INTRODUCTION
This Teacher's Guide provides information to help you get the most out of Circulatory System: The Plasma Pipeline. The contents in this guide will allow you to prepare your students before using the program and present follow-up activities to reinforce the program’s key learning points.

This program covers the circulatory system’s important roles in transportation, purification, and regulation. Topics include the structure and function of the heart; the role of blood as a connective tissue; arteries, veins, and the flow of blood; the functions of red blood cells, white blood cells, platelets, and plasma; the lymphatic system; and maintaining a healthy circulatory system.

LEARNING OBJECTIVES
After viewing the program, students will be able to:

- Describe how the circulatory system carries oxygen and vital nutrients to body cells and tissues, rids the body of impurities, and protects it against disease.
- Name the various parts of the circulatory system and explain the function of its parts.
- Understand how the heart operates and the vital role it plays in the cardiovascular system.
- Name and explain the components of the blood and its corresponding functions.
- Compare arteries and veins.
- Understand the purpose of the lymphatic system and its importance to the body.
- Discuss contributing factors to heart disease and ways to prevent it.
- Understand the role of exercise and nutrition in maintaining the circulatory system.

EDUCATIONAL STANDARDS
National Standards
This program correlates with the National Science Education Standards from the National Academy of Sciences, Project 2061 Benchmarks for Science Literacy by the American Association for the Advancement of Science, and the National Health Education Standards: Achieving Health Literacy by the Joint Committee on National Health Education Standards. The content has been aligned with the following educational standards and benchmarks from these organizations.

- Demonstrate the ability to practice health-enhancing behaviors and reduce health risks.
- Comprehend concepts related to health promotion and disease prevention.
- Understand matter, energy, and organization in living systems.
- Understand regulation and behavior.
- Understand structure and function in living systems.
- Understand the cell.
- Understand personal health.
- Understand form and function.
- Understand systems, order, and organization.
- Understand that a system may stay the same because nothing is happening or because things are happening but exactly counterbalance one another.
- Understand that many systems contain feedback mechanisms that serve to keep changes within specified limits.
- Understand that things can change in detail but remain the same in general (the players change, but the team remains; cells are replaced, but the organism remains). Sometimes counterbalancing changes are necessary for a thing to retain its essential constancy in the presence of changing conditions.
Understand that in many physical, biological, and social systems, changes in one direction tend to produce opposing (but somewhat delayed) influences, leading to repetitive cycles of behavior.

Understand that a system usually has some properties that are different from those of its parts, but appear because of the interaction of those parts.

Understand that a system can include processes as well as things.

Understand that thinking about things as systems means looking for how every part relates to others. The output from one part of a system (which can include material, energy, or information) can become the input to other parts. Such feedback can serve to control what goes on in the system as a whole.

Understand that any system is usually connected to other systems, both internally and externally. Thus a system may be thought of as containing subsystems and as being a subsystem of a larger system.

Understand that organs and organ systems are composed of cells and help to provide all cells with basic needs.

Understand that for the body to use food for energy and building materials, the food must first be digested into molecules that are absorbed and transported to cells.

Understand that to burn food for the release of energy stored in it, oxygen must be supplied to cells, and carbon dioxide removed. Lungs take in oxygen for the combustion of food and they eliminate the carbon dioxide produced. The urinary system disposes of dissolved waste molecules, the intestinal tract removes solid wastes, and the skin and lungs rid the body of heat energy. The circulatory system moves all these substances to or from cells where they are needed or produced, responding to changing demands.

Understand that like other animals, human beings have body systems for obtaining and providing energy, defense, reproduction, and the coordination of body functions.

Understand that the amount of food energy (calories) a person requires varies with body weight, age, sex, activity level, and natural body efficiency. Regular exercise is important to maintain a healthy heart/lung system, good muscle tone, and bone strength.

Understand that white blood cells engulf invaders or produce antibodies that attack them or mark them for killing by other white cells. The antibodies produced will remain and can fight off subsequent invaders of the same kind.

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This represents the work of the Joint Committee on National Health Education Standards. Copies of National Health Education Standards: Achieving Health Literacy can be obtained through the American School Health Association, Association for the Advancement of Health Education or the American Cancer Society. Reprinted with permission.

English Language Arts Standards
The activities in this Teacher’s Guide were created in compliance with the following National Standards for the English Language Arts from the National Council of Teachers of English.

Apply knowledge of language structure, language conventions (e.g., spelling and punctuation), media techniques, figurative language, and genre to create, critique, and discuss print and nonprint texts.
Use spoken, written, and visual language to accomplish their own purposes (e.g., for learning, enjoyment, persuasion, and the exchange of information).

Adjust their use of spoken, written, and visual language (e.g., conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes.

Use a variety of technological and information resources (e.g., libraries, databases, computer networks, video) to gather and synthesize information and to create and communicate knowledge.

Employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences for a variety of purposes.

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Technology Standards
The activities in this Teacher’s Guide were created in compliance with the following National Education Technology Standards from the National Education Technology Standards Project.

- Demonstrate a sound understanding of the nature and operation of technology systems.
- Develop positive attitudes toward technology uses that support lifelong learning, collaboration, personal pursuits, and productivity.
- Practice responsible use of technology systems, information, and software. Students use technology to locate, evaluate, and collect information from a variety of sources.
- Develop positive attitudes toward technology uses that support lifelong learning, collaboration, personal pursuits, and productivity.

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PROGRAM OVERVIEW
This program investigates how the circulatory system acts as a purification plant, cleansing the body of impurities and protecting it against disease. The heart and blood as two prominent components of the circulatory system are presented in detail, along with input from leading professionals about contributing factors in heart disease.

MAIN TOPICS
Topic 1: What is the Circulatory System?
This section provides an introduction to the overall purpose of the circulatory system and the organs involved in the process of circulation. Specific emphasis is on the heart, its responsibilities, and components. The two types of circulation are also mentioned.

Topic 2: Blood and Blood Vessels
A description is provided of the blood, its components, and purpose. The types of blood vessels are named and described.

Topic 3: Contents of the Blood
This section discusses in more detail the properties of blood. Information on red blood cells, white blood cells, plasma, and platelets is presented. The role of blood in the regulation of body temperature is introduced.
**Topic 4: Lymphatic System**
The lymphatic system’s purpose in protecting the body against disease is the focal point of this section, along with information pertaining to the job of the lymph nodes and other organs of the lymphatic system.

**Topic 5: Maintaining Your Health**
The final section of the video emphasizes exercise as a critical component in maintaining the health of the circulatory system. Professionals present data on cholesterol, hypertension, and heart disease.

**FAST FACTS**
- Your circulatory system is made up of your cardiovascular system and your lymphatic system.
- The human body contains 93,000 miles of blood vessels. It is up to the heart muscle to get adequate blood supply through all those miles.
- The heart beats 70 times a minute in a typical person. Over the course of a day the heart has over 100,000 beats and pumps 3600 gallons of blood a day.
- The heart only weighs 11 ounces and is no bigger than the size of your fist.
- If tissues don’t get enough oxygen they will die.
- Your heart is divided into two sides and four chambers. The upper two chambers are the right and left atrium and the lower two chambers are the right and left ventricle.
- When you exert yourself, the powerful heartbeat you hear is actually the heart’s chambers contracting and pumping blood. They contract, then rest, then contract again in an attempt to move blood through the chambers and out to the body again.
- Your pulse beats once about every 8/10 of a second, or 75 times per minute.
- Your heart’s contractions pump the body’s six quarts of blood through its blood vessels over 1000 times a day. This totals 6,000 quarts of blood per day.
- Blood flows through arteries into smaller vessels called arterioles, and then into even smaller vessels called capillaries before heading toward the body’s cells.
- Through the walls of the capillaries, substances are exchanged between blood and body tissues.
- Before leaving the body’s tissues, groups of capillaries join to form small vessels called venules, which then merge to form veins.
- Blood makes up about 8% of our total body weight. Its volume is about 5 to 6 quarts in healthy adults.
- In adults, the manufacturing of the cells occurs in the red bone marrow in the sternum, ribs, vertebrae and pelvis, and in lymphoid tissue, which is found throughout the body.
- Blood plays a key role in regulation of normal body temperature because it contains such a large volume of water, which acts as a heat absorber and coolant.
- The four main blood types are A, B, O, and AB.
- Hemoglobin binds with oxygen in the red blood cells to give blood its red color.
- As lymph is transported to the heart it is filtered through a network of thousands of lymph nodes where bacteria, viruses, and other foreign materials are destroyed in the lymph before it is returned to the blood.
- The most important thing you can do to help keep your circulatory system healthy is to develop a regular exercise program. A cardiovascular workout will help reduce the oxygen need of skeletal muscles, decrease blood pressure, and help reduce the build-up of cholesterol on the walls of arteries.
- Hypertension is the most common form of heart disease today. One out of every five Americans is affected with this condition.
- Some associated risk factors for heart disease include obesity, lack of exercise, and formation of plaque in arteries.
**VOCABULARY TERMS**

**arteries:** Blood vessels that carry blood away from the heart under relatively high pressure; have thick elastic walls that allow them to dilate and contract to regulate blood flow.

**atrial ventricular (AV) valves:** Valves located between the atria and ventricle. They prevent backflow of blood into the atria.

**blood:** A bodily connective tissue that is unique because it is the only fluid tissue; made up of cells, platelets, and plasma.

**blood vessels:** Network of tubes which carry blood back and forth between the heart and organ tissues.

**capillaries:** Smallest blood vessels in the body responsible for transporting nutrients to and from the cells.

**cardiovascular system:** The part of the circulatory system responsible for the direct transportation of oxygen, nutrients, and waste products. It is made up of the heart, blood, and blood vessels.

**circulatory system:** The body system responsible for transporting oxygen and nutrients to body cells, tissues, and organs, and for carrying waste products away after it processes those substances. It is made up of the cardiovascular system and the lymphatic system.

**coagulation:** The blood clotting process.

**diastole:** State of the heart at rest.

**heart:** A hollow muscular organ that by rhythmic contractions and relaxations keeps the blood circulating throughout the body.

**hematopoiesis:** The process by which blood cells are formed in the red bone marrow of the body.

**lymph:** A clear yellowish, slightly alkaline fluid, containing white blood cells in a liquid resembling blood plasma that is derived from the tissues of the body and conveyed to the bloodstream by the lymphatic vessels.

**lymphatic system:** The part of the circulatory system responsible for battling disease and infection. Its function is to make sure that no organs become overrun with bacteria or viruses, which can cause destruction of organs and lead to death.

**lymph nodes:** Any of the gland-like masses of tissue in the lymphatic vessels containing cells that become lymphocytes. An area where bacteria, viruses, and other foreign material are destroyed in the lymph before it is returned to the blood.

**pericardium:** A loose fitting membrane which surrounds and protects the heart.

**Peyers patches:** Tissue areas that destroy bacteria in the small intestine; similar to the tonsils in function.

**plasma:** The liquid portion of blood, which doesn’t contain red blood cells. It is the straw colored liquid that remains after the living cells are removed from the blood. Its role is the transportation of red and white blood cells and platelets; also helps distribute heat throughout the body.

**platelets:** Known as thrombocytes, their main function is to prevent blood loss by initiating a chain reaction that results in clotting.

**pulmonary circulation:** The process by which oxygen-poor blood from the veins is pumped out through the pulmonary artery to the lungs, where the blood picks up oxygen and toxic carbon dioxide is unloaded. The pulmonary veins then return the blood back to the left side of the heart.

**pulse:** The alternating expansion and relaxation of the heart, which sends a pressure wave through the entire arterial system.

**red blood cells:** Known as erythrocytes, their main function is the transportation of oxygen to body cells and tissue, and of carbon dioxide back to the respiratory organs; contain hemoglobin.

**spleen:** A blood-rich organ, located on the left side of the abdominal cavity, which cleanses the blood and helps supply blood to the circulatory system in the case of a hemorrhage.

**systole:** State of the heart when it is pumping blood.
thymus: Produces hormones critical to the protective function and performance of the lymphocytes.
tonsils: Small masses of lymphatic tissue, located in the pharynx, which are responsible for trapping and removing bacteria that enters the throat.
veins: Blood vessels that carry blood from tissues toward the heart under relatively low pressure; blood vessel walls are thinner than arteries.
white blood cells: Known as leukocytes, their main function is to combat toxic microbes which have entered the body, and to fight cancer.

**PRE-PROGRAM DISCUSSION QUESTIONS**
1. How do oxygen and important nutrients reach the organs and tissues of your body?
2. In what ways does the circulatory system act as a purification facility?
3. What makes blood different from the other tissues of the body?
4. How are the circulatory system and respiratory system related?
5. Why does your heart beat faster after exercise?

**POST-PROGRAM DISCUSSION QUESTIONS**
1. What causes high blood pressure? Why is this condition dangerous?
2. What are some ways you could lower your blood pressure?
3. How do you think the American diet contributes to problems with cholesterol, high blood pressure, and heart disease? In terms of health, how do we compare with other countries?
4. Have you ever given blood? Describe your experience. If you haven’t given blood, what has stopped you from doing so? Would you consider giving blood in the future?
5. The heart is one of our most vital organs. What are your thoughts on organ donations? Is it something you would ever consider? Why or why not?
6. How would you expect the heart rate of an athlete to compare with that of a person in average physical condition? Would it be higher, lower, or the same? Explain your answer.

**GROUP ACTIVITIES**

**The Beating Heart**
Ask the school nurse to visit the class and demonstrate how blood pressure and pulse are measured. Students should then demonstrate their knowledge by taking each other’s blood pressure and pulse in order to compare the resting heart rate to the working heart rate. Students should take their first pulse reading immediately following the nurse’s demonstration. Then each student should jog in place for 3 minutes and take their pulse again. Why does pulse rate increase as the activity level increases?

**School Blood Drive**
Organize a school-wide blood drive. Begin by contacting a local organization, such as the American Red Cross, to arrange for the blood drive, then set a date and create a list of tasks. Work in small groups to accomplish the tasks related to the blood drive. Students may be responsible for organizing volunteers to assist in the blood drive, and advertising the blood drive. Have students brainstorm a list of ideas about how to accomplish their task before starting this project. The following web site may prove helpful: www.redcross.org/donate/give
INDIVIDUAL STUDENT PROJECTS
The Circulation Department
Write a fictional story or article for a class of younger students to explain some aspect of the circulatory system. Facts may be related to function of the circulatory system as a whole, or to more specific information related to the heart, blood, or lymphatic system. Be sure your fictional story has a clear storyline including a beginning, middle, and end, and include illustrations, sketches of the characters, and diagrams. If possible, arrange to “circulate” your story among a group of younger students.

The Heart in Culture
The heart is one of our body’s most vital organs. Our organs would start to shut down within minutes if the heart stopped beating. Throughout history, in both fiction and nonfiction contexts, the physical, emotional, and psychological workings of the awesome heart have been explored. Use the Internet or library resources to discover interesting ways in which the heart serves as a central component of a culture’s beliefs, traditions, celebrations, or ceremonies. Write a one to two page paper to present your findings.

INTERNET ACTIVITIES
Who Is at Risk?
Design a visual aid (chart, diagram, table), which compares different populations and their risk of heart disease. Comparisons can be made by gender, age, and race. Which population(s) has a greater risk of heart disease? What factors contribute to higher risk? Are men or women more likely to suffer from heart disease? Does the age of onset differ according to gender or race? What studies have been are being done related to heart disease? After compiling your data, use the information to draw conclusions. The following website may be useful in your research: The American Heart Association: www.americanheart.org

ASSESSMENT QUESTIONS
Q: What are the two subsystems of the circulatory system?
A: The cardiovascular system and the lymphatic system
Feedback: The cardiovascular system is made up of the heart, blood, and blood vessels. Its main function is the transportation of nutrients, oxygen, and waste products. The lymphatic system assists the body in fighting bacteria and viruses which can cause disease, and destruction of the organs.

Q: Why is the heart such an important component of the circulatory system?
A: It is up to the heart muscle to get an adequate blood supply through the many miles of blood vessels. The blood carries the oxygen and nutrients the body needs to survive.
Feedback: The heart, while only weighing 11 ounces, is a tremendously strong muscle. Over the course of a day, it beats over 100,000 times and pumps 6,000 gallons of blood.

Q: Your heart is divided into ____ sides and ____ chambers.
A: 2; 4
Feedback: The upper two chambers are the right and left atrium, and the lower two chambers are the right and left ventricle. A thick muscular wall called the septum divides the two sides.

Q: Describe the journey of the blood as it passes through the heart.
A: Returning from the body via veins, blood enters the heart through the right atrium. It goes to the right ventricle, which pumps it on to the lung, where it accumulates oxygen. Afterwards, it returns to the heart through the left atrium and then moves on to the left ventricle. The
blood accumulates in the left ventricle, then gets pumped back out to the rest of the body, supplied with oxygen and nutrients.

Feedback: Though the heart is a single organ, it works as a double pump. During each heart-beat, each heart chamber relaxes as it fills and then contracts as it pumps blood. The two atria relax together and contract together, and the two ventricles relax together and contract together.

Q: Arteries carry blood to the heart under high pressure. Veins carry blood away the heart under relatively low pressure. (True or False)
A: False
Feedback: Arteries carry blood away from the heart under high pressure. Veins carry blood toward the heart under relatively low pressure.

Q: The components of blood do not include ________________.
(a) platelets
(b) plasma
(c) pericardium
(d) red and white blood cells
A: (c)
Feedback: The pericardium is a loose-fitting membrane that surrounds and protects your heart.

Q: Why is plasma an important component of our blood?
A: Plasma’s primary role is to transport the cells that make up its connective tissue. These cells are the red blood cells, white blood cells, and platelets. Plasma is 90% water, and contains over 100 dissolved substances including salts, hormones, fats, sugar, and proteins. Plasma also helps distribute heat evenly throughout the body.
Feedback: Plasma is the straw-colored liquid that remains after the living cells are removed from the blood.

Q: Name some important components of the lymphatic system.
A: Lymph nodes, spleen, tonsils, Peter patches, and thymus
Feedback: The lymphatic system works with the circulatory system to protect our bodies from bacteria, viruses, and other foreign materials.

Q: How does the lymphatic system protect our bodies against disease?
A: The lymphatic system acts as a purification system for the circulatory system by removing impurities found in the blood. It is imperative to the body’s immune system.
Feedback: The lymphatic system is set up as a one-way vascular system. Most of the lymphatic vessels have valves like those in the veins to keep the lymph flowing in the right direction, toward two large lymph ducts located in the neck. These lymph ducts empty the lymph back into the blood through the veins.

Q: Obesity, lack of exercise, and formation of plaque in arteries are all ________________.
(a) caused by low blood pressure
(b) associated risk factors for heart disease
(c) associated risk factors for secondary hypertension
(d) all of the above
A: (b)
Feedback: Secondary hypertension is a genetic condition that can be traced to particular sources like adrenal tumors, kidney disease, or thyroid disease. High blood pressure is the source of many medical problems. Diet, exercise, and medication will help to lower blood pressure.
ADDITIONAL RESOURCES

WEB SITES

The American Heart Association
www.americanheart.org

MEDtropolis: Virtual Body
www.medtropolis.com/VBody.asp

NOVA Online—Electric Heart
www.pbs.org/wgbh/nova/eheart/human.html

The Franklin Institute Online: The Heart: An Exploration
http://sln.fi.edu/biosci/heart.html

BOOKS


OTHER PRODUCTS

Circulatory, Respiratory, Digestive, and Urinary Systems, CD-ROM, Cambridge Educational
This program helps students understand that the human organism has systems dedicated to specific body functions. After completing Part 1 of the CD-ROM series, students will understand the functions of the circulatory, respiratory, digestive, and excretory systems of the human body. In addition, they are introduced to how these systems interact with one another, and how each system is important to a person’s overall health.
Order #: 32696, www.cambridgeeducational.com, 1-800-468-4227

Systems of the Body Poster Set, Cambridge Educational
Simply indispensable in the classroom, this set of ten posters vividly depicts and describes the human body’s major systems. Each poster features inset illustrations providing highly detailed looks at key organs and system components, along with “neat-to-know” supplementary facts.
Order #: 33021, www.cambridgeeducational.com, 1-800-468-4227
Circulatory System (Sparkcharts), Teaching Chart, Spark Publishing
This two-page chart includes diagrams of the arterial and venous systems, the right and left ventricles, blood flow in the heart, coronary and superior/inferior mesenteric arteries, portal vein system and celiac trunk, and Circle of Willis.
Order #: 1586636553, www.BarnesandNoble.com

Human Heart Video and Poster Series, VHS/DVD, Poster, Jaguar Educational
This fascinating journey into the human heart features state-of-the-art 3D animation vividly illustrating the heart’s basic structure and function. Succinct and well organized, the video combines easy-to-follow narrative with dynamic imagery. Physicians and other health experts discuss the mechanics of the heart and explain how nutrition, exercise, and smoking affect this vital muscle.
1-800-776-8093