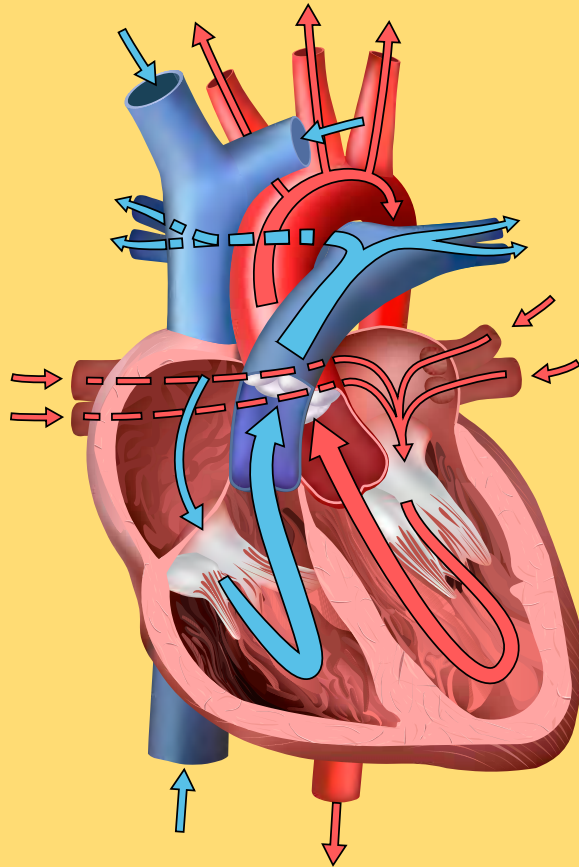


SCIENTIFIC DECISION-MAKING

SUPPLEMENTARY ACTIVITIES ON THE CARDIOVASCULAR SYSTEM



Baylor
College of
Medicine

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SUPPLEMENTARY ACTIVITIES ON THE CARDIOVASCULAR SYSTEM



CENTER FOR
EDUCATIONAL
OUTREACH

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BioEdSM

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Images: All persons depicted in photographs throughout this guide are models and their images are used strictly for illustrative purposes only. The images are not intended to represent the model, nor any person living or deceased. Cover illustrations of the heart © Peter Junaidy.

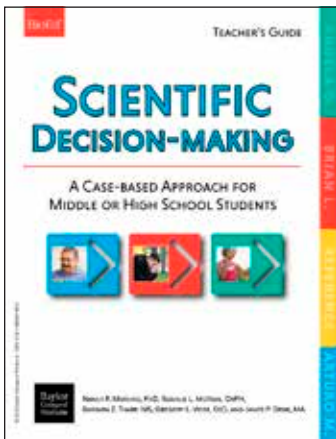
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Related Unit Teacher's Guide



To help students understand how to make better informed decisions using case studies on the heart, see *Scientific Decision-making Teacher's Guide: A Case-based Approach for Middle or High School Students*.

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ABOUT THE PROJECT



The Scientific Decision-making curricular unit, produced as part of the project entitled AHRQ's Ischemic Heart Disease Products Translated for High School Populations, was funded by a grant (R18HS019248) from the Agency for Healthcare Research and Quality (AHRQ). The project's goal is to develop—and evaluate the effectiveness of—high school-level teaching materials focusing on evidence-based decision-making using examples related to cardiovascular health.

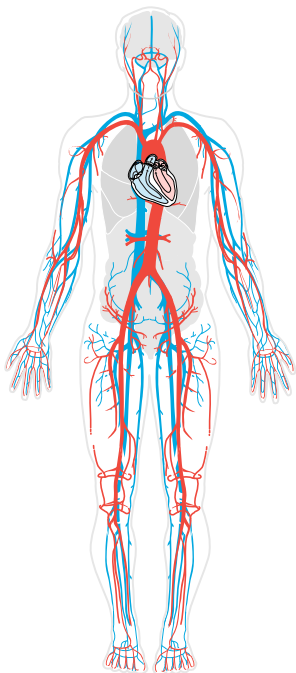
Activities described in this book are intended for middle or high school students under direct supervision of adults. The authors, Baylor College of Medicine and AHRQ cannot be held responsible for any accidents or injuries that may result from conduct of the activities, from not specifically following directions, or from ignoring cautions contained in the text. The opinions, findings and conclusions expressed in this publication are solely those of the authors and do not necessarily reflect the views of BCM or the sponsoring agency.

HEART AND CIRCULATION: OUTSIDE AND INSIDE

Overview

This activity offers several different ways to teach students about the heart and circulation, and it may be adapted to a variety of teaching situations. To promote deeper understanding of key concepts, the activity also includes a procedure for observing preserved sheep hearts.

The Circulatory System



Modified illustration by M.S. Young © Williams & Wilkins. All Rights Reserved.

The heart is a complex pump made of a special kind of muscle, called cardiac muscle, which is very resistant to fatigue. Although it is made of living cells, the heart shares many characteristics with mechanical pumps we see everyday.

A pump is a mechanical device that uses pressure or suction to move fluid or gas. For example, consider a liquid soap dispenser. A plastic tube extends from the dispenser's top into the soap. When you depress the top, soap already in the tube squirts out. A one-way valve prevents any soap from flowing back down the tube. When you release the dispenser top, a spring-driven pump pushes it back up, while simultaneously "pulling" more soap from the bottle to refill the tube. It is important to note that a pump requires a "pumping" mechanism and a one-way valve in order to work.

The hearts of birds and mammals consist of two side-by-side pumps, with a total of four chambers. Two chambers, called atria, receive blood, and two chambers, called ventricles, pump blood out to the lungs and the rest of the body.

In the circulatory system, veins carry blood toward the heart, and arteries carry blood away

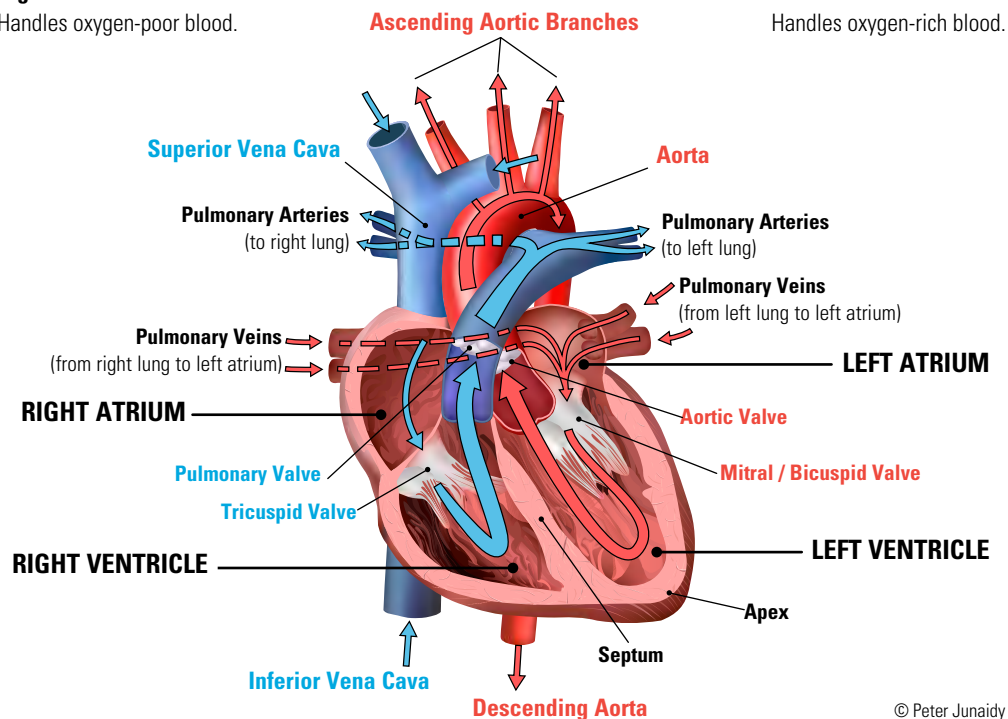
The Heart Pumps Blood In and Out

Right Side

Handles oxygen-poor blood.

Left Side

Handles oxygen-rich blood.



© Peter Junaidy

BioEd Online Video: Sheep Heart Dissection



A video demonstration of a sheep heart dissection is available at <http://www.bioedonline.org/videos/lesson-demonstrations/human-organism/heart-and-circulation/>.

Slide image © Baylor College of Medicine.

from the heart. The large arteries that carry blood away from the heart divide into smaller and smaller vessels, called arterioles, until they become capillaries, the smallest blood vessels. Capillaries form a network between arteries and veins; they make oxygen and nutrients available to cells, and remove carbon dioxide and other wastes from cells. After passing through the capillaries, blood begins its journey back to the heart via small vessels, called venules. Venules combine into larger and larger vessels, called veins, and eventually become the major veins (inferior and superior vena cava) that enter the right atrium of the heart.

Circulation within the heart and body is described on the "Blood Pathways" sheet (see p. 8).

MATERIALS

Teacher (see Safety)

- Several copies of "Red Blood Cell Journey," printed on card stock and cut into multiple sets (one set per student team)
- Computer and projector, or an interactive white board if using video with students

If conducting dissection

- Masking tape and straight pins (10 pins per student group)

Per Team of 2–4 Students

- Copies (one per student) of "The Heart: External," "The Heart: Internal," and "Blood Pathways" pages
- Set of Red Blood Cell Journey cards
- Copies of "Heart Guide: Outside and Inside" (copy for each student)

If conducting dissection, each group of students also will need:

- 10 straight pins with masking tape flags, numbered 1 through 10
- 2 pipe cleaners
- Sheep heart (preserved)
- Dissection kit (including scalpel and dissecting scissors)
- Dissection tray (paper plates may be substituted)

If conducting dissection, each student also will need:

- Dissection kit (including scalpel and dissecting scissors)
- Pair of disposable plastic gloves
- Pair of safety goggles
- Personal copy of "Heart Guide: Outside and Inside"

SETUP

Copy or print the "Red Blood Cell Journey" sheet on card stock and cut into cards.

Make individual copies of "The Heart: External," "The Heart: Internal," and "Blood Pathways," student sheets.

For the dissection activity, make individual copies of "Heart Guide: Outside and Inside," for each student.

Purchase sheep hearts ahead of time from a biological supply company (hearts are preserved and can be used for several weeks). Keep the sheep hearts in tightly sealed plastic bags and store under a ventilation hood, if possible. Place all necessary dissecting materials on paper plates or trays, with one set of materials for each student group. Prepare straight pins with masking tape flags for each group, or have students make their own. Have students perform the heart dissections in groups of two to four, or conduct the activity as a class demonstration.

A video demonstration of a sheep heart dissection, including external and internal features

of a mammalian heart, is available on BioEd Online at <http://www.bioedonline.org/videos/lesson-demonstrations/human-organism/heart-and-circulation/>.

Have students work in groups of 2–4 for this activity.

Animation: Heart Contraction and Blood Flow



If students are unfamiliar with the heart and circulatory system, show the following animation, Heart Contraction and Blood Flow, at the National Heart, Lung and Blood Institute's website (<http://www.nhlbi.nih.gov/health/health-topics/topics/hhw/contraction.html>).

Image courtesy of the National Heart, Lung, and Blood Institute, National Institutes of Health.

SAFETY

Before beginning the heart dissection, instruct the students on the proper way to handle sharp instruments. All students should wear gloves and goggles. After the activity, sanitize all surfaces exposed to the heart, using a 10% bleach solution or commercial disinfecting spray. Refer to the Material Safety Data Sheet shipped with the hearts for instructions on the proper disposal of dissected sheep hearts. Students should wash their hands thoroughly with soap and water before and after any science activity, even if wearing gloves. Always follow all district and school laboratory safety procedures.

Commercial science education suppliers of dissection specimens are inspected by the United States Department of Agriculture to ensure that they comply with the Animal Welfare Act. Many specimens offered by suppliers originated in the food industry.

PROCEDURE

Part One. Heart and Circulation

1. Ask students, *Have you learned anything surprising about the heart so far? What do you think the heart looks like?* After students have shared their ideas, tell them that they will be studying external and internal features of mammalian hearts. If your class is conducting the dissection, inform students that they will be observing preserved sheep hearts.
2. Distribute copies of the student sheet, "The Heart: External," to each student group. Explain that when looking at the diagram, students should imagine they are facing another person's heart. This means that the side of the heart labeled "right" is on the left side as they face the diagram.
3. Instruct students to locate the right side of the heart on the diagram. Next, have them find and label the corresponding area on the photograph. Within their groups, students should continue to locate and label on the photograph each part that is identified on the diagram. When students have finished labeling their heart diagrams, have them compare their work within their groups to check answers and discuss any discrepancies.
4. Next, give each student a copy of "The Heart: Internal." Direct students to identify and label the receiving areas (atria) and pumping areas (ventricles) of the heart on the diagram, and find and label the same structures on the photograph. Point out the valves and ask, *What might the valves do?* [prevent blood from flowing backward] Have students locate and label on the photograph each part that is identified on the diagram, and share their results as before.
5. Conduct a class discussion about the internal structures of the heart, asking questions such as, *Which chambers of the heart have thicker walls?* [Ventricles] *Why do you think ventricle walls are thicker than atrium walls?* [Ventricles work harder to circulate blood around the body.]
6. Inform students that having examined how blood flows into and out of the heart, they now will investigate how blood travels throughout the body. Provide each student with a copy of the "Blood Pathways" sheet, and have students read each numbered step to follow the path of blood around the body.
7. Provide a set of Red Blood Cell Journey cards to teams of 2–4 students. Have students sort the cards into the same order as the blood circulation steps depicted in the "Blood

Interactive Tool: Examine a Sheep Heart

This interactive tool for examining a sheep's heart is available at

<http://www.gwc.maricopa.edu/class/bio202/cyberheart/anthrt.htm>.

The Cardiovascular System tutorial is part of the Human Biodyssey website (http://www.gwc.maricopa.edu/home_pages/crimando/jcHuman-Biodyssey.htm) © Crimando/GWCC.

Pathways" sheet. Then, have the teams mix up their cards. Challenge the teams to one or more races, to see which team can re-sort the cards into the correct circulation order most quickly. Start each race at a different point in the circulation path (e.g., "left ventricle" or "aorta"). The correct pathway (starting in the lungs) is given below.

Capillaries in Lung → Pulmonary Veins → Left Atrium → Mitral (Bicuspid) Valve → Left Ventricle → Aortic Valve → Aorta → Arteries → Capillaries in Body → Veins → Superior and Inferior Vena Cava → Right Atrium → Tricuspid Valve → Right Ventricle → Pulmonary Valve → Pulmonary Arteries

- Use one of the following options to conclude Part One of this activity, either in class or as homework.
 - Have each student write an essay from the perspective of a red blood cell. Describe the blood cell's path as it travels from a capillary in the left little finger, through the body, and back to the left little finger. Students may use the Blood Pathways page as a reference.
 - Have each student complete the "Draw the Heart" activity. Download the PowerPoint® file from the link below and work with students as they produce a basic drawing of the heart. (This set of slides was developed by the University of North Texas.)
http://cte.unt.edu/content/files/_HS/curriculum/Draw_the_Heart.ppt
 - Use the virtual Sheep Heart anatomy interactive tool to enable students to examine a sheep heart (**<http://www.gwc.maricopa.edu/class/bio202/cyberheart/anthrt.htm>**). Clicking on the sections provides different external and internal views. *This tool was developed and copyrighted by J. Crimando, PhD, at Gateway Community College in Phoenix, Arizona.*

Part Two. Outside of the Heart

Requires preserved sheep heart.

- Distribute copies of "Heart Guide: Outside and Inside" (one per team) and have one member of each team pick up supplies for the dissection.
- Have each team observe its preserved heart, following the "Heart Guide: Outside and Inside," and complete Part One: Outside the Heart (p. 10). You may want to point out the front, back, and bottom of the heart. The front is somewhat rounded; the back is flat, with openings where major vessels were attached. The bottom of the heart comes to a tip, or apex. After students are familiarized with the general orientation to the heart, teams should work independently from the teacher as much as possible. Students should refer to the diagram on "The Heart: External," sheet to help locate the structures.
- When all of the labeling pins are in place, have teams switch hearts and crosscheck each other's work to see if they agree with placement. If there is disagreement in the positioning, instruct the teams to resolve the differences by reexamining the diagrams.
- When step 3 is complete, have the students remove all pins and proceed to Part Three.

Part Three. Inside of the Heart

Requires preserved sheep heart

- Teams will follow and complete Part Two: Inside the Heart (p. 11), of the Heart Guide student sheet. Students will open the sheep hearts through a series of cuts made by scissors or a scalpel. You may wish to demonstrate how to make the first cut into the

The Virtual Heart

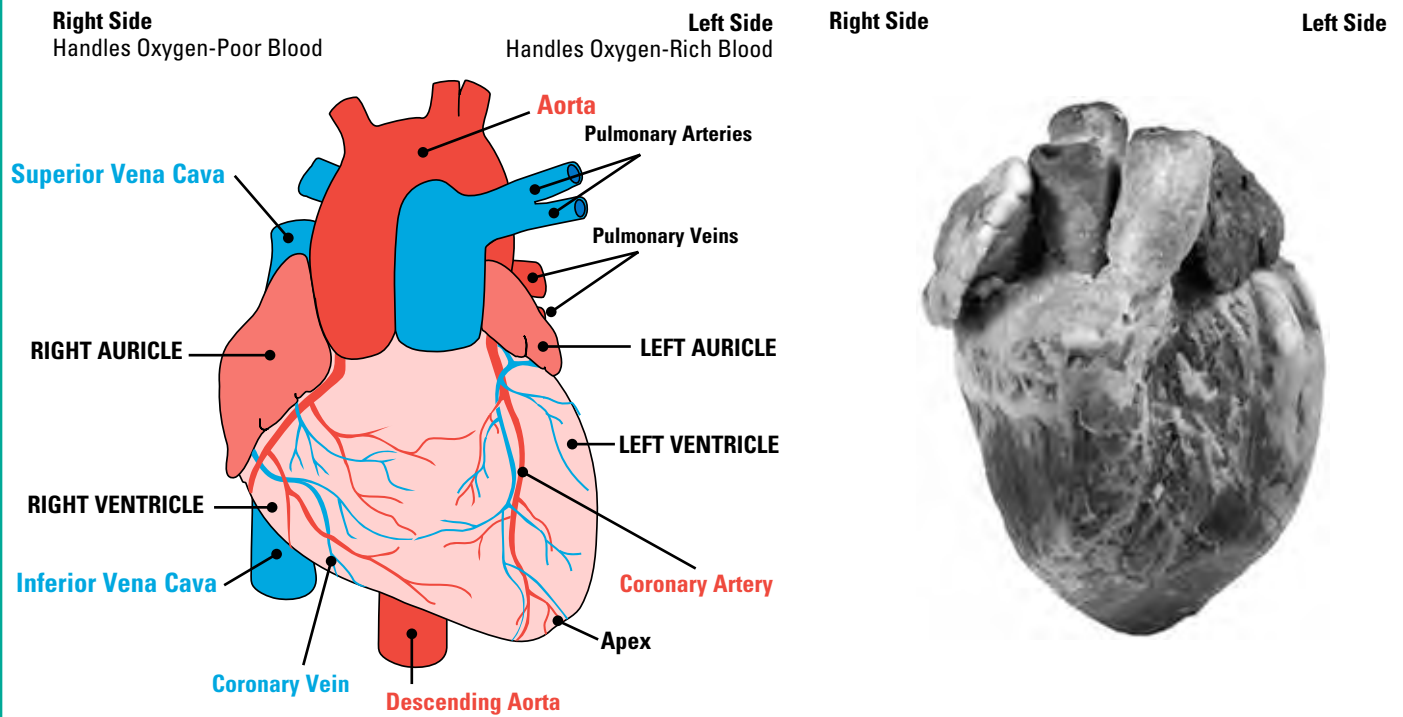
For additional detailed anatomy and other heart-related information, visit the Virtual Heart Web website (<http://thevirtualheart.org>).

Image of The Virtual Heart website courtesy of Flavio H. Fenton and Elizabeth M. Cherry.

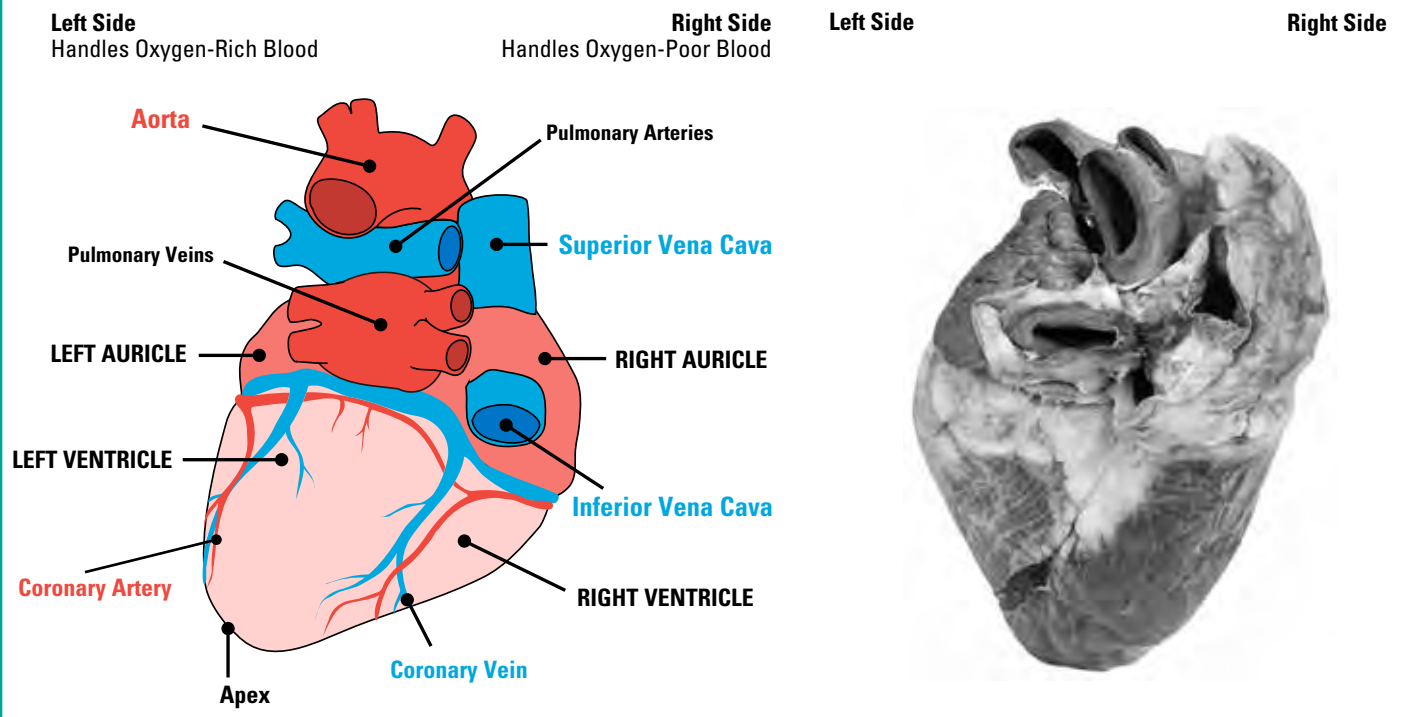
- heart, or simply complete this step for students. First, insert the point of a pair of dissection scissors or a scalpel into the superior vena cava (large vein that enters the right atrium, sometimes visible only as a large hole). Cut down the superior vena cava into the anterior wall of the right auricle and continue down to the apex. Students should be able to see the right atrium and ventricle.
2. Students will make a second incision to open the left atrium and ventricle. You may wish to assist students with the incision. Insert scissors or knife into the pulmonary vein (may appear as a large hole) on the left side of the heart, and cut through the anterior wall of the left auricle. Once again, continue forward toward the apex.
 3. Have students refer to the diagram on "The Heart: Internal," sheet to locate and pin the structures listed in Part Two of the Heart Guide.
 4. When all labeling pins are in place, have student teams switch hearts and crosscheck each other's work to see if they agree with placement. If there is disagreement regarding pin positioning, instruct the teams to try to resolve the differences before involving the teacher.
 5. Have students discuss and demonstrate the flow of blood through their heart specimens, beginning with the point of entry at the superior vena cava. Direct students to push pipe cleaners through the large vessels to discover where they lead. To prevent punctures or damage to the hearts, have students bend the ends of the pipe cleaners back about an inch.
 6. Once students understand the flow of blood via heart-lung-heart-body circulation, explain that the right and left atria contract at the same time, followed by contractions of right and left ventricles. In a properly functioning heart, the synchronized work of the four chambers causes the atria to expand and fill with blood while the ventricles are contracting.
 7. Have teams clean and return all dissection equipment and remove, clean and return the numbered straight pins. Students should thoroughly clean their desktops and wash their hands with soap and water. Dispose of sheep hearts properly, and in accordance with school policy.
 8. After completing the activity, you may wish to assess students' understanding of heart anatomy and movement of blood through the heart and body. This can be accomplished informally through a class discussion, or more formally by having students draw the dissected, labeled hearts in their science notebooks. Alternately, you may want to set up a lab practical assessment using heart specimens. ■

THE HEART: EXTERNAL

Anterior Views



Posterior Views



Not shown on photographs of sheep heart: vena cavae, pulmonary vein.

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THE HEART: INTERNAL

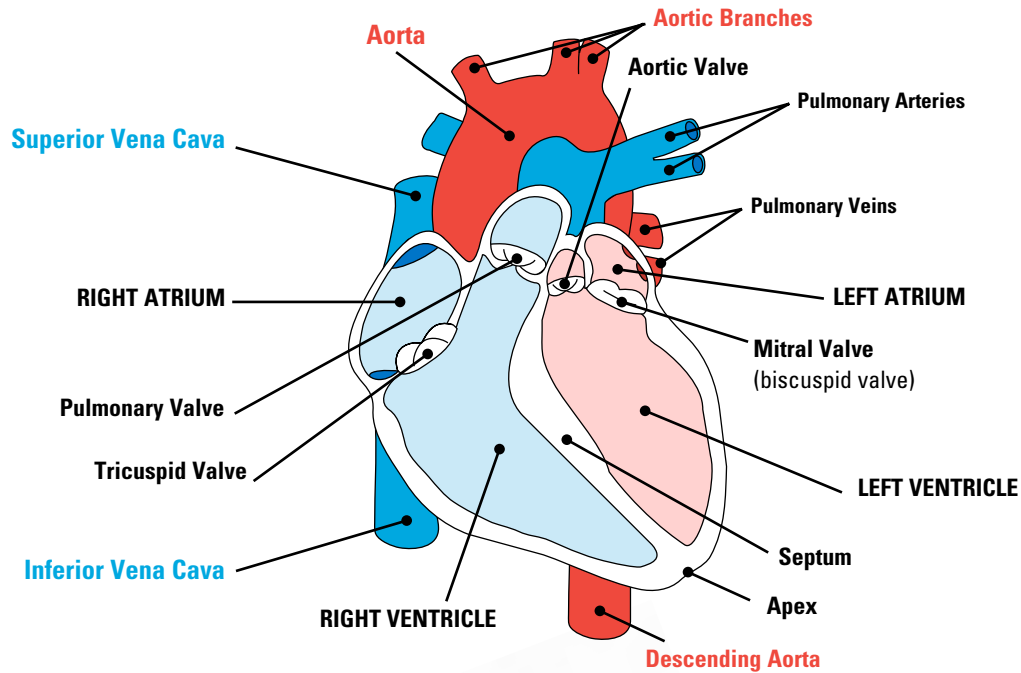
Anterior Views

Right Side

Handles Oxygen-Poor Blood

Left Side

Handles Oxygen-Rich Blood



Not shown on photographs of sheep heart: vena cavae, pulmonary vein.

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BLOOD PATHWAYS

Now that you know more about how the heart is put together, it will be easier to understand the flow of blood through the heart and circulatory system. Remember that blood flows in only ONE direction, thanks to one-way valves. Let's start with drops of blood in the tiny capillaries of your fingertips and follow the path of that blood through the circulatory system. The journey begins at the bottom left corner of the page, with Item 1.

5 Out of the Heart / Into the Lungs

The arteries that carry blood from the heart to the lungs are called **pulmonary arteries**.

4 Into the Right Ventricle

When the right atrium is filled with blood, it contracts, pushing the blood through the one-way **tricuspid valve** into the **right ventricle**. When the right ventricle is filled, it contracts, pushing blood through the **pulmonary valve** into arteries leading to each lung.

3 Into the Right Atrium

Blood from both vena cava enters into the **right atrium** of the heart.

Blood returning to the heart is low in oxygen. It must be replenished with oxygen from the lungs before it can make another trip around the body.

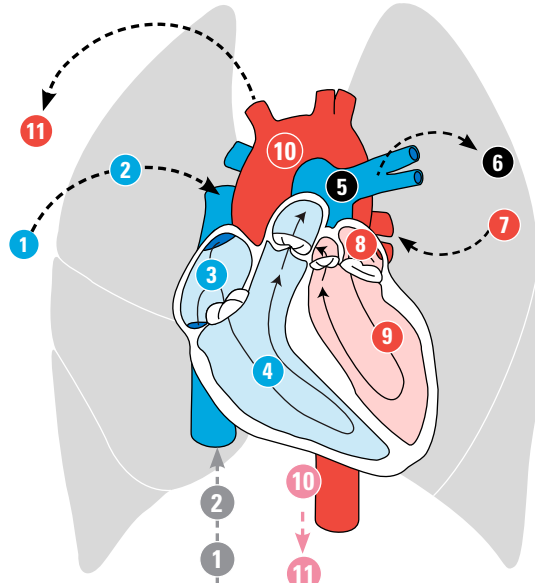
2 Out of the Veins / Into the Vena Cava (See both illustrations.)

Smaller veins carry blood to two large collecting veins that connect to the heart. Blood from the hand (and upper parts of the body) flows into the **superior vena cava**, above the heart. Blood from veins in the lower part of the body flows into the **inferior vena cava**, below the heart (see "2" located beneath the heart in the upper illustration).

1 Out of the Capillaries / Into the Veins

Capillaries are very fine, branching blood vessels that form a network between arteries and veins. Because capillaries are very narrow, it is easy for nutrients, water and oxygen to move from the blood to body cells, and for wastes and carbon dioxide to be transferred from the cells into the blood.

As blood travels from the capillaries in the hand toward the heart, it enters tiny veins that connect to larger veins. One-way valves in the veins keep blood from moving upward—especially in your legs.



The complex flow patterns between the heart and lungs are shown in the illustration above.

6 Inside the Lungs

Once in the **lungs**, blood moves into smaller and smaller arteries, and finally, into capillaries that surround the tiny air sacs in the lungs. Here, the blood drops off carbon dioxide (breathed out of the body), and picks up oxygen (breathed into the body), which it will carry to cells of the body.

7 Out of the Lungs / Into the Heart

The oxygen-rich blood moves from the lung's capillaries, to veins, and back to the heart through the **pulmonary veins**.

Notice that the oxygen-rich blood on the left side of the heart is kept separate from the oxygen-poor blood on the right side.

8 Into the Left Atrium

Blood in the pulmonary veins moves into the heart's **left atrium**. When the left atrium is full of blood, it contracts and forces blood out through the **mitral valve** (also called the bicuspid valve) into the left ventricular chamber of the heart.

9 Into the Left Ventricle

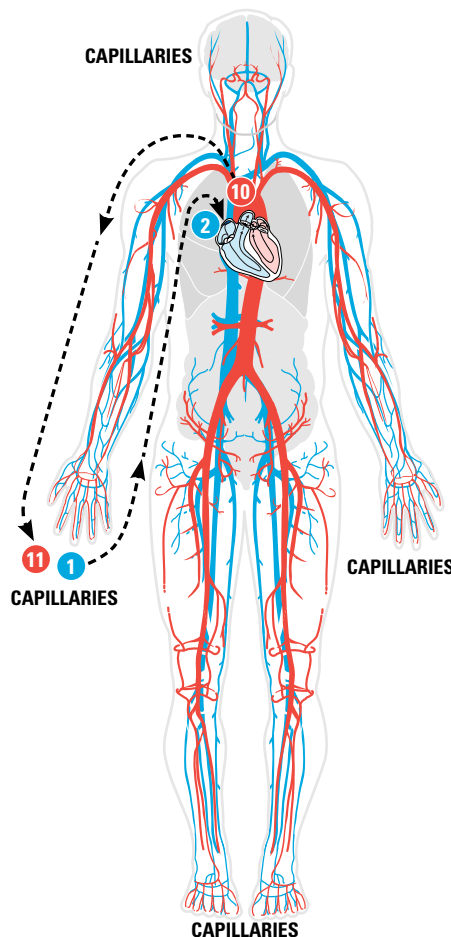
Blood is pumped from the left atrium into the **left ventricle**. When full of blood, the left ventricle contracts, pushing blood through the **aortic valve** and into the largest artery in the body (the aorta).

10 Out of the Aorta / Into the Arteries (See both illustrations.)

This large artery is called the **aorta**. From the aorta, blood travels out to the rest of the body through smaller and smaller branching arteries.

11 Out of the Arteries / Into the Capillaries

Now, blood has made a full circuit and returned to the capillaries in your fingertip, rich with oxygen and ready to pick up waste and carbon dioxide to start the circle again.



FULL CIRCUIT

A drop of blood releases oxygen and picks up waste and carbon dioxide at the body cells. It circulates through the right side of the heart, and to the lungs to release carbon dioxide and pick up oxygen. It then circulates through the left side of the heart and returns to the body cells to start this path of continual circulation again.

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RED BLOOD CELL JOURNEY CARDS



Superior and Inferior Vena Cava



Right Atrium



Tricuspid Valve



Right Ventricle



Pulmonary Valve



Pulmonary Arteries



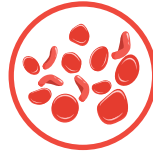
Capillaries in Lung



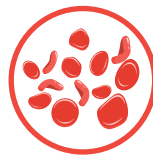
Veins



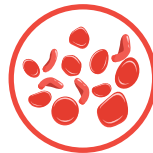
Pulmonary Veins



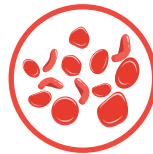
Left Atrium



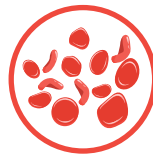
Mitral (Bicuspid) Valve



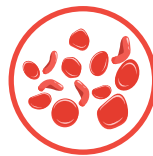
Left Ventricle



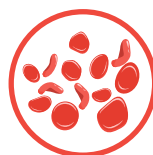
Aortic Valve



Aorta



Coronary Arteries



Capillaries in Body

HEART GUIDE: OUTSIDE AND INSIDE

PART ONE: OUTSIDE THE HEART

The instructions below will guide the dissection and help you to locate and identify various parts of the heart. Read carefully and make observations as you go.

1. You will learn about the heart by examining the outside of a sheep heart.
2. As you and your team progress through this activity, use numbered pins to identify the parts of the heart listed below.
 1. **Right auricle**
 2. **Right ventricle (general area)**
 3. **Left auricle**
 4. **Left ventricle (general area)**
 5. **Pulmonary artery**
 6. **Aorta**
 7. **Coronary artery (general area if not seen)**
 8. **Superior vena cava (opening)**
 9. **Inferior vena cava (opening)**
 10. **Pulmonary vein (opening)**
3. Find and observe the “front” (or anterior) side of the heart. This is the side you would see if the chest were opened. From this angle, the heart usually appears rounded. Note that the back of the heart is flat, with several large openings for blood vessels. Refer to the diagram, “The Heart: External,” to locate the structures.
4. The whitish yellow material is a layer of fat. A little fat is normal. It protects and covers some of the blood vessels around the heart. Using scissors, very carefully remove as much fat as possible. (This will take some time.)
5. The heart has four chambers: two at the top and two at the bottom. The chambers at the top of the heart are the right and left atria (atria is plural for atrium). Those at the bottom are the right and left ventricles.
6. Observe the flaps, called auricles, on either side of the heart. They expand to enable the atria hold more blood. Auricle means “ear,” and these structures were given this name because they resemble puppy dog ears when their thin walls hang down along the heart.
7. Arteries are vessels that transport blood away from the heart (think “Arteries Away”). The walls of an artery are more muscular than those of a vein, so arteries will stand open and are easier to find than veins are. Veins transport blood toward the heart, with the help of skeletal muscle contraction. Because they have less muscle in their walls than arteries do, veins are not as easy to identify. To distinguish a vein from connective tissue, you may have to locate the opening with a blunt probe or closed scissors. Blood flowing in veins must fight gravity, so veins have structures, called valves, to prevent blood from moving backward.
8. When certain that you are facing the front of the heart, find the two large blood vessels at the top. The first vessel, in the center of the heart, is the pulmonary artery. Deoxygenated blood (blood not carrying oxygen) in the pulmonary artery is pumped from the right ventricle to the lungs, where it delivers carbon dioxide from the body’s cells, and becomes re-oxygenated. This circuit through the lungs is called the pulmonary circulatory system and includes the pulmonary veins, which carry oxygenated blood to the left atrium.
9. The large vessel just behind pulmonary artery is the aorta, the largest blood vessel in the entire body. The aorta carries oxygenated blood from the lower chamber of the heart—the left ventricle—and sends it off to all parts of the body, from head to toe. This circuit through the body is called the systemic circulatory system.
10. Coronary arteries are not visible when viewing the anterior (front) side of your sheep heart, but the anterior heart diagram shows the location of one of these important blood vessels. Because the heart is made up of cardiac muscle cells, it needs a constant supply of oxygen and nutrients from coronary arteries to survive. The left anterior descending (or LAD) artery shown in the diagram is just one of several coronary arteries, but it is a critical one when looking at disease states involving reduced blood supply to the heart.
11. Turn the heart over to observe its back (or posterior) side. The severed vessel nearest the right auricle is the superior vena cava. Blood drains from the superior, or upper, body into the superior vena cava, and from there into the right atrium. Just below and a little toward the center of the heart is the severed inferior vena cava, the second vessel entering the right auricle. It carries blood from the lower (or inferior) part of the body to the right atrium.
12. To the left of the inferior vena cava is the severed pulmonary vein, which enters the left auricle.
13. When your team has placed pins in all ten spots on the heart, ask another team to check your work to see if they agree with your locations. Your team should check their work at the same time. If there is disagreement, reread the instructions and try to resolve the matter before involving the teacher.
14. Once your team has completed “Part One: Outside the Heart,” remove all numbered pins from the specimen. Proceed to “Part Two: Inside the Heart,” only when your teacher says to do so. ■

HEART GUIDE: OUTSIDE AND INSIDE

PART TWO: INSIDE THE HEART

1. As you and your team progress through this activity, use numbered pins to identify the internal parts of the heart listed below. Refer to the diagram on your handout, "Inside the Heart," for help in locating the structures.
 1. **Right atrium**
 2. **Right ventricle**
 3. **Tricuspid valve**
 4. **Pulmonary valve (general area)**
 5. **Left atrium**
 6. **Left ventricle**
 7. **Septum**
 8. **Mitral valve (bicuspid valve)**
 9. **Aortic valve**
 10. **Aorta**
2. Your teacher will demonstrate how to make the first cut through the right side of the heart. The upper chamber is the right atrium; the lower chamber is the right ventricle. You will notice that the ventricle walls are thicker than those of the atrium.
3. Pull apart the two sides of the heart. Then, look inside for three flaps, or membranes, on the right side, between the upper and lower chambers. These flaps make up a one-way "door," called the tricuspid valve. When the right ventricle contracts, this valve closes to prevent blood from traveling back into the right atrium.
4. The large opening in the center-top of the heart is the attachment point for the pulmonary artery, which carries blood to the lungs. Thread a pipe cleaner through this opening into the right ventricle. The pipe cleaner also will pass through the (less noticeable) pulmonary valve, which prevents blood from flowing back into the right ventricle after its contraction.
5. Make a lengthwise cut through the pulmonary vein (you will see only an opening) on the left side of the heart. Continue through the anterior wall of the atrium and ventricle, and down toward the apex (tip) of the heart. Pull the two sides apart. Here, you will find another valve with two flaps, separating the left atrium and the left ventricle. This is the mitral or bicuspid valve. Blood flows from the left atrium through this valve into the left ventricle.
6. The lower left and right chambers of the heart are separated by a dividing structure, called the septum. Notice that the muscle surrounding left ventricle is noticeably thicker than the right ventricle muscle. Both atria have even thinner walls than the right ventricle. Why do you think the different chamber walls have different thicknesses?
7. As blood flows from the left ventricle, it passes through the aortic valve and to the aorta, which supplies blood to distant parts of the body.
8. When your team has placed pins in all ten spots on the heart, ask another team to check your work to see if they agree with your locations. Your team should check their work at the same time. If there is disagreement, reread the instructions and try to resolve the matter before involving the teacher.
9. Have members of your team quiz each other to be sure everyone understands the path of blood through the heart.
10. When instructed by the teacher, clean and return all dissection tools and numbered straight pins. Dispose of the sheep hearts as instructed by your teacher. Clean your tabletops and wash your hands thoroughly with soap and water. ■



CORONARY ARTERY DISEASE MODEL

Overview

In this discovery activity, students learn how coronary artery disease begins and how it causes arteries of the heart to become partially or completely blocked, thereby restricting the flow of oxygen and nutrients to the heart muscle.

Why is Cholesterol Important?

High blood cholesterol is one of the major risk factors for heart disease or heart attack. In the US, heart disease is the number one killer of women and men. The following are steps to take at home to help improve cholesterol levels.

- Follow a low-saturated fat diet.
- Lose weight if overweight.
- Be physically active for at least 30 minutes on most, if not all, days.

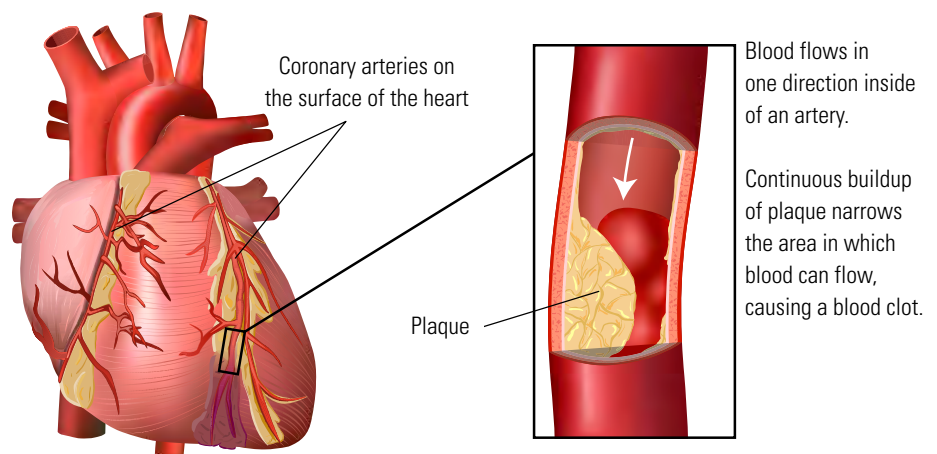
Courtesy of the National Heart, Lung, and Blood Institute, National Institutes of Health (<http://www.nhlbi.nih.gov/health/public/heart/chol/wyntk.htm>).

In the *Scientific Decision-making Teacher's Guide*, students follow the personal stories of Arturo, Brian and Angela, all of whom may be suffering from heart problems brought about by coronary artery disease.

What is CAD? Coronary artery disease or CAD develops when the arteries of the heart become damaged or diseased. CAD usually is a result of plaque build-up in the arteries. This condition, called atherosclerosis (Greek for hard paste), begins with inflammation of, and damage to an artery's innermost layer (endothelium). The cause of this inflammation isn't understood, but elevated levels of cholesterol in the blood, high blood pressure or smoking may contribute to the initial damage. Inflammation in the artery attracts cholesterol and other substances, which build up just below the inner arterial wall. As we age, this buildup, called plaque, may become thick enough to cause significant blockage, resulting in a condition known as ischemia (reduction in blood flow through the vessel). Cardiac ischemia (or myocardial ischemia) is a reduced flow of blood and oxygen to the heart muscle. It can cause damage to, and a general weakening of the heart muscle, or even total heart failure. Common symptoms included chest pressure or pain, neck or jaw pain, nausea and vomiting. However, it also can be "silent" (showing no symptoms).

Over time, plaque can become unstable and rupture, producing blood clots that may block an artery completely. Such blockage in one of the coronary arteries feeding the heart results in a heart attack, or myocardial infarction (MI). Blockage of an artery that feeds the brain results in a stroke.

Plaque Build-up in a Coronary Artery



© Peter Junaidy

Information on Cholesterol

For additional detailed information about cholesterol and other cardiovascular related topics, visit the Watch, Learn and Live Interactive Cardiovascular Library (http://watchlearnlive.heart.org/CVML_Player.php?moduleSelect=chlscri).

The Watch, Learn and Live Interactive Cardiovascular Library © American Heart Association, Inc. All rights reserved.

Good and Bad Cholesterol

Cholesterol is a kind of lipid (fat) molecule, which is required by the body to build and maintain membranes. It also is an important precursor molecule for the synthesis of vitamin D and several hormones. All animals manufacture cholesterol. Within the body, about 20–25 percent of cholesterol production occurs in the liver. Cholesterol is stored and transported inside an envelope of lipids and proteins, creating particles called lipoproteins. There are five kinds of lipoproteins, but only two—low density lipoproteins (LDLs) and high density lipoproteins—(HDLs) are measured in a person's cholesterol score.

For more information about cholesterol, watch the slide show prepared by the American Heart Association (http://watchlearnlive.heart.org/CVML_Player.php?moduleSelect=chlscri).

MATERIALS

Teacher (see Safety)

- Computer and projector or an interactive white board to display the online animation, What Causes a Heart Attack?
- Small amount (tablespoon) of vegetable shortening in a plastic cup
- Small amount (tablespoon) of vegetable oil in a plastic cup
- Bag of unpopped, plain popcorn kernels
- 3 boxes of small (#1 size) paper clips (15 clips needed per team of students)
- 18 mm x 150 mm glass or plastic test tubes, or six-inch sections of clear tubing (one per team)
- Small cups or sandwich bags to hold about 50 kernels of unpopped popcorn
- Nickel- or quarter-size magnets; most refrigerator magnets will work well (one per group)

Each team of students will need:

- One clear 18-mm x 150-mm glass or plastic test tube (or six-inch section of clear plastic tubing)
- 15 small (#1 size) paper clips
- Small cup or plastic bag containing about 50 unpopped kernels of popcorn
- One nickel- or quarter-sized magnet
- Masking tape (approximately 12-inch strip)
- Two sheets of notebook paper

SETUP

Students will work in teams of four. Place all materials in a central location.

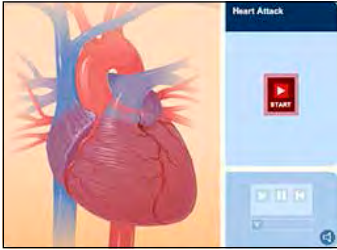
SAFETY

Students should wash their hands with soap and water before and after any science activity, even if wearing gloves. Always follow all district and school laboratory safety procedures.

PROCEDURE

1. In the *Scientific Decision-making Teacher's Guide*, one or more characters may have suffered a heart attack. Tell students that they will create a model to learn more about coronary artery disease (CAD) and investigate what happens during a heart attack (myocardial infarction).

Animation of a Heart Attack



The video animation, found at the URL below, shows how plaque build-up or a coronary artery spasm can lead to a heart attack. (<http://www.nhlbi.nih.gov/health/health-topics/topics/heartattack/causes.html>).

Image courtesy of National Heart, Lung, and Blood Institute, National Institutes of Health.

MODEL PART	WHAT DOES EACH MODEL PART REPRESENT?
Test tube or tubing	Artery, or more specifically, a coronary artery
Popcorn kernels	Red blood cells
Paper clips	Excess cholesterol and other substances
Magnet and tape	Initial inflammation leading to building inside artery walls

- Show the following video clip (two minutes) on coronary artery disease. The video describes how "plaque" build-up in the arteries leads to heart attack. What Causes a Heart Attack? (<http://www.nhlbi.nih.gov/health/health-topics/topics/heartattack/causes.html>)
- Ask students, *What do you think plaque in the arteries looks like?* Allow students time to share their ideas. Tell students that plaque consists of fat, cholesterol, calcium and other substances found in blood; and is waxy in appearance.
- Then, hold up the cup of vegetable oil and ask students to identify the substance. Tell students that it is cooking oil (a kind of fat or lipid), which typically is extracted from plant seeds (corn, canola, olive, etc.). Next, hold up the shortening, and ask students to identify it. Tell students that shortening can be manufactured from plant oils or it can come from animals (i.e., lard). Pass both containers around the class. Ask, *Which of these two kinds of fats is healthier to eat?* Tell students that fats that are liquid at room temperature generally are healthier for the cardiovascular system, and can contribute to higher percentages of HDL cholesterol (HDL), which removes cholesterol from the blood stream. Animal fats and fats that are solid at room temperature contribute to higher levels of circulating LDLs. LDL particles are responsible for depositing cholesterol in blood vessels, which can lead to plaque formation.
- Provide to each student team: one test tube, 15 paper clips, one magnet, one strip of tape (from which they can tear off pieces), and popcorn kernels, as described in the Materials section.
- Instruct each team to build a model of coronary artery disease from the materials provided. The models should show a narrowing of the passageway (due to plaque), but still allow "red blood cells" to pass through. Accept all reasonable models.
- On a sheet of notebook paper, have each team create and fill in a table that describes its model. The first column should list all parts of the model (test tube, popcorn kernels, magnet, paper clips). The second column should indicate what is represented by each component. If students need additional direction, tell them that their model should include an artery, red blood cells, plaque and a source of inflammation (something that causes the lining of the artery to become "sticky").

Note: It is anticipated that most groups will design a model in which the magnet is taped to the side of the tube. One or more paper clips are dropped into the tube (artery) and attracted by the magnet to simulate plaque buildup. Popcorn kernels added to the tube represent red blood cells flowing through the artery.
- Next, ask each team to build a model of heart attack. This can be accomplished in at least two ways: by creating a build-up of plaque (paper clips) that completely blocks the tube or by making the tube so narrow that red blood cells (popcorn) form a clot that blocks the tube.

8. Have the teams share their models with the class, and explain their designs.
9. Have students return all materials to the original location. Instruct students to use the second sheet of notebook paper to write three things he or she learned from this activity about CAD. Have students submit their answers as they leave the classroom, or complete the assignment as homework.

EXTENSION OR HOMEWORK

- Make copies of the student page, "Heart Disease Risk Factors," for each student. Have students read the essay in class or as homework.
- Have students work in teams of 2–3 to create posters on heart-healthy themes, such as describing the process of CAD; risk factors; negative effects of smoking; importance of physical activity, diet and nutrition; or teens and heart disease.
 - Approve each team's poster idea, and have groups create standard 22-in. x 28-in. posters.
 - Exhibit the posters in school public areas, such as hallways and cafeterias. Consider having team members stand near their posters to answer questions during a lunch period or school-wide heart event, such as a walk-a-thon or blood drive.
 - A poster-grading rubric is included at the end of this activity (see p. 17). ■

HEART DISEASE AND RISK FACTORS

REFERENCE

When discussing health, risk factors are conditions or behaviors that increase the likelihood of developing a disease. Some risk factors can be controlled, but others cannot. Not everyone has the same risk for coronary artery disease (CAD) or a heart attack. It is important to know behaviors that increase or decrease the risk for developing heart disease.

The three main risk factors for heart disease that cannot be modified are gender (sex), age, and heredity (family history and genetics). You cannot control the genes you inherit, or the reality that risk for heart attack increase with age. In fact, 82% of people who die from CAD are 65 or older. Men's risk of a heart attack increases during middle age; women's rises noticeably after 55 years of age. But even then, a woman's risk is lower than a man's. People of African American, Mexican American, American Indian, and native Hawaiian descent are at higher risk for heart disease than members of other groups. And individuals whose parent or parents had heart disease are more likely to than others to develop CAD.

The inability to change our age or heredity makes it even more important to manage risk factors over which we have some control. Personal choices about diet, exercise and smoking can affect cholesterol levels, blood pressure, body weight and blood sugar levels, all important factors related to the risk for heart attack. By understanding our risks and making decisions to lower risks that may be modified, we can take steps, even at an early age, to reduce the chances for CAD or heart attack.

Smoking is a major risk factor in men and women, and combined with other risk factors, it greatly increases the chance of cardiovascular problems. Smokers are 2–4 times more likely than non-smokers to develop CAD or have a heart attack. Further, constant exposure to other people's cigarette smoke (secondhand smoke) increases the risk of heart disease in the nonsmoker. The *2012 Report of the United States Surgeon General* describes tobacco use among youth ages 12–17 as epidemic, and 90% of all smokers begin before age 18. Tobacco use causes immediate and long-term damage, including CAD. Among young people who continue to smoke, one in three will die prematurely. Among youth who continue to smoke, one in three will die prematurely from smoking. Smoking harms nearly every organ in the body and is one of the main preventable causes of death and disease in the United States.

High total cholesterol and “bad” LDL cholesterol are associated with increased risk for heart disease. Total cholesterol values typically should not be higher than 200 mg/dL. LDL cholesterol is the main source of cholesterol that builds up in the walls of the arteries and causes CAD. Foods high in saturated fats are high in cholesterol; we can reduce the risk for CAD by limited these foods. “Good” HDL cholesterol lowers the risk for heart disease by helping to (1) remove LDL cholesterol from the bloodstream, (2) prevent formation of plaque in the arteries, and (3) remove

plaque that already has collected on artery walls. Higher HDL values are associated with lower risk of heart disease. Regular, vigorous exercise is a great way to increase HDL cholesterol levels.

Blood pressure is the force of the blood against the walls of the arteries. When it stays elevated over time, it is called high blood pressure. This condition increases the heart's workload, and strains the heart, blood vessels and kidneys. High blood pressure has been associated with heart attack, stroke and kidney failure. Because it usually has no warning signs or symptoms, high blood pressure is especially dangerous and sometimes is referred to as the silent killer. When combined with other risk factors, such as obesity, diabetes, high cholesterol, or smoking, high blood pressure can increase the risk of a heart attack several fold.

In the last 30 years, obesity has tripled among people aged 12–19 years. Excess body fat, especially around the waist, increases the risk of a heart attack, even in the absence of other risk factors. Quite simply, the heart must work harder to supply nutrients and oxygen to the extra body mass. Losing just 10 pounds lowers the risk of a heart attack. Even in young people, overweight or obesity increases the risk of developing heart disease, high blood pressure, type 2 diabetes, gallstones, breathing problems and certain cancers.

Physical inactivity is a risk factor that almost anyone can change. Regular exercise, such as 30 minutes of walking per day, helps to prevent heart and blood vessel disease, and it actually strengthens the heart. The combination of regular exercise and a healthy diet is one of the best defenses against heart disease, because it helps control risk factors like high cholesterol, high blood pressure and diabetes.

Diabetes (uncontrolled high blood sugar) is a major risk factor for heart and blood vessel disease. In combination with other risk factors, it can harm the heart and cause more severe cardiovascular problems, and at a younger age. Surgical treatments for heart disease, such as bypass surgery or angioplasty, are less successful in persons with diabetes. In fact, people with diabetes have the same risk for future heart problems as do individuals who have had a heart attack. Sixty-five percent of diabetes patients die from some form of heart or blood vessel disease, so it is important for people with diabetes to work closely with healthcare providers to manage and control blood sugar levels through a program of diet and exercise.

There are three kinds of diabetes. Type 1 diabetes is inherited and usually is diagnosed in children or teenagers. Type 2, the most common form, can develop at any age. Being overweight and inactive increases the risk for type 2 diabetes. A third form of diabetes, gestational diabetes, develops in some women during pregnancy. It usually goes away after the baby is born, but it does increase a woman's risk of developing type 2 diabetes later in life. ■

POSTER PRESENTATION GRADING RUBRIC

FOR ACTIVITY EXTENSION

TEAM MEMBERS _____

DATE _____

POSTER THEME _____

CRITERIA	SCORE				POINTS
	7 points	8 points	9 points	10 points	
Display	No evidence of planning. Not neat or poorly designed.	Some evidence of planning. Design, layout, and neatness are satisfactory.	Well planned in terms of design, layout, and neatness.	Exceptionally well-planned and executed in terms of design, layout, and neatness.	_____ x 2 _____
Organization and Visual Appeal	Information is not organized clearly (presented randomly)	Information somewhat difficult to follow, and eyes are drawn to areas out of sequence.	Logical progression and sequence of information. Information is easy to follow.	Excellent logical progression for poster. Eyes naturally follow the flow of information.	_____ _____
Content	Many content errors. Theme is not addressed and content is inaccurate or not useful.	A few errors in content, and theme is ineffectively addressed. Some content is difficult for intended age.	Most of the content is accurate and addresses the theme in a clear and effective manner. Age appropriate.	All content is accurate and addresses the theme in a clear and effective manner. Age appropriate.	_____ x 2 _____
Creativity and Originality	No planning or thought given to the theme. Ineffective in conveying message in a creative or original way.	Message is presented with a theme, but lacks originality.	Message has a theme and shows some creativity and originality.	Shows exceptional creativity and originality.	_____ _____
Use of Text	Too many words and terms are too technical or are undefined. Evidence of cut and paste from sources.	Several long statements and wordy. Several terms are not defined or need explanation.	Statements are mostly brief and convey the thought. Most terms are defined, if needed.	Statements are brief and convey the thought. All terms are defined, if needed.	_____ _____
Grammar	More than 3 grammatical or mechanical mistakes.	There are 2–3 grammatical or mechanical mistakes.	There is 1 grammatical or mechanical mistake.	No grammatical or mechanical mistakes.	_____ _____
Pictures and Diagrams	Graphics are poor (wrong size, resolution or missing) and do not further understanding of the topic.	Some of the graphics make the topic easier to understand, but few are of appropriate size and resolution.	Most of the graphics make the topic easier to understand, and most are of appropriate size and resolution.	Graphics make the topic easier to understand and are interesting. Size and resolution are appropriate.	_____ _____
Labels	None of the items are labeled.	Some items labeled correctly, and few can be read from at least 3 feet away.	Most items labeled correctly, and most can be read from at least 3 feet away.	Items labeled correctly, and can be read from at least 3 feet away.	_____ _____
Total					_____ _____



IS IT A HEART ATTACK?

Overview

Using reference materials and their own knowledge, students compile a list of warning signs and symptoms of a heart attack.

Students also view a video showing what happens immediately before, during and after a heart attack.



© Paul Vasarhelyi

Your class has learned about plaques that form, over time, inside the arteries. These plaques may become unstable and rupture, resulting in formation of blood clots that can block an artery completely. Blockage of a coronary artery results in a heart attack, or myocardial infarction (MI). Blockage of an artery that feeds the brain causes a stroke. A severe reduction or full stoppage of blood flow to any part of the heart for more than a few minutes deprives heart muscle cells of oxygen, causing permanent injury and death of the cells. Extensive damage and loss of heart muscle can kill or disable an individual. This is why it is so critical to recognize and treat a heart attack as quickly as possible.

Someone having a heart attack may experience one or more signs and symptoms. The most common warning sign is mild to severe chest pain or discomfort, uncomfortable pressure, or squeezing in the center or left side of the chest. However, one-third of heart attack patients report no chest pain. Another warning sign is shortness of breath, either during or before the onset of chest pain. Heart attack pain sometimes feels like indigestion or heartburn. Some individuals also experience nausea, vomiting, light-headedness and/or dizziness. Some victims break out in a cold sweat, or feel discomfort in one or both arms, the back, neck or jaw. Women account for nearly half of all heart attack deaths, and are more likely than men to experience shortness of breath, nausea/vomiting, and back or jaw pain.

The survival of a heart attack victim may depend on how quickly these signs are recognized and medical aid is rendered. If you think you or someone else may be having a heart attack, call 911 immediately. It is better to be safe than sorry. The sooner treatment begins, the less damage the heart will sustain, and the greater the chances for recovery.

MATERIALS (SEE SAFETY)

Teacher

- Signs Introduction PowerPoint® file included with this unit
- Copies of "Warning Signs and Symptoms of a Heart Attack," reference material
- Computer and projector or interactive white board
- Internet connection (to view the video, YouTube must be allowed in your school)

Each team of students will need:

- Notebook paper (one sheet per student)

SETUP

Have the PowerPoint® slideshow, Signs Introduction, ready for viewing before class. If using the video, be sure the video links or files are open and ready to project.

Conduct a discussion with the entire class. Then have students work in teams of four for the remainder of the activity.

SAFETY

Students should wash their hands with soap and water before and after any science activity, even if wearing gloves. Always follow all district and school laboratory safety procedures.

Information Resources

- **American Heart Association**
<http://www.heart.org>
- **National Heart, Lung and Blood Institute**
<http://www.nhlbi.nih.gov>
- **Mayo Clinic**
<http://www.mayoclinic.com>

Body Story: Episode 3

YouTube links for the three, ten-minute video segments are shown below (see Step 9).

Part 1, Episode 3:

http://www.youtube.com/watch?v=MyZ1-haX_ZE

Part 2, Episode 3:

<http://www.youtube.com/watch?v=RtCbJolDsIE&feature=related>

Part 3, Episode 3:

<http://www.youtube.com/watch?v=9hxzHqG5Vg8&feature=related>

PROCEDURE

1. Show the first PowerPoint® slide (road sign indicating danger from falling rocks). Ask students, *What does this picture say to you?*
2. Move to the second slide (road sign showing a sharp curve). Ask, *What is the meaning of this picture?*
3. Show to the third slide (sign warning of children at play). Repeat your questions to prompt students' discussion.
4. Display the fourth slide and ask students, *What do all of these pictures have in common?* [All contain "danger" warning signs.]
5. Ask the class, *How important is it to understand the meaning of these signs? Why?*
6. Show the fifth slide (man clutching his chest in pain) and ask the class, *What do you think might be happening to the person in this picture?* Students should realize the man might be having a heart attack. Ask, *Are there warning signs for heart attacks?*
7. Distribute a copy of "Warning Signs and Symptoms of a Heart Attack," to each team. Have each team member read a portion of the material out loud. Using the reference materials, have each team create a list of at least 8 warning signs and symptoms. Possible answers include the following.
 - No warning signs or symptoms
 - Chest pain or discomfort
 - Squeezing sensation or pressure in the chest that doesn't go away
 - Feeling of indigestion or heartburn that cannot be relieved
 - Aching in one or both arms (most commonly the left arm if only one)
 - Ache or pain in the neck, jaw, or stomach
 - Shortness of breath
 - Nausea or vomiting
 - Light-headedness or sudden dizziness
 - Cold sweat
 - Fatigue (malaise or lack of energy)
 - Sleep disorders
8. Have each team place a star in the margin next to three signs or symptoms that surprised them. Then, lead a class discussion in which students share some of their surprises. Most commonly, students are surprised by "no signs at all," "jaw pain," and "back pain."
9. Show the Discovery Channel video, "Body Story: Episode 3, The Beast Within – Heart Attack," (for URLs, see "Body Story: Episode 3," left sidebar).
10. End with a class discussion of what happened during the video, or have students conduct a "3-2-1" exercise for discussion or submission (each student notes 3 things he/she learned; 2 interesting facts; and 1 question he/she still has). ■

WARNING SIGNS AND SYMPTOMS OF A HEART ATTACK

REFERENCE



Does this man have indigestion or is he having a heart attack?

© Alice Day

Over time, plaque that forms inside arteries may become unstable and rupture, producing blood clots that may block an artery completely. Such blockage in a coronary artery feeding the heart results in a heart attack, or myocardial infarction (MI). Blockage of an artery that feeds the brain results in a stroke. A severe reduction or full stoppage of blood flow to any part of the heart for more than a few minutes deprives heart muscle cells of oxygen, causing permanent injury and death of the cells. Extensive damage and loss of heart muscle can kill or disable an individual. Early recognition and treatment of a heart attack can help minimize damage to the heart muscle, and even might save a life.

Someone having a heart attack may feel one or more symptoms, and not all victims experience the same signs. Sometimes a heart attack is silent—occurring with no warning symptoms at all. The most common sign is mild to severe chest pain or discomfort, uncomfortable pressure or “fullness,” or squeezing in the center or left side of the chest. This chest pain may not go away, or it may last a few minutes, go away, and return. However, chest pain is not always a symptom. One-third of patients experiencing a heart attack report no chest pain.

Another warning sign of a heart attack is a feeling similar to indigestion or heartburn that does not respond to antacids. Pain or numbness in one or both arms may indicate a heart attack. If the pain is in only one arm, it is

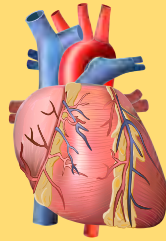
usually the left. Some victims feel pain in the back, neck or jaw. Other possible symptoms include shortness of breath, nausea, vomiting, cold sweat, light-headedness and/or sudden dizziness, sleep disorders, malaise (lack of energy), and fatigue. Women, account for nearly half of all heart attack deaths, and are more likely than men to experience shortness of breath, nausea/vomiting, and back or jaw pain. In general, the more signs and symptoms that are present, the more likely a person is having a heart attack.

Heart disease is the number one killer of both women and men, and women account for nearly half of all heart attack deaths. They are more likely than men to experience shortness of breath, nausea/vomiting, and back or jaw pain during a heart attack. Typically, female heart attack victims are about ten years older than their male counterparts. Women are less likely than men to believe they are having a heart attack, and less likely to seek medical help.

If you or someone nearby is experiencing one or more warning signs and symptoms, call 911 to seek medical attention immediately. The survival of a heart attack victim may depend on how quickly the signs are recognized and medical aid is rendered. It is better to be safe than sorry. The sooner treatment begins, the less damage the heart will sustain, and the greater the chances for recovery. The person should not drive while experiencing the symptoms. ■

SCIENTIFIC DECISION-MAKING

SUPPLEMENTARY ACTIVITIES ON THE CARDIOVASCULAR SYSTEM



TEACHER'S GUIDE