Exercise 19

Blood Cells

Laboratory Objectives

On completion of the activities in this exercise, you will be able to:

- Describe the functions of blood.
- Describe the difference between the formed elements of blood and blood plasma.
- Identify all blood cell types when viewed with a light microscope.
- Perform a differential white blood cell count.
- Safely use a blood lancet to collect a blood sample.
- Safely determine your ABO and Rh blood type.
- Use the proper safety techniques to discard wastes that have been contaminated with blood.

Materials

- Prepared microscope slides of human blood smears
- Compound light microscopes
- Clean microscope slides
- Gloves
- Face masks
- Protective eyewear
- Wax labeling pencils
- Sterile blood lancets
- Sterile alcohol pads
- Warming tray
- Paper towels
- Containers for the disposal of biohazardous wastes
- Anti-A, anti-B, and anti-Rh blood typing solutions
- Simulated blood typing kits (an optional alternative to using human blood)

Blood is a highly specialized connective tissue that consists of various blood cells (**formed elements**) suspended in a fluid matrix (**blood plasma**). Its various functions include the transportation of substances, the regulation of various blood chemicals, and protection against infections and diseases.

The formed elements, comprising 45% of the total blood volume, include the **red blood cells (erythrocytes)**, **white blood cells (leukocytes)**, and **platelets** (Table 19.1). Red blood cells are flattened biconcave discs that lack nuclei and most organelles. Most of the cytoplasm is filled with the protein **hemoglobin**, which is used to transport oxygen and carbon dioxide.

WHAT'S IN A WORD The term *erythrocyte* is derived from two Greek words: *erythros*, meaning "red," and *kytos*, meaning "cell." Thus, red blood cells are called erythrocytes.

The term *leukocyte* is also derived from Greek and means "white cell" (*leukos* means "white"). ■

The five white blood cell types are categorized into two major groups (Table 19.1). The **granulocytes** have distinct granules in their cytoplasm. They include the **neutrophils**, **eosinophils**, and **basophils**. The **agranulocytes** lack cytoplasmic granules, and include the **monocytes** and **lymphocytes**. White blood cells play essential roles in defending the body against infection (Table 19.1).

Platelets are not true cells, but cytoplasmic fragments derived from cells called **megakaryocytes**. Platelets have a critical role in the blood clotting mechanism and the repair of damaged blood vessels.

Plasma makes up the remaining 55% of the total blood volume. It is 90% water, but it also includes a wide variety of dissolved substances including gases, nutrients, hormones, waste products, ions, and proteins.

Blood performs a variety of essential functions that fall into three major categories.

1. *Transportation of substances*
   - Oxygen and nutrients are delivered to all body tissues for metabolism.
   - Cellular wastes are brought to the lungs and kidneys for elimination.
   - Hormones from endocrine glands are distributed to various target organs.
2. *Regulatory activities*
   - Body temperature is regulated by distributing heat throughout the body and shunting excess heat to the skin's surface for elimination.
   - Blood proteins act as buffers that function to maintain stable blood pH levels.
   - Various blood proteins and dissolved ions prevent dramatic fluctuations in blood volume by maintaining osmotic balance between the blood plasma and surrounding tissue fluids.
3. *Defensive activities*
   - White blood cells, antibodies, and various blood proteins protect the body from infections caused by bacteria, viruses, and other pathogens.
   - Platelets and various blood proteins protect the body from excessive blood loss by repairing damaged blood vessels and forming blood clots.

Table 19.1 Formed Elements in the Blood

Cell type	% total	Average # cells/µl	General description	Function
Erythrocytes (red blood cells; RBCs)	99.9% of all blood cells	4.4–6 million	Biconcave discs; lack nuclei and most other organelles; 7–8 µm diameter	Oxygen and carbon dioxide transport
Leukocytes (white blood cells, WBCs)	0.1% of all blood cells	6000–9000		
Granulocytes				
Neutrophils	40%–70% of WBCs	1800–7300	Multilobed nuclei; pale-staining granules; 10–14 µm diameter	Attack bacteria by phagocytosis
Eosinophils	1%–4% of WBCs	0–700	Bilobed nuclei; bright red or orange granules; 10–14 µm diameter	Attack parasitic worms; mitigate the effects of allergy and inflammation
Basophils	<1% of WBCs	0–150	Bilobed nuclei; blue-purple granules; 10–12 µm diameter	Enhance inflammatory response and tissue repair by releasing histamine and heparin
Agranulocytes				
Monocytes	4%–8% of WBCs	200–950	Kidney-shaped nuclei; pale-staining cytoplasm; 14–24 µm diameter; on average, the largest blood cells	Differentiate into macrophages—attack and destroy bacteria and viruses by phagocytosis
Lymphocytes	20%–45% of WBCs	1500–4000	Relatively large spherical nuclei; thin rim of pale-staining cytoplasm; size is variable, ranging from 5–17 µm in diameter	Regulate the immune response by direct cellular attack and by antibody production
Platelets		150,000–500,000	Cellular fragments of megakaryocytes	Repair of damaged blood vessels; involved in blood clotting 2–4 µm diameter

Formed Elements in Blood

Red Blood Cells

Red blood cells (erythrocytes) make up 99.9% of the formed elements. Thus, when you examine a slide of a normal human blood smear, you should expect the vast majority of the cells that you observe to be red blood cells. Careful and patient scanning of the slide will be required to locate and identify the various white blood cell types and platelets.

ACTIVITY 19.1 Identifying Blood Cells

1. Obtain a slide of a normal human blood smear, prepared with Wright's stain.
2. View the slide under low power with a compound light microscope. Almost all the cells that you see in the field of view are the relatively small, pink-staining red blood cells (erythrocytes). You might also see a few larger and more darkly stained white blood cells (leukocytes) scattered among the erythrocytes (Figure 19.1). If white blood cells are not present in your field of view, carefully scan the slide until you identify them.
3. Examine red blood cells more closely under high magnification. They are uniquely shaped as **biconcave discs** (Figure 19.2), with a relatively thin central region and thick peripheral region. Many resemble doughnuts or life-saver candies, because the thinner center is stained more lightly than the periphery. In addition, notice that mature erythrocytes lack a nucleus.
4. Identify any white blood cells in the field of view (Figure 19.1). Unlike the red blood cells, white blood cells contain distinct nuclei that are usually stained a deep blue or purple. In addition, most white blood cells are much larger than red blood cells.

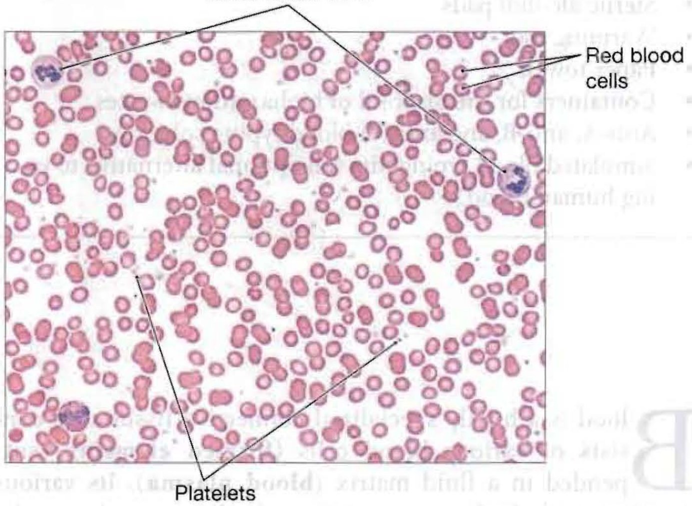

Figure 19.1 Human blood smear. The bulk of the formed elements in blood consists of red blood cells (erythrocytes). White blood cells and platelets are also shown.

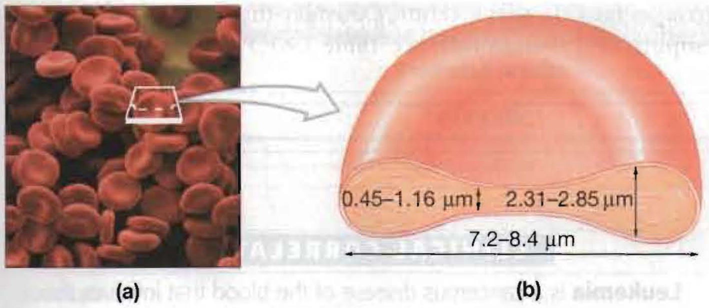

Figure 19.2 Structure of red blood cells. a) Electron microscopic view illustrating the three-dimensional structure of erythrocytes (LM × 800); **b)** sectional view illustrating the unique biconcave shape of a normal erythrocyte.

5. Attempt to identify small fragments of cell cytoplasm in your blood smear, known as platelets (Figure 19.1), which are important for blood clotting.

QUESTIONS TO CONSIDER 1. The vast majority of oxygen that is transported in the blood is bound to hemoglobin molecules in red blood cells. Given that another gas, carbon monoxide, has a much stronger affinity than oxygen to the same hemoglobin binding sites, describe how carbon monoxide poisoning would occur.

____

____

2. How does the lack of a nucleus help to explain why mature red blood cells have a relatively short life span (less than 120 days)?

____

____

CLINICAL CORRELATION

The **hematocrit** is a value that records the percentage of whole blood that is composed of cells (the formed elements). Since red blood cells comprise the vast majority (99.9%) of the formed elements, the hematocrit value is used to measure erythrocyte levels and thereby assess oxygen carrying capacity. The normal hematocrit range is 42 to 52 for men and 37 to 47 for women.

Another diagnostic measure for oxygen carrying capacity is **hemoglobin (Hb) concentration** in red blood cells. Hb concentration is measured in grams per deciliter (g/dl). Typically, a decline in the hematocrit value will also cause a decline in Hb concentration. Normal Hb concentrations are 14 to 18 g/dl in males and 12 to 16 g/dl in females.

Anemia is a condition characterized by a reduction in oxygen carrying capacity and a resulting decline in oxygen transport to cells and tissues. Anemia can occur when the hematocrit and/or the Hb concentration is lowered.

White Blood Cells

White blood cells play vital roles in defending the body from pathogens and foreign proteins. When these cells are activated, they are capable of migrating from blood vessels to surrounding tissues by a process called **diapedesis**. Neutrophils, eosinophils, and monocytes are able to ingest pathogens and debris from dead cells by phagocytosis. Basophils release chemicals (histamines and heparin) that enhance inflammation when tissue damage occurs. Lymphocytes are responsible for defenses against a specific pathogen. These activities include direct cellular attacks and the production of antibodies.

WHAT'S IN A WORD The word *diapedesis* is derived from Greek and means "leaping through." White blood cells can pass or "leap through" the walls of blood vessels to enter surrounding tissues where they destroy disease-causing organisms and ingest the remains of dead cells.

You have already discovered that white blood cells are not nearly as abundant as red blood cells. However, white blood cells are easy to identify because of their relatively large size and distinctive nuclei.

ACTIVITY 19.2 Identifying White Blood Cell Types

1. Under high power, carefully scan a slide of a normal human blood smear prepared with Wright's stain.
2. When you identify a white blood cell, use immersion oil and the oil immersion lens to observe the cell at a higher magnification and to identify the specific white blood cell type. For help, refer to Table 19.1 and Figure 19.3, and consider the following general features of white blood cells.
   - On average, white blood cells are approximately twice as large (10–12 µm in diameter) as red blood cells. Monocytes are the largest white blood cells, ranging from 14 to 24 µm in diameter. Lymphocytes range in size from 5 to 17 µm in diameter, and are often classified as small (5–8 µm), medium (9–12 µm), and large (13–17 µm).
   - The nuclei of white blood cells, which stain a deep blue or purple, have distinctive shapes. For example, a neutrophil has a multilobed nucleus, whereas in a basophil or an eosinophil, the nucleus is bilobed. The typical monocyte nucleus possesses a deep indentation on one side, giving it a kidney shape. In a lymphocyte, the nucleus is round and occupies the vast majority of the cell volume, leaving only a narrow rim of cytoplasm around the periphery.
   - Neutrophils are the most abundant white blood cells and will be the easiest to identify. Lymphocytes and monocytes are also relatively common. Eosinophils and especially basophils are quite rare and difficult to identify. If you think that you have found either of these cell types, verify the identification with your instructor. Be patient in your attempt to identify these cells, but do not be discouraged if you cannot find one. Perhaps your instructor will have better luck!

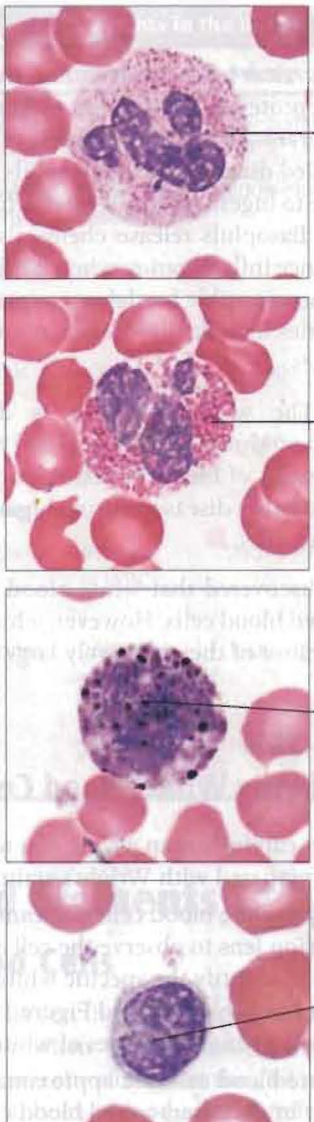

Figure 19.3 Structure of white blood cells. a) neutrophil; **b)** eosinophil; **c)** basophil; **d)** lymphocyte; **e)** monocyte.

QUESTION TO CONSIDER Over-the-counter antihistamine drugs are used to relieve the pain and discomfort of inflammation due to allergies, cold, and fever. However, overuse of these drugs could prolong your symptoms. Speculate on a reason for this effect. (Hint: Consider the function of basophils and eosinophils; see Table 19.1.)

____

____

CLINICAL CORRELATION

Leukemia is a cancerous disease of the blood that involves the uncontrolled propagation of abnormal white blood cells in the bone marrow. Leukemias can be classified according to the type of leukocyte involved. **Myeloid leukemias** involve granulocytes; **lymphoid leukemias** involve lymphocytes. For both categories, the disease can advance quickly (acute) or slowly (chronic). As leukemia progresses, abnormal leukocytes gradually replace normal cells, and bone marrow function is impaired. As a result, the production of red blood cells, normal white blood cells, and platelets declines significantly, leading to anemia, infections, and reduced blood clotting. One option to fight leukemia is a **bone marrow transplant.** In this procedure, the patient is exposed to a massive dose of radiation or chemotherapy to kill any abnormal and cancerous cells in the bone marrow. This exposure also kills the normal cells, so the individual is left highly susceptible to infections that could be fatal. Next, the patient is given healthy bone marrow tissue that, hopefully, will generate new populations of normal blood cells. Compatibility of blood and tissue types is a critical factor in transplant operations. If tissue rejection occurs, the donor's lymphocytes could attack and destroy the recipient's tissues, a condition that could cause death.

Differential White Blood Cell Count

White blood cells play vital roles in protecting us from infections and promoting inflammation in response to tissue damage and allergies. Under normal conditions, the blood will contain a certain percentage of each white blood cell type (Table 19.1). Any deviation in the normal percentage ranges could indicate an abnormal condition such as a bacterial, viral, or parasitic infection.

In a clinical laboratory, a **differential white blood cell count** is performed to determine the percentages of each white blood cell type. Although this procedure can be completed rather quickly using computers, the manual method described here will yield similar results.

ACTIVITY 19.3 Performing a Differential White Blood Cell Count

Form a Hypothesis **To complete your differential white blood cell count, you will be required to identify at least 100 white blood cells. Before you begin, use the information in Table 19.1 to predict the number of each white blood cell type that**

Table 19.2 Differential White Blood Cell Count

	Predicted results	Observed results	
Cell Type	# of Cells	# of Cells	% of Total Leukocytes
Neutrophil			
Eosinophil			
Basophil			
Monocyte			
Lymphocyte			
Total	100		100

you expect to identify. Record your prediction in the "Predicted Results" column in Table 19.2.

1. Obtain a slide of a human blood smear prepared with Wright's stain.
2. Move your slide to the upper left margin of the blood smear and focus under low power.
3. Switch to a high power and observe the upper left region of the blood smear. Find an area in which the blood cells are dispersed evenly throughout the field of view. For the most accurate results, the oil immersion lens should be used, although you can complete this activity with the highest dry objective lens.
4. Beginning at the upper left region of the blood smear, carefully scan the entire slide in the back-and-forth pattern illustrated in Figure 19.4. When you observe a white blood cell, identify the type and record it in Table 19.2.
5. After you have identified at least 100 white blood cells, convert the number of each cell type to a percentage of the total, using the following equation. Record these results in Table 19.2.

Percentage (%) = (# cells observed ÷ total # counted) × 100

Assess the Outcome **Examine the data that you have collected in Table 19.2. Do your predicted results agree with your observations? Provide an explanation for your observations.**

____

____

QUESTION TO CONSIDER **Infectious mononucleosis** is a disease believed to be caused by an infection of the Epstein-Barr virus. It is characterized by fever, sore throat, swollen lymph nodes, and an enlarged spleen. Discuss how a differential white blood cell count from an individual with this disease would differ from a normal count.

____

____

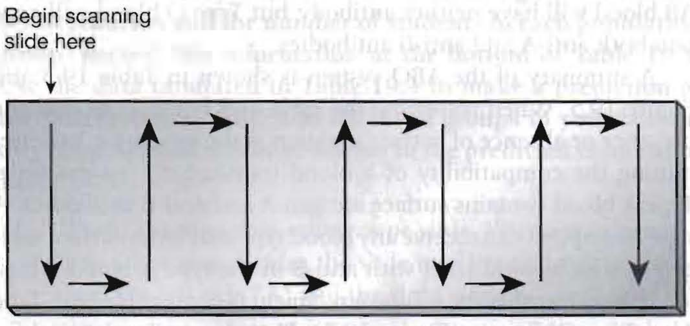

Figure 19.4 Method for performing a differential white blood cell count. Observations of a blood smear begin at the upper left corner of the microscope slide. The slide is scanned in a back-and-forth pattern as indicated by the arrows until the entire blood smear is viewed.

Blood Types

An individual's blood type is a genetically determined trait. It is based on the presence or absence of specific glycoprotein molecules, called **surface antigens** or **agglutinogens**, which are located on the cell membranes of erythrocytes. The immune system recognizes the surface antigens as being normal and will not attack them as a foreign substance.

Blood plasma contains **antibodies** or **agglutinins**, which are each genetically programmed to react with a specific surface antigen if it is present. Thus, if blood of two different types are mixed, an **antigen–antibody reaction** will occur and the result will be **agglutination**, or clumping of red blood cells.

In humans, there are over 50 blood groups, but most do not cause significant reactions when different types are mixed. In this activity, you will be studying two blood groups, the **ABO group** and the **Rh system**, which are significant for their antigenic reactions.

The ABO group is based on the presence or absence of two surface antigens on red blood cells, called A and B. Persons with **Type A** blood have surface antigen A on their red blood cell membranes, and persons with **Type B** blood have surface antigen B. If both surface antigens are present, the blood is **Type AB**;

Table 19.3 ABO Blood Groups

Blood type	Surface antigen	Antibody	Compatible donor	Incompatible donor
A	A	Anti-B	Type A, Type O	Type B, Type AB
B	B	Anti-A	Type B, Type O	Type A, Type AB
AB	A, B	None	Type AB, Type A, Type B, Type O	None
O	None	Anti-A, Anti-B	Type O	Type A, Type B, Type AB

if both surface antigens are absent, the blood is **Type O.** Blood plasma will contain antibodies for the surface antigen that is not present on red blood cells. Thus, Type A blood will have the **anti-B** antibody, and Type B blood will have **anti-A antibody**. Type AB blood will have neither antibody, but Type O blood will contain both anti-A and anti-B antibodies.

A summary of the ABO system is shown in Table 19.3 and Figure 19.5. When reviewing the table and figure, note that the presence or absence of surface antigens is the key factor in determining the compatibility of a blood transfusion. For example, Type A blood contains surface antigen A and anti-B antibodies. A type A recipient can receive any blood type that lacks surface antigen B, which could react with anti-B in the type A blood. Thus, for a blood transfusion, a Type A recipient is compatible with Type A or Type O donors (Figure 19.5). Using a similar rationale, a Type B recipient can receive blood from Type B or Type O donors.

Type O is a special blood type because both surface antigens A and B are absent. Thus, red blood cells in donor Type O blood will not agglutinate with antibodies that might be present in a recipient's blood. Because of this feature, Type O is the **universal donor** (Table 19.3; Figure 19.5). However, because Type O blood contains small levels of anti-A and anti-B antibodies, some agglutination can occur if it is mixed with different blood types. Type AB blood is unique because it lacks both anti-A and anti-B antibodies. Since there are no antibodies to cause agglutination, Type AB blood is referred to as the **universal recipient** (Table 19.3; Figure 19.5). However, antibodies that are present in Types A, B, and O blood could cause some agglutination in a Type AB recipient. The lesson to be learned from this information is that donor and recipient blood types can be different, but the best case scenario is always when the two blood types are the same.

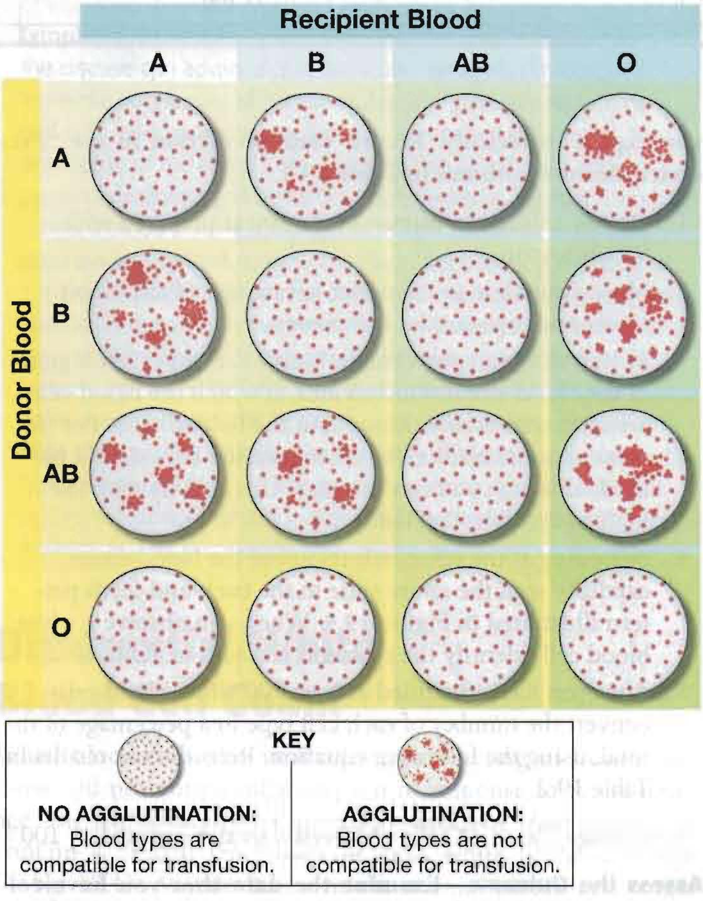

Figure 19.5 Transfusion results for the ABO blood types. A transfusion is compatible if the donor's blood lacks the antigens (A, B) that will react with antibodies (anti-A, anti-B) in the recipient's blood and cause agglutination. Notice that type O blood is the universal donor and Type AB is the universal recipient.

CLINICAL CORRELATION

An error in blood typing, leading to an incompatible blood transfusion, could prove to be a fatal mistake. Surface antigens on the red blood cells of the recipient blood will react with antibodies in the donor blood. As agglutination proceeds, some cells will swell and eventually rupture (**hemolysis**), releasing hemoglobin into the blood. As clumps of erythrocytes become trapped in capillary beds, blood delivery to cells and tissues in all parts of the body could be dramatically reduced, leading to multiple organ failure and possibly death.

The Rh system is named after the rhesus monkey, the primate in which the surface antigen, the **Rh factor**, was first discovered. For Rh blood typing, a plus (+) sign is used if Rh factor is present and a negative (−) sign is used if it is absent. For example, a person with Type A blood can be either A (+) or A (−), depending on whether the Rh factor is present or absent. Unlike the ABO group, a person who is Rh negative does not normally produce anti-Rh antibodies unless he or she is inadvertently exposed to Rh factor (e.g., through a blood transfusion).

CLINICAL CORRELATION

If an Rh (−) woman becomes pregnant, it is possible for the fetus to be Rh (+) if the father is Rh (+). During the pregnancy, fetal blood could leak from the placenta to the maternal bloodstream. As a result, the mother becomes sensitized to the Rh factor by producing anti-Rh antibodies. The fetus will not be affected because anti-Rh is not typically produced in a high enough concentration until after birth. However, potentially fatal consequences could result if there is a second pregnancy and the fetus is Rh (+). Antibodies from the maternal blood could cross the placenta, enter the fetal blood, and react with Rh factor. The resulting agglutination and hemolysis, known as **hemolytic disease of the newborn (HDN),** could be fatal. HDN can be easily prevented. If a mother is Rh (−), a drug called RhoGAM is given after the first pregnancy. RhoGAM prevents the production of anti-Rh antibodies by the mother and protects the second fetus from the dangers of fetal–maternal blood incompatibility.

Before you proceed with the next activity, please remember that you will be working with blood, a body fluid that may contain infectious organisms. Adhere to the following safety procedures when handling blood (or any other body fluid).

- Always assume that the blood with which you are working is infected with a disease-causing organism. This attitude will put you in the right frame of mind to work with extreme caution.
- Work with your own blood *only.* Under no circumstances should you collect or conduct experiments with the blood of another individual.
- Always wear gloves, safety eyewear, and a mask when working with blood. Never allow blood to come in contact with unprotected skin. Protective gear should be worn throughout the experiment and during cleanup.
- Mouth pipetting should never be done under any circumstances.
- If any part of your skin is accidentally contaminated with blood, disinfect the area immediately with a 70% alcohol solution for at least 30 seconds, followed by a 1-minute soap scrub and rinsing.
- Any blood that spills onto your work area should be disinfected with a 10% bleach solution or a commercially prepared disinfectant. The contaminated area should remain covered with the bleach/disinfectant for at least 30 minutes before wiping it off.
- Lancets, needles, and other sharp instruments (sharps) should be used only once. After use, disinfect all sharps in a 1:10 solution of household bleach and 70% alcohol for 30 minutes and then place in a puncture-proof container for disposal.
- All reusable glassware and other instruments should be disinfected in a 10% bleach solution for 30 minutes and then washed in hot, soapy water. If available, autoclaving this equipment before washing is recommended.
- Work areas should be cleaned with a 10% bleach solution or a commercially prepared disinfectant before and after any laboratory activity during which blood is used.
- As an alternative, simulated blood typing kits are available. These kits will allow you to conduct blood typing experiments without using human blood products.

ACTIVITY 19.4 Determining Your Blood Type

Form a Hypothesis **Before you begin the blood typing experiment, review the data in Table 19.4, which lists the distribution of blood types in the United States. Conduct a demographic survey of your class by counting the total number of students and the number of students in each population group. Record this information at the bottom of Table 19.5. Use the data tabulated in Table 19.4 to make a prediction of the distribution of ABO and Rh blood groups in your laboratory class. Record this information in the predicted columns in Table 19.5.**

1. Obtain a sterile glass microscope slide. With a wax pencil, draw a line that divides the slide into left and right sides. Label the left side "A" and the right side "B."
2. Obtain a second sterile glass microscope slide and label it "Rh."
3. Place a paper towel on your work space. This towel will be used to place blood collecting instruments prior to disposal.
4. Wash your hands thoroughly with warm water and soap and dry them completely with a paper towel.
5. You will be collecting a blood sample from yourself. Put on your protective eyewear and face mask. Place a surgical glove on the hand that will hold the lancet. The hand that will be used for collecting the blood sample should remain uncovered.
6. Use a sterile alcohol pad to clean the tip of your index finger on all sides. Place the used pad on the paper towel.

Table 19.4 Distribution of Blood Types in the United States

Incidence of blood types (%)

Population Group	O	A	B	AB	Rh (+)
White	45	40	11	4	85
African American	49	27	20	4	95
Korean	32	28	30	10	100
Japanese	31	38	21	10	100
Chinese	42	27	25	6	100
Native American	79	16	4	1	100

7. Open a sterile blood lancet to expose the sharp tip. With a swift and deliberate motion, jab the lancet tip into the fingertip. After use, place the lancet on the paper towel until it can be properly discarded. The lancet should not be used more than once under any circumstances.
8. Squeeze a drop of blood to each half of the slide labeled A and B, and another drop to the slide labeled Rh.
9. Add a drop of anti-A serum to blood sample A. As you add the serum, keep the dropper from directly contacting the drop of blood. In the same way, add a drop of anti-B serum to blood sample B and a drop of anti-Rh serum to blood sample Rh.
10. Mix the blood samples and antisera with clean toothpicks. Be sure to use a different toothpick to mix each sample. Place the used toothpicks on the paper towel until they can be discarded safely.
11. Place both slides on a warming tray. Gently agitate the samples in a back-and-forth manner for 2 minutes.
12. Examine the blood samples for evidence of agglutination. Agglutination will occur when antibodies in the antiserum react with the corresponding surface antigen on red blood cells (Figure 19.6).

    For the ABO group, agglutination is possible when the following occur.

    - Type AB blood is exposed to either anti-A or anti-B serum (Figure 19.6a).
    - Type B blood is exposed to anti-B serum (Figure 19.6b).
    - Type A blood is exposed to anti-A serum (Figure 19.6c).
    - Type O blood will not agglutinate when exposed to either antiserum (Figure 19.6d).

    For determining the Rh status, Rh (+) blood will agglutinate when exposed to anti-Rh serum, but Rh (−) blood will not. The Rh agglutination is often difficult to observe with the unaided eye. If this is the case, use a microscope to observe the reaction.
13. Record your blood typing observations in Table 19.6 by writing a (+) or (−) for the presence or absence of agglutination.

Assess the Outcome **Collect the blood typing results from the rest of the class, and sort the data according to the various population groups that are represented. Calculate the incidence of blood types in each population group and record the data in the "actual" columns in Table 19.5. Did your predictions for blood type incidence agree with the actual results? Provide an explanation for your results. If the sample size in your class is small, discuss the limitations that this would have on your analysis.**

Table 19.5 Distribution of Blood Types in the Laboratory Class

Incidence of blood types (%)

Population Groups	O		A		B		AB		Rh(+)	
in the Class	Predicted	Actual	Predicted	Actual	Predicted	Actual	Predicted	Actual	Predicted	Actual
1.										
2.										
3.										
4.										
5.										

Total number of students in class ______

Number of students in each population group:

Population group	# students
1.	
2.	
3.	
4.	
5.	

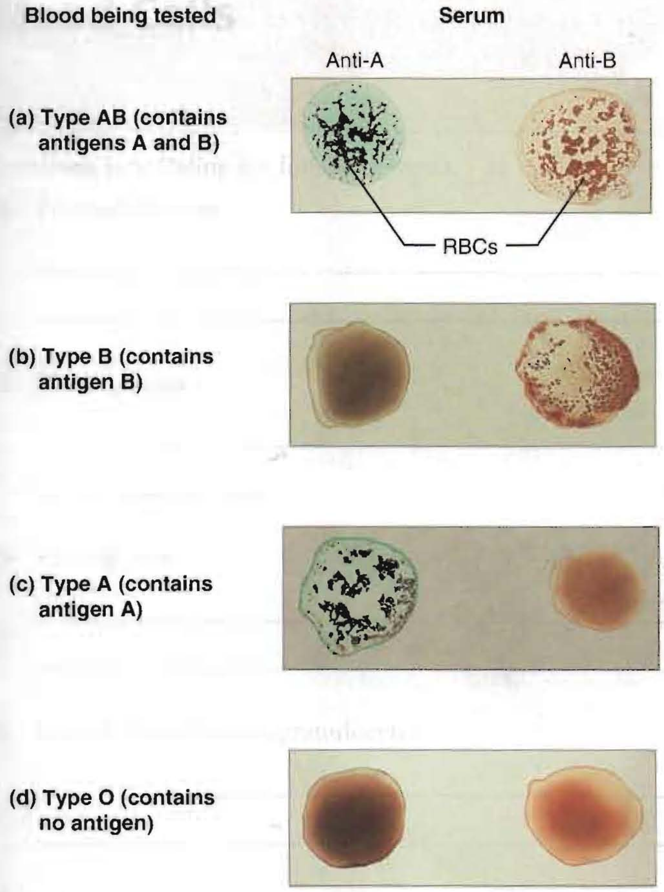

Figure 19.6 ABO blood typing results. a) For Type AB blood, agglutination occurs when it is exposed to both anti-A and anti-B sera. **b)** For Type B blood, agglutination occurs when it is exposed to anti-B serum, but not to anti-A serum. **c)** For Type A blood, agglutination occurs when it is exposed to anti-A serum, but not to anti-B serum. **d)** For Type O blood, agglutination does not occur when it is exposed to either anti-A or anti-B serum.

QUESTIONS TO CONSIDER

1. While typing the blood of a patient who is about to undergo surgery, the medical technician determines that agglutination occurs when the blood is exposed to both anti-A and anti-B. Agglutination does not occur when the blood is exposed to anti-Rh. Based on the results of these tests, what is the blood type of the patient? Provide a brief explanation for your answer.

____

____

____

____

2. The destruction of fetal red blood cells can occur if anti-Rh antibody enters the blood of an Rh-positive fetus. For this potentially fatal situation to occur, the parents must have the following Rh blood typing characteristics.

- The mother is Rh (−) but possesses anti-Rh antibodies in her blood.
- The father is Rh (+).

Explain why these two conditions must be correct.

____

____

____

____

Table 19.6 Blood Typing Results

Name	Presence of agglutination (+/−)			
	Anti-A	**Anti-B**	**Anti-Rh**	**Blood Type**
1.				
2.				
3.				
4.				
5.				

Exercise 19 Review Sheet

Blood Cells

Name ____________________

Lab Section ____________________

Date ____________________

Questions 1–5: Define the following terms.

1. Formed elements

2. Blood plasma

3. Hemoglobin

4. Granulocytes versus agranulocytes

5. Diapedesis

6. Describe the basic functions of blood.

Questions 7–13: Match the cell type in column A with the correct description in column B.

A	B
7. Neutrophils ______	a. Large cells with kidney-shaped nuclei and no granules in the cytoplasm
8. Erythrocytes ______	b. Regulate the immune response
9. Monocytes ______	c. Involved in the repair of damaged blood vessels and blood clotting
10. Basophils ______	d. Biconcave discs that lack nuclei
11. Platelets ______	e. Contain bilobed nuclei with bright orange-red granules in the cytoplasm
12. Eosinophils ______	f. Enhance inflammatory response by releasing heparin and histamine
13. Lymphocytes ______	g. The most abundant white blood cell; contain multilobed nuclei; attack infectious agents by phagocytosis

14. Explain how the blood types in the ABO group are derived.

15. Explain why Type O blood is the universal donor and Type AB blood is the universal recipient.