Contents

2 Introduction
   • A Message to teachers

3 TRANSPORTATION

4 Make a body-sized poster of the circulatory system

5 More Interactivities:
   • Make a blended image
   • Listen to your heartbeat

6 Explore the vessels in a goldfish

7 Make an action picture of the heartbeat cycle

9 Change your heart rate

10 The heart and blood pressure

11 REGULATION

12 How does your blood get rid of carbon dioxide?

13 Capillary gas exchange

14 PROTECTION
   • Create a model of a blood cell

15 Are you my type?

16 Mistaken identity: compatibility testing

17 Clotting and diseases

18 The case of sickle cell anemia

19 Fighting blood pathogens

19 Life cycle of a parasite

20 Phagocytosis in action

21 Blood defenders: make a flipbook

22 CONSIDERATION
   • Making an ethical decision
   • Encouraging blood donation

23 GLOSSARY

24 RESOURCES

Introduction

The Foundation for America’s Blood Centers is committed to increasing public awareness about the need for blood donation to help ensure that all Americans have access to a safe and adequate blood supply. The creation of My Blood, Your Blood underscores this commitment. While fostering altruism and community spirit, this Teacher’s Guide and the entire My Blood, Your Blood curriculum provide up-to-date information and creative strategies to help teach the science of blood. Developed by a team of physicians and educators, My Blood, Your Blood is designed to be a turnkey education program easily adapted to a variety of learning levels. America’s Blood Centers hopes you and your students enjoy the learning activities. We encourage you to visit the My Blood, Your Blood Web site at www.MyBloodYourBlood.org.

A Message to Teachers

The center of our universe!

This My Blood, Your Blood Teacher’s Guide is designed to extend and complement the information presented in the My Blood, Your Blood Video. In writing the Guide, we collected activities and information to help you plan a curriculum centered around the importance of blood in our lives. For us, the only problem was where to stop. Clearly, blood can be considered our physiological “center of the universe” since it carries out the essential functions of transporting nutrients and molecules, regulating our internal environment, and protecting us from disease. Because we couldn’t include all the possibilities for studying the role of blood in our lives, we hope you will consider the activities and information that follow as take-off points for you and your students to continue learning about this fascinating subject.

In organizing the content of the My Blood, Your Blood Teacher’s Guide, we chose not to categorize the lessons by age group. Instead, the activities are grouped by blood functions: Transportation, Regulation, and Protection, as well as a section we titled Consideration which addresses decision-making and the importance of blood donation. Because you know your students and their abilities, this information can be adapted to suit your situation, whether it is a traditional classroom or a home-school.

We hope you and your students enjoy learning about the importance of blood, and learning, as Granville, the animated white blood cell character from the video, says, “how important it is to become a volunteer blood donor.”

Kathleen Buckley, E.D.D.
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Our My Blood, Your Blood Guide follows current National Science Education Standards:

The National Science Education Standards, developed by the National Research Council and the National Academy of Sciences, are criteria for the development of curricula to increase science literacy of all students.

The My Blood, Your Blood Video and Teacher’s Guide can assist educators in designing science lessons that will aid student understanding in the following content areas established by the National Science Education Standards:

Life Sciences:
• Characteristics of Organisms (Level K-4)
• Structure and Function in Living Organisms (Level 5-8)
• The Cell and M atter, Energy, and Organization in Living Systems (Level 9-12)

Science in Personal and Social Perspectives:
• Personal Health (Level K-8)
• Personal and Community Health (Level 9-12)
• Science and Technology in Local Challenges and Society (Level K-12)
Blood is a mixture of constantly circulating red blood cells, white blood cells, platelets, and plasma. Even though you usually can’t see your blood, it’s not that hard to find. It’s carried to every part of your body by thousands of blood vessels—arteries, veins, and capillaries.

“Think of your blood as the transportation system in your body that’s always on the move, making deliveries and pick-ups day and night. Pumped by your heart, your blood is circulated non-stop, carrying oxygen and nutrients to wherever they’re needed, and collecting waste products called carbon dioxide.” —Rory

A special protein called hemoglobin makes red cells look red and gives them the ability to bind and transport oxygen.
Blood takes two main paths in its trip through the body. Blood is pumped out to the body in vessels called arteries. Arteries carry oxygenated blood to all parts of the body. Once the blood has delivered oxygen and nutrients and picked up waste products, such as carbon dioxide, it is transported back to the heart through vessels called veins. The heart contracts, sending blood into the lungs to be reoxygenated and to rid itself of carbon dioxide. From the lungs, the blood re-enters the heart and the cycle begins again. There are many organs that are involved in the filtering and transportation process and that are related to those body systems. Below are other organs that are involved in the transportation of blood throughout your body by way of the circulatory system.

Activity

See where the circulatory organs are connected by creating a body-sized poster (or reproduce the diagram on page 3 as a sketch in your journal).

1) Trace your body onto a large piece of butcher paper (this can be done in groups — choose one student to draw, one to be sketched, etc.).

2) Draw the major veins and arteries into your “body” on the butcher paper.

3) Draw and cut out the different organs that assist in the cleaning and feeding of your blood and glue these organs onto your drawing. Label each organ with its name and function. (Refer to page 3.)

For a red blood cell like me, one complete round-trip through your body will take, on average...only 30-45 seconds.
More inter\textit{a}ctivities

Make a Blended Image of the Circulatory System

Drawn below are the body’s larger blood vessels: the arteries on the left, the veins on the right. Photocopy the drawings onto thick paper. Cut along the lines and glue the two pieces back to back. Color the arteries red and the veins blue. Attach two rubber bands to the card. Twist the bands and then pull on them. Watch the images blend together to provide you with an overview of the circulatory system.

Vocabulary:

- HEART RATE
- STETHOSCOPE
- CIRCULATORY SYSTEM

Listen to your heartbeat

Build your own stethoscope!

You can make your own stethoscope, too! All you need is a cardboard tube from a paper towel roll.

First, you need to know where your heart is located: 1/3 of it is on the right side of your chest and 2/3 of it is on your left side. That is why your left lung is smaller than your right!

Now, place the tube over a friend’s heart. Listen carefully. Count the number of beats you hear over a 30-second period of time and multiply by two for the number of beats per minute.

Questions to Ponder

What makes my heart beat faster?

Does my heart ever stop working?

When I sleep does my heart sleep too?

How big is my heart?

If you live to be 80 years old, how many times will your heart have beaten?

History: Over 170 years ago, a man named Laennec invented the first stethoscope that made it possible to hear the “lubb-dubb” sound of the heart more effectively. It was a wooden tube about one inch in diameter and about 10 inches long.

A mouse has a heart rate of 500 beats per minute, an elephant about 20 and a blue whale, less than 5 beats per minute! Smaller animals have smaller hearts that beat faster because they use up energy faster.
A rteries take oxygenated blood from the heart out to all areas of the body. The walls of the arteries are too thick for oxygen and nutrients to pass through so arteries lead to smaller vessels called capillaries. The walls of the capillaries are thin enough for red and white blood cells to squeeze through and enter other body tissues. The circulation of blood can easily be observed moving though arteries, capillaries and veins.

Would you believe that the human body has so many blood vessels inside of it that they could encircle the earth once...twice...and then a little bit more? It’s true!

**Further Inquiry:** What effect would you expect epinephrine (adrenaline), nicotine or ethanol to have on the circulation of blood in the fin of a fish?

Add three drops of solution to the fin. The response of the vessels can then be observed. Take note of the observations and discuss the reaction. Is this what you expected?
Make an action picture of the heartbeat cycle.

Instructions:

Cut out a cardboard disc using the pattern outlined on this page.

Bend the tabs upward. Cut out the two strips of the images of the heart on the next page. Glue the strips together to make one long strip, then glue the two ends together into a ring with the images of the heart facing inwards.

Make a tagboard ring of the same pattern as a backing for the strip. Glue the tabs of the disc to the outside of the tagboard ring. Paint the outside of the frame (cardboard disc and tagboard ring) black. Slip the ring of hearts inside the frame. Fix a pin down through the center of the disc into a cork, with a bead on either side of the disc for smooth spinning. Place the cork in a bottle. Stand under a light. Look sideways through the slits. Spin the disc, and watch the heart beat.

Background information for activity: The heart is a dynamic organ. It is located between the lungs. It is held in place by a structure, the pericardium, designed to keep it in position, yet allow it enough movement so that it can beat hard and fast when you are exercising, stressed or frightened. It beats over 100,000 times a day, pumping 1,835 gallons of blood through over 60,000 miles of vessels. The heart has four chambers: two upper chambers called atria and two thicker-walled lower chambers called ventricles. The atria are basically receiving chambers. The ventricles are pumps. Four valves allow blood to move through the heart in only one direction. As your blood circulates, oxygen and nutrients are carried to all parts of your body and harmful wastes are removed.

Viewing information: With your animation of the inside view of the heartbeat cycle, watch the heart relaxing as it refills with blood. Next see both atria contracting, squeezing blood from the atria into the ventricles. Then notice the ventricles start contracting as the valves open and blood is forced into the aorta (carrying oxygenated blood to every part of the body) and pulmonary artery (carrying deoxygenated blood to the lungs). Some other things you might like to try: You hear two sounds (lubb-dubb) when you listen to your heart with a stethoscope. They come from the turbulence in blood flow created by the closing of your heart valves. Mark 1 and 2 on the disc next to the contraction and relaxation phases of the heart cycle, respectively. Borrow, purchase or make a stethoscope, then try spinning the action strip at the same speed as your heart rate. Maybe you’d like to try making your own action strip. How about making some sequential drawings of the flow of electrical impulses through the heart, which cause its regular, rhythmic beating? Or, how about spinning a strip of a recording of the electrical changes that accompany the cardiac cycle, an electrocardiogram (ECG or EKG)?
Change your heart rate

HOW THE PULSE RATE CHANGES

Instruct students to place one hand (palm-side up) on their desks and ask them to count how many times they can open and close their hands for one minute. Their hands should start getting tired after about 45 seconds. The students might start to wonder what they are doing. Be sure they record how many times they opened and closed their hands. Their hands opening and closing represent their beating hearts.

Your heart rate changes as a response to a change in physical, emotional and/or chemical conditions. Has anyone told you a scary story or snuck up behind you and scared the heebie-jeebies out of you? Has too much candy or caffeine ever affected your heart rate? How about running to catch a bus? Many factors can affect your heart rate. In this activity we’ll explore the relationship between exercise and heart rate. You can check your heart rate by locating arteries that lie close to the surface. They can be found in your neck, your wrist, behind your knee, along your ankle and on the top of your foot (see photo on page 3).

Resting pulse rate.

- Have students locate their pulse. (Do not use the thumb.)
- Have them count the beat for 6 seconds.
- Multiply this count by 10 to find the number of beats per minute.

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
</table>
| 1)   | My Resting Heart Rate  
|      | Beats in 6 Seconds x 10 = Beats per Minute |
| 2)   | My Active Heart Rate  
|      | Beats in 6 Seconds x 10 = Beats per Minute |
| 3)   | My Resting Heart Rate 5 minutes after exercising  
|      | Beats in 6 Seconds x 10 = Beats per Minute |

Active pulse rate.

- Jog in place for one minute and take another pulse rate.
- Place index and middle fingers on your wrist or neck. (Do not use your thumb.)
- Hold fingers in place until you feel the steady beating of your pulse.
- Say “go” and have the students count the beats for 6 seconds. Multiply this count by 10 to find the number of beats per minute.
- Have students rest 5 minutes after exercising, then record their heartbeat again.

Why does your heart beat faster while exercising?

To keep the O₂ supply and CO₂ removal equal to the body’s demands.

What other body conditions change?

Your body temperature increases as your heart rate increases; body sweat increases in order to regulate the body temperature.

Questions to ponder

Ellie wants to know...

3) My Resting Heart Rate 5 minutes after exercising = Beats per Minute

Have students: 1) record their resting heart rate; 2) record their active heart rates after exercising; 3) record their heart rate five minutes after they stop exercising. Have students share their data on the board, and then transfer the data from the board onto their own data charts. Each student will create a graph to illustrate averages by age or sex or rates.
The two halves of the heart are separated by a muscular wall called the septum. This wall prevents the flow of blood between the two atria or the two ventricles. The heart pumps blood in two phases. In the systolic phase, the ventricles contract, pumping blood into the arteries. In the diastolic phase, or second phase, the ventricles relax, allowing blood to flow into them from the atria. These two phases of the heartbeat are measured when blood pressure is taken. The valves within the heart are one-way valves. This means that blood can flow into the heart but not back-

Vocabulary: ATRIUM • VENTRICLE • SYSTOLIC • DIASTOLIC • SEPTUM • SPHYGMOMANOMETER

Sphygmomanometer and Stethoscope are used to measure blood pressure.

- Place the cuff of the sphygmomanometer on the bare arm, just above the elbow. You should be able to read the pressure gauge.
- Inflate the cuff by closing the valve on the rubber bulb and squeeze the bulb until the pressure gauge reads 90mm.
- Using the stethoscope, listen for the tapping sound of blood flowing through the artery constricted by the cuff.
- To do this, you must place the stethoscope in your ears and place the bell (the round, cold, silver part of the stethoscope) over the artery in the crook of the elbow.

- Once you have found the sound, you can pump the cut-off to 160mm of pressure.
- Now, open the valve on the bulb just a bit so that the pressure in the cutoff drops SLOWLY. When you begin to hear a faint tapping sound, close the valve and record the amount of pressure on the gauge. This is called systolic pressure.
- Again, with the stethoscope in place, open the valve slightly and close it when you can no longer hear any sounds. Record the amount of pressure indicated on the pressure gauge. This is called diastolic pressure.
- List some of the factors that might account for variations found among classmates.
- Try the same thing when lying down or while your hand is submerged in cold water and record the differences.
"Take a real deep breath. Well, what better place to get oxygen than your lungs, huh? Each time you take a breath, pairs of oxygen atoms called O₂ molecules enter your lungs.

Then they pass through smaller and smaller tubes called bronchi until reaching air sacs called alveoli. These air sacs are covered by thin blood vessels known as capillaries.

And it’s here that the gas exchange takes place. The O₂ molecules pass easily into the blood vessels and bind or attach to our hemoglobin (a red blood cell protein).

Now loaded with this cargo of oxygen, we red blood cells first travel at high speed through the heart, the large aorta artery and other arteries... just like on a freeway.

The faster you move, the faster we red blood cells have to move through the vessels! Your heart pumps faster to provide your body with more oxygen and to get rid of all that carbon dioxide waste faster! I can prove it to you." — Rory

**Activities In This Section**

**Activity:**
How does your blood get rid of carbon dioxide? . . . . . . .12
Capillary gas exchange ...........................................13
INTERACTIVITY

How does your blood get rid of carbon dioxide?

As your cells use food molecules for energy, they produce carbon dioxide as a waste product. Your blood helps keep your cells' environment constant by carrying away this carbon dioxide in the plasma and hemoglobin. But then what? As you know, the blood travels to the lungs where the carbon dioxide can be exhaled.

What affects the amount of carbon dioxide you produce?

For this activity, you'll need a clock with a second hand, a clear plastic cup or a beaker (an Erlenmeyer flask works well if you have it), a drinking straw, and limewater.

- Fill the cup half full of limewater.
- With one end of the straw in the solution, breathe out through the straw, bubbling your exhaled air through the solution.
- Time how long it takes to make a change in the appearance of the solution. What happens?

Carbon dioxide combines with water to make carbonic acid. (The limewater reacts with acids to become cloudy.) Now, do some mild exercise such as jogging in place. With fresh limewater, repeat the procedure. How long does it take for the solution to change? Why is there a difference in the amount of time required for the change to occur?

To make limewater, add calcium hydroxide or calcium oxide to water until no more calcium compound dissolves. Let the solution sit for 24 hours and then pour off the clear solution into a bottle to keep for this activity. The remaining solid can be discarded.
Capillary Gas Exchange

Activity

How do substances move in and out of our blood?

Our blood helps us to maintain a constant internal environment. It carries necessary substances to our body tissues and carries away waste products produced by cells. Most of these substances are dissolved in the blood plasma. Red blood cells are specialized to carry oxygen to the cells. How can molecules move into and out of the plasma and the red blood cells? This happens through a process called diffusion.

Diffusion is the movement of small molecules from an area of high concentration to an area of low concentration...in other words, from where they are packed together, to areas where they are few and far between. Have you ever been in a crowd of people and then wandered out to where there was some room to stretch? In a way, that's what happens in diffusion. But in diffusion, small molecules can pass through the spaces of a cell membrane to get into or out of a cell. When water is the molecule that is diffusing, the process is called osmosis.

You can observe the effects of diffusion by doing the activities described next.

(To make a starch solution, add about one teaspoon of corn starch to one cup of water. Heat this mixture slowly until the starch dissolves and the solution becomes clear. Let this cool before you use it).

Osmosis in an Egg

Put a raw egg with its shell intact into a bowl of vinegar. Let it sit overnight. Gently touch it the next day. What is happening? The vinegar has dissolved the eggshell. When the eggshell has completely dissolved, pour off the vinegar and add water to the bowl. Let the egg sit for a few hours or overnight. (Keep it in the refrigerator.) How has the egg changed? Do you think water moved into or out of the egg? Why?

You can put the egg into other solutions such as corn syrup or salt water. Predict what you think will happen. Will the water move into or out of the egg?

Watching Diffusion through a Membrane

For this activity, you'll need a clear plastic cup or a beaker, 15 cm of dialysis tubing, string, an eyedropper, some starch solution (see directions below-left), and some iodine solution.

Twist one end of the dialysis tubing and then tie it off with some string. Use the eyedropper to fill the tubing with the starch solution to about 5 cm from the top. Twist this end shut and tie it with string as you did before. Rinse off the tubing with water in case any of the starch solution spilled onto the outside. Put the tubing into a clear cup filled with water. Add iodine to the water until it looks yellow. Let the cup sit overnight and observe. Can you explain what happened?
Create a model of a blood cell

Project and Presentation

Instruct students to create a cell out of any medium they like as long as they do not simply draw on a piece of paper. Some may use clay or gel while others will use Legos®, nuts and bolts or even paper maché (these are just suggestions). Whatever is used, remember to do the following:

1) Label the cell type.
2) Label all the cell structures discussed in class.
3) Make sure that the material you use to represent each structure resembles that structure in shape.
4) Write a paper that clearly defines the function of the cell type chosen.
5) Bring the cell to school for presentation on the date indicated below.

Cell Types Circulating in the Blood
1) Erythrocytes (red blood cells);
2) Leukocytes (white blood cells), which include Granulocytes: (Neutrophils, Basophils and Eosinophils); Lymphocytes and Monocytes;
3) Platelets.

Presentation date:

Cell Structures
1) Cell membrane
2) Cytoplasm
3) Nucleus
4) Mitochondria
5) Endoplasmic Reticulum
6) Ribosome
7) Granules
8) Golgi Body or Golgi Complex

Red blood cells, Lymphocyte T cell (green), Monocyte (gold) and Platelets. ©Dennis Kunkel, Ph.D.
It was Karl Landsteiner, in 1901, who first reported that blood had TYPES. By matching these types one could achieve success in blood transfusion. The basis of these types are specific proteins called antigens that are found on the surface of the red blood cells and antibodies found in the plasma.

There are four basic groups:

1) Type A with A antigen on the red cells and anti-B antibodies in the plasma.

2) Type B with B antigen on the red cells and anti-A antibodies in the plasma.

3) Type AB with both A and B antigens on the red cells and neither anti-A nor anti-B in the plasma.

4) Type O with no A or B antigens on the red cells and both anti-A and anti-B antibodies in the plasma.

Antibodies can recognize markers on foreign cells. When the blood of two people mixes during a transfusion, the antibodies will act against any cells bearing the wrong marker. If you are blood type A, you do not carry antibodies against A markers. But you do have antibodies against type B blood. The B persons have antibodies against type A cells. If you are type O, you have antibodies against both type A and B! The antibody reaction that occurs when two different types are mixed causes the foreign red cells to be destroyed (hemolysis). This can lead to kidney damage and death.

Red blood cells also have many other surface markers that can cause hemolytic responses. Unlike the AB substances, which are sugars, most other blood group markers are proteins on the red cell surface. For example, the Rh blood typing is based on the presence or absence of the RhD protein (named because it was first identified in the blood of a Rhesus monkey). Rh+ individuals have blood cells with this marker; Rh- individuals do not. Ordinarily, people do not have antibodies that react against Rh markers, but Rh- people can make them if they are exposed to Rh+ red cells.

As a result, people who receive Rh- blood may be exposed to Rh+ red cells and suffer hemolysis. Because Rh- individuals are relatively rare, Rh+ individuals must be cautious about giving blood. Blood ABO typing is essential for any blood transfusion.

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Any physical characteristics are inherited. Genetic information is transmitted within chromosomes from both parents to their child: twenty-three chromosomes from each.

Blood type is one of those inherited traits. If you look at the parents' genotype (inherited genes) you can determine possible phenotypes (inherited physical traits) of their offspring. Scientists do this using a Punnett square. In the example above, if Mom has the genotype of AA (an A from one parent, and an A from the other), and Dad has the genotype of AO (an A from one parent, and an O from the other), the possible genotypes are AA and AO. However, you can also see that the phenotypes (blood type) are 100% type A since type A (and type B) are dominant over type O. Now you try it! Determine the possible genotypes and phenotypes of the offspring from these two parents: Mom = AO and Dad = BO. [Answer: There are four possible genotypes: (AB, BO, AO, OO), and four possible phenotypes: (AB, B, A, O)].
Mistaken Identity?

COMPATIBILITY: WHO CAN GIVE RED CELLS TO WHOM?

**INTERACTIVITY**

**Who’s who?**

This is an activity that will illustrate which types of blood can be mixed safely, and which can’t. In doing it, your students will determine, “Who is the real Katie Curtis?”

Here is your set-up:

Five beakers marked and containing the following:

<table>
<thead>
<tr>
<th>BLOOD TYPE</th>
<th>COLOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Red</td>
</tr>
<tr>
<td>B</td>
<td>Blue</td>
</tr>
<tr>
<td>AB</td>
<td>Purple</td>
</tr>
<tr>
<td>O</td>
<td>Clear water</td>
</tr>
</tbody>
</table>

Donor (test) — (Katie is type O. The donor is whatever you like.)

Label 5 test tubes: A, B, AB, O and Donor. Fill test tube 1/4 full with labeled blood type.

You will test each donor. Start with type A. Add 15 drops of the donor type to each blood type and on your data chart, indicate if there is a color change or not. Any color change means that the recipient dies, because their blood types are not compatible!

Next, clean out all the test tubes and begin again. Test the donor type B, and then AB, then O. Record all observations.

**SCENARIO:** Last night, after the school dance, Katie Curtis, the Homecoming Queen, was discovered to be missing from the premises. The students and staff were distraught as the local police chief searched desperately trying to find her whereabouts. In the wee hours of the morning, a man stepped forward and claimed to have Katie. He demanded a million dollars in cash for the safe return of the popular and loved Katie Curtis. The ransom was paid and the kidnapper brought a young lady looking very much like Katie to the school. However, friends, family and staff aren’t so sure that this gal is who she says she is! Your job, as scientists, is to determine whether or not this person claiming to be Katie is the real one or an amazingly good imposter. How, you ask, are you supposed to determine this? Clinical tests have proven that only certain types of blood can be mixed safely with other kinds of blood. Your first task is to determine these mixtures. Then you will be given a sample of Katie’s blood, and a sample of blood from the person who claims to be Katie. Your only clue about the real Katie is that she has given red cell transfusions to patients with types A, B and AB blood. Is this young lady the real Katie Curtis or an imposter? Good luck!

**Mistaken Identity?**

COMPATIBILITY: WHO CAN GIVE RED CELLS TO WHOM?

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>AB</th>
<th>O</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
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</tr>
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<td>B</td>
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<td>O</td>
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</tbody>
</table>

**Some questions that students should be able to answer from their data:**

- Which blood type is the universal red cell donor (can give to almost anyone safely)?
- Which type is the universal red cell recipient (can receive from almost anyone safely)?
- Can people with AB blood give red cells to patients with type B? Why?
- Can people with type B blood give red cells to patients with type AB? Why?
- What is the blood type of the released hostage?
- Is this person Katie Curtis? Why do you say this?
- Which type of blood do you think is the most sought-after by blood banks?

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Clotting and Diseases

**BLOOD CLOTTING AND BLEEDING DISORDERS**

If a blood vessel is broken, a chain reaction begins at the site of the injury. First, the nearest platelets, tiny disc shaped cells that float by the billions in the bloodstream, suddenly enlarge and become studded with long, spiny filaments that they use to stick to the site of the injury. These cells send out chemical signals that attract more platelets that join to form a temporary plug. Some of the chemicals also function as vasoconstrictors, which decrease the blood flow to the injured area by narrowing the blood vessels. Meanwhile, a series of proteins floating in the plasma, called clotting factors, start a marvelous cascade of events which cause a strong netting of fibrin strands to appear in exactly the right spot and reinforce the platelet plug. As red blood cells are caught in the fibrin net, the plug turns into a solid clot that stops the bleeding. Most of the clotting factor is absorbed at the site and the rest is carried away and neutralized in the bloodstream so that clotting does not extend beyond the site of damage. Scab tissue comes off the skin surface when repairs have been made. The blood contains natural anticoagulants to dissolve the clots after injuries have healed on the inside.

When people volunteer to donate blood, their blood is checked for sufficient iron levels. This is known as hematocrit testing.

**Simulated Hematocrit Testing Activity:**

**Powder = Platelets**
Corn syrup and red food color = Red Blood Cells
Vegetable oil = Plasma

1) Draw “blood” into capillary tube.
2) Seal end with plug of clay.
3) Place tubes into a borrowed centrifuge and spin at 10,000 RPM for 5 minutes.

**Thrombosis** (blood clots) The body must maintain a balance between too much bleeding and too much clotting. If the blood clots form too easily or land in the wrong place, the result can be blockage of blood vessels or the heart, causing a stroke or heart attack. Every year over half a million Americans die because of clots that stop the flow of blood to the heart, brain or lungs. Most of these lethal clots form when fatty lumps, or plaques, that build up on the artery walls break open, producing a jagged surface. The crack is patched with a clot which blocks blood flow to downstream tissues. Anticoagulant medications are used to dissolve the blood clots to restore circulation. Sometimes surgery is required. Clots can also appear when the blood flows too slowly.

**Polycythemia** Polycythemia is a disorder in which there are an abnormally large number of red blood cells. It is a condition manifested by over-production of red cells, platelets, and in some cases, white cells.

**Hemophilia** (bleeding) People with hemophilia lack a clotting factor. Their blood cannot make a meshwork of fibrin strands to reinforce clots at the site of an injury. Treatment involves transfusions of the appropriate clotting protein. Doctors are investigating the possibility of gene therapy, the insertion of normal genes into patients’ cells, to supply the needed clotting factors.

**Leukemia** Leukemia is a form of cancer of the bone marrow cells that produce white cells. Too many white cells are produced and the leukemic white cells often cannot function properly. The cancer cells crowd out normal bone marrow cells which prevents normal production of red cells, white cells and platelets. Anemia, infections and bleeding problems result. Transfusions, drug therapy and stem cell transplants are treatments for leukemia. Hematocrit testing (see figure at left) is a simple, accurate way to measure the amount of red blood cells in a sample of blood. This measure is useful in diagnosing diseases where you have increased or decreased numbers of cells.

**Anemia** (too few red cells) The production of red cells is normally balanced with the daily loss so that the volume of red cells (the hematocrit) stays between 40 and 45% of the volume of the blood. Anemia can result from either large blood loss due to, for example, injuries, from abnormal breakdown of red cells in the blood (hemolysis), or from decreased production. • The failure of stem cells causes a rare disease known as aplastic anemia. In this disease, neither red cells nor white cells nor platelets are made. Aplastic anemia can be treated by bone marrow or stem cell transplantation. • Genetic abnormalities causing the abnormal production of hemoglobin molecules are responsible for two inherited anemias: thalassemia and sickle cell anemia. • Iron (Fe) is a necessary chemical nutrient in the body. Each day the bone marrow produces about 20 ml of red cells. In order to make the hemoglobin in 1 ml of red cells, roughly 1 mg of Fe is needed. The bone marrow needs 20 mg of Fe a day to make red cells. Most of this is recycled.

(Continued on next page)
from recently destroyed red cells but in order to keep the body's Fe stores adequate, 1-3 mg of Fe must be absorbed from food each day. If one eats a diet poor in iron or has chronic blood loss over many months, the bone marrow iron stores can become depleted. Too little iron then is available to make hemoglobin and anemia results. Iron-deficiency is the commonest cause of anemia worldwide because of dietary deficiencies and small chronic blood loss from parasitic infections. Because of repeated loss of iron during pregnancies and menstrual periods, women tend to have lower iron stores than men and should take more care to include sources of Fe in their diet. • Pernicious anemia is a disease caused by a deficiency of vitamin B12, an essential chemical for DNA metabolism. A lack of vitamin B12 causes defective red cells to be made which die before they are released from the bone marrow. In effect, the production of red cells is too low. • Rarely, an individual may develop antibodies which react with and destroy his or her own red cells. This rapid destruction can lead to severe autoimmune hemolytic anemia. Sometimes, it may be effectively treated by removing the spleen, the organ in which most of the red cells are destroyed, or by giving anti-inflammatory adrenocorticosteroids, which decrease the hemolytic effect of the autoantibodies.

Blood Pathogens Living conditions in the bloodstream are great—plenty to eat, central heating and air conditioning, waste removal, water quality control facilities, and convenient means of transportation. It's worth the trouble to get in and exploit the system. Living creatures take advantage of an opportunity that provides the things they require. They adapt themselves, step by step, to the environmental conditions found or upon a host organism. Microorganisms have devised every means possible to gain entry and evade the body's protection systems. But the host fights back by developing countermeasures just as sophisticated. This biological warfare has had an enormous impact on the course of humanity.

Bacteria Pathogenic bacteria can enter the body through breaks, cuts and abrasions in the skin and mucus membranes. Some bacteria make a substance that dissolves the "cement" that holds the tissue cells together, so the pathogen can penetrate the tissues.

Blood poisoning or septicemia is caused by toxins produced by bacteria in the blood. Pathogenic staphylococci can cause fatal septicemia. Some staphylococci produce a toxin causing the blood to clot. Others make toxins to poison the white cells. Streptococci, causing diseases such as scarlet fever, have capsules to inhibit, or poisons to kill phagocytes.

Some pneumococci camouflage themselves in carbohydrate capsules to escape detection altogether. If they're in the same vicinity, pneumococci, without the gene program for the cloaking device take it and copy it from those that do, and use it themselves.

Viruses Viruses are a major cause of disease. Ultra-microscopic viruses protect themselves by hiding inside living cells. Viruses cannot function or reproduce outside of living cells. Viruses are like a set of blueprints with no factory of their own where their plans can be put into action. Within the host cell the viruses steal supplies and duplicate themselves by using the cells' chemical machinery. Human Immunodeficiency Virus (HIV), the AIDS virus, attacks lymphocytes in the white blood cell group. The body has trouble warding off infection.

The Case of Sickle Cell Anemia
The sickling gene is a good example of genetic resistance. People who inherit a sickling gene have a resistance to malaria, a factor that has appeared to have had survival value in the malaria belt around the world, including parts of Mediterranean, Europe, and subtropical Africa and Asia. Unfortunately, a person who inherits two copies of the sickle gene develops sickle cell anemia. This disease affects millions of people in Africa and other parts of the globe. Because of the shape of the sickled cells, they tend to get stuck in blood vessels. This can cut off blood supply to organs of the body. Sickled cells also rupture easily. The loss of red blood cells reduces the amount of oxygen that can be supplied to the tissues causing extreme pain and damage. People with sickle cell anemia sometimes need transfusions to relieve their symptoms.

Sickle cells (stained green) among healthy red blood cells. © Dennis Kunkel Ph.D.
Parasites have developed boring, biting, piercing and sucking structures to gather the infinite supply of rich, red blood, often spreading disease in the process. The Black Death, or bubonic plague, spread by fleabites, is one of the major calamities of history. Historians say that the plague undoubtedly contributed to the destruction of classical civilization. In the 14th century epidemic, one fourth of the population of Europe was struck down by the plague when rats infested with fleas carrying the plague bacillus swarmed over the continents of the world.

Mosquitoes have developed tiny hypodermic needles to pierce the skin and sip the blood. They even inject an anticoagulant to keep the blood from clotting as they sup. Sometimes when mosquitoes "bite" they spread disease. The parasitic protozoan which causes malaria lives part of its life cycle in the Anopheles mosquito and part of its life cycle in people.

Fighting Blood Pathogens

The body has developed a defense strategy for all types of invasions. White cells such as Neutrophils are always on patrol in the circulatory system. When our body detects toxins produced by bacteria, it produces antitoxins, which neutralize the poisons. Lymphocyte T cells provide an early warning detection system. The warning is sent to a central coding facility (the immune system) by way of T helper cells. T helper cells warn the B cells by providing the structure of the intruders. B cells making the right antibody for use against the invader are then selected. Once the immune cells have fought off a specific microbe, some defender cells called "memory cells" remain on alert just in case the invader tries again. Antibodies and complement proteins work together to tear holes in bacteria, causing them to explode. Cells produce interferons in response to virus infections. Interferons spread to neighboring uninfected cells and make them unusually resistant to virus infections. Interferon stops the virus from hooking up to the cell machinery in the first place. Dying cells signal killer T cells with viral antigens to show they are already infected with virus. Killer T cells then inject a poison destroying the infected cell before fresh viruses can be made.

If our immune system doesn't already know how to fight a blood disease, our minds will search for a way. Understanding the history and nature of diseases often leads to eradication or cures. Sanitary practices, antibiotics, and vaccines have been developed to control bacterial, viral, and protozoan infections.

To safeguard against contamination through transfusions, people with blood diseases cannot donate blood.
Phagocytosis is in action

While there are at least six main types of white blood cells, each with a specialized job in maintaining our defense against intruders, two types of white blood cells, the neutrophils and macrophages (a type of monocyte), have the job of engulfing invaders whole—a process known as phagocytosis. Neutrophils are first at the scene, chomping down on anything that's foreign to our bodies, be it a bacterium or a fragment of a wood splinter. These cells also send out a chemical signal that tells other immune cells there's a problem. The macrophages are "big eaters" just as their name says. They respond to the neutrophils' call for help and swallow microbes such as yeast or bacterial cells. Macrophages continue the immune response in two ways. First, they release chemicals called cytokines that tell the body the invasion is still underway and more defenses are needed. Second, they digest the microbe they've engulfed into smaller pieces and display some of these pieces on their own cell surface. It's as if the macrophages are flashing a big sign that tells other immune cells (the lymphocytes) the identity of the enemy so they can prepare an attack.

Interactivities

You can observe phagocytosis in a single-celled organism called Amoeba proteus. You'll need a culture of Amoeba proteus obtained from a commercial supplier, a microscope, a glass slide, a coverslip, fine beach sand, and an eyedropper. Take a drop of liquid from the bottom of the culture jar and put it on a microscope slide. Place a few grains of sand in the drop and add the coverslip. (The sand will keep the coverslip from crushing the amoeba. You could also use a few cotton fibers from a cottonball instead of the sand.) Adjust the light on the microscope to a low level using the iris diaphragm and view the slide under low power. After you have focused the microscope, slowly move the slide so that you can begin your search for the amoeba. Be patient. The amoeba will be a grayish color. Other debris from the culture will be brown. If you see slow movement, you've found an amoeba! Adjust the microscope to medium and then to high power, focusing on the amoeba at each step. Under high power, you can watch the Amoeba form pseudopods ("false feet") which can reach out to surround an object, just as macrophages do.

For a better view of amoeba in action, you can add fast-moving, single-celled organisms to the amoeba and watch them eat. To do this, add a drop of amoeba to a culture dish. Then add one drop of "amoeba food." If you like, add one drop of 1-% neutral red. (This is a pH indicator that will change color as the food is digested inside the amoeba. Neutral red is yellow-red in a base, bright red in a mild acid, and blue in a strong acid.) Wait 15 minutes and then transfer one drop of the mixture to a depression slide. Add a coverslip and focus carefully as described earlier. If you're lucky, you may see an amoeba engulf and digest its prey. Watch the food vacuole form and note the color changes if you have added neutral red. Macrophages digest foreign microbes in a similar way, using enzymes to chop up invaders into smaller pieces.
Neutrophils are one type of phagocyte that are constantly on patrol in the blood stream. Neutrophils kill and digest microorganisms in a process called phagocytosis. Neutrophils have chemical detectors to sense and lead them to the invaders. This chemical attraction is called chemotaxis. When they make contact with their target, they attack or trap the invader against a rough surface like a blood clot where it can’t escape. Next, the neutrophils surround the invaders with their pseudopods until they are entirely engulfed in little sacs called vesicles. Digestive fluids flow into the vesicles and the invaders are usually destroyed. Vesicles containing undigested material travel to the rim of the cell where they pop and release their contents.

Instructions for flip book:
1) Photocopy the flip book pictures onto thick, white paper. 2) Color the frames boldly using the same color scheme throughout. 3) Cut out the rectangles. 4) Punch holes through the marked dots. 5) Stack the pictures together in numbered order. 6) Bind the pictures together by threading a string through the holes and tying it tightly. 7) Wrap the left hand edge of the book with strapping tape to keep the pages in place. 8) Flick the edges of the frames with your thumb to see the action picture.
The Importance of Blood Donation

“Do you realize that for every 100 people who could give blood, only 5 people actually do?” —The Sticklers

“Did you know that someone needs a blood transfusion every three seconds?” —Alice

Making an Ethical Decision: Becoming a Blood Donor

Through viewing the My Blood, Your Blood Video and incorporating elements of this Teacher’s Guide into your course curriculum, your students have had the opportunity to learn about the vital importance of blood in maintaining life. Unfortunately, due to cancer, diseases of the heart and blood vessels, emergencies, such as car accidents and burns, and other reasons, some people find themselves in a situation where they need and receive blood transfusions. It’s easy to see why donating blood is so essential when the critical importance of blood is understood.

For the sake of their own health and that of others, some people can’t donate blood. If they have been exposed to certain diseases, are in ill health, or don’t have enough blood volume of their own, donating blood isn’t an option. However, many people who could donate blood choose not to. Their reasons include being scared of the donation process, being too busy, and being afraid they will become infected with HIV or hepatitis if they donate. People who donate blood cannot become infected while donating. Donating blood is a safe, sterile procedure.

Increasingly, we have choices to make involving life-sustaining technologies, and the choices we make affect others. It’s natural that after viewing My Blood, Your Blood, your students will have questions about donating blood. Any of them will know people who have needed blood, as well as people who donate blood. This is an opportune time for a class discussion. To have a meaningful discussion, it’s essential that students have some knowledge of blood biology. The purpose of My Blood, Your Blood and this Teacher’s Guide is to help you in providing that information. But, as difficult questions arise and students present conflicting views, it’s helpful to have a process for discussing and examining an ethical issue.

The Hastings Center has developed one model for ethical decision-making which involves six steps: (1) To begin, the ethical problem for discussion is clearly identified. For example, “Should people donate blood?” (2) Relevant facts are gathered. Students might ask, “What are the consequences of giving blood?” and “What happens if people don’t donate blood?” (3) Then, those who will be affected by the decision, the stakeholders, are identified. Depending on the type of decision, these could be individuals (the donor); groups of people, such as those with blood diseases or society in general; and even non-human beings or entities, such as the environment. (4) Also, the values at stake are identified. These could include justice, independence, doing good, and other social principles. (5) Next, students consider and evaluate all the options available to the decision-maker, even those obviously unacceptable. Once this list is constructed, students consider what should be done, evaluating options in terms of the values each option supports. (6) Finally, students reflect upon the decision-making process examining, among other issues, whether the process was fair and whether all those involved were considered (Campbell, 1990).

Depending on the maturity, abilities, and interests of your students, the Hastings Model can be adapted to many age levels and many types of decisions—you know your students best. It may also be valuable to have access to experts who can answer students’ questions about donating blood. Your local blood center and the My Blood, Your Blood web site (www.mybloodyourblood.org) can provide helpful information.

References:

A Role-playing Activity

How Can We Encourage More People to Donate Blood?

After viewing My Blood, Your Blood, your students may enjoy exploring the importance of blood donation from a public policy perspective. In this activity, students role-play different individuals attending a town meeting. The goal of this meeting is to encourage blood donation in the community.

You can expand this scenario and the scope of this activity based on your students’ abilities and interests. They may wish to give the town a name, invite parents and administrators to be present, and even videotape the meeting. Advanced students may develop a public health policy to present, in which they outline a plan to promote education of the community and awareness of the critical need for blood.

To prepare your class for the activity, assign each of the students a role. If you have many students participating, you can assign a role more than once, using different names for different students. They will undoubtedly develop the character in a variety of ways. You may want to ask students to keep their identity a secret. Each student should make a name card with their character’s name and place it in front of them during the town meeting.

Each student should prepare a short speech for the meeting. In this speech, students will describe their character’s knowledge, point of view, and concerns about blood donation. They will state what they think should be done to solve the shortage of blood. They may need to do research to make a convincing proposition.

On the day of the meeting, review the rules for the proceedings. At a minimum, you should ask students to raise their hands when they wish to speak and to respect the teacher as the moderator of the meeting. At times, you may need to call for order. Remind the students that, even though they disagree with someone, they need to remain courteous.

Open the meeting and call on students to deliver their speeches. After everyone has had a turn to speak, each character is free to ask questions of other characters. As moderator you may need to begin this process. When it’s time to draw the meeting to a close, you should ask the class to summarize the suggestions for encouraging blood donation.

After the meeting, allow the students time to de-brief. What did they learn from the simulation? What surprised them about the role-play? Should other characters be heard from? What issues were raised?

Possible Role Descriptions
(Ask students to make up names for their characters, or provide your own.)

• The town mayor
• High school students who have organized a blood drive
• A person with hemophilia
• A parent whose child has sickle cell anemia
• A person who has leukemia
• A representative from the local blood bank
• A person who has heard it’s possible to become infected through blood donations
• A person who has been donating blood regularly for the past 30 years
• A person who required blood transfusions after being in a severe car accident
• The doctor who is director of the blood bank
• A person who had hepatitis when he/she was younger and now volunteers to help at blood drives
• A person who dislikes needles and is afraid of the process of donating blood
• A person who has received an organ transplant
• A person who is very busy with work and family and doesn’t have time to donate
A substance that when introduced into the body stimulates an immune response.

**Antigen** A substance that when introduced into the body stimulates an immune response.

**Antibody** A protein that is made by certain white blood cells (lymphocytes), in the body, in response to the invasion of a foreign substance.

**Aorta** The main trunk of the arterial system, carrying blood from the left ventricle of the heart to any part of the body except the lungs.

**Arteries** Blood vessels that carry blood from the heart to all of the body except the lungs.

**Bacteria** One-celled organisms, spherical, spiral, or rod-shaped and appearing singly, in chains, or in clusters.

**Blood** The fluid that circulates in the principal vascular system of human beings and other vertebrates; in humans consisting of plasma in which red blood cells, white blood cells, and platelets are suspended.

**Bronchi** The main branches of the trachea.

**Capillaries** The tiny blood vessels between the terminations of the arteries and the beginnings of the veins.

**Chemotaxis** Movement of a cell toward or away from a chemical stimulus.

**Cytoplasm** A jellylike material that surrounds the nucleus of a cell and contains most of the cell’s organelles.

**Differentiation** (of cells or tissues) to change from relatively generalized to specialized kinds, during development.

**Erythrocyte** A red blood cell.

**Fibrin** The insoluble protein end product of blood coagulation.

**Germs** Any microorganisms that cause disease.

**Granulocyte** A circulating white blood cell having prominent granules in the cytoplasm and a nucleus of two or more lobes.

**Hemoglobin** The oxygen-carrying protein of red blood cells that gives them their red color and serves to carry oxygen to the tissues.

**Immunity** The condition that permits either natural or acquired resistance to disease.

**Leukocyte** A white blood cell.

**Lymphocyte** A type of white blood cell having a spherical nucleus surrounded by a thin layer of nongranular cytoplasm.

**Megakaryocyte** A large bone marrow cell having a lobulate nucleus (one with lobes); the source of blood platelets.

**Monocyte** A large, circulating white blood cell, formed in bone marrow and in the spleen, that ingests large foreign particles and cell debris.

**Nucleus** The part of the cell that holds genetic information as DNA. Bacterial cells have no nucleus.

**Nutrients** Substances that give sustenance to an organism.

**Organelle** A specialized part of a cell having some specific function.

**Phagocyte** Any cell that ingests and destroys foreign particles.

**Phagocytosis** The ingestion of a smaller cell or a fragment.

**Plasma** The liquid part of blood or lymph, as distinguished from the suspended elements.

**Platelets** Small non-nucleated (having no nucleus) cells which form the first plug to stop bleeding.

**Red Blood Cells** One of the cells of the blood, which, in mammals, are non-nucleated disks concave on both sides, containing hemoglobin and carrying oxygen to the cells and tissues and carbon dioxide back to the respiratory organs.

**Spleen** A highly vascular, glandular, ductless organ, situated in humans at the cardiac end of the stomach, serving chiefly in the formation of mature lymphocytes, in the destruction of worn-out red cells, and as a reservoir for blood.

**Transfusion** The direct transfusing of blood, plasma, or the like into a blood vessel.

**Virus** A tiny object that is composed of RNA or DNA and is surrounded by a protein cap or capsid.

**Vessel** A tube or duct such as an artery or vein, which contains or conveys blood or some other body fluid.

**White Blood Cells** Any of various nearly colorless cells of the immune system that circulate mainly in the blood and lymph.
Resources

Recommended Reading


Kittredge, Mary. Organ Transplants. Chelsea House, 2000


Recommended Web Sites

America’s Blood Centers
www.AmericasBlood.org

My Blood, Your Blood
www.MyBloodYourBlood.org

American Library Association’s Great Web Sites for Kids
www.ala.org/greatsites

Cells Alive
www.cellsalive.com

Center for Disease Control
www.cdc.gov

Dennis Kunkel Microscopy, Inc.
www.denniskunkel.com

Human Anatomy Online
www.innerbody.com

Nobel e-Museum: Play the Blood Typing Game!
www.nobel.se/medicine/educational/index.html

Puget Sound Blood Center’s High School Partnership Program
www.psbhighschool.org

UK’s National Blood Service “Fun Zone”
www.blood.co.uk/pages/bzone.html

Elementary School Teacher’s Guide Credits

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