Section 1: The Circulatory System

Every cell in the body needs food and oxygen to survive. In order to meet the needs of all of these cells, we have a complex system that circulates a versatile fluid, blood, around the body in order to bring cells the nutrients they need to continue doing their various jobs. Without blood the body would be like a land whose inhabitants have no food, water, air, or any means of disposing of waste.

The circulatory system involves the movement of blood from the heart through arteries, capillaries and veins and back to the heart. The circulatory system performs several important jobs. It carries food, water, oxygen and wastes to and from all the cells in the body. The circulatory system includes the heart, blood, arteries, veins and capillaries.

The biggest job the circulatory system does is the transportation of essential elements throughout the body. Nutrients taken from the food you eat, oxygen found in inhaled air, and antibodies and hormones are all carried to the cells in your body by the blood.

The heart pumps this blood through a complex network of vessels to every part of the body. Every living organ tissue and cell are provided with food and oxygen. Waste products, the non-usable things brought into the body, are also taken away from cells to their disposal sites by the blood. The waste products are taken to organs such as the liver, lungs and kidneys. Here, they are treated and expelled from the body.

Fact: The heart beats, circulating all of the blood through the body, more than 100,000 times per day.

Fact: The heart pumps a total of 5,000 to 6,000 quarts of blood through the body each day.

Something To Do

1. If you have 6 quarts of blood in your body how many pints, cups, and tablespoonfuls of blood are in your body?
2. List several important jobs the circulatory system does.
3. The word circulatory is derived from the word circulate. What does circulate mean? What does circuit mean? How do these words relate to the circulatory system?
4. If the heart beats about 100,000 times per day, how many times does it beat per minute?

Section 2: It's Just Blood

People tend to have all sorts of reactions when they see blood, especially when it is their own. Taking a closer look, you will find that blood is an incredible liquid that flows through the body, carrying nutrients and chemicals to all the cells in the body. Blood contains red blood cells, white blood cells, plasma and platelets. About half of blood is a liquid called plasma. The other half is specialized cells (red, white and platelets), all of which perform different roles. Blood plays an important role in every bodily activity. It is the body's main system of transportation; a way to move various elements around to various parts of the body.

Infants are born with less than a quart of blood. An adult has between 6 and 10 quarts of blood. The exact amount of blood depends on body size and weight. The total supply of blood is in the circulatory system. There is, however, a backup supply of red blood cells stored in the liver and spleen that can be released when needed. There are no extra white blood cells, but when the body needs them, it can manufacture them quickly.

Blood performs several important jobs for the body. Some of these jobs are:

1. Red blood cells carry oxygen from the lungs to cells and carbon dioxide from the cells to the lungs where it can be exhaled.
2. Plasma transports antibodies that protect the body from infection.

3. The blood picks up dissolved food from the intestines and carries it to all cells that use it for energy.

4. It takes waste products out of the kidneys for disposal.

5. Blood transports hormones from glands to where they are needed in the body for sending chemical signals to tissues.

6. Clotting factors in the plasma prevent excessive blood loss when blood vessels are damaged.

7. It regulates the water content in tissue cells.

8. It equalizes body temperature by carrying heat from one part of the body to another.

**Something To Do**

1. **Hemat**- is a root word meaning blood. Make a list of other words that have been derived from this root word. Give a definition for each word.

2. List at least four of the main jobs that blood does. Underline a key word (or two) for each thing you list.

3. Press upwards on a fingernail with the thumb on your other hand. Watch your flesh under the nail turn white as you squeeze all the blood from its capillaries. Stop pressing your nail. Watch the original color return as the blood returns.

**Section 3: Oxygen Carriers**

One of the most important elements of blood is the **red blood cells**. These cells are responsible for transporting oxygen to all the cells of the body and taking the waste product, carbon dioxide, from cells to the lungs where the blood cells can exchange carbon dioxide for oxygen and it can be exhaled from the body.

Red blood cells are formed in the marrow of some bones; mainly in the skull, spine, ribs, breastbone, and thighs. Soon after formation they lose their nuclei and become envelopes of **hemoglobin**. Hemoglobin is a protein made partly of **iron**. This is what gives the blood its red color. Hemoglobin combines easily with oxygen, so it is primarily responsible for the transfer of oxygen and carbon dioxide that takes place both in the lungs and in all the cells. Every cell needs oxygen, and red cells are an efficient means for a speedy and safe delivery.

Red blood cells are disk shaped and do not have a nucleus like other cells. Because red blood cells do not have a nucleus, they cannot reproduce like other cells can. The cells live for about 120 days and then they die. During this brief life, a red blood cell will travel about 1,000 miles through the circulatory system. New red blood cells are constantly being produced, however, in the spongy marrow of the larger bones. There are about two million new red blood cells being produced each second to replace the number that die. There are a total of about 5 million red blood cells in each cubic millimeter of blood. They are a thousand times more numerous than the white blood cells. People who live in higher altitudes usually will have more red blood cells. Because the air is thin (therefore contains less oxygen) they need extra red cells in order to get all the oxygen they need.

**Something To Do**

1. Explain why hemoglobin is important.

2. How are red blood cells different from white blood cells?

3. Write an obituary for a red blood cell.

4. Underline five key concepts to remember about red blood cells.
Section 4: To The Rescue

Besides red cells, the other common cell in blood is the **white blood cell**. This cell is the body's defense against infection and poison. There are actually three different kinds of white blood cells (granulocytes, lymphocytes, and monocytes), each with a different job to perform in protecting the body against infection.

White cells are larger, sometimes twice as large as red cells. White cells are not as numerous as red cells, however. For every white blood cell there are between 500 to 1,000 red blood cells. White cells are produced in bone marrow and also in other parts of the body, primarily the lymph system. They have no color and no real shape. They live for only 13 to 20 days. New cells are continually being produced to replace older ones.

White cells may live a shorter life than red cells, but the job they carry out during that lifetime is an extremely vital one. It is the function of a white blood cell to attack harmful bacteria or viruses that enter the body. The bacteria or virus may enter through the air that is breathed in, through a break in the skin, or even from contaminated food and water.

When one of these disease organisms enters the body, white cells bring out their secret weapon, the immune system. Antibodies are quickly produced to combat the virus or bacteria. Antibodies are produced in the lymph system. Lymph vessels spread to almost every part of the body, making a vast network of disease-fighting cells. A body can produce several kinds of antibodies to combat all kinds of diseases. Antibodies fight infection in three ways. They cause the invading organisms to clump together, they quickly latch onto the surface of special white cells called lymphocytes. These cells remember which disease they are designed to destroy, so when this organism enters the body, they multiply and grow rapidly. Once caught, the disease organism is destroyed. The immune system is on alert at all times, its white blood cells ready to fight the germs that can cause the body harm.

Something To Do

1. Underline six key points in the information above.
2. Discover how inoculations make your body immune to specific diseases.
3. Create a comic strip illustrating white blood cells at work. Make a white cell the hero or heroine

Section 5: Plasma Plus Platelets

Without plasma, red and white blood cells could never travel to where they are needed. Plasma is the yellowish liquid in blood that makes cell transportation possible. Plasma is ninety percent water, but suspended in it are blood cells, salts, hormones, vitamins, food nutrients, and proteins. It is constantly changing, gaining and losing chemical substances. Plasma is similar to fluid found in the tissues of the body and around cells in other parts of the body. It accounts for over half of the volume of the blood that flows through the body.

Plasma carries red and white blood cells and also tiny bits of cells called **platelets**. These cell bits have been broken off from larger cells found in the bone marrow. These cell pieces are smaller than the white blood cells and are forty times more numerous than white cells.

A platelet lives for only four to eight days but does an extremely important job. Platelets help blood to clot. They contain a chemical that is released at the site of an injury to assist in the initial stages of blood clotting when blood vessels are damaged. They clump together around a wound on the body's surface, trapping the red and white cells so they cannot escape. The platelets seal the cut while the body begins to repair itself. This seal is called a scab.

Scabs are seen on the surface of the skin. Bruises are the work of platelets doing their job under the skin. The capillaries in the body are injured when you fall or hit something hard. Although your skin was not cut, you still damaged the tissue underneath the skin. The black and blue mark that appears as a bruise indicates that blood vessels beneath the skin have been broken. Platelets go to work, clotting the blood under the skin as well as on the surface. In a sense, a bruise is a scab under the skin.
Something To Do

1. Outline the four components of blood. Provide at least three statements under each heading.

2. Write five questions concerning plasma, platelets, red blood cells and white blood cells.

3. Compose a riddle about each of the four components of your blood.

4. Find the meaning of hemorrhage.

Section 6: Power Pump

Every fine piece of machinery has a main source of power. The power source in your body is your heart. Basically a pump, the heart pushes blood through the body one push after another, day in and day out. It begins to work during the fourth week of fetal development and continues throughout a person's entire life. During the course of a day, it pumps about 2,000 gallons of blood. A newborn baby's heart beats about 140 times a minute. An adult's heart beats 70 to 80 times a minute (or over 100,000 times a day), but this rate can be doubled with heavy exertion or stress.

The heart is located in the middle of the chest between the lungs. It is about the size and shape as a fist and weighs a little less than a pound. It tilts and points slightly over the left side of the body and is surrounded and protected by the ribs and the hard breastbone at the front of the chest. It has a very workable, powerful design that enables it to pump blood throughout the body.

The heart is like a tough, rubber balloon. It is hollow inside, and made out of a thick, sturdy muscle that is able to endure a constant and mighty pumping action. The heart is made of special muscles (cardiac muscles) that keep it working all the time. Most of the body's other muscles get tired after continuous use, but not the heart. A heart muscle will work tirelessly every day and does not need to take a rest except the momentary rest it takes between beats. No other muscle in the body works as hard as the heart muscle. Because it does so much work, it requires about ten times the nourishment of other tissues. It, therefore, requires a large supply of blood for its cells. It uses about 1/20 the body's supply of blood.

The heart has a built in rhythm of contractions. The pacemaker is a small area of specialized nerve tissue in the heart. The pacemaker makes sure that the chambers of the heart work in a coordinated way. It receives messages from the brain and, in turn, sends impulses of electricity through the walls of the heart causing them to contract, and this forces blood out of the heart. It keeps the heart beating at its 70 beats per minute rate. Without the pacemaker, the heart would beat about 40 times per minute. This would not be fast enough to satisfy the body's need for oxygen.

Something To Do

1. Underline the most important facts or concepts in each paragraph. Be prepared to explain why you think these are the most important.

2. Write a physical description of the heart.

3. Why does the heart need a greater amount of nourishment than other muscles?

Section 7: Heart Parts

If your circulatory system is a transportation system, the heart is the powerhouse of that system. The heart is a pump that is designed to circulate blood in a way that allows it to pick up and drop off its cargo in every cell in the body. There are four chambers in the heart and blood flows in a figure-eight pattern with the heart at the center. During one heartbeat oxygenated blood enters the left side of the heart from the lungs and then is sent out to all parts of the body, while deoxygenated blood is received from the body into the right side of the heart and then sent to the lungs so the carbon dioxide can be traded for oxygen.
The heart contains four rooms, or **chambers**. Two of the chambers receive blood, while the other two pump it out into other parts of the body. A thick wall, called the **septum**, divides the heart down the middle. The two top chambers receive the blood that is returning to the heart either from the lungs or the body. They are called the **left atrium** and the **right atrium**. The atria can be thought of as holding chambers where blood is contained before it flows into the two bottom chambers. The right atrium receives blood from the body that contains carbon dioxide, while the left atrium receives blood from the lungs that contains oxygen.

The two bottom chambers are called the **left ventricle** and the **right ventricle**. They are much stronger and more muscular than the two atria on top. The ventricles have a bigger job to do. They pump blood out of the heart. They can be thought of as the pumping centers. The right ventricle pumps blood to the lungs, while the left ventricle pumps blood all over the body.

An important feature that allows the heart to work like a pump and makes sure blood moves in one direction is the valves in the heart. These valves close if blood attempts to move against its proper direction. It is the opening and closing of the valves that makes the lub-dub sound typically associated with the heart.

**Something To Do**

1. Make a diagram that shows the inside of the heart and its four chambers. Label the parts.

2. Make a webbing of facts you have learned about the heart. Place the word heart in the center of your paper. Surround it with facts describing its structure and duties.

3. Choose five terms as answers to questions. Give the terms to a friend who will then invent five questions to go along with the answers.

**Section 8: All Around the Body**

The heart performs a constant and powerful task as it pumps blood through the body's network of blood vessels. To begin the trip, the right ventricle pumps blood to the lungs where it picks up some fresh oxygen and rids itself of the useless carbon dioxide. Next, this oxygen-rich blood enters the left atrium, one of the top chambers of the heart. Then it travels down to the left ventricle, where it is forced out to every part of your body.

After a trip around the body where blood picks up food nutrients in the intestine and carries this food along with the oxygen from the lungs to all the cells where it exchanges the food and oxygen for wastes, blood comes back to the heart. On its return, it is filled with carbon dioxide. It then enters the right atrium and is squeezed through a one-way valve to the right ventricle below where it is pumped to the lungs. At this point it has completed the entire circuit.

The blood keeps moving in this way constantly. It only moves in one direction. It is a one-way system, because it needs to keep the fresh oxygen-carrying blood separate from the blood carrying carbon dioxide. Tiny flaps, or valves, inside the heart and inside the walls of the blood vessels, keep the blood flowing in one direction.

Blood travels from the heart to the lungs, back to the heart, all through the body, and then back to the heart once again. It begins its trip with fresh blood, but by the time it finally returns to the heart, the oxygen has all been used up. So, the trip begins all over again.

The route blood takes as it circulates through the heart is the following:

**Something To Do**

1. If blood travels about 61,320 miles in one year, how far does it travel in one day?
2. Blood travels the same way each trip through your body. Outline this systematic journey and tell what happens at each point. Begin with the blood being pumped to your lungs by the right ventricle.

**Section 9: Blood Vessels**

Just as there are narrow side streets, two-lane roads, and major expressways for our cars to travel on, there are different types of tubes carrying blood to all parts of the body. As blood travels around the body, it travels in three major types of blood vessels called veins, arteries, and capillaries.

On its journey away from the heart, blood travels in major expressways called arteries. These arteries are the largest of the blood vessels. They are built with strong walls to receive and control large amounts of blood being circulated at a powerful pace with every beat of the heart. Blood in the arteries is under high pressure, so they are able to yield slightly with each surge of pressure from each of the heart's contractions. This slight expansion is your pulse.

The largest artery is called the aorta. It is nearly 1 inch in diameter. It runs out of the left ventricle of the heart, travels down the front of the spine, and branches out to supply blood to all parts of the body. It carries most of the blood being pumped away from the heart.

Arteries branch into smaller vessels called arterioles and then into the very smallest tubes, the narrow side streets of your body, called capillaries. The walls of capillaries are only one cell wide. They are incredibly thin; fifty times thinner than a piece of human hair. Capillaries are found all over the body. They comprise a huge network of tiny vessels that find their way to every spot in the body. It is only in these capillaries that oxygen and food can pass through the walls and travel to each cell in the body.

Once the blood in capillaries exchanges oxygen and other materials for carbon dioxide and waste from all of the cells, it drains into venules and then into larger tubes called veins. Veins take blood back to the heart. To make sure the blood continues to flow back to the heart, tiny valves found along the inside walls will close if the blood starts to flow backwards. Veins have thinner walls than arteries and are able to expand and collapse to adjust to different volumes of blood moving through them. The superior vena cava and inferior vena cava are two of the more important veins that return blood from the body back to the heart.

**Blood Route**

heart -> arteries -> capillaries -> veins -> heart -> lung -> heart

**Something To Do**

1. If you took all of the blood vessels in the body and laid them out end to end, they would measure about 60,000 to 70,000 miles. Using various kinds of reference books find three examples of a 60,000 to 70,000 mile distance.

2. Make a list of all the main arteries, veins and valves connected to the heart. Find out more about each one and the role it plays in the circulatory system.

3. Find out about arteriosclerosis and its relation to cholesterol. Tell why this condition is harmful.

**Section 10: Lub-Dub, Lub-Dub**

"Lub-dub, lub-dub, lub-dub." What you are hearing is not your heart beating, but the small valves inside the heart that keep the blood flowing in one direction opening and closing. These valves close after each push of blood. With each push, or beat, of the heart, blood surges through the body's blood vessels. The blood vessels close to your skin's surface enable you to feel this pushing of blood through your body. This is called your pulse.

Pulse rate (the number of times your heart beats per minute) is not the same throughout your whole life. It changes as you change. It becomes slower as you get older. A newborn infant's heart could beat between 110-140 beats per minute. A child's pulse rate ranges from 90-120 beats per minute; and in an adult, it averages around 70 beats per minute. Each heart beat actually has three stages. The first stage is the contraction of the two atria. The second stage is the contraction of the two ventricles, and the last stage is a rest period.
The heart is able to speed up and slow down according to different needs of the body. The autonomic nervous system controls the heart, adjusting the output of blood to different situations. When the body is working hard, so is the heart. An increase in the body's activity causes the heart to beat faster, bringing oxygen and nutrients to the body's cells at a faster pace. When you are doing something like running or jumping, your heart needs to beat faster to send the blood to the muscle cells more quickly. The heart can respond to emotional stimuli the same way it responds to physical exertion. When you are nervous, surprised or scared, your heart may begin to race. This is all done automatically, without you having to think about it.

**Something To Do**

Feel your pulse. Find an artery close to the skin, like at the wrist. Place your fingertips on the inside of the wrist on the side closest to the thumb. Count your pulse (heart beats) for 1 minute while sitting down. This is your resting pulse.

Perform the following activities. Check your pulse for one minute after each activity. Graph the results. Make sure to give yourself some rest or recovery time between each activity. Activities: a) lying down, b) sitting, c) standing, d) running for one minute, e) jumping rope for one minute.

**Section 11: Heart Work**

The heart pumps about 2,500,000,000,000 times during a lifetime. Keeping your heart strong and healthy will keep you strong and healthy too. There are several things you can do to keep your heart healthy; like eating proper foods, getting exercise, and reducing high blood pressure.

Like any muscle, the heart will benefit from exercise. It will become stronger and larger as it is used more often. Most athletes live longer lives than those who chose not to exercise their bodies. By exercising, their hearts became strong enough to do the same amount of pumping work with fewer beats. They are able to spread those 2,500,000,000,000 lifetime pumps over a longer period of time, so they live longer.

Being active is an important way of keeping you and your heart healthy. Here is a list of extremely low pulse rates that trained athletes have achieved. These are resting pulse rates. These show just what exercise can do for a body.

<table>
<thead>
<tr>
<th>athlete</th>
<th>beats per minute</th>
</tr>
</thead>
<tbody>
<tr>
<td>average person</td>
<td>72</td>
</tr>
<tr>
<td>fencer</td>
<td>68</td>
</tr>
<tr>
<td>weight lifter</td>
<td>65</td>
</tr>
<tr>
<td>volleyball player</td>
<td>60</td>
</tr>
<tr>
<td>sprinter</td>
<td>58</td>
</tr>
<tr>
<td>football player</td>
<td>55</td>
</tr>
<tr>
<td>oarsman</td>
<td>50</td>
</tr>
<tr>
<td>swimmer</td>
<td>40</td>
</tr>
<tr>
<td>distance runner</td>
<td>35</td>
</tr>
</tbody>
</table>

In addition to getting adequate exercise, your heart will remain healthy if you restrain from smoking, eat a low fat/low cholesterol diet, and keep your weight within a normal range. True, there are some diseases or conditions that damage the heart that you have no control over, but everyone can provide basic good health for their heart by following the simple, accepted guidelines for diet and exercise.

**Something To Do**
1. In the chart above, you will notice that various sports develop the heart differently. State your hypothesis as to why a weight lifter's heart rate is greater than a swimmer's and a sprinter's heart rate is greater than a long distance runner's.

2. Underline three important concepts in the information above.

3. Give yourself and your family a grade for each of the following factors that contribute to good heart health: a) low fat diet b) no smoking c) normal weight d) exercise. If you did not rate well, make a plan for improvement.

4. Try this experiment to see how much work your heart does. Get a tennis ball and squeeze and release it continuously at the rate of seventy times per minute for as long as you can. Describe what happens.

Focus Page

I. Read the definitions and descriptions in the right column. Find the word in the left column that matches the description in the right column. Write the correct letter on the blank next to each word.

| __1. heart | a. smallest of the body's tubes carrying blood |
| __2. iron | b. do not have a nucleus |
| __3. septum | c. largest artery |
| __4. antibodies | d. pushing of blood through the body |
| __5. capillaries | e. fights foreign organisms and toxins |
| __6. ventricles | f. hemoglobin is composed partly of this mineral |
| __7. aorta | g. two bottom chambers of the heart |
| __8. red blood cells | h. parts of blood that aid in clotting |
| __9. pulse | i. thick wall dividing heart down the middle |
| __10. platelets | j. made of cardiac muscle |

II. Fill in the blanks with one of the words listed below.

Transportation  infection  heart  receive  veins  hemoglobin
Capillaries  supply  valves  needs

1. The heart requires one twentieth of the body's _____ of blood.
2. _____ is the carrier of oxygen in red blood cells.
3. The _____ begins pumping at one month of fetal development.
4. The top two heart chambers _____ blood returning to the heart.
5. _____ take blood back to the heart.
6. The biggest job of the circulatory system does is the _____ of essential elements throughout the body.
7. Oxygen passes through the walls of the _____ and enters the bloodstream to travel to all cells in the body.
8. _____ keep the blood flowing in one direction.
9. White blood cells protect the body against _____.
10. The heart speeds up or slows down according to the _____ of the body.

Put your answers to these questions on a separate piece of paper.

III. Define the following terms.

Chambers  pacemaker  plasma  pulse  blood cells

IV. Answer the following questions in clear, concise sentences.

a. Give three examples of jobs that are performed by the blood in the body.
b. Compare and contrast red and white blood cells.
c. Explain the circulation of blood through the body. Begin at the right ventricle.
d. Identify and define the three different types of blood vessels.
e. Make a list of ideas for keeping your heart strong and healthy.