

SCIENTIFIC DECISION-MAKING

HEART AND CIRCULATION: OUTSIDE AND INSIDE



ABOUT THE PROJECT

Baylor
College of
Medicine

CENTER FOR
EDUCATIONAL
OUTREACH

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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.

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BioEdSM

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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.

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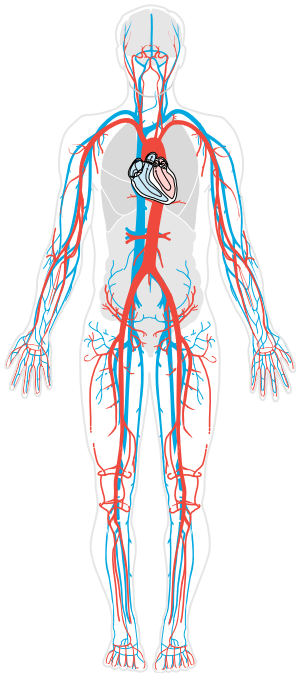
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HEART AND CIRCULATION: OUTSIDE AND INSIDE

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



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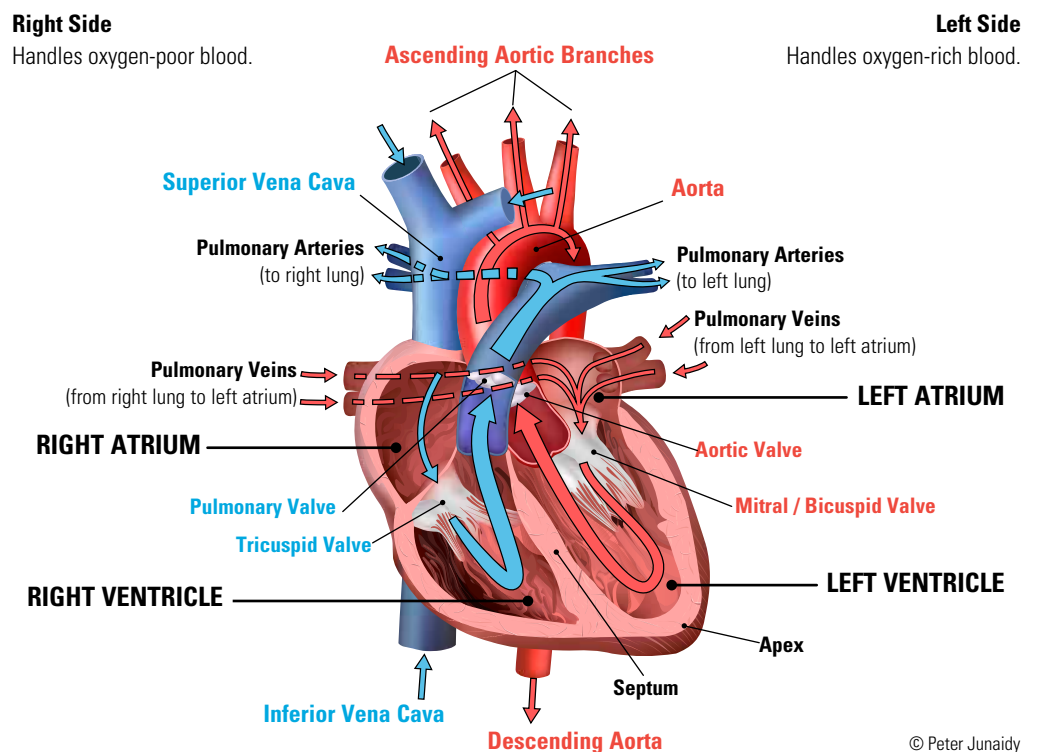
The heart is a complex pump made of a special kind of muscle, called cardiac muscle, which is very resistant to fatigue. Although it is made of living cells, the heart shares many characteristics with mechanical pumps we see everyday.

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.

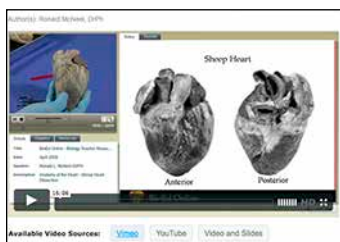
In the circulatory system, veins carry blood toward the heart, and arteries carry blood away

The Heart Pumps Blood In and Out



© 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

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.

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.

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

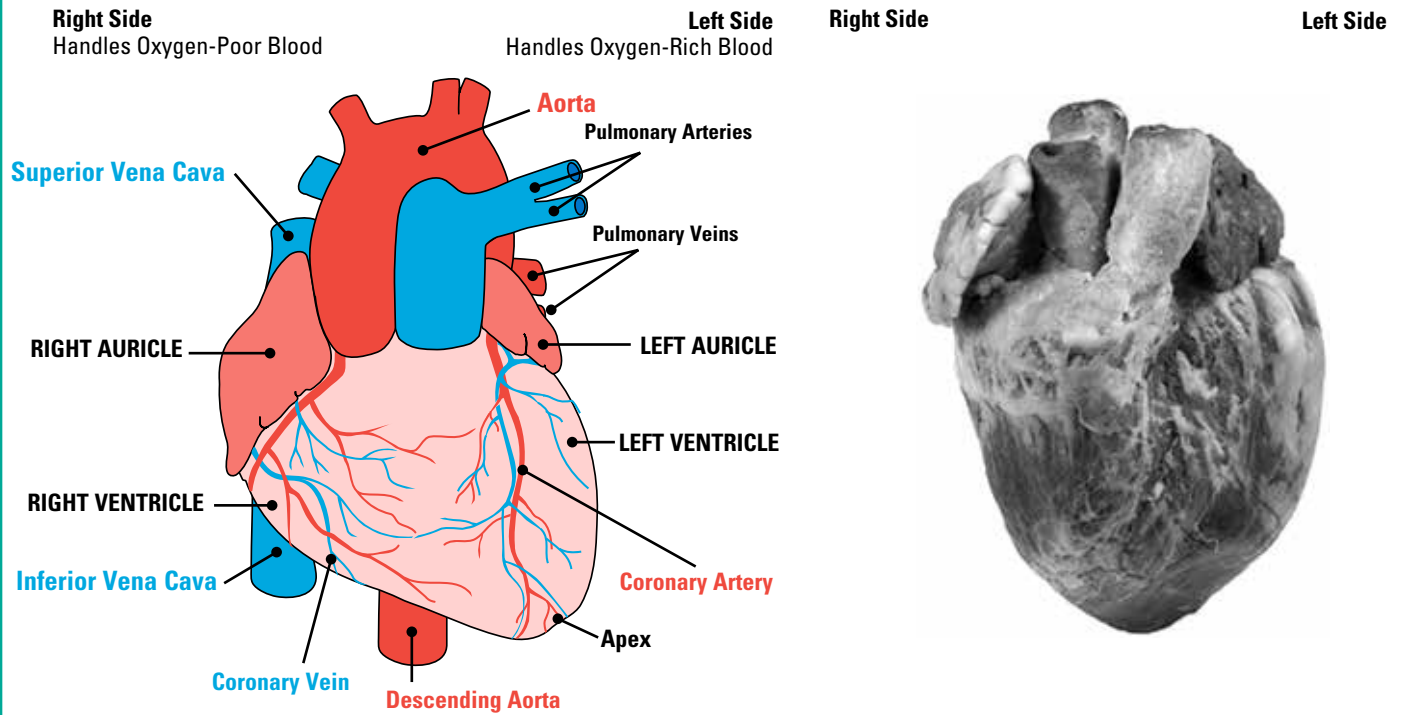
For additional detailed anatomy and other heart-related information, visit the Virtual Heart Web website (<http://thevirtualheart.org>).

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

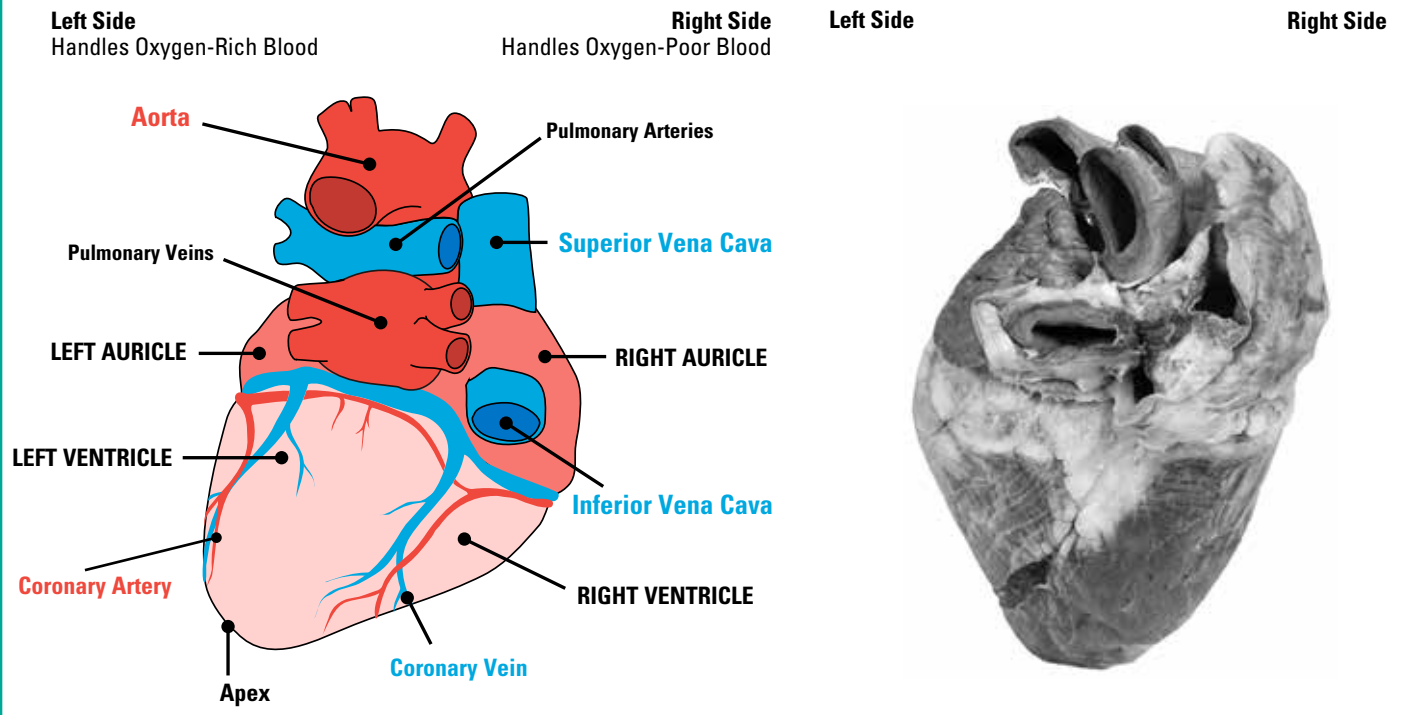
- heart, or simply complete this step for students. First, insert the point of a pair of dissection scissors or a scalpel into the superior vena cava (large vein that enters the right atrium, sometimes visible only as a large hole). Cut down the superior vena cava into the anterior wall of the right 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.

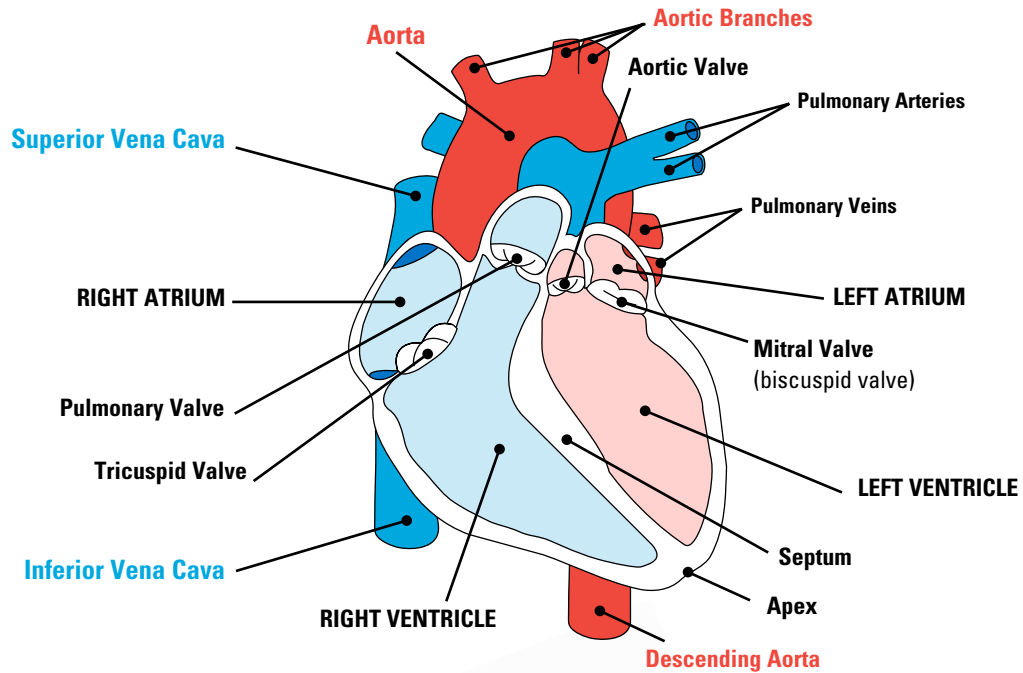
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THE HEART: INTERNAL

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.

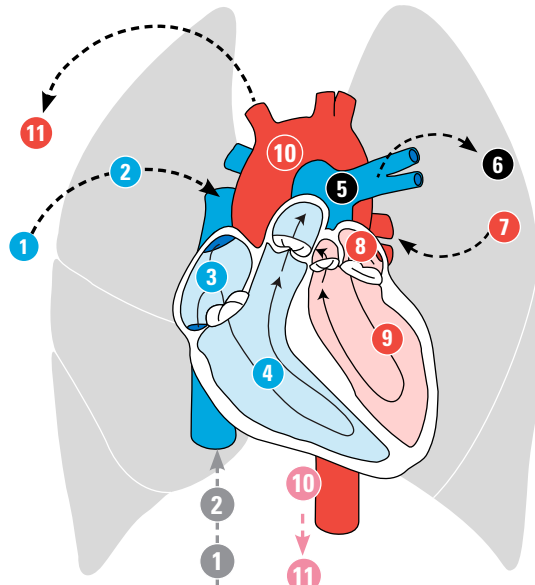
2 Out of the Veins / Into the Vena Cava (See both illustrations.)

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).

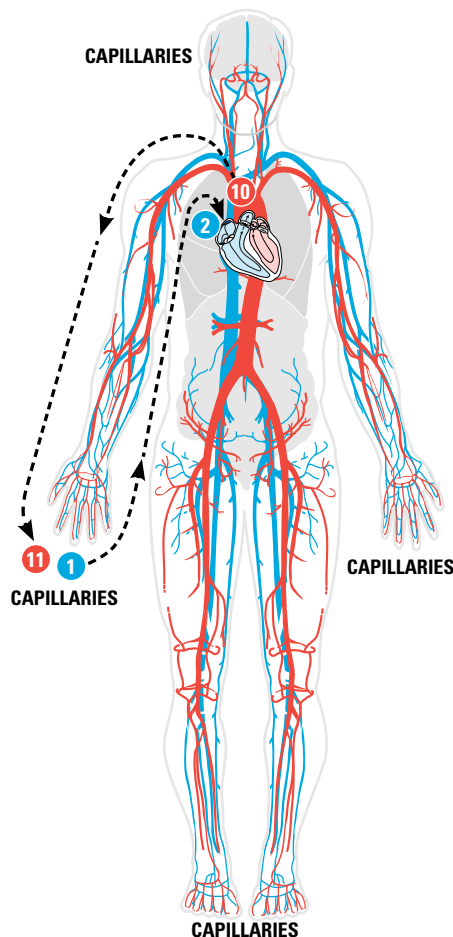
1 Out of the Capillaries / Into the Veins

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



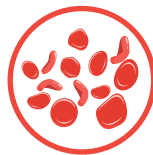
Veins



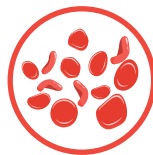
Pulmonary Veins



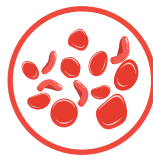
Left Atrium



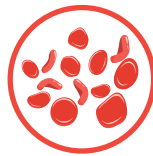
Mitral (Bicuspid) Valve



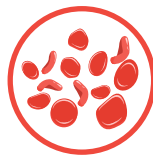
Left Ventricle



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. ■