of the sense of smell are found</td>
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<tr>
<td>Cystic Fibrosis</td>
<td>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.</td>
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<tr>
<td>Diffusion</td>
<td>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.</td>
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<tr>
<td>Epidemic</td>
<td>An outbreak of a disease or illness that spreads rapidly among individuals in an area or population at the same time</td>
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<td>Epiglottis</td>
<td>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</td>
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<tr>
<td>Epithelium</td>
<td>Any tissue layer covering body surfaces or lining the internal surfaces of body cavities, tubes, and hollow organs</td>
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<tr>
<td>Exhale</td>
<td>To breathe out</td>
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<tr>
<td>Gestation</td>
<td>The period during which unborn young are “carried” inside the womb</td>
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<tr>
<td>Goblet Cells</td>
<td>Cells in the respiratory tract that produce mucus</td>
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<tr>
<td>Influenza</td>
<td>A highly contagious and often epidemic viral disease characterized by fever, tiredness, muscular aches and pains, and inflammation of the respiratory passages</td>
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<tr>
<td>Inhale</td>
<td>To breathe in; inspire</td>
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<tr>
<td>Iron Lung</td>
<td>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</td>
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<tr>
<td>Laryngitis</td>
<td>Inflammation of the larynx, often with accompanying sore throat, hoarseness or loss of voice, and dry cough</td>
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<td>Word [Pronunciation]</td>
<td>Definition</td>
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<tr>
<td>Larynx</td>
<td>lar·ynx</td>
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<tr>
<td>Lower Respiratory Tract</td>
<td>lo-wer res-pir-a-tory tract</td>
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<td>Mucus</td>
<td>mu-cus</td>
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<td>Nares</td>
<td>nar-is</td>
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<td>Nasal Turbinate</td>
<td>Na-sal tur-bi-nate</td>
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<tr>
<td>Organogenesis</td>
<td>or-gan-o-gen-e-sis</td>
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<tr>
<td>Pandemic</td>
<td>Pan-dem/ic</td>
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<tr>
<td>Pharynx</td>
<td>phar-ynx</td>
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<tr>
<td>Physiologist</td>
<td>phys-i-ol-o-gist</td>
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<tr>
<td>Pleura Sac</td>
<td>pleu-ra sac</td>
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<tr>
<td>Pneumotaxic Center</td>
<td>pneu-mo-tax-ic sen-ter</td>
</tr>
<tr>
<td>Polio</td>
<td>po-li-o</td>
</tr>
<tr>
<td>Word [Pronunciation]</td>
<td>Definition</td>
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<tr>
<td>Sinuses si-nus-es</td>
<td>A cavity or hollow space in a bone of the skull, especially one that connects with the nose</td>
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<tr>
<td>Stethoscope steth-o-scope</td>
<td>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</td>
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<tr>
<td>Surfactant sur-fac-tant</td>
<td>Surfactant reduces the surface tension of fluid in the lungs and helps make the small air sacs in the lungs (alveoli) more stable.</td>
</tr>
<tr>
<td>Trachea tra-che-a</td>
<td>A thin-walled, cartilaginous tube descending from the larynx to the bronchi and carrying air to the lungs; also called windpipe</td>
</tr>
<tr>
<td>Tracheostomy tra-che-os-to-my</td>
<td>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</td>
</tr>
<tr>
<td>Upper Respiratory Tract up-per res-puh-rah-tow-ree tract</td>
<td>Composed of the parts of the upper respiratory system: the nose, sinuses, pharynx, and larynx</td>
</tr>
<tr>
<td>Ventilation ven-ti-la-tion</td>
<td>The exchange of air between the lungs and the environment, including inhalation and exhalation</td>
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<tr>
<td>Virus vi-rus</td>
<td>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.</td>
</tr>
<tr>
<td>Vocal Cords vo-cal cords</td>
<td>The two folded pairs of membranes in the larynx (voice box) that vibrate when air that is exhaled passes through them, producing sound</td>
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</tbody>
</table>

*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.”
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.
Isn’t it amazing what doctors can do today! Surgeries to repair damage to parts of your body, including those of an infant’s lung like this one, can now be done safely.

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!
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.
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.

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

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

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

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

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

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.

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.

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.

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.
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.

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.
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.

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.
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:**

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<tbody>
<tr>
<td>Isaiah 11:4</td>
<td>Ezekiel 37:5–10</td>
<td>Isaiah 30:28</td>
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</table>
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.