# Disease Fighters 46

2 40- to 50-minute session


## ACTIVITY OVERVIEW

### SUMMARY

Students investigate how the human immune system helps fight invading organisms. Students view microscope slides of normal human blood and perform simulated tests for blood-type compatibility. The fact that immune reactions are not always beneficial is addressed.

### KEY CONCEPTS AND PROCESS SKILLS

1. The microscope can be used as a tool for investigation.
2. Microscopes reveal organisms that cannot be seen with the naked eye.
3. All living things are composed of microscopic units called cells.
4. Cells of different organisms have some similar structures, such as the cell membrane. These structures function similarly in different organisms. Other structures vary among cells.
5. The human body has natural defenses against infectious diseases. These include barriers such as skin, linings such as mucus, and white blood cells in the immune system. These reactions are not always beneficial, as in the case of blood transfusions and organ transplants.

### KEY VOCABULARY

| | |
|---|---|
| **ABO blood types** | magnify/magnification |
| cell | nuclear membrane |
| cell membrane | nucleus |
| cytoplasm | organelles |
| field of view (optional) | **red blood cell** |
| **immune system** | **white blood cell** |

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## MATERIALS AND ADVANCE PREPARATION

**Part One: Blood Type and the Immune Response**

*For the teacher*

1 Transparency 46.1, "Compatibility of Human Blood Types"

* 1 overhead projector

*For each group of four students*

1 bottle of Donated Blood Type A containing calcium chloride solution and red food coloring

1 bottle of Donated Blood Type B containing sodium carbonate solution and red food coloring

1 bottle of Donated Blood Type O containing distilled water and red food coloring

1 bottle of Sasha's Blood Serum (Type A) containing calcium chloride solution and yellow food coloring

1 bottle of Fong's Blood Serum (Type B) containing sodium carbonate solution and yellow food coloring

1 bottle of Jordan's Blood Serum (Type AB) containing distilled water and yellow food coloring

*For each pair of students*

1 SEPUP tray

**Part Two: Blood Cells**

*For each pair of students*

1 slide of normal human blood

* 1 microscope

**Not supplied in kit*

While students are expected to complete this activity in pairs, there are only enough microscope slides to provide one to every group of four students. As stated in the Procedure in the Student Book, one pair of students is expected to complete Part One while the other pair completes Part Two. Students can then switch materials.

Sasha's Blood Serum (Type A) and Donated Blood Type A are made with 10% calcium chloride by mass. Fong's Blood Serum (Type B) and Donated Blood Type B are made with 10% sodium carbonate by mass.

## TEACHING SUMMARY

### Getting Started

1. The class reads about how the immune system helps fight infectious diseases.

### Doing the Activity

2. Half of the class tests blood compatibility among different human blood types.
3. Half of the class makes microscope observations of human blood.
4. Student pairs switch roles and complete the other half of the Procedure.

### Follow-Up

5. Review the role of the immune system in preventing infectious diseases.

### Extension 1

Students can go to the SALI page of the SEPUP website to link to sites that have scanning electron photos of blood as well information about diseases of the blood.

### Extension 2

Invite a guest speaker from the local blood bank or Red Cross. Some professionals may be able to show blood products such as whole blood and blood serum and demonstrate how blood is sampled.

## BACKGROUND INFORMATION

### Human Blood

Under a light microscope, normal human blood can be seen to contain two different types of cells. Red blood cells appear all over the slide as light pink circles. White blood cells are not as common; they are usually stained a purple color and have a very dark center, the nucleus. (Blood also contains platelets—small fragments of large precursor cells that help blood to clot. They are more difficult to see with a light microscope.)

Like all cells, red blood cells have cell membranes and cytoplasm. The cytoplasm of red blood cells appears red because it contains the protein hemoglobin. The lack of a nucleus in these cells leaves more space in the cytoplasm for more hemoglobin. It also allows for the unusual shape of red blood cells, which gives them an especially high ratio of surface area to volume, facilitating oxygen diffusion. Their shape also helps them flow through narrow capillaries.

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White blood cells defend the body against foreign substances. They can move in and out of the bloodstream and rally at the site of an infection. During their development, cells (and antibodies) that would perceive the body's own cells as foreign are specifically screened out. Although called white blood cells, these cells can be found throughout the body. They are most numerous in organs such as the spleen, and in the nodes and vessels of the lymphatic system, a filtering system that pervades the body. White blood cells do not have a rigid cell structure and are able to change shape dramatically. This flexibility allows the cells to squeeze through tiny holes in the capillaries and move into the body's tissues when needed there. Their cell membranes are folded into a number of finger-shaped structures that stick out from the cell. White blood cells have a nucleus that may be very large or have an unusual shape. Unless treated with a stain, their cytoplasm is clear. Staining reveals that white blood cells contain many more organelles than red blood cells.

Plasma is the liquid that remains when all of the blood cells—red, white, and platelets—are removed from the blood. This pale yellow-gold liquid plays an important role in the transport of materials, from carbon dioxide waste to antibodies and other dissolved proteins. The plasma protein fibrinogen helps the blood to clot. Because it has had the red blood cells removed, plasma does not provoke immune reactions, as whole blood does. Plasma can be given to patients to restore blood pressure when compatible whole blood is not available. Blood serum is plasma with the fibrinogen removed.

In testing for compatibility before blood transfusions, the recipient's serum, which contains antibodies, is used. Mixing the recipient's serum with donor blood shows whether the recipient's immune system will recognize the donor blood as foreign. If clots form, the donor blood has been attacked by the recipient's serum and is incompatible.

**Antibodies**

Some white blood cells produce antibodies. Antibodies recognize and attach to foreign substances such as bacteria, clumping them in a process called agglutination. Another group of white blood cells recognizes the antibodies and then engulfs and kills the bacteria. Still another type of white blood cell is able to recognize foreign substances and engulf them directly.

Antibodies are incredibly diverse and specific. For example, the human body produces different antibodies for the chicken pox virus than for a cold virus. It



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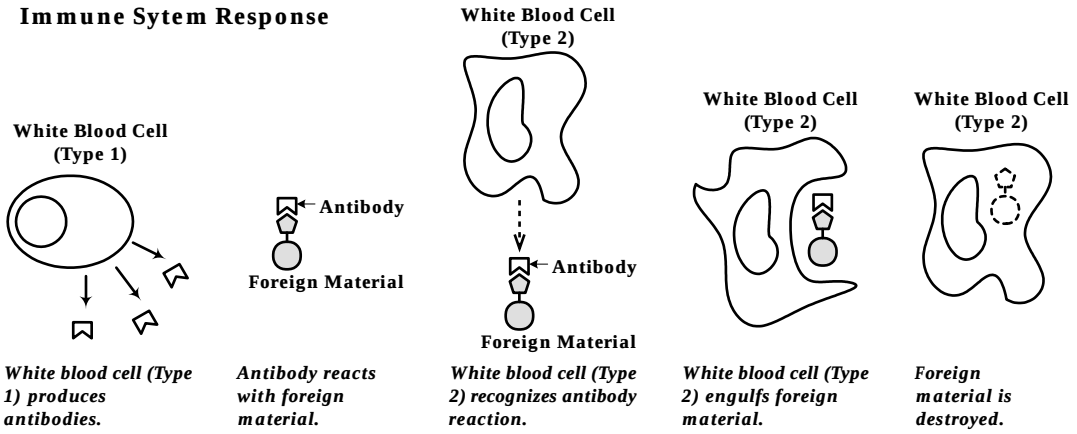


takes time for the body to produce large quantities of the appropriate antibodies. The first time a person catches a disease such as chicken pox, it takes a week or so for the body to respond and begin to recover. However, if the person has had the disease before, his or her immune system has already produced the specific antibodies and white blood cells necessary to fight off the disease. As a result, it has a group of cells that know how to make these antibodies. If the person has another encounter with the same invader, the body uses these "memory" cells to speed up production of the same antibodies.

A person can get diseases such as colds and flu more than once because there are numerous strains of these viruses. Each strain requires its own specific antibodies. However, over time, as a person builds up antibodies to different strains, he or she is likely to develop these illnesses less often.

**Human Blood Types**

There are four types of human blood: A, B, AB, and O. (Actually, there are many more than this, when other antigens besides those of the ABO blood group are considered.) The compatibility of blood types is based on the immune response. For example, type A red blood cells have the A antigen on their surfaces; the immune system of such an individual produces anti-B antibodies, but no anti-A antibodies. A type A person will therefore respond to both type B and type AB blood transfusions as foreign, that is, by agglutinating the "invading" cells.

People with blood type O are universal donors, but can receive blood only from type O donors. The immune systems of those with blood types A, B, and AB do not produce antibodies against type O blood. They are therefore able to accept type O blood,

though it is different from their own. The immune systems of people with type O blood, however, recognize all other blood types as foreign and consequently produce antibodies against cells of those blood types, resulting in clumping.

People with blood type AB are universal recipients, but can donate blood only to type AB recipients. The immune system of those with blood type AB does not produce antibodies against types A, B, or O blood. They are therefore able to accept any blood type, though it is different from their own. The immune systems of people with other blood types (A, B, and O), however, recognize type AB blood as foreign and consequently produce antibodies against the cells of AB blood, resulting in clumping.



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## TEACHING SUGGESTIONS

### ■ GETTING STARTED

**1. The class reads about how the immune system helps fight infectious diseases.**

Begin by reading the Introduction on page C-77 in the Student Book, in which the role of the immune system is explained. Discuss with students the ways in which the human body resists disease. In addition to the immune system, the body has physical barriers, such as skin, that reduce the possibility of infection. In addition, many of the body's openings are lined with fluids, such as mucus, to carry away or block foreign materials.

Use the photos of blood in the Introduction to prepare students for their observations. Explain that the blood has both liquid and cellular components. Point out the red cells as the most common cells, but leave a more complete description of them until later. Also point out the white blood cells. Students can look for variations in white blood cell types under the microscope, but the different types are not stressed in the activity.

### ■ DOING THE ACTIVITY

**2. Half of the class tests blood compatibility among different human blood types.**

Review the Materials and Procedure for the activity. Begin by reading aloud the Scenario. Students should understand that their job is to determine which donated blood can be used for each of the three patients. Only after gathering evidence about blood compatibility will students determine whether the hospital has enough blood for each patient (see Analysis Question 1). In the simulation, incompatible blood types will cause a precipitation reaction that resembles the agglutination caused when serum reacts to donated blood as foreign. The serum (the fluid portion of the blood) of a recipient will not trigger an immune response in the donated blood (this compatibility is irrelevant in transfusion scenarios, since the donor does not receive blood from the recipient). The only response of interest is that in the recipient's serum.

■ **Teacher's Note**: The simulated bloods and sera (see Materials) have been designed for the activity to be conducted and interpreted exactly (and only) as written. (Note that both type O blood and type AB serum in the simulation are represented by distilled water and food coloring alone. This is necessary, since salt precipitation is a much less complex phenomenon than antigen/antibody reactions.) In reality, donor/recipient compatibility is not reciprocal—for example, though A, B, and O blood types are accepted by a type AB recipient, only type O blood is accepted by a type O recipient (see Background Information in this activity and Transparency 46.1). Thus, in interpreting the results of the simulation, students must not confuse or exchange the roles of the donor bloods and recipient sera, lest they conclude that both type O and type AB are universal recipients and universal donors.

Although each group of four students must share the blood sample bottles, each pair of students is provided with a SEPUP tray. Therefore, students can conduct the activity and construct a data table in pairs. If your students are proficient at constructing data tables, you may wish to assess them on the "Organizing Data" element of the DESIGNING AND

| Sample Data Table: Blood Compatibility | | | |
|---|---|---|---|
| Patient | Donor type A | Donor type B | Donor type O |
| **Sasha (type A)** | *remains clear* | *clumps* | *remains clear* |
| **Fong (type B)** | *clumps* | *remains clear* | *remains clear* |
| **Jordan (type AB)** | *remains clear* | *remains clear* | *remains clear* |

CONDUCTING INVESTIGATIONS (DCI) variable. A completed data table might look like the one above.

**3. Half of the class makes microscope observations of human blood.**

Circulate around the room, making sure that students are using the microscopes properly and are able to find the red and white blood cells on the slides. The nuclei in the white blood cells will vary. In some cases they are irregular in shape, and may have several lobes. Lobed nuclei may look like more than one nucleus depending on the focus and the number of granules in the cells. If students observe and ask about the granular organelles in some of the cells, explain that they help the cells perform their function as defenders against invaders. In comparing red and white cells, students may note the relatively simple, round appearance of the red cell and its lack of a nucleus. In contrast, the white cells are larger, have a nucleus that may have an irregular shape, and may show evidence of granular organelles. Be sure to point out that the staining helps differentiate the cells, but that the colors are not the natural colors of the cells.

**4. Student pairs switch roles and complete the other half of the Procedure.**

After students have completed one part of the Procedure, have them switch materials within their group of four and complete the other part.

## ■ FOLLOW-UP

**5. Review the role of the immune system in preventing infectious diseases.**

Discuss students' observations of the red and white blood cells. Ask questions such as, ***Which type of cell was more common? Which type of cell was larger? Which type of cell had a nucleus?*** Students should notice the absence of a nucleus in the red blood cells. (Red blood cells are formed from precursor cells that have a nucleus, but they lose the nucleus before being released into the blood.) Emphasize the unique structure of the red blood cell relative to other animal cells. Its unique shape increases its surface area, enhancing its ability to absorb oxygen; its flexibility allows it to move easily through narrow blood vessels. Point out that white blood cells have the primary role in attacking foreign substances, and that their particularly flexible structures allow them to enter and exit the blood vessels.

Use Transparency 46.1, "Compatibility of Human Blood Types," to review Part One of the activity. If the donor's blood type is not compatible with the recipient's blood type, the bloods will clump as they mix. These clumps can create blocks in the circulatory system and cause death. Reinforce the idea that the incompatibility of some of the blood types is due to the recognition by the recipient's immune system



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that a foreign material is present. Analysis Question 1 can be used to assess students' ability to apply their understanding of blood compatibility to a practical problem. Use the UNDERSTANDING CONCEPTS (UC) scoring guide to assess students' responses.

■ **Teacher's Note**: Students may comment on the fact that the type O donated blood was acceptable for all three patients. In fact, blood type O is often referred to as the "universal donor." However, many individuals of blood type O are not truly universal donors, due to the existence of additional blood groups (such as the Rh factor). Other students may wonder which blood type(s) someone of blood type O can receive safely. The following reasoning is possible without understanding blood type compatibility in great depth: Sasha, who is type A, cannot receive blood from a type B (or type AB) donor. Fong, who is type B, cannot receive blood from a type A (or type AB) donor. Jordan, who is type AB, can receive blood of any donor type. A person with type O blood couldn't receive blood from anyone but a type O donor; A, B, and AB blood would all be recognized as foreign.

To summarize ideas presented over several units of *Science and Life Issues*, ask students to make a list of all the functions they can think of for blood. They can work on this in their groups or individually. Allow just a few minutes for them to make their lists and then use their suggestions to develop a list on the board or a transparency. They may suggest some or all of the following:

- defense against foreign organisms and substances
- clotting to prevent loss of blood from wounds
- transport of oxygen from the lungs to the body
- transport of carbon dioxide wastes from the body to the lungs

transport of digested food products to cells and transport of metabolic waste products to excretory system

Students are less likely to suggest the following functions. You may want to mention them, depending on your students' background.

- transport of chemical messengers (hormones) from glands to rest of body
- transport of water
- temperature regulation
- buffering the pH of the blood

Emphasize the idea that the human body has natural defenses against microbial diseases. In this activity, the role of the blood in defending against foreign organisms and substances was explored.

**Extension 1**

Students can go to the SALI page of the SEPUP website to link to sites that have scanning electron photos of blood as well information about diseases of the blood.

**Extension 2**

Invite a guest speaker from the local blood bank or Red Cross. Some professionals may be able to show blood products such as whole blood and blood serum and demonstrate how blood is sampled.

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## SUGGESTED ANSWERS TO ANALYSIS QUESTIONS

**Part One: Blood Type and the Immune Response**

1. *Each patient required one pint of blood. The hospital received one pint each of type A, B, and O blood. Explain whether the hospital had enough of the right type of blood for each patient.* **UC**

   Complete and correct level 3 responses follow:

- The hospital did have enough blood for each patient. Sasha had type A blood and could have received the donated type A blood. Fong had type B blood and could have received the donated type B blood. Jordan had type AB blood and could have received the donated type O blood. These combinations of blood types did not clump. The patients could receive these transfusions without any immune problems.
- The hospital did have enough blood. Since each patient needed only one pint and the hospital had three pints, there was enough blood. Sasha could have received either type A or O blood. Fong could have received either type B or O blood. Jordan could have received type A, B, or O blood. The hospital had the right blood types to give each patient blood without clumping.

2. *What prevents your body from accepting transfusions of certain types of blood?*

   Most of the time, your immune system protects you from microbes and other foreign substances. But white blood cells and antibodies can also attack blood or organs that have been deliberately introduced into the body, if the donated cells are perceived as foreign by the immune system. This makes it more difficult to treat or cure other conditions that a person might have.

**Part Two: Blood Cells**

3. *Think back to all the work that you have been doing on cells. Compare and contrast different types of cells by copying and completing the table below.*

   See completed table below.

4. *In what ways does your body prevent you from catching an infectious disease?*

   First, skin acts as a barrier to prevent microbes from entering. Tears, saliva, and mucus also remove some of the microbes. Finally, white blood cells can identify and attack microbes, preventing you from getting sick.

| Cell Type | Cell Shape | Cell Membrane? | Cytoplasm? | Nucleus? |
|---|---|---|---|---|
| Bacteria | *Varies, but includes rods, circles, and chains of circles; extremely tiny* | *yes* | *yes* | *no* |
| Protist | *Varies, but includes blob-like, oval, and twisted; larger* | *yes* | *yes* | *yes* |
| Plant (onion) | *Rectangular* | *yes* | *yes* | *yes* |
| Animal: cheek | *Circular with angled sides* | *yes* | *yes* | *yes* |
| Animal: red blood cell | *Tiny ovals* | *yes* | *yes* | *no (in humans)* |
| Animal: white blood cell | *Blob-like, but larger than red blood cells* | *yes* | *yes* | *yes* |



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# Compatibility of Human Blood Types

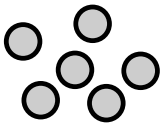
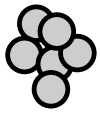
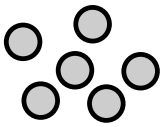
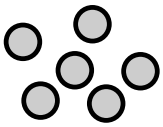
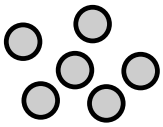
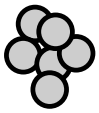
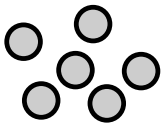
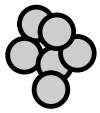
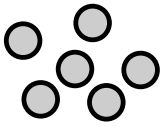
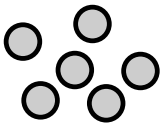
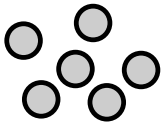
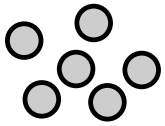
**Key**

 **blood cells**

 **clumped blood cells**

**Donors**

**Recipients**

| | O | A | B | AB |
|---|---|---|---|---|
| O |  |  |  |  |
| A |  |  |  |  |
| B |  |  |  |  |
| AB |  |  |  |  |

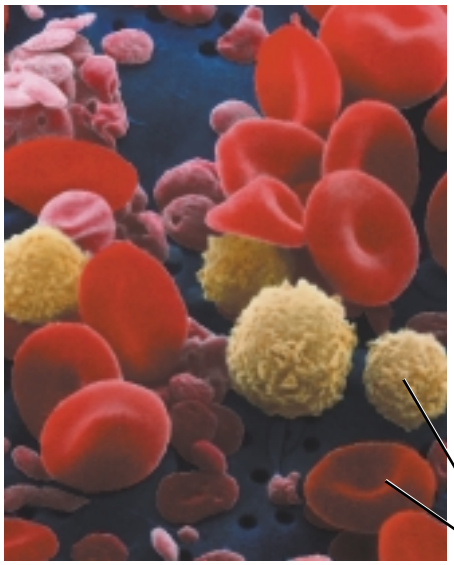
When the blood type of the donor is not compatible with that of the recipient (patient), the antibodies present in the recipient's blood cause the transfused red blood cells to clump. These clumps can create blockages in blood vessels and cause death. Because of differences in what antibodies are present, type O individuals are universal donors but type AB individuals are universal recipients.

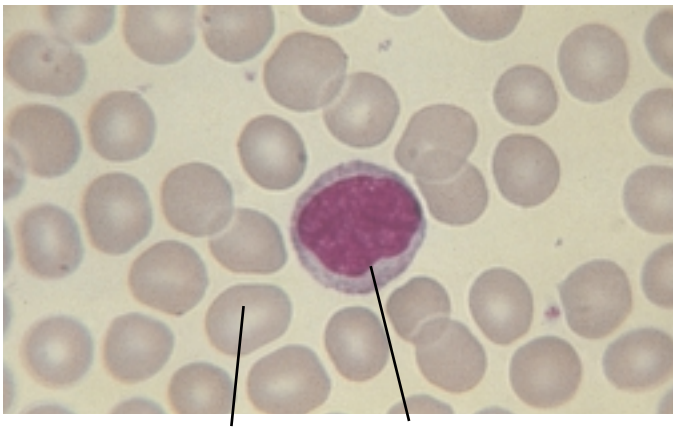
# 46 Disease Fighters

INVESTIGATION

What does your body do to protect itself from invading microbes? Even before an organism can enter your body, your skin provides a protective barrier. But foreign substances can still enter through cuts or natural body openings, such as your mouth or your nose. Tears, saliva, and mucus help to remove some invaders at these sites. But when foreign substances cross these barriers, your **immune** (ih-MYOON) **system** comes to the rescue.

Your immune system has the amazing ability to distinguish between the substances of your own body and foreign substances, such as bacteria and viruses. A healthy immune system can then mount a defense against these invaders. Several kinds of cells, particularly white blood cells, are responsible for this immune response. The pictures here show normal human blood cells. Note that the red blood cells are the most common. Also note the detail of the white blood cells. They increase in number when the body is under attack from a foreign substance.




*The photograph on the left was taken through a scanning electron microscope, while the photograph on the right was taken through a light microscope .*

Immune responses of the human body are not always helpful. Any new material in the body, including blood and organs, can trigger an immune response. It is this reaction of the immune system that makes organ transplants and blood transfusions difficult. If the blood type of the blood donor is not compatible with that of the person receiving the blood, the transfused blood cells are seen as foreign by the immune system and they clump together. These clumps can create blockages in blood vessels and cause death. That is why it's important to know which types of blood can be donated safely to people with each of the four human **blood types: A, B, AB, and O**. You will simulate what happens to a person's blood when blood from a donor is added.

For links to more information on the blood and diseases of the blood, go the SALI page of the SEPUP website.

## CHALLENGE

**How does your blood help fight infectious diseases?**

### MATERIALS

*Part One: Blood Type and the Immune Response*

*For each group of four students*

- **1 bottle of Donated Blood (Type A)**
- **1 bottle of Donated Blood (Type B)**
- **1 bottle of Donated Blood (Type O)**
- **1 bottle of Sasha's Blood Serum (Type A)**
- **1 bottle of Fong's Blood Serum (Type B)**
- **1 bottle of Jordan's Blood Serum (Type AB)**

*For each pair of students*

- **1 SEPUP tray**

*Part Two: Blood Cells*

*For each pair of students*

- **1 slide of normal human blood**
- **1 microscope**



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## PROCEDURE

*Within each group of four students, one pair begins with Part One and the other pair begins with Part Two. When both pairs have completed their parts, they can switch roles.*

### Part One: Blood Type and the Immune Response

#### BLOOD EMERGENCY!

Three patients needing blood transfusions have arrived at the local hospital. This is the chart showing their blood types. In order to supply the blood, the hospital staff has asked the community to help. Several people respond by donating blood. The hospital receives blood donations of types A, B, and O, but these blood types might not be compatible with each patient.

| Patient | Blood Type |
|---|---|
| Sasha | A |
| Fong | B |
| Jordan | AB |

Does the hospital have enough of the right type of blood for each patient? Find out by testing samples of each blood type.

1. Collect the three blood samples and the three serum samples.

   Note: *Serum* is blood that has had the red blood cells removed. In blood transfusions, the donor's blood must be compatible with the patient's serum.

2. Design a data table to record your experimental results. You will test each of the three donated blood types with serum from each of the three patients.

3. Place two drops of Sasha's Blood Serum in Cups 1–3 of your SEPUP tray.

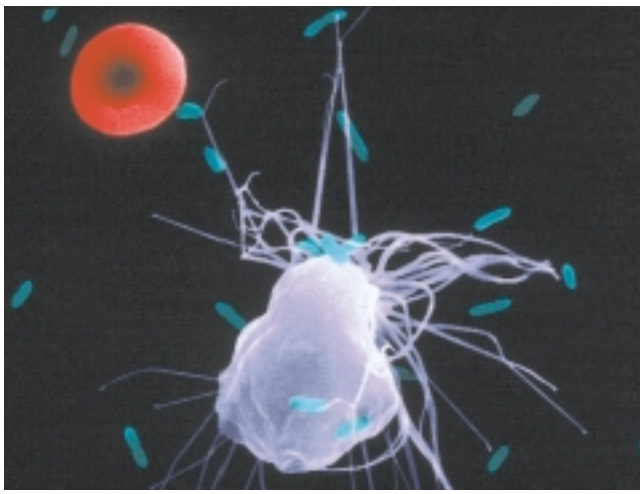
4. Add two drops of Donated Blood Type A to Cup 1. Record the results in your data table.

5. Test Sasha's Blood Serum with the remaining donated blood samples. Record the results in your data table.

6. Use Cups 4–9 to test the samples from the other two patients, Fong and Jordan. Record the results in your data table.

## Part Two: Blood Cells

7. You and your partner should receive a microscope slide of normal human blood.



*This high power scanning electron microscope photograph has been colorized. A red blood cell is near the top of the picture. A white blood cell (colored purple) is attacking bacteria (colored blue-green).*

8. Be sure that your microscope is set on the lowest power (shortest objective) before placing your slide onto the microscope stage. Center the slide so that the specimen is directly over the light opening and adjust the microscope settings as necessary.

   Hint: To check that you are focused on the material that is on the slide, move the slide slightly while you look through the eyepiece—the material that you are focused on should move at the same time you move the slide.

9. Begin by observing the slide on low power (usually the 4x objective). Scan the slide and focus on a section that shows more than one kind of cell.

   Hint: Remember that stains are often used to make structures on a slide more visible. Look carefully for a light pink smear with a dark purple blob. If material on the slide is too light to see, reduce the amount of light on the slide: do this by slightly closing the diaphragm under the stage.

10. Without moving the slide (which can be secured with stage clips), switch to medium power (usually 10x). Adjust the microscope settings as necessary.

11. Without moving the slide, switch to high power (usually the 40x objective). *Be careful not to smash the objective against the slide!* Adjust the microscope settings as necessary.

Hint: If material on the slide is too dark to see, increase the amount of light on the slide: do this by slightly opening the diaphragm under the stage.

12. In your science notebook, describe the two different kinds of cells that you see. In your description, include which type of cell is more common, the shape of each cell, the relative size, and any cell structures you are able to identify in either cell.

## ANALYSIS

### Part One: Blood Type and the Immune Response

1. Each patient required one pint of blood. The hospital received one pint each of type A, B, and O blood. Explain whether the hospital had enough of the right type of blood for each patient.

2. What prevents your body from accepting transfusions of certain types of blood?

### Part Two: Blood Cells

3. Think back to all the work that you have been doing on cells. Compare and contrast different types of cells by copying and completing the table below.

4. In what ways does your body prevent you from catching an infectious disease?

| Cell Type | Cell Shape | Cell Membrane? | Cytoplasm? | Nucleus? |
|---|---|---|---|---|
| Bacteria | | | | |
| Protist | | | | |
| Plant (onion) | | | | |
| Animal: cheek | | | | |
| Animal: red blood cell | | | | |
| Animal: white blood cell | | | | |

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