BLOOD

Teacher’s Guide
Blood

catalog #2228

Teacher’s Guide

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BLOOD
Viewing Time: 22 minutes

PROGRAM SUMMARY

This program, designed for 8-12th grade students, examines and compares the four major components of blood: plasma, red blood cells, white blood cells, and platelets, and shows how they all work together to form a liquid connective tissue that sustains animal life.

The following information is presented:

• PLASMA: The role of electrolytes; the role of plasma proteins; nutrient absorption and transport; waste transport; hormone transport; cholesterol and atherosclerosis.

• RED BLOOD CELLS: Their role as transporters of oxygen and carbon dioxide; the method of exchange of respiratory gases in the lungs; cell respiration (compared to combustion); the role of hemoglobin; anemia (iron deficiency); sickle cell anemia.

• WHITE BLOOD CELLS: The role of phagocytic white cells in the immune system; B-cell lymphocytes; T-cell lymphocytes; antibodies; antigens; vaccines; AIDS and the destruction of the immune system by HIV infection; lymph and the lymphatic system.

• PLATELETS: Their role in the process of blood clotting.

For your teaching convenience, a script of the video narration is provided in this Teacher’s Guide beginning on page 13.
STUDENT OBJECTIVES

After viewing this video and participating in the lesson activities, students should be able to:

• Summarize the roles of the four major components of blood: plasma, red blood cells, white blood cells, platelets.

• Explain several different ways that blood functions as a connective tissue.

• Compare the process of respiration we call "breathing" with the process of cell respiration.

• Compare cell respiration and combustion.

• Explain how the different types of white blood cells presented in this program function in the immune system.

• Describe how HIV creates the disease called AIDS.

• Compare blood and lymph.

SUGGESTED LESSON GUIDE

TEACHER PREPARATION

Before presenting this lesson to your students, we suggest that you preview the video and review this guide and the accompanying blackline masters in order to become familiar with their content. Duplicate the blackline masters you intend to use. See page 3 for a description of the blackline masters. An answer key is provided on page 6.

As you review the instructional program outlined in this guide and the accompanying blackline masters, you may find it necessary to make some changes, additions, or deletions to meet the specific needs of your class. We encourage you to do so, for only by tailoring this pro-
gram to your students will they obtain the maximum instructional benefits afforded by the material.

It is also suggested that the video presentation take place before the entire group under your supervision. The lesson activities grow out of the content of the video; therefore, the presentation should be a common experience for all students.

**Materials Needed**

1. Make arrangements to have a VHS player and television set available for use at the time and place selected for viewing.

2. To enhance and complement this video lesson most effectively, set up microscopes and obtain from school collections or purchase slides to demonstrate typical human blood, sickle cell anemia blood, leukemic blood, and a lymph node. You may wish to retain these slides for student use after viewing the video. See Follow-Up Activities on page 5.

**Blackline Master Descriptions**

*(An Answer Key for those Blackline Masters that require answers begins on page 6.)*

**Blackline Masters 1, 2, & 3, Vocabulary List,** is a list of words used in the video and their definitions. This list can be distributed to the class before the video presentation so students can better understand the terms presented. This list should be retained by students for reference. The list has also been included in this Teacher’s Guide beginning on page 8.

**Blackline Master 4, Crossword Puzzle,** allows students to use some of the terms introduced in the video lesson. It can be used as an in-class activity or as a take-home assignment.

**Blackline Masters 5 and 6, Sickle Cell Anemia,** are fact sheets on this often deadly disease. Students are to answer the questions after studying this information.
Blackline Masters 7 and 8, The Components of Blood, show the components of blood and their major functions. Have students complete the matching exercise to test their knowledge of this material.

Blackline Master 9 is the Lesson Quiz for this video presentation.

**INTRODUCING THE VIDEO**

Talk about blood in general: only animals have blood and, even at that, several of the lower animal phyla lack blood. Describe their strategies for survival without blood.

Describe human blood and outline its critical role in sustaining life. Describe its function as a liquid connective tissue.

Describe how blood cells are produced in the bone marrow (and in the lymph nodes) and how old blood cells are removed from the circulatory system.

**Did You Know...**

Guide your students in their viewing of the video by pointing out some of the interesting facts presented in this video lesson...

- Did You Know that blood has four basic ingredients?
- Did You Know that plasma is 92% water?
- Did You Know that the chemical compound cholesterol is an ingredient of plasma?
- Did You Know that the average human body contains 4 to 5 liters of blood plasma?
- Did You Know some white blood cells eat other cells?
- Did You Know that red blood cells are basically all the same size?
- Did You Know platelets are crucial to the process of blood clotting?
- Did You Know that sickle cell anemia affects over 70,000 African-Americans?
- Did You Know that blood is red and metallic tasting due to the unique protein molecule hemoglobin?
Before starting the video, distribute the blackline masters you have chosen to use.

**VIDEO PRESENTATION**
The viewing time is 22 minutes.

**FOLLOW-UP ACTIVITIES**

**Discussion:**
Ask for questions and comments, then discuss some of the health issues brought up in the program:

- **Cholesterol:** What does the American Heart Association have to say about the intake of fats, dietary cholesterol, and exercise in preventing cholesterol build-up in the blood vessels? Discuss the mechanisms of heart disease.

- Discuss the mechanism of the genetic disease called sickle cell anemia. Contrast it to the form of anemia that results from lack of iron in the diet.

- Discuss HIV infection and the destruction of the immune system (The progression of AIDS is typically followed by keeping track of declining T-Cell counts). Outline the stages of AIDS and the kinds of infections from which AIDS victims suffer. Discuss AIDS prevention.

**Demonstrations:**
To reinforce the information presented in the video, you may wish to involve your students in one or more of the following activities using the slides listed under Materials Needed on page 3:

- Examine slides of normal blood smears and compare to slides from victims of sickle cell anemia and leukemia. Have students chart the differences and present their findings to the class.

- Identify red blood cells, phagocytic white cells (such as monocytes), lymphocytes and platelets. Look at a slide of a cross section of a lymph node and find the lymph vessels and lymphocytes. Have students illustrate their observations.
• Examine the living phagocytic white cells that are usually visible at high power in samples of plaque taken from teeth (near the gumline). Have students record their findings.

Projects:
• Students could be assigned the task of scanning newspapers or magazines to find articles on new discoveries relating to AIDS, leukemia, sickle cell anemia, treatment of hypercholesterolemia, and any other subjects related to blood and its diseases. Written or oral reports could be completed on their findings.

• Students could be assigned written or oral reports comparing the characteristics of blood from earthworms, mollusks, insects, amphibians, birds, reptiles and mammals.

• Students could make posters depicting the changes that occur in the body during an immune response. Likewise, students could create posters showing how HIV attacks the immune system.

BLACKLINE MASTER ANSWER KEY

Blackline Master 4, Crossword Puzzle

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Blackline Master 6, Sickle Cell Anemia
1. True
2. 18%
3. 8.04%
4. 92%
5. False- A child needs to receive the defective sickle cell gene from each parent in order to get sickle cell anemia; a child receiving only one sickle cell gene will possess resistance to the disease of malaria.

Blackline Master 8, Components of Blood
1. G
2. C
3. F
4. H
5. J
6. B
7. A
8. E
9. D
10. I

Blackline Master 9, Lesson Quiz
Fill in the blanks:
1. oxygen and carbon dioxide
2. hemoglobin
3. plasma or blood plasma
4. white blood cells
5. fibrinogen, platelets or thrombocytes
6. phagocytosis
7. lymphocytes
8. thymus
9. antibodies
10. antigens

True or False:
1. False-Hormones are transported in the blood by plasma.
2. True
3. True
4. False- Persons with anemia suffer from too little oxygen in the blood.
5. True
6. True
7. False- There is no known vaccine for the HIV virus.
8. True
9. False-The HIV virus attacks the white blood cells.
10. True

**VOCABULARY LIST**

**ADRENAL GLANDS** Endocrine glands located on the top of each kidney that release the hormone called adrenalin.

**AIDS** An abbreviation for the disease called "Acquired Immune Deficiency Syndrome." This deadly disease, caused by the Human Immunodeficiency Virus or HIV, destroys the body's immune system.

**ALVEOLI** The tiny sacs in the lungs where the exchange of gases takes place between the blood and the air.

**ANEMIA** An illness marked by a reduction in the number of red blood cells or of properly functioning hemoglobin in the blood.

**ANTIBODIES** Immunoglobin proteins that clump onto particular antigens in the process of fighting infectious diseases.

**ANTIGEN** A large foreign molecule, usually on the surface of a virus, that results in an “immune response,” i.e., the production of antibodies by B-cell lymphocytes.

**ANTIGEN: ANTIBODY COMPLEX** A highly specific clumping reaction between a certain antigen and the specific antibody for that antigen.
ARTERY  A thick-walled blood vessel that carries blood away from the heart.

ATHEROSCLEROSIS  A thickening of the blood vessel walls due to a build-up of cholesterol.

B-CELLS  A type of lymphocyte that produces the immunoglobin proteins called antibodies.

BLOOD GROUPS  Designated A, B, AB, and O, these blood groups indicate which antigens are present on the surface of the red blood cells. Blood group A has only A antigens, group B only B antigens, group AB has both A and B antigens, whereas group O has neither A or B antigens. The presence of these antigens means a person with type B blood cannot receive blood from a type A donor and vice-versa. Type AB individuals can receive blood from all the other blood groups, but people with type O blood can only receive blood from type O donors.

BLOOD PLASMA  The liquid matrix of blood.

CAPILLARIES  Very small thin-walled blood vessels.

CELL RESPIRATION  The oxygen consuming process used by cells to release energy from carbohydrate molecules.

CHOLESTEROL  A chemical component of blood plasma that is employed in making cell membranes and certain hormones. Cholesterol can build up inside blood vessels causing partial or total blockage--a condition known as atherosclerosis.

CLOTTING FACTORS  Chemicals produced by the platelets following an injury that cause the plasma protein fibrinogen to be converted into the threads of fibrin. Fibrin threads then help form a blood clot.

COMBUSTION  A chemical oxidation process that occurs when wood is burned which is similar to cell respiration, because carbohydrates and oxygen are consumed and carbon dioxide, water, and energy are produced.
ELECTROLYTE  A general name for the inorganic salts present in the blood stream. Electrolytes and water must be properly balanced for blood cells to remain intact and healthy.

ENDOCRINE GLANDS  Special organs that release hormones directly into the blood stream; also called the "ductless glands."

ERYTHROCYTES  Red blood cells.

FIBRIN  A substance formed from the plasma protein called fibrinogen that traps red blood cells to form a blood clot and then dries to form a scab.

FIBRINOGEN  The plasma protein that forms the blood clotting substance called fibrin.

HELPER T-CELLS  T-cell lymphocytes that cause B-cells to multiply and to make more antibodies.

HEMOGLOBIN  An iron-containing protein molecule found in great abundance in red blood cells that binds oxygen and carbon dioxide.

HIV  An abbreviation for "Human Immunodeficiency Virus." This virus attacks the immune system, resulting in the disease known as AIDS.

HORMONES  Chemical messenger molecules produced by the endocrine glands.

HYPERTENSION  High blood pressure.

INFECTIOUS DISEASE  A disease caused by viruses or by living organisms, such as bacteria, protozoa, or fungi.

IMMUNE RESPONSE  The body’s response to an infection, especially the production of antibodies by B-cell lymphocytes.

IMMUNE SYSTEM  The system of defense against infectious diseases that is based on the white blood cells.
IMMUNITY  A person is said to have an "immunity" to a particular illness if he or she can no longer catch that illness.

IMMUNOGLOBINS  Antibody proteins used in fighting infectious diseases.

KILLER T-CELL  A type of T-cell lymphocyte that destroys infectious organisms on contact.

LEUCOCYTES  Another name for white blood cells.

LEUKEMIA  A form of cancer of the blood in which many more white blood cells are produced than is healthy for the body.

LYMPH  A pale-colored liquid that circulates through the vessels of the lymphatic system and contains all the components of blood except red blood cells. In particular, lymph contain huge numbers of lymphocytes and, as a result, is a very important component of the body’s system of defense against infectious diseases.

LYMPH NODES  Swellings of lymphatic tissue that filter the lymph and produce lymphocytes.

LYMPHOCYTES  Non-phagocytic white blood cells that are also the predominant cells present in lymph.

MEMORY CELLS  Lymphocytes that enable the immune system to combat that same antigen more effectively during future infections.

MITOCHONDRIA  The subcellular organelles where cellular respiration occurs.

PHAGOCYTIC WHITE BLOOD CELLS  A class of white blood cells that eat viruses and bacteria.

PHAGOCYTOSIS  The process of "cell eating."
PITUITARY GLAND  An endocrine gland located beneath the brain that releases many different hormones.

PLATELETS  Cell fragments, also called thrombocytes, that release the clotting factors that cause fibrinogen to be converted into fibrin.

RED BLOOD CELLS  Also called erythrocytes, cells that transport the respiratory gases oxygen and carbon dioxide. Red blood cells outnumber the white blood cells 700 to 1.

Rh FACTOR  The so-called "Rhesus factor" blood antigen that is either present or absent in blood. The presence of the Rh factor in the blood of the developing child, if the mother is Rh negative, can cause complications during pregnancy.

SICKLE CELL ANEMIA  A painful and often deadly genetic disease that results in the production of pointed or "sickle shaped" red blood cells.

SPLEEN  An organ considered to be part of the lymphatic system that removes old red blood cells by causing them to disintegrate.

STEM CELLS  Cells located in the bone marrow which can give rise to every type of blood cell as well to the cell fragments called platelets.

SUPPRESSOR T-CELLS  Lymphocytes that cause other types of lymphocytes to lessen their immune responses.

T-CELLS  Non-antibody producing lymphocytes that develop under the influence of the thymus gland. These cells make use of the surface proteins called T-cell receptors to react to antigens.

THROMBOCYTES  Another name for platelets.
THYMUS GLAND A gland located in the chest that affects the way that lymphocytes develop.

VACCINE A substance made from dead or weakened viruses that, after it has been administered, results in an immunity to a particular disease.

WHITE BLOOD CELLS Also called leucocytes, they are lightly-colored cells present in the blood whose primary function is to fight disease. There are several different types of white blood cells, but only one white cell exists for every 700 red blood cells.

Script of Video Narration

Blood

Human life, as well as the lives of most animals, is completely dependent upon the marvelous liquid we call blood.

Inside of our bodies, circulating blood creates a perfectly balanced aquatic world that is filled with a fantastic array of cells and other components essential to animal life.

Blood, just like bone and cartilage, is considered by biologists to be a connective tissue because it provides crucial links of supply, defense and communication between all the cells of the body.

To accomplish its role as a connective tissue, blood employs four basic ingredients--plasma, red blood cells, white blood cells and platelets.

Each of these components has a unique and critical role to play in sustaining animal life.

Now let us look at each of these components more closely.
PLASMA: THE MATRIX OF BLOOD

Plasma, a pale transparent liquid that separates out from the darker colored cells when blood is allowed to stand, is the matrix that carries the blood cells through the circulatory system, and although it is 92% water, plasma is surprisingly complex.

The smallest chemical compounds found in blood plasma are called electrolytes, which are simple inorganic salts.

The presence of electrolytes in the plasma helps ensure that the correct osmotic balance is maintained both in the bloodstream and in the body as a whole.

To ensure the correct osmotic balance, the body constantly adjusts the ratio of water to electrolytes in the plasma, and it is this balance that prevents cells from either blowing apart or shriveling up.

Electrolytes also act as chemical buffers that minimize the changes in the acidity of the blood plasma.

Besides these small electrolyte molecules, blood plasma abounds in a wide variety of proteins--a class of large molecules made up of long chains of amino acid subunits.

One group of proteins, the immunoglobins, act as antibodies that help combat viruses and other foreign substances that invade the body.

A second group of plasma proteins serve as escorts for fat molecules, because, on their own, fats will not dissolve in water.

A third group of plasma proteins are the fibrinogens, which are essential to blood clotting.

Besides proteins and electrolytes, plasma is also filled with nutrients, such as sugars, vitamins and amino acids, that are absorbed into the bloodstream in the small
inside of the small intestine are thousands of tiny finger-like projections called **villi**. Here nutrients on the inside of the intestine are taken into a complex network of very tiny blood vessels called **capillaries**; then the nutrients in the plasma are distributed through the circulatory system so that nourishment is provided to every cell in the body.

Besides carrying nutrients, the blood plasma also transports wastes produced by cells to the kidneys where they are removed from the plasma and are eventually eliminated from the body in the urine. The kidneys also help to control the body’s electrolyte balance by removing excess water from the plasma.

Another way that blood plasma acts to link distant cells of the body is by transporting the tiny chemical messenger molecules called **hormones**.

Hormones are produced by special organs called **endocrine glands**; examples include the pituitary, the thyroid, adrenals, and part of the pancreas.

Receptor molecules in target cells, usually far away from the endocrine glands, trap hormones from the blood plasma, and, as a result, the target cells respond and change in specific ways.

Another ingredient of blood plasma, the chemical compound called cholesterol, is needed to build certain hormones and to construct the outer membranes of cells.

Some people possess too much cholesterol in their plasma and this can lead to a potentially deadly situation, for cholesterol can build up on the inside of their blood vessels causing the vessels to narrow, resulting in a disease of the circulatory system called **atherosclerosis**.
The narrowing of the blood vessels means that the heart must work harder to force blood through the circulatory system, so that people who suffer from blocked arteries usually also suffer from hypertension, or high blood pressure, and a combination of these two diseases generally indicates a greatly increased risk of death by heart attack.

**RED BLOOD CELLS: ERTHYROCYTES**

The 4-5 liters of blood plasma found in the average human being typically contains about 25 trillion red blood cells, also called erythrocytes.

Red blood cells serve just two functions—first, they carry oxygen to all of the other cells of the body, and second they help transport waste carbon dioxide away from the cells.

When we inhale, oxygen is drawn into our lungs and here in the tiny air sacs called alveoli, it is captured by the red blood cells as they pass through the delicate networks of tiny capillaries that make up the alveolar walls.

Then the oxygenated blood returns to the heart which pumps it out through a system of thick-walled arteries to the cells that make up organs, muscles and even bones.

Cells require a constant supply of oxygen and they will quickly die without it; this is because oxygen is required to release the energy stored in the nutrient molecules which are the cell’s food.

Inside of cells, energy is released as oxygen is consumed during cell respiration—a process that takes place in the tiny sub-cellular organelles called mitochondria.

During cell respiration, carbohydrates, such as sugars, are essentially "burned" by the cells, for cell respiration, in many respects, resembles the combustion of wood by fire.
In both combustion and in cell respiration, sugars and oxygen are consumed, and in each case, energy is released while carbon dioxide and water are formed as by-products of either reaction.

As cells obtain needed energy as a result of cell respiration, it is important that the carbon dioxide formed during this process be continuously removed from the cells so, as the red blood cells "unload" oxygen, they simultaneously pick up waste carbon dioxide.

Then the red blood cells containing carbon dioxide are carried back to the heart in the thin-walled blood vessels called veins.

Next the heart pumps the blood back into the lungs where carbon dioxide is once again exchanged for fresh oxygen.

Finally, the waste carbon dioxide is removed from the body during the process of exhalation.

Blood owes its ability to transport oxygen and carbon dioxide, its red color, and also its metallic taste to the unique protein molecule called hemoglobin that is present in great abundance inside red blood cells.

Hemoglobin employs four atoms of iron to help bind oxygen; therefore, an adequate amount of iron must be present in the diet to prevent one form of the blood disease called anemia. Anemia results in a loss of energy owing to the fact that the body is being constantly starved for oxygen.

The deadly disease called sickle cell anemia that affects over 70,000 African-Americans results from a genetic mutation that causes the shape of the hemoglobin molecules to be altered; as a result, the red blood cells change from their normal disc-like shapes into the pointed shapes seen here.
Because these pointed cells tend to clump together, they have difficulty passing through tiny capillaries. Because of this, persons with sickle cell anemia can experience a great deal of pain because their tissues do not receive enough oxygen that they need to function properly.

A COMPARISON OF RED & WHITE BLOOD CELLS

Blood cells are classified into two basic groups: red blood cells and white blood cells. Before we go on to look at white cells in detail, let us compare these two groups of cells.

Red and white cells both develop from identical stem cells in the bone marrow, but as they mature, they become increasingly distinct from one another, not just in color, but in many other ways as well.

For example, human beings possess many different types of white blood cells that vary from one another, both in their physical appearance and in their specific biological functions, although all of them are employed in one way or another in fighting disease; whereas all normal human red blood cells are basically identical in appearance and all of them perform the same function of transporting the respiratory gases, oxygen and carbon dioxide.

In addition, white blood cells exist in a range of different sizes whereas red blood cells, which outnumber white cells 700 to one, are basically all the same size. And finally, every white blood cell possesses a nucleus, while all mature red blood cells have lost their nuclei.

Now let us look at some of the most important types of white blood cells and learn how they function.

WHITE BLOOD CELLS: LEUCOCYTES

As we have just learned, there are many types of white blood cells, which are also called leucocytes.
The reason the white blood cells we see here are dark colored instead of white is because this blood smear has been treated with a particular biological stain to make them more easily identifiable under the microscope.

This cell belongs to a class of white blood cells called the phagocytic leucocytes that defend against infectious organisms by literally gobbling them up and digesting them, a process known as phagocytosis or "cell eating."

Many phagocytic white blood cells, such as these living examples, actually leave the circulatory system and wander freely throughout the body where they consume not only bacteria and viruses, but dead body cells as well.

The type of white blood cell seen here does not eat other cells. It is called a lymphocyte. Lymphocytes defend against infectious organisms in a wide variety of ways quite distinct from those used by phagocytic cells. In fact, the methods of defense employed by lymphocytes are at the very heart of the body’s immune system.

It is the ability of lymphocytes to create antibodies that has made it possible to develop vaccines against specific diseases.

In order to better understand how the immune system works, let us learn how a vaccine against the viral disease called mumps is made.

The process of making a mumps vaccine begins by raising large numbers of the virus in the laboratory. Then the viruses are weakened by heating so they can no longer produce the symptoms of the disease.

These "neutralized" viruses are then used as the basis for a mumps vaccine which can be injected into the body.

Any large foreign molecules present in the blood, especially those that exist on the outer coats of viruses, are called antigens, which is an abbreviation for antibody generators.
The presence of mumps antigens in the blood triggers a response from one of the two major classes of lymphocytes, called the B-cell lymphocytes, to release the specific immunoglobin proteins called antibodies that produce an immunity to this disease.

Immunity occurs because the mumps antibodies attach to the viruses and form antigen-antibody complexes. Once "tagged" in this way, the viruses become much more desirable targets to the phagocytic leucocytes and are immediately devoured by them.

Most of the antibody producing B-cells in blood undergo all of their developmental stages in the bone marrow; however certain other developing lymphocytes migrate to a gland located in the chest called the thymus gland, and under the influence of this gland are transformed into the second major class of lymphocytes called T-cell lymphocytes, or simply T-cells.

T-cells do not make antibodies, instead they make proteins that end up on the cell’s surface called T-cell receptors.

Many different types of receptor proteins are made in response to different antigens, and after the receptors are exposed to these antigens, the generalized T-cells are changed into one of four different categories of cells.

The first type, called Killer T-cells, kill foreign cells and viruses on contact.

The second type, called Helper T-cells, cause the B-cells both to multiply and to make more antibodies.

The third type, called Suppressor T-cells, cause other types of lymphocytes to lessen their immune responses.

And finally, some of the generalized T-cells can change into memory cells that enable the immune system to combat the same antigen more effectively in future infection.
HIV: THE HUMAN IMMUNODEFICIENCY VIRUS

Most viruses are annihilated by the strong defenses provided by the lymphocytes; unfortunately, HIV or Human Immunodeficiency Virus, has found a way around this system of defense.

Helper T-cells are actually invaded by these viruses. HIV take over the T-cell’s genetic machinery to reproduce themselves, and it is not long before all the helper T-cells are destroyed by these viruses.

Without the helper T-cells that are so important in assisting other lymphocytes to function properly, the entire immune system begins to slowly collapse, resulting in the condition called AIDS, or Acquired Immune Deficiency Syndrome.

Because their immune systems have been destroyed by HIV, most people with AIDS usually die from a variety of minor infections that have little or no effect on persons with healthy immune systems.

It is fortunate that HIV is not spread via the air or water as are many viruses. Instead AIDS can only be acquired through intimate sexual contact, or by direct exposure to HIV contaminated blood.

So far, it has been impossible to develop a vaccine against AIDS because the genetic material of HIV is constantly mutating and, as a result, the chemical structure of its outer coat is always changing. Consequently, each new vaccine that has been developed has failed to prevent HIV infection.

LYMPH

Besides blood, the body employs another marvelous fluid in combatting infectious diseases called lymph.

Lymph flows through the complex network of thin-walled vessels that, along with the spleen, the thymus...
gland, and the swellings called lymph nodes, make up the lymphatic system.

Lymph is continually absorbed into the blood and, in fact, has all the components of blood except red blood cells and, in particular, it contains huge numbers of lymphocytes.

This microscope slide of a stained slice of a lymph node shows what an enormous number of lymphocytes are present in just one small area of just one of these nodes.

The swellings we feel in our necks when we have a sore throat are actually just enlarged lymph nodes that have responded to the throat infection by producing more lymphocytes and by filtering out dead viruses or bacteria.

PLATELETS: THROMBOCYTES

The final components of blood are called platelets, or thrombocytes, and they are absolutely essential to the process of blood clotting, for a person suffering from even the smallest cut would rapidly bleed to death if it were not for these tiny cell fragments.

When a wound first occurs, the platelets immediately rush to plug up the leaking blood vessel.

Then, in a complex series of steps, the clump of platelets releases clotting factors that help convert the plasma protein fibrinogen into the strong threads of fibrin.

As more and more threads of fibrin condense from the plasma, they bind together with one another, as well as with any red blood cells that happen to be around, to form a blood clot.

Soon new tissue fibers weave their way through the threads of fibrin and, in time, the wound heals.
CONCLUSION

As we have learned, blood is a very complex substance—a delicately balanced mixture of water, electrolytes, proteins, nutrients, hormones, waste products, gases, red and white blood cells, and platelets that, when pumped through a healthy circulatory system, is able to deliver to each cell of an animal’s body virtually everything it needs to survive.

Producer’s Note

The most recent scientific information as of this writing (June, 1995) indicates that HIV promotes actual "cellular suicide" among T-cells. It appears that HIV infection promotes the production of "T-cell suicide proteins" that, when present in the blood plasma, cause T-cells to self-destruct. This process can occur even if HIV has not entered the T-cell.
ADRENAL GLANDS  Endocrine glands located on the top of each kidney that release the hormone called adrenalin.

AIDS  An abbreviation for the disease called "Acquired Immune Deficiency Syndrome." This deadly disease, caused by the Human Immunodeficiency Virus or HIV, destroys the body's immune system.

ALVEOLI  The tiny sacs in the lungs where the exchange of gases takes place between the blood and the air.

ANEMIA  An illness marked by a reduction in the number of red blood cells or of properly functioning hemoglobin in the blood.

ANTIBODIES  Immunoglobin proteins that clump onto particular antigens in the process of fighting infectious diseases.

ANTIGEN  A large foreign molecule, usually on the surface of a virus, that results in an "immune response," i.e., the production of antibodies by B-cell lymphocytes.

ANTIGEN: ANTIBODY COMPLEX  A highly specific clumping reaction between a certain antigen and the specific antibody for that antigen.

ARTERY  A thick-walled blood vessel that carries blood away from the heart.

ATHEROSCLEROSIS  A thickening of the blood vessel walls due to a build-up of cholesterol.

B-CELLS  A type of lymphocyte that produces the immunoglobin proteins called antibodies.

BLOOD GROUPS  Designated A, B, AB, and O, these blood groups indicate which antigens are present on the surface of the red blood cells. Blood group A has only A antigens, group B only B antigens, group AB has both A and B antigens, whereas group O has neither A or B antigens. The presence of these antigens means a person with type B blood cannot receive blood from a type A donor and vice-versa. Type AB individuals can receive blood from all the other blood groups, but people with type O blood can only receive blood from type O donors.

BLOOD PLASMA  The liquid matrix of blood.

CAPILLARIES  Very small thin-walled blood vessels.

CELL RESPIRATION  The oxygen-consuming process used by cells to release energy from carbohydrate molecules.

CHOLESTEROL  A chemical component of blood plasma that is employed in making cell membranes and certain hormones. Cholesterol can build up inside blood vessels causing partial or total blockage—a condition known as atherosclerosis.

CLOTTING FACTORS  Chemicals produced by the platelets following an injury that cause the plasma protein fibrinogen to be converted into the threads of fibrin. Fibrin threads then help form a blood clot.

COMBUSTION  A chemical oxidation process that occurs when wood is burned which is similar to cell respiration, because carbohydrates and oxygen are consumed and carbon dioxide, water, and energy are produced.
**ELECTROLYTE**  A general name for the inorganic salts present in the blood stream. Electrolytes and water must be properly balanced for blood cells to remain intact and healthy.

**ENDOCRINE GLANDS**  Special organs that release hormones directly into the blood stream; also called the “duct-less glands.”

**ERYTHROCYTES**  Red blood cells.

**FIBRIN**  A substance formed from the plasma protein called fibrinogen that traps red blood cells to form a blood clot and then dries to form a scab.

**FIBRINOGEN**  The plasma protein that forms the blood clotting substance called fibrin.

**HELPER T-CELLS**  T-cell lymphocytes that cause B-cells to multiply and to make more antibodies.

**HEMOGLOBIN**  An iron containing protein molecule found in great abundance in red blood cells that binds oxygen and carbon dioxide.

**HIV**  An abbreviation for “Human Immunodeficiency Virus.” This virus attacks the immune system, resulting in the disease known as AIDS.

**HORMONES**  Chemical messenger molecules produced by the endocrine glands.

**HYPERTENSION**  High blood pressure.

**INFECTIOUS DISEASE**  A disease caused by viruses or by living organisms, such as bacteria, protozoa, or fungi.

**IMMUNE RESPONSE**  The body's response to an infection, especially the production of antibodies by B-cell lymphocytes.

**IMMUNE SYSTEM**  The system of defense against infectious diseases that is based on the white blood cells.

**IMMUNITY**  A person is said to have an “immunity” to a particular illness if he or she can no longer catch that illness.

**IMMUNOGLOBINS**  Antibody proteins used in fighting infectious diseases.

**KILLER T-CELL**  A type of T-cell lymphocyte that destroys infectious organisms on contact.

**LEUCOCYTES**  Another name for white blood cells.

**LEUKEMIA**  A form of cancer of the blood in which many more white blood cells are produced than is healthy for the body.

**LYMPH**  A pale-colored liquid that circulates through the vessels of the lymphatic system and contains all the components of blood except red blood cells. In particular, lymph contain huge numbers of lymphocytes and, as a result, is a very important component of the body's system of defense against infectious diseases.
LYMPH NODES Swellings of lymphatic tissue that filter the lymph and produce lymphocytes.

LYMPHOCYTES Non-phagocytic white blood cells that are also the predominant cells present in lymph.

MEMORY CELLS Lymphocytes that enable the immune system to combat that same antigen more effectively during future infections.

MITOCHONDRIA The subcellular organelles where cellular respiration occurs.

PHAGOCYTIC WHITE BLOOD CELLS A class of white blood cells that eat viruses and bacteria.

PHAGOCYTOSIS The process of “cell eating.”

PITUITARY GLAND An endocrine gland located beneath the brain that releases many different hormones.

PLATELETS Cell fragments, also called thrombocytes, that release the clotting factors that cause fibrinogen to be converted into fibrin.

RED BLOOD CELLS Also called erythrocytes, cells that transport the respiratory gases oxygen and carbon dioxide. Red blood cells outnumber the white blood cells 700 to 1.

Rh FACTOR The so-called “Rhesus factor” blood antigen that is either present or absent in blood. The presence of the Rh factor in the blood of the developing child, if the mother is Rh negative, can cause complications during pregnancy.

SICKLE CELL ANEMIA A painful and often deadly genetic disease that results in the production of pointed or “sickle shaped” red blood cells.

SPLEEN An organ considered to be part of the lymphatic system that removes old red blood cells by causing them to disintegrate.

STEM CELLS Cells located in the bone marrow which can give rise to every type of blood cell as well to the cell fragments called platelets.

SUPPRESSOR T-CELLS Lymphocytes that cause other types of lymphocytes to lessen their immune responses.

T-CELLS Non-antibody producing lymphocytes that develop under the influence of the thymus gland. These cells make use of the surface proteins called T-cell receptors to react to antigens.

THROMBOCYTES Another name for platelets.

THYMUS GLAND A gland located in the chest that affects the way that lymphocytes develop.

VACCINE A substance made from dead or weakened viruses that, after it has been administered, results in an immunity to a particular disease.

WHITE BLOOD CELLS Also called leucocytes, they are lightly-colored cells present in the blood whose primary function is to fight disease. There are several different types of white blood cells, but only one white cell exists for every 700 red blood cells.
ACROSS
1. Chemical messenger molecules carried in the blood are called __________.
2. A white blood cell is also called a ____________.
3. The common name for Acquired Immune Deficiency Syndrome is ________.
4. The white blood cells that make it possible for our bodies to respond more effectively when confronted with a second infection by the same virus are called ________ cells.
5. White blood cells form the basis of the body's ______ system that is used in combatting infectious diseases.
6. A specific immunoglobin protein produced by a B-cell is called an ____________.
7. The Human Immunodeficiency Virus is commonly called ________.
8. Electrolytes in blood plasma are usually simple inorganic ______.
9. _______ T-cells cause the B-cell lymphocytes to multiply in response to an infection.

DOWN
1. The iron containing protein found in red blood cells is called ____________.
2. A type of lymphocyte called a ____________ can produce antibodies.
3. Some white blood cells eat invading bacteria—a process called ______________.
4. Lymphocytes become T-cells under the influence of a gland in the chest called the ________ gland.
5. A foreign protein in the blood that causes antibodies to be produced is called an ____________.
6. Suppressor ____________ cause the immune responses of other lymphocytes to be lessened.
7. Red blood cells carry the respiratory gases ________ and carbon dioxide.
8. Immunity to a viral disease can be developed by receiving a ____________ made from dead or weakened viruses.
9. Platelets are also called ________cytes.
Hundreds of thousands of Africans and persons of African descent are currently afflicted with a debilitating blood disease called sickle cell anemia. Under the microscope, red blood cells taken from the victims of this disease, have a pointed appearance instead of the smooth disc shape possessed by normal red blood cells.

Because sickle cell anemia is the result of a mutation in the gene that makes hemoglobin (the protein molecule that carries oxygen in the blood stream), it can be transmitted from parent to child. However, because this gene is "recessive," the traits of the disease will be observed only if both parents carry the mutated gene, for even if one parent possesses the defective gene, the other parent will still supply the correct information for making normal hemoglobin.

The following steps result in sickle cell anemia:

1. A sickle cell mutation exists in the DNA of the hemoglobin gene of both parents. This means their children will receive a defective set of chromosomes from each parent.

2. Because of these paired identical mutations, an incorrect amino acid will be inserted into every hemoglobin molecule present in the child's red blood cells.

3. As a result of this single incorrect amino acid, every hemoglobin molecule will change its three dimensional shape.

4. Then, because red blood cells contain huge numbers of hemoglobin molecules, the red blood cells change from rounded to pointed shapes due to the fact that the mutated hemoglobin can only carry a reduced amount of oxygen.

5. Because of these changes, the red blood cells easily disintegrate or else get hung up moving through the tiny capillaries because they tend to clump together.

6. Consequently, tissues do not receive all the oxygen they need.

7. This results in a physical sensation of pain. Additionally, this disease can cause permanent disability and death.

(continued on Blackline Master 6)
THE SICKLE CELL GENE AND "THE HETEROZYGOTE ADVANTAGE"

Geneticists have discovered a very interesting fact about this disease which may explain why the sickle cell gene is fairly prevalent in Africa, a continent where the disease called malaria, the leading cause of death worldwide, is very common.

If a person has received normal hemoglobin genes from each parent, that is, is homozygous for the normal hemoglobin gene, he or she has no resistance to malaria but, at the same time, has no anemia.

But if a person receives a normal hemoglobin gene from one parent and a defective sickle cell gene from the other parent, that person is said to be heterozygous for the sickle cell gene. People in this category suffer from very mild anemia, but amazingly possess resistance to the disease of malaria. Geneticists call this condition the Heterozygote Advantage, because a definite advantage—immunity to malaria—exists in having one sickle cell gene and one normal hemoglobin gene.

Persons who have received the defective sickle cell gene from each parent, however, are at a great disadvantage because they will likely die from the condition of sickle cell anemia.

HEMOGLOBIN DISTRIBUTION

<table>
<thead>
<tr>
<th></th>
<th>% of normal hemoglobin homozygotes</th>
<th>% of sickle-cell heterozygotes</th>
<th>frequency of sickle-cell homozygotes</th>
</tr>
</thead>
<tbody>
<tr>
<td>African Blacks</td>
<td>82</td>
<td>18</td>
<td>.09</td>
</tr>
<tr>
<td>Black African-Americans</td>
<td>92</td>
<td>8</td>
<td>.04</td>
</tr>
</tbody>
</table>

Answer the following questions using this sheet or a separate sheet of paper.

1. True or False: Sickle cell anemia is more prevalent among African blacks than African-Americans.
2. What percentage of African blacks would be expected to have an immunity to malaria?
3. What percentage of African-Americans carry the gene for sickle cell anemia?
4. What percentage of African-Americans would be expected to have neither immunity to malaria nor sickle cell anemia?
5. True or False: If you were a black African child, you would be more likely to contract sickle cell anemia than become immune to malaria.
COMPONENTS OF BLOOD

PLASMA (55% of TOTAL VOLUME OF BLOOD)

<table>
<thead>
<tr>
<th>INGREDIENT</th>
<th>MAJOR FUNCTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>WATER</td>
<td>Solvent for carrying other substances</td>
</tr>
<tr>
<td>ELECTROLYTES (SALTS)</td>
<td>Osmotic balance, buffering, regulation of membrane permeability</td>
</tr>
<tr>
<td>PROTEINS</td>
<td>Fibrinogens: blood clotting, fat escort proteins</td>
</tr>
<tr>
<td></td>
<td>Immunoglobin: defense (antibodies), albumin: buffering and osmotic balance</td>
</tr>
</tbody>
</table>

OTHER SUBSTANCES TRANSPORTED IN BLOOD PLASMA

| NUTRIENTS (Sugars, fatty acids, vitamins, amino acids) | Food for cells |
| WASTES                                                   | By-products of metabolism |
| HORMONES                                                 | Chemical messengers produced by endocrine glands that affect cells in tissues far away from the glands |
| RESPIRATORY GASES                                        | Oxygen, needed for cell-respiration, (Note: Most oxygen is transported by red blood cells). Carbon dioxide, a by-product of cell respiration |

(continued on Blackline Master 8)
**COMPONENTS OF BLOOD (CONTINUED)**

**THE FORMED ELEMENTS (45% OF TOTAL VOLUME OF BLOOD)**

<table>
<thead>
<tr>
<th>FORMED ELEMENT</th>
<th>NUMBER (per cubic mm)</th>
<th>FUNCTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>RED BLOOD CELLS (Erythrocytes: one cell type, all the same size)</td>
<td>5-6 million</td>
<td>Transport oxygen and help transport carbon dioxide</td>
</tr>
<tr>
<td>WHITE BLOOD CELLS (Leucocytes: several different cell types of different sizes)</td>
<td>5-10 thousand</td>
<td>Defense and immunity</td>
</tr>
<tr>
<td>PLATELETS (Thrombocytes: small fragments of cells)</td>
<td>250-400 thousand</td>
<td>Blood clotting</td>
</tr>
</tbody>
</table>

**Matching Exercise:**

Directions: Match the correct term in Column B with the definitions in Column A.

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Hormones are transported by this component of blood. ______</td>
<td>A. carbon dioxide</td>
</tr>
<tr>
<td>2. Cells that transport most respiratory gases. ______</td>
<td>B. water</td>
</tr>
<tr>
<td>3. Cell fragments in blood that aid in blood clotting. ______</td>
<td>C. erythrocytes</td>
</tr>
<tr>
<td>4. The fewest cells present in blood. ______</td>
<td>D. fibrinogens</td>
</tr>
<tr>
<td>5. Plasma components that help maintain osmotic balance, membrane permeability and buffering. ______</td>
<td>E. nutrients</td>
</tr>
<tr>
<td>6. The major component of blood plasma. ______</td>
<td>F. platelets</td>
</tr>
<tr>
<td>7. A major chemical by-product of cell respiration that contains no hydrogen. ______</td>
<td>G. plasma</td>
</tr>
<tr>
<td>8. Amino acids are placed in this category of blood plasma components. ______</td>
<td>H. leucocytes</td>
</tr>
<tr>
<td>9. Plasma proteins needed for blood clotting. ______</td>
<td>I. hormones</td>
</tr>
<tr>
<td>10. Endocrine gland products. ______</td>
<td>J. electrolytes</td>
</tr>
</tbody>
</table>
Directions: Fill in the blanks with the correct answers.

1. Red blood cells do two things: they transport _________ and _________ in the blood stream.

2. The iron-containing protein called ________________ is an essential ingredient in all red blood cells.

3. The watery matrix of blood is called ______________.

4. Leucocytes is the scientific name for ________________.

5. For blood to clot properly, the dissolved blood protein ______________ must be exposed to the "clotting factors" released by the cell fragments called ________________.

6. Some white blood cells actually eat invading bacteria and viruses. This process is called ________________.

7. Both T-cells and B-cells belong to a class of white blood cells called ________________.

8. The "T" in T-cell reflects the fact that it developed under the influence of a gland in the chest called the ______________ gland, which begins with the letter "T."

9. B-cells produce the immunoglobin proteins called ______________ when viruses invade the body.

10. Proteins and other large molecules present on the outer coats of viruses, bacteria, and red blood cells are referred to by the general term ______________.

TRUE OR FALSE

Directions: Place a "T" after the true statements and an "F" after the false statements.

1. Hormones are transported in the blood by red blood cells. ______

2. Electrolytes in the blood act as buffers, minimizing the changes in the acidity of the blood. _____

3. The blood loses most of its carbon dioxide in the lungs. _____

4. Persons with anemia usually suffer from too much oxygen in their blood. ______

5. Although cholesterol can be harmful, it is still needed to make cell membranes and certain hormones. ______

6. A person who obtained a sickle cell anemia gene from one parent and a normal gene from the other parent would probably not be affected by malaria. ______

7. Most people with AIDS rapidly recover if they are vaccinated against the HIV virus. ______

8. Blood is considered to be a connective tissue. ______

9. The HIV virus attacks the body's red blood cells. ___

10. Fibrin is a common component of blood clots. ______