

Lainna
Callentine
M.Ed., M.D.

The Complex Circulatory System

First printing: April 2016

Copyright © 2016 by Dr. Lainna Callentine. All rights reserved. No part of this book may be used or reproduced in any manner whatsoever without written permission of the publisher, except in the case of brief quotations in articles and reviews. For information write:

Master Books®, P.O. Box 726,
Green Forest, AR 72638

Master Books® is a division of the
New Leaf Publishing Group, Inc.

ISBN: 978-0-89051-908-0

Library of Congress Number: 2015960972

Cover and Interior Design by Diana Bogardus

Unless otherwise noted, Scripture quotations are from the New International Version of the Bible.

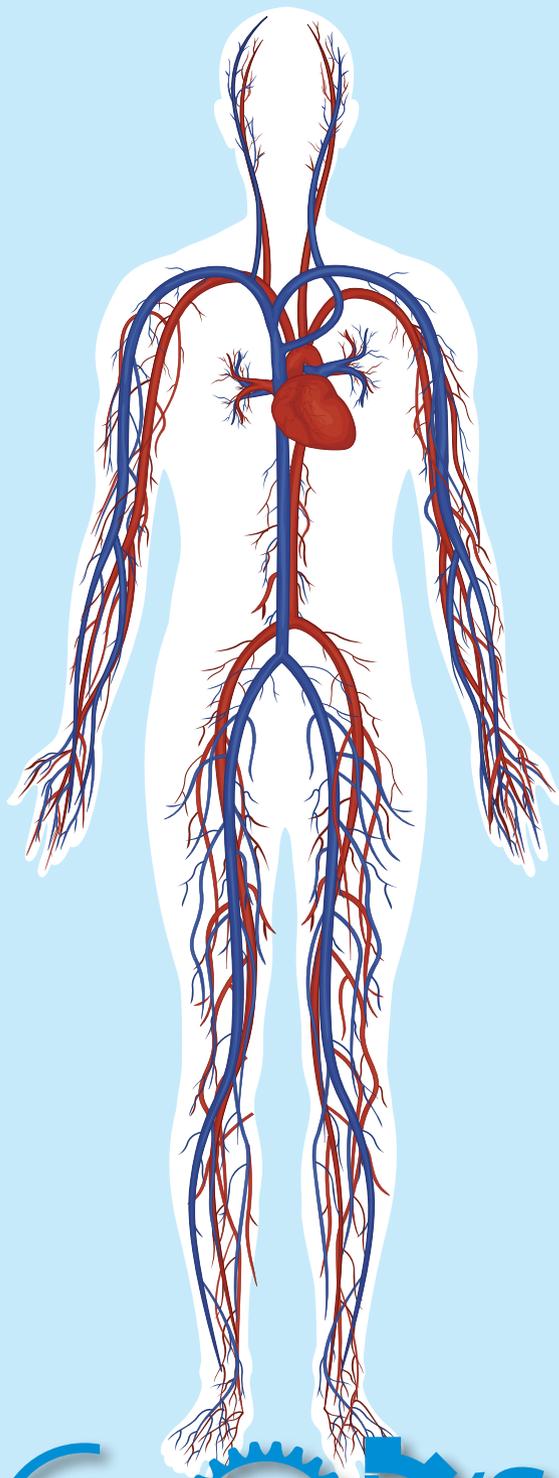
Please consider requesting that a copy of this volume be purchased by your local library system.

Printed in China

Please visit our website for other great titles:
www.masterbooks.com

For information regarding author interviews,
please contact the publicity department at
(870) 438-5288


Master
Books®
A Division of New Leaf Publishing Group
www.masterbooks.com



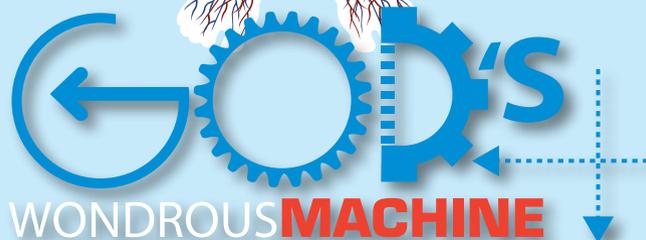

GOD'S
WONDROUS MACHINE

TABLE OF CONTENTS

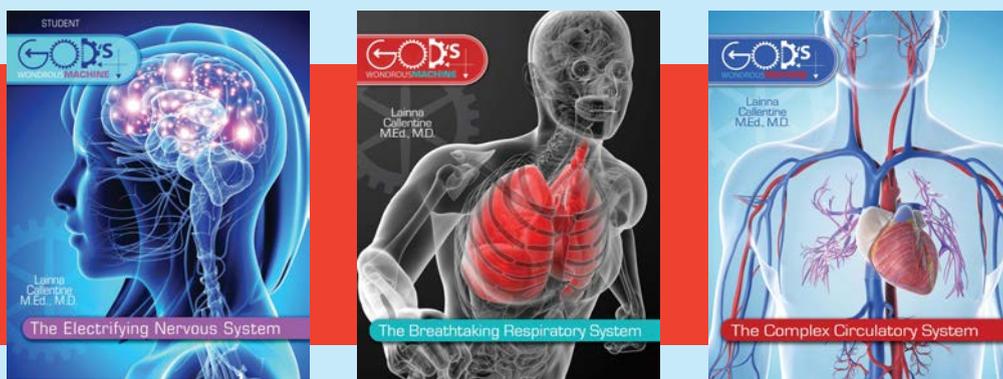
How to Use This Book (All about Us!)	4
Using the Teacher Guide	5
About the Author	6
A Note from the Author	7
Vocabulary Levels	8
See It, Say It, Know It!	9
Introduction	12
Biblical References to the Heart	13
1 Historical Timeline of Circulatory System	14
2 Blood	24
3 Highways of Blood	36
4 Blood-Sucking Critters	38
5 Take Heart: Getting to the Heart of the Matter	42
6 In the Beginning: The Development of the Heart	50
7 Technology	54
8 An Apple a Day Keeps the Doctor Away: Good Health	58
9 Ponder This	60
10 Facts: Bizarre and Gross	64
11 Fun Stuff	66
Bibliography	74
Index	76

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 third book in an innovative anatomy curriculum that focuses on the human body's circulatory 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:



This book series is 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.

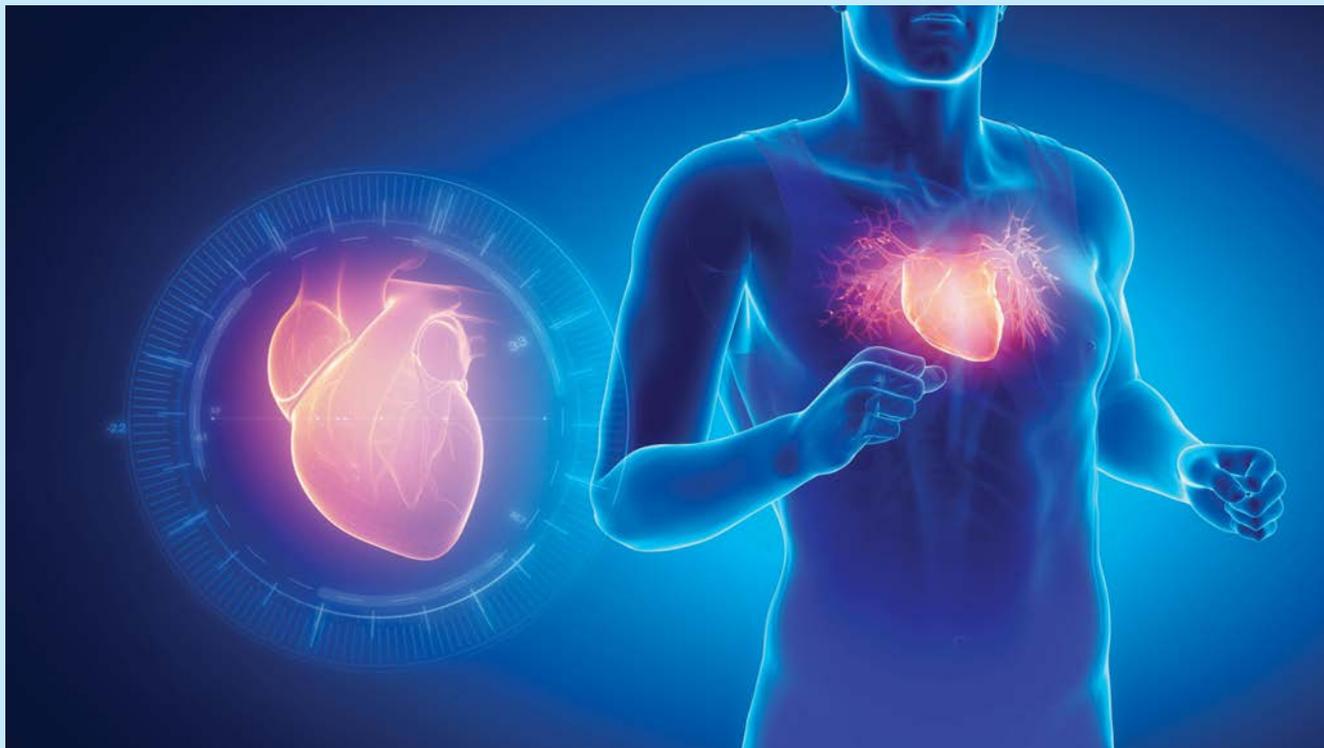
Using the Teacher Guide

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 for themselves!



Exercise is important! Running can help stimulate muscles and help make the heart pump more efficiently. Doctors can check your heart by using a stethoscope, a device invented in 1816 by a young French physician who was embarrassed to place his ear to the chest of a young female patient, which at the time was the standard way to check someone's heartbeat.

About the Author

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 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 children.

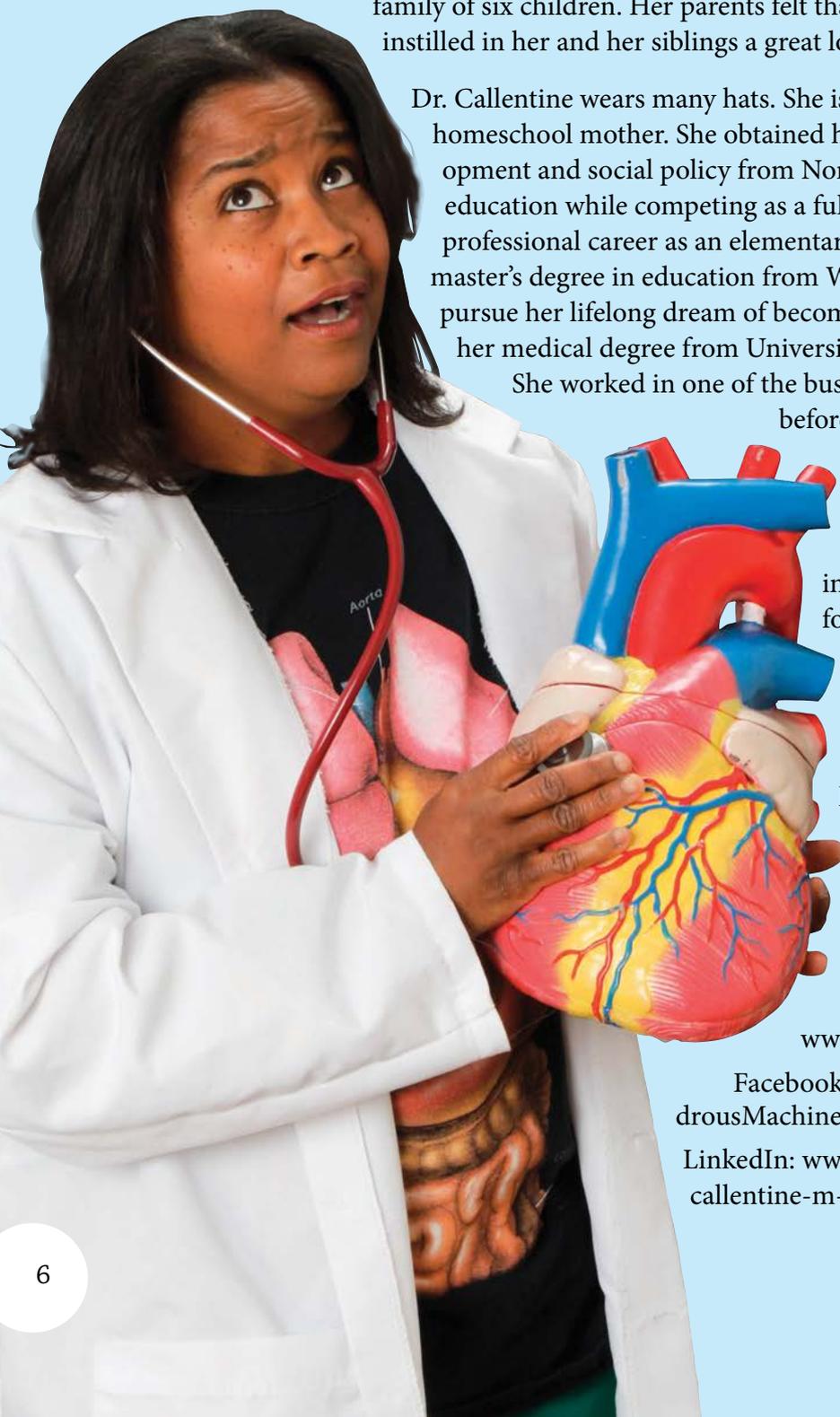
She founded Sciexperience and travels nationally as a speaker doing inspiring hands-on science workshops for all ages. She continues to utilize her medical training as a missionary doctor in a clinic for the uninsured. She is an adjunct professor at Wheaton College as an instructor of clinical kinesiology. She is a member of the Christian Medical and Dental Society. She enjoys basketball, time with her husband and three kids, and the outdoors.

Web information:

www.sciexperience.com

Facebook page: www.facebook.com/GodsWondrousMachine

LinkedIn: www.linkedin.com/pub/lainna-callentine-m-ed-m-d/50/744/a0b/



A Note from the Author

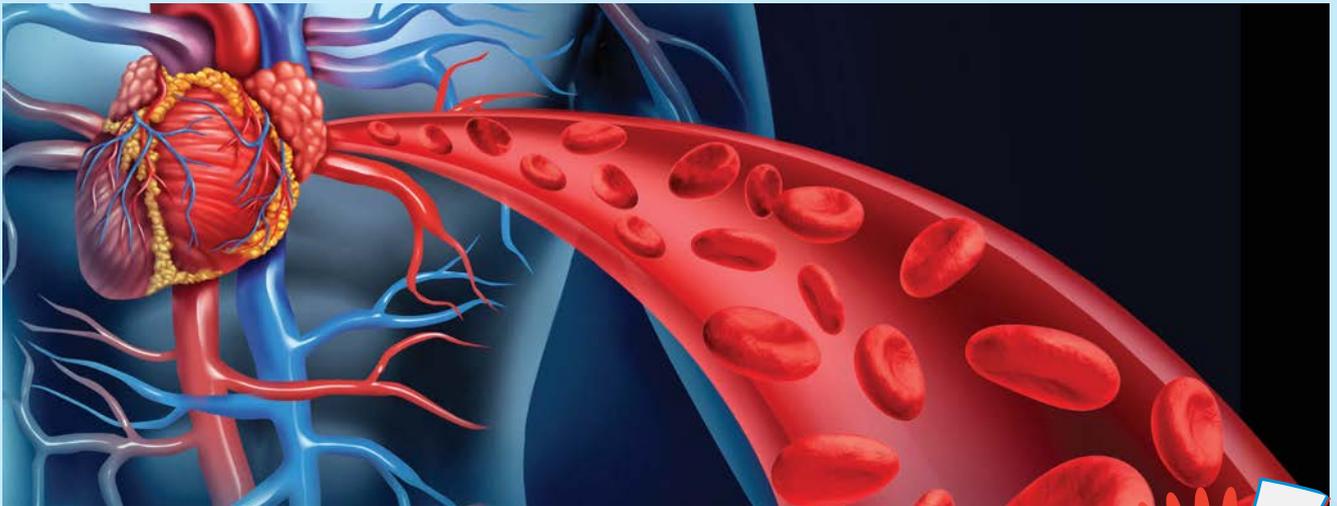
Wow! Congratulations! You are actually reading “A Note from the Author” page! Really? Who really reads these anyway? I have a sad confession — when I was a kid I would always skip this section. “Who cares?” I would say. “This is not assigned, and I certainly won’t be tested on this.”

I am glad you stopped by to spend some “quality” time prior to digging into *The Complex Circulatory System*. I am blown away by the complexity of life. This is not a random sequence of events. Design is everywhere.

My prayer for you is to continue to grow in the love of Christ. I am absolutely sure that God has big plans for your life. You are His wondrous creation. My hope is that this book as well as the other books in this series of God’s Wondrous Machine will draw you to the Great Designer. You are deeply loved by your Heavenly Father. There are many distractions and arguments about this design, as well as the time period that God created it. Make no mistake, God’s Word is true. This is a battle for souls. May you walk boldly and heed His call.

In His Service,

Dr. Lainna Callentine



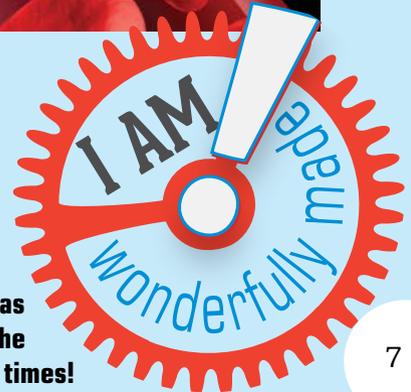
Dedication

To my dear family, thanks for standing by my side.

D.R., my best friend, thanks for your steadfast love and unending encouragement. You have been there in sickness and health.

My children: Michael, Jay, and Hannah, where does time go? Thank you for your support and love.

Your blood travels 12,000 miles throughout your body each day. That is the same distance basically as travelling across the United States four times!



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

- Anemia
- Aorta
- Arteries
- Arterioles
- Atrium
- Bone marrow
- Closed circulatory system
- Fetus
- Hemoglobin
- Open circulatory system
- Prothrombin
- Red Blood Cells
- Stethoscope
- Valves
- Veins
- White blood cells

Level 2 Vocabulary

Review and Know Level 1 Vocabulary

- Antibodies
- Antigens
- Buffy coat
- Capillary
- Coronary
- Epicardium
- Erythrocytes
- Hematophagic
- Hemophilia
- Hemostasis
- Malaria
- Myocardium
- Pericardial sac
- Platelets
- Sickle cell anemia
- Stem cell
- Syncope
- Systole
- Tachycardia
- Universal donor
- Universal receiver
- Ventricles

Level 3 Vocabulary

Review and Know Level 1 and 2 Vocabulary

- Auscultate
- Bradycardia
- Centrifuge
- Chordae tendineae
- Diastole
- Electrocardiogram
- Endocardium
- Hematopoiesis
- Myocardial infarction
- Prothrombin
- Sinoatrial node
- Tricuspid valve
- Venules

See It, Say It, Know It!

Word [Pronunciation]	Definition
Anemia [ah-ne 'me-ah]	A problem with the blood in which oxygen delivered to the organs and tissues is decreased. It can be a symptom of many different diseases.
Antibodies [an-ti-bod-eez]	Blood proteins that are made to attack a specific invader, like bacteria or viruses. They set off a cascade of events to assist the body in a stronger defense.
Antigens [an 'ti-jenz]	A foreign substance, like bacteria or virus, that triggers an immune response and causes antibodies to spring into action.
Aorta [a-or 'tah]	The largest artery in the body that originates from the left ventricle and sends oxygenated blood to the body.
Arteries [ahr 'ter-ez]	Vessels that carry oxygenated blood from the heart to the body.
Arterioles [ahr-te 're-ōlz]	Small vessels that carry oxygenated blood that connects to capillaries.
Atrium [a 'tre-um]	The upper chambers of the heart in which blood enters the heart. There are two atrium, the right and left atriums.
Auscultate [ō 'skəl-tāt ']	To listen; to listen to the sounds of the body.
Bradycardia [brady-car-dia]	A slow heartbeat that is typically less than 60 beats a minute for an adult.
Bone marrow [bohn mar 'o]	The soft, spongy material in the middle of bones.
Buffy coat [bufé kōt]	When blood is centrifuged, spun in a test tube in a machine, the blood separates into three parts. This middle part is composed of white blood cells and platelets
Capillary [kap 'i-lar "e]	Smallest arterial blood vessel; connects the arterioles with the venules.
Centrifuge [cen 'trī-fūj]	To spin around; a machine used to spin test tubes of blood at high speeds in order to cause the parts of blood to separate.
Closed circulatory system	A blood system composed of vessels of different sizes that encloses the blood at all times. The blood is pumped by the heart and does not fill body cavities.
Chordae tendineae [kor 'dah ten di nee a]	Fibrous strings that connect to the edges of the heart valves. They keep the valves from inverting or flipping backwards. Also known as the "heart strings."

Word [Pronunciation]	Definition
Coronary [kôr'ə-nēr'ē,]	The blood vessels that line the outside of the heart.
Diastole [dī-ās'tə-lē]	The phase in the heartbeat when the heart muscle relaxes and allows the heart chambers to fill with blood.
Electrocardiogram [ĭ-lĕk'trō-kār'dē-ə-grām']	A machine that graphically records the heart's electrical activity.
Endocardium [ĕn'dō-kār'dē-əm]	The inner muscle layer of the heart; the muscle that lines the inside of the heart.
Epicardium [ĕp'ī-kār'dē-əm]	The outer muscle layer of the heart that lies under the pericardial sac.
Erythrocytes [ē•rith•rō•sits]	A red blood cell that contains hemoglobin and transports oxygen.
Fetus [fē'təs]	An unborn baby.
Hematophagic [hĕmă-tō-fă'jē-ă]	The act of an animal or insect like a mosquito drinking blood.
Hematopoiesis [he'mah-to-poi-e'sis]	The formation of blood cells. In the fetus, it takes place at sites including the liver, spleen, and thymus. From birth throughout the rest of life, it is mainly in the bone marrow.
Hemoglobin [he'mo-glo'bin]	A protein housed in red blood cells that contain iron. Hemoglobin facilitates in carrying oxygen.
Hemophilia [hee-muh-fil-ee-uh]	Any of several X-linked genetic disorders transmitted from the mother's genes, is a disease that occurs mainly in males. Excessive bleeding occurs due to the absence or abnormality of a clotting factor in the blood.
Hemostasis [he'mo-sta'sis]	Stopping the escape of blood by natural means (either clot formation or vessel spasm).
Malaria [muh-lair-ee-uh]	A disease transmitted by mosquitos in which a parasite infects the red blood cells; can be deadly.
Myocardial infarction [mi'o-kahr'de-al in-fark'shun]	A heart attack.
Myocardium [mi'o-kar'de-um]	The middle and thickest layer of the heart wall muscle.
Open circulatory system	System in which the blood is pumped by the heart and fills the body cavities. The blood does not stay within the vessels.

Word [Pronunciation]	Definition
Pericardial sac [per"i-kahr' de-al sak]	Fibrous double-layered sac that surrounds the heart. It is filled with a lubricant that allows the heart to move without friction.
Platelets [plat'lits]	Small cells in the blood that are important in hemostasis, forming blood clots.
Prothrombin [pro-throm'bin]	A clotting factor, made in the liver, that is in the blood. It is activated to thrombin for clot formation.
Red blood cells	Cells in the blood that contain hemoglobin, an iron that carries oxygen.
Sickle cell anemia [ah-ne'me-ah]	A blood disease that is inherited in which the red blood cells become misshaped to a sickle-like appearance. Causes long-term problems.
Sinoatrial node [sahy-noh-ey-tree-uh]	A mass of muscle tissue on the top of the right atrium that is the electrical pacemaker of the heart.
Stem cell	A cell that has the ability to differentiate to other specialized cells.
Stethoscope [steth'o-skop]	A medical device used to listen and magnify the sounds heard in the body.
Syncope [sing'kah-pe]	To lose consciousness; pass out.
Systole [sis'to-le]	The phase in the heart cycle of beating in which the heart chambers contract to expel blood out of the heart.
Tachycardia [tak"e-kahr'de-ah]	A fast heartbeat that typically is over 100 beats a minute in an adult.
Tricuspid valve	The heart valve between the right atrium and right ventricle.
Universal donor	A person who has type O blood.
Universal receiver	A person who has type AB blood.
Valves [valv]	The "door" between the chambers of the heart that prevents blood from flowing backwards.
Veins [van]	Blood vessels in the body that carry deoxygenated blood. They transport blood to the heart.
Ventricles [ven'tri-k'l]	The lower chambers of the heart.
Venules [ven'ul]	Small blood vessels that carry deoxygenated blood toward the heart. They connect the capillaries to the veins.
White blood cells	Blood cells that are part of the immune system that fight invaders that attack the body.

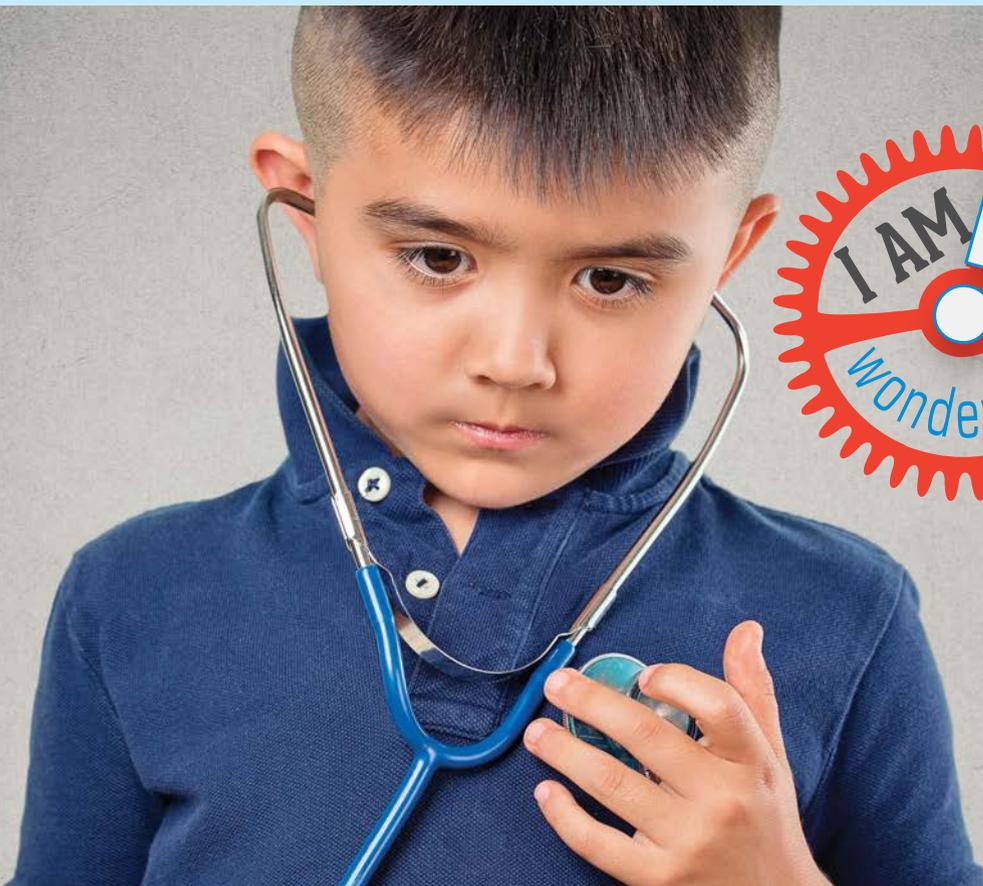
*Pronunciation Keys from <http://medical-dictionary.thefreedictionary.com>

Introduction

Lightning flashed. The cloud hurled its pellets downward. A blood-curdling scream resonated through the cold, dank, and dreary marble halls . . . a suspenseful way to begin a book on *The Complex Circulatory System*, right? Just the mention of the word or seeing blood causes some people to feel woozy and go wobbly in the knees. Some people will even pass out at the very sight of blood. Take heart. There will be no need to be faint of heart.

Our heart beats passionately. It never stops. It never rests. It works around the clock, day and night. It starts to beat after you were conceived in your mother's womb at 3 to 4 weeks (a full-term pregnancy is 40 weeks), and continues until the day God calls you heavenward. Aside from our Heavenly Father, Lord, God, and Jesus, no two words are more heavily mentioned in the Bible than "blood" and "heart." The word blood is mentioned in the Bible over 400 times. Heart is mentioned over a staggering 900 times. We will take a look at some of the powerful images illustrated and represented by these words.

The Complex Circulatory System will catapult you into a whole new dimension. First, we will take an historical excursion through the pages of time and see how our knowledge of the circulatory system has expanded. We will learn all about blood, where it comes from, and how clots develop. Next, we will wade through the life-giving fluid that courses through the highways of your body. We will explore bloodsucking critters and enter the atrium of the heart and peer into the heart's many rooms. My prayer is that as we journey through the tributaries of your body, you will gain a deeper understanding of the magnificent artistry God has fashioned in you.



**Trust in the Lord
with all your
heart, and
do not lean
on your own
understanding.
In all your ways
acknowledge him,
and he will make
straight your paths
(Proverbs 3:5–6).**

Biblical References to the Heart

The heart knows, thinks, sees, is wise, speaks, and understands.
Proverbs 15:13–14
Psalm 90:12

The heart is very intentional.
Psalm 27:14
Psalm 119:112

The heart desires, wishes, and envies.
Proverbs 14:30
Psalm 139:23

The heart can be good, pure and holy
Psalm 51:10
Proverbs 21:2

The heart is emotional. It loves. It feels things good and bad.
Matthew 22:37
2 Thessalonians 3:5

The 66 books that make up the framework of the Bible are the words of God. God has a great deal to tell us. It states in 2 Timothy 3:16–17, “All Scripture is God-breathed and is useful for teaching, rebuking, correcting and training in righteousness, so that the servant of God may be thoroughly equipped for every good work.” I am so glad God has given us instructions by which to guide our lives. From the earliest records of time, humans have known about this pulsating organ in the middle of our chest and the crimson tide that surges through the vessels of our body. The meaning of the word “heart” emerges through several themes in the Bible. Seven of these themes are knowledge, desire, intention, emotion, goodness, hardness, and wickedness.

The heart can be wicked and store evil.
Jeremiah 17:9

The heart can be hard, stubborn and calloused.
Ezekiel 36:26
Proverbs 28:14

It has taken us many generations to acquire the understanding of the heart in the context of our biological processes. Our Lord amazes me. Before man made these “great” discoveries, God’s creation and order already existed. We have just begun to understand some of the complexities of His handiwork, to put words and descriptions

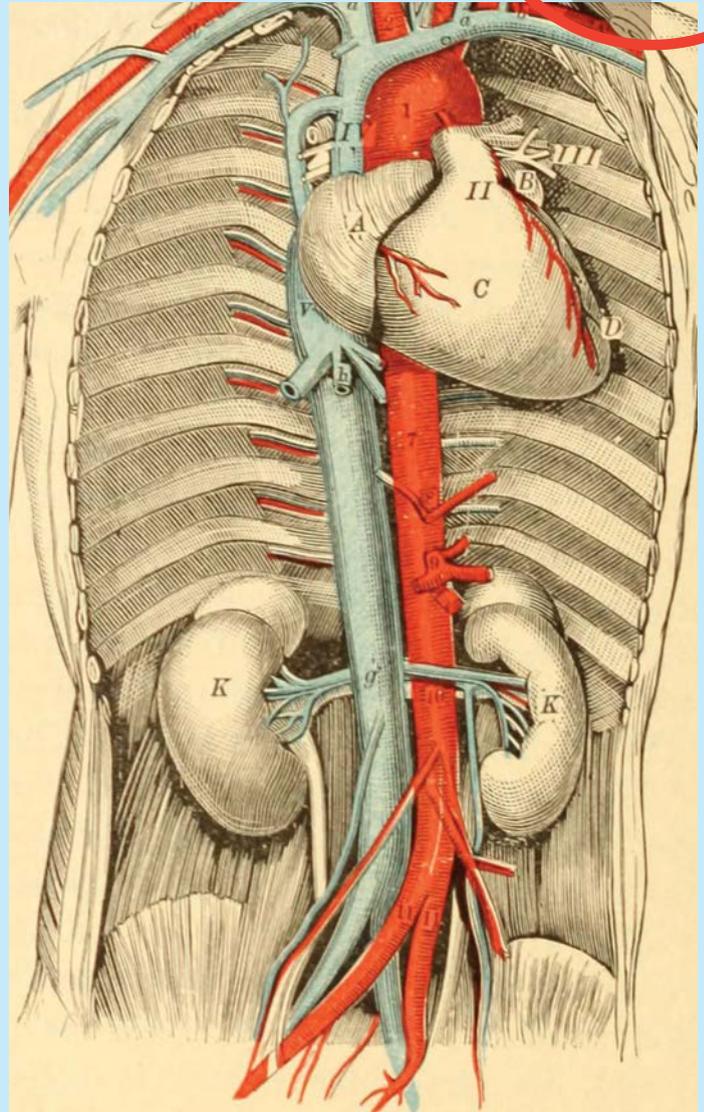
to this order. We continue to gain increasing understanding of this order. Never will our understanding and intellect put us on equal footing with our Lord. May our hearts become tender to the soothing words and guidance of our Heavenly Father.

1 Historical Timeline of Circulatory System

Any time when we peek back at the timelines of history, it is important to remember that it is an account of the past. People's accounts can differ depending on that particular person's perspective. The context in which an historical event occurs is important to take in consideration. Context is the circumstances or situation in which something happens. These discoveries did not happen inside an airless and weightless vacuum. Our progress in science builds on our prior knowledge. Each intellectual discovery provides a foothold to reach up to further our understanding. Scientific reasoning can be very delicate and at times silenced depending on a person's or culture's worldview. We will take a look at this as we tour the historical timeline of the circulatory system.

We begin in the year 384 B.C. with Aristotle who was born in Macedonia. He was a Greek philosopher and scientist. He believed the heart was the center of a person. The heart was where the soul dwelled and was where blood was manufactured in the body. In 340 B.C., Praxagoras was the first to differentiate between arteries and veins. He believed that the arteries had their origin in the heart and carried "pneuma." Pneuma has its origins in Greek. It means to "breathe" and is related to the "spirit" and the "soul" in the religious context. Arteries were full of "spiritual" air. Erasistratus, a Greek anatomist (one who studied the body) and royal physician, described the heart as being a pump. He also in 250s B.C. saw the heart as a source of both arteries and veins. This was the wisdom of the times. This set the stage for one of the most influential physicians of the middle ages.

Claudius Galenus, was born in Pergamum, Asia Minor (Western Turkey), during the peak of the Roman Empire in the approximate year of A.D.



129. He was better known as Galen. Galen left an indelible mark on the anatomical world. So deep was his impact that his view of the circulatory system was believed for 15 centuries!

Word Wise!

TOURNIQUET is any device that uses pressure to stop the flow of blood, usually through the arteries of an arm or leg, as after a serious injury.

If you lived in these times you would believe the following about the body:

The body's function was to refine the food you ate. Natural spirits had their beginnings in the food and drink you consumed. Vital spirits were derived from the air. Veins carried natural spirits. Arteries carried vital spirits.

Food was transformed in the liver. Veins originated at the liver. These veins contained the four humors or liquids of the body: yellow and black bile, blood, and phlegm. The blood of the veins went to the heart, and air and blood mixed in the left side of the heart. The heart was like a burning cauldron that produced heat and provided body warmth. (The brain

cooled the body.) The humors naturally flowed around the body and went only where they were needed. The blood was consumed.

Why was this view so important? This theory guided the ideas about the origin of disease. Illness and disease were seen as functions of an imbalance of humors or a shift in its flow in the body. Treatment was aimed at restoration of this natural balance. Bloodletting was the practice of bleeding someone to restore this "healthy" balance. (We will talk a bit more about this later.) Tourniquets, which stop blood flow in an artery or vein, were also applied to parts of the body in attempts to redirect the flow of blood to other areas of the body. Today, we only use tourniquets in emergency situations to stop the bleeding from a wound.

Galen began his study of medicine at the age of 16. At the age of 28, he was appointed to the post of surgeon to the gladiators. He received a great deal of on-the-job training patching up wounded gladiators. In the year A.D. 162, became the leading authority on medical knowledge and was appointed to the position of physician to the emperor. Galen left the world a legacy of these essential views:

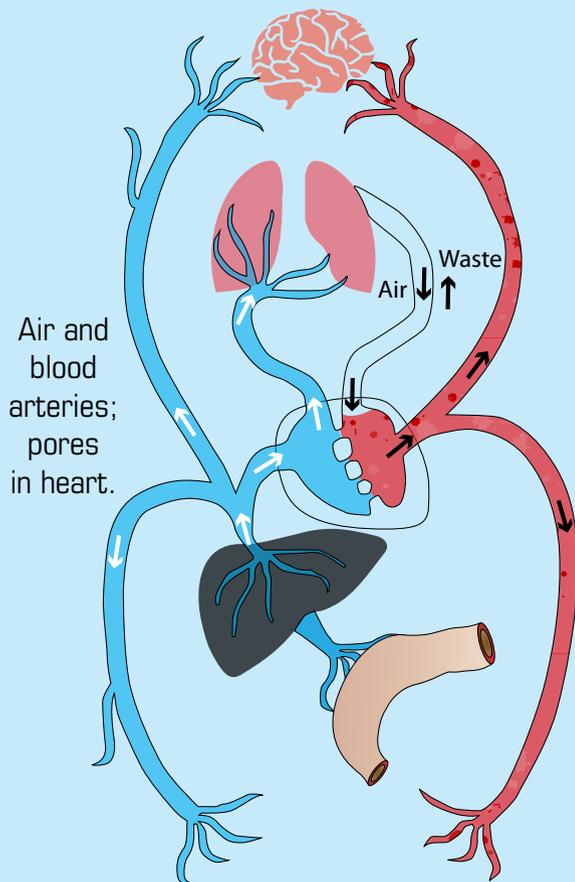
	Galen's View	Modern View
1.	Veins contained blood. These veins were open ended, and the blood bathed the organs.	Veins do in fact carry blood. They are not open ended or bathe the organs. They carry deoxygenated blood.
2.	A small amount of the blood provided nourishment to the lungs.	All the blood in the body is transported to the lungs to obtain oxygen.
3.	The heart pulsed.	The heart does beat and therefore it could be considered to "pulsate."
4.	Breathing cooled the heated body and yielded the vital spirits.	Breathing is not the essential way that the body cools itself. "Vital" spirits are not taken up by the lungs.
5.	Arteries contained air and blood.	Arteries do contain blood. Oxygen is dissolved in the blood and is transported on hemoglobin in the red blood cells.
6.	Arteries were located deep in the body and pulsed. The blood in the arteries was hotter, thinner, and more "spirituous." Veins were located close to the surface.	Arteries can lay deep and superficially in the body. They do pulsate with each beat of the heart.
7.	The whole body breathes in and out.	The lungs do the breathing.

This accepted view of the body did not advance for nearly 15 centuries. History and science discovery was guided by the worldview of the times. Over the course of these 15 centuries, the Roman Catholic Church dominated the attitudes and direction of the world of medicine. In essence, anyone who disagreed with the established church was labeled a heretic and was severely punished. A heretic is someone who dissents or disagrees from the established views or what is thought as the revealed truth. Illness was seen strictly as punishment from God. Today we have a process called the scientific method in which one asks questions, develops a hypothesis, and tests this hypothesis through experimentation. During this time, there was no tradition in the way scientific knowledge was acquired. People feared testing commonly

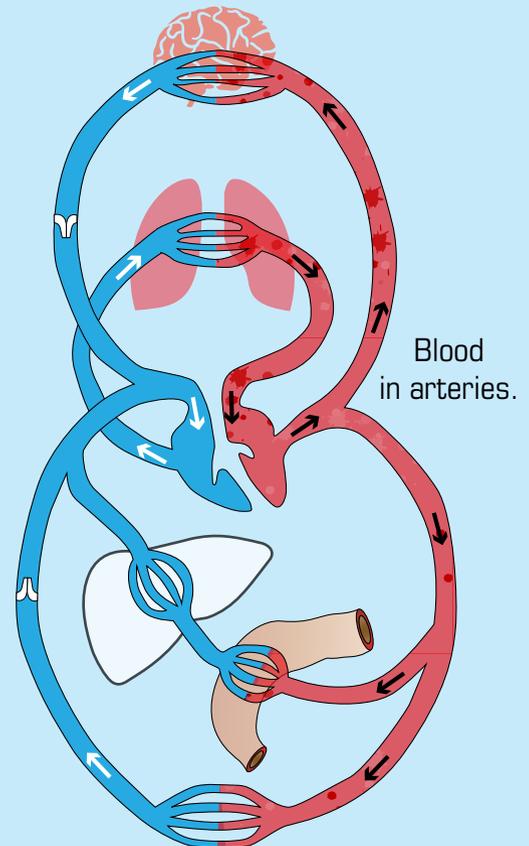
held beliefs proposed by Galen. They also feared the church. It wasn't until the Reformation, among other events, when Martin Luther on October 31, 1517, nailed his 95 *Theses* on the door of the All Saints' Church in Wittenberg. He challenged the church. The two over-arching points of his theses were that the Bible was the center of religious authority and that we reach salvation by our faith and not just by our deeds.

Fast forward hundreds of years to modern times, and we still have a battle of worldviews. Faith and belief in the Bible do not suppress scientific ideas and advancement. In fact, they are supported more and more with each new discovery, which furthers us to magnify the great designer in our Heavenly Father.

Galen's open-ended vascular system



Harvey's closed circulatory system





This symbol for the barber's pole began during the Dark Ages; the red represented the bloody bandages wrapped around a pole. Early versions had a brass wash basin on the top and bottom. The top basin was a representation of where the leeches were kept. The bottom one was the symbol for the basin used to collect the blood. The staff was the item that a patient would grasp to encourage the flow of blood after a bloodletting procedure.



2000 B.C.

to A.D.1500

Mayan kings and queens who ruled in Central America would open their own veins so that their blood could be used in ceremonies.



460-377 B.C.

Ancient Greek doctor Hippocrates (460–370 B.C.), was considered the father of medicine. He is credited with the idea of the four humors.



355 B.C.

Herophilus (335–280 B.C.), a Greek doctor, was considered to be the father of anatomy.

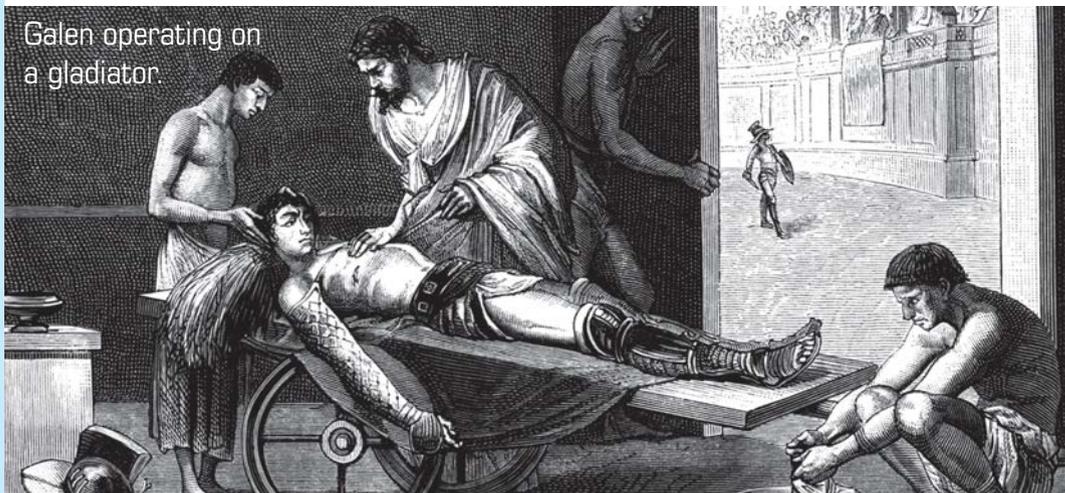


129-200 B.C.

Claudius Galen of Pergamon (129–200) operated on gladiators. He greatly influenced the understanding of medicine and anatomy in the middle ages based on Hippocrates theory of the four humors.

410-1095 B.C.

In medieval times, barbers were also surgeons. Doctors of the time considered surgery messy and beneath them. Barbers were good with a sharp blade, not only could they cut hair, but they would practice procedures from bloodletting to amputation of limbs. The barber pole was originally red and white striped.





1500 B.C.

Leonardo Da Vinci (1452–1519) noted tiny “hairs” in tissues. He was interested in the link between form and action of the body. He made the first accurate drawing of the body as well as the heart and its valves.



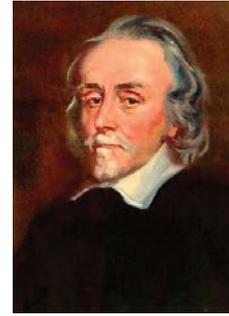
1553 B.C.

Michael Servetus (1511?–1553) was a theologian and physician who was burned at the stake. He was considered a heretic for his description of the circulation of the blood through the lungs.



1543 B.C.

Andreas Vesalius (1514–1564) wrote one of the first books on the human anatomy entitled *De Humani Corporis Fabrica (On the Fabric of the Human Body)*.



1578 B.C.

William Harvey (1578–1657), an English physician, was the first to describe blood circulation in the body. He stated that blood flowed in a closed circuit — it was conserved, which means that the blood was not consumed by the organs. His discovery caused him much concern because it went against centuries of medical thought. He said, “Not only do I fear danger to myself from malice of a few, but I dread lest I have all men as enemies.”



1666 B.C.

Richard Lower (1631–1691), a physician, followed the works of William Harvey. He pioneered the idea of blood transfusions. He experimented on transfusing dogs. He even transfused a lamb’s blood into a human — but such practices were very dangerous so laws in both England and France were created to stop it!



Lower transfusing blood into a man’s arm from a lamb.



1670 B.C.

Marcello Malpighi of Bologna (1628–1691), a biologist and physician, utilized a primitive microscope and discovered a network of tiny vessels called capillaries in the lung of a frog. This discovery linked the arteries and veins.



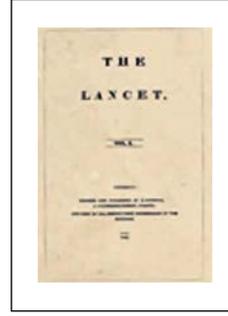
1799 B.C.

George Washington (1732–1799) died due to bloodletting. After a day of riding his horse out in the cold, he returned to find his throat sore. Soreness and the swelling in his throat advanced. He became short of breath, and a team of doctors were called. They utilized the most “effective” treatment of the times, bloodletting. It is said nearly 40 percent of his blood volume was removed, and he died. Before dying, George Washington thanked the doctors for their excellent care.



1818 B.C.

James Blundell (1791–1878) became the first in the United States to perform a successful blood transfusion. The transfusion was performed on a woman who had just delivered a baby. She immediately suffered from severe bleeding. He took 4 ounces from the woman’s husband and transfused it into her. Today we know it’s not that simple. People have one of four different types of blood, and it can be deadly if you receive the wrong kind during a transfusion.



1823 B.C.

The first medical journal, *The Lancet*, was published. *The Lancet* still exists today. It is one of the leading medical journals. Thomas Wakley (1792–1862) first published it on October 5, 1823. As the journal was going to press he stated, “A lancet can be an arched window to let in the light or it can be a sharp surgical instrument to cut out the dross and I intend to use it in both senses.” A lancet was the indispensable tool utilized in bloodletting. It was used to cut the skin and blood vessels.



1832 B.C.

The laws were changed, and medical professionals could legally use donated bodies for study and dissection.

The picture above is Rembrandt van Rijn’s *The Anatomy Lesson of Dr. Nicolaes Tulp*, completed in 1632. Dissection was not limited to the eager learning eyes of apprentice doctors of the day; dissections were also held for public “amusement.” You could even buy tickets for these events.



1893 B.C.

Daniel Hale Williams (1856–1931) was an African American general surgeon who performed the first successful open heart surgery and founded the first non-segregated hospital in the United States. He operated on James Cornish at Provident Hospital in Chicago. Mr. Cornish had been stabbed in the heart. Today's common practice of blood transfusion and the use of blood products was not safely utilized at that time. Even without this life-saving practice, he was able to suture (sew) the covering around Cornish's heart, saving his life.



1896 B.C.

Ernest Henry Starling (1866–1927), an English physiologist (a person who studies the body's processes), was the first to explain the maintenance of a fluid balance in the body. It is called Starling's Law. The law states that the stroke volume (the amount of blood pumped into the left ventricle per a heartbeat) of the heart will increase with additional blood filling into the ventricle. The more the heart wall stretches due to increased blood flow, the more force the heart muscle will use to contract.



1903 B.C.

Willem Einthoven (1860–1927) was a Dutch doctor and physiologist who invented the first electrocardiogram (EKG or ECG). It was already understood and accepted in medicine that the heart generated electrical activity. However, prior to Einthoven's invention, the only way to record this activity was placing electrodes directly on the heart muscle. This was impractical. He won the Nobel Prize in Physiology or Medicine in 1924.



1900's B.C.

Karl Landsteiner (1868–1943) an Austrian-born biologist and physician was the first to identify the major blood groups: A, B, AB, and O. He discovered that agglutinins were found on blood red blood cells that caused an immune reaction in which blood clumps when two different types of blood are mixed.



1919 B.C.

Jules Bordet (1870–1961), physician, was awarded the Nobel Prize in Physiology or Medicine for his discovery of factors in blood that destroy bacteria and how the blood breaks apart (called hemolysis) due to foreign blood cells in the body.



1920s B.C.

Werner Forssmann (1904–1979), a physician born in Berlin, used himself as a test subject to prove the medical procedure for cardiac catheterization was possible. He inserted a catheter, a type of tube, threading it into a vein at the fold of his arm and pushed the tube deeper and deeper until the top was inside the right side of his heart. With the tube still in, he went to the hospital radiology department and took x-rays to confirm his findings. He was awarded the Nobel Prize in Physiology or Medicine in 1956.



1930s B.C.

Charles Richard Drew (1904–1950), was an African American physician and surgeon who is credited for blood banks. He studied how blood transfusions were given, and invented better techniques for storing blood. During World War II, he utilized this new knowledge to help provide life-saving blood storage to help wounded soldiers in the field.



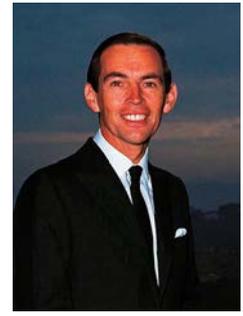
1944 B.C.

Helen Brooke Taussig (1898–1986), physician, is credited with being the founder of pediatric cardiology. She assisted in the development of the Blalock-Taussig Shunt. This is a surgical procedure that helps children born with heart defects, “blue baby syndrome,” that cause them to be blue. She was awarded the Medal of Freedom from President Lyndon Johnson. In 1965, she became the first woman president of the American Heart Association.



1952 B.C.

Michael DeBakey (1908–2008) invented a new kind of graft for repairing torn arteries. In 1932, he invented a part for the first heart-lung machines. These machines are utilized for heart surgery. He was the first person to identify the smoking of cigarettes as a connection to lung cancer. In the 1950s, the DeBakey Dacron Graft was used in repairing damaged blood vessels.



1967 B.C.

Christiaan N. Barnard (1922–2001), a South American cardiac surgeon, was a pioneer who performed the first successful human heart transplant. Although his patient lived only 21 days after, it was still considered a great success.



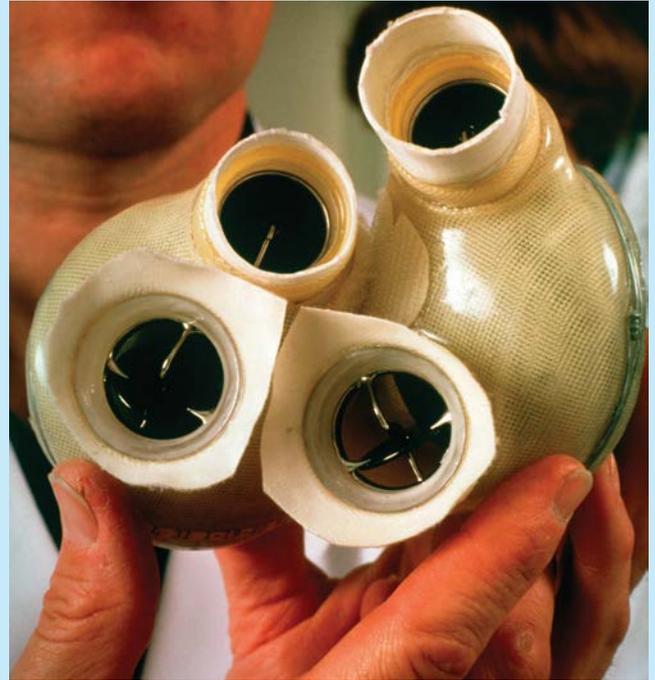
1982 B.C.

Barney Clark at 61 years of age survived a Jarvik-7 artificial heart for 112 days. Dr. William DeVries (1943–) performed the surgery. Clark knew that his chances for long-term survival were not likely, but he agreed to the heart to help further medicine.

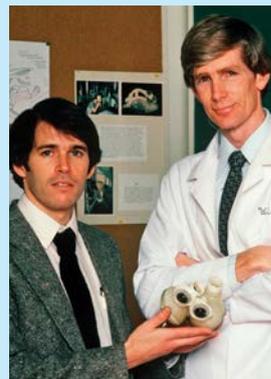


1991 B.C.

Dr. Drew Gaffney (1946–), physician, flew on NASA's space shuttle as a "payload specialist." A payload specialist is someone who rides as an expert in a particular field. While on board, he studied how the heart and the circulatory system adapted to flight in space. This was the first mission to explore the human body in space. A catheter, a long tube, was inserted into his elbow prior to lift off and threaded to his heart. This allowed close measurement of his heart functions.



A number of artificial hearts were proposed and experimented with since the first one by Vladimir Demikhov in 1937, who transplanted it into a dog. There were limited successes in tests with animals, but this helped to advance understanding of the challenges. Here you can see the major blood vessels on the Jarvik-7, an aluminum and plastic artificial heart used during the first successful human implant in 1982 at the University of Utah Medical Centre in Salt Lake City. The Jarvik-7 heart relied on external power for compressed air and electricity. The patient had a six-foot lifeline to the support equipment.



Dr. Robert Jarvik, developer of the Jarvik-7 artificial heart, and Dr. William DeVries who, with Dr. Tom Kessler (not pictured), performed the first successful permanent artificial heart surgery.



The first total artificial heart implanted in a human body was developed by Domingo Liotta and placed by surgeon Dr. Denton Cooley in 1969 at St. Luke's Episcopal Hospital in Houston. (Dr. Liotta joined the staff at the hospital in Texas in 1961 as the director of the Artificial Heart Program. He was hired by Dr. Michael DeBakey.) The patient lived for sixty-four hours with the artificial heart pumping oxygenated blood through his body until a human heart could be available for transplant. The patient died soon after receiving a real heart, and there was criticism about the use of the Liotta-Cooley plastic heart. However, it did show how artificial hearts could be used until real hearts were donated.

Word Wise!

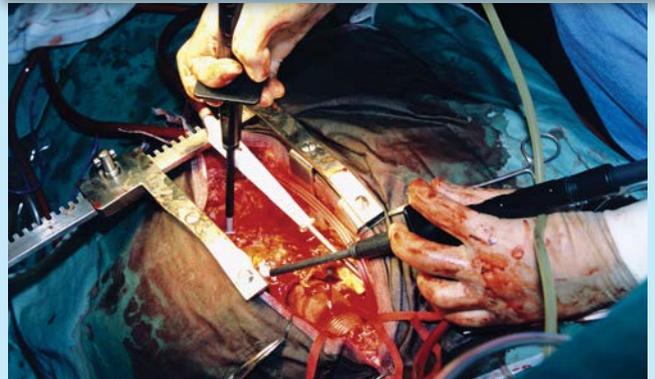
The HIPPOCRATIC OATH, named after Hippocrates, is an oath that doctors are required to swear upon upholding professional standards in practicing medicine and the care of the patients.

Our knowledge of medicine continues to march on.

Today, we are looking at new ways to diagnose heart disease much earlier. An item with great promise is the Computed Tomography Angiography or CTA. It helps to find small blocks in the arteries that surround the heart. A dye is injected in a vessel in a patient's arm. A special x-ray machine called a CT scanner takes images of the heart and the dye flowing through the blood vessels. It can show where blockage exists in the vessels.

A new artificial blood is being tested in the United Kingdom. If successful, it could provide an answer to blood shortages. Perhaps it can be used in patients who refuse blood transfusion on the grounds of religious objection.

Maybe God has a plan for you to make contributions to the field of cardiology. He has given you unlimited potential. Walk boldly. Keep your eyes on Him. Look for ways to magnify His wonder.



Racial segregation existed in the United States and even existed in the donation of blood. Charles Richard Drew resigned from his position with the American Red Cross over

this issue. The American Red Cross did not change its position on this policy of segregation until 1950.