Handout 2-A
Unlocking the Mysteries of Blood Types

Name _____ Date _____

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Your Job

Use cutouts of red blood cell (RBC) surface antigens and plasma antibodies to find the make-up of each blood type. Determine the donors and recipients for each blood type.

Your Steps

Part 1: Blood Antigens and Antibodies

1. Get a "Blood Antigens and Antibodies" cutout set for your group of four. Take the red blood cells (RBCs) with attached antigens out of the bag. Put one type (A, B, AB, or O) in front of each person.

2. In "Matching Blood Types" (Handout 2-B), read aloud through the end of the section "What Determines Blood Type?"

3. In "Blood Types: What Did I Discover?" (Handout 2-C), answer #1 and #2.

4. Put the the antibodies in the center of the table. From the handout "Matching Blood Types," read aloud the section "What Are Blood Antibodies?" and answer #3 in the handout "Blood Types: What Did I Discover?"

5. Look for an antibody that fits the shape of your RBC's antigen. Fit the two together and show your group. Then show how your same three RBC antigens can be locked together by several antibodies and cause the blood to clot.

Part 2: Donating and Receiving Blood

1. From the handout "Matching Blood Types," read aloud the section "Is This Blood Friend or Foe?" and answer #4 and #5 in the handout "Blood Types: What Did I Discover?"

2. Put all the antibodies back into the center of the table. Look at the shapes and figure out which antibodies will be found naturally in your blood type's plasma. *Remember:* These antibodies should not cause clotting, so they can not match the shape of the antigens.

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3. In the handout "Blood Types: What Did I Discover?" answer #6 and #7.

4. When can a person with one blood type safely donate to a person with a different blood type? *Answer:* A donor should not give RBC antigens to a recipient if the antigens will clot with the recipient's plasma antibodies. If the blood clots, the recipient could die.

   To demonstrate this:

   a. Lay the RBC antigen and antibody cutouts for one blood type in front of each person.
   b. If you are the student with type A, you are the first donor. Hold your antigen card next to each of the blood types, including your own. Ask your group, "Can type A donate to (this blood type) and not cause clotting?" Look at the antibodies.
   c. Record your answers in #8 (table) in "Blood Types: What Did I Discover?"
   d. Repeat this process using the other three blood types as donor blood types.

5. From the handout "Matching Blood Types," read aloud the section "Who Can a Person Donate Blood To?"

6. When can a person with one blood type safely receive blood from a person with a different blood type? *Answer:* A recipient is the person who receives a donor's antigens. The recipient's antibodies should not clot with the donor's antigens.

   To demonstrate this:

   a. Lay out the cutouts as you did in Step 4 above.
   b. If you are type B, you are the first blood recipient. Have each student hold the RBC antigen card for his or her blood type next to the RBC antigen and antibody combination for your blood type. Ask your group, "Can type B receive antigens from this blood type and not clot?"
   c. Record your answers in #9 (table) in "Blood Types: What Did I Discover?".
   d. Repeat this process using the other three blood types as recipients.

7. From the handout "Matching Blood Types," read aloud the section "Who Can a Person Receive Blood From?"

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8. From the handout "Matching Blood Types," read aloud the section "What Is the Rh Factor in Blood?"

   To demonstrate this:

   a. Put the other cutouts away and get the "Rh Antigens and Antibodies" cutouts from your teacher.
   b. Set an RBC antigen in front of each student. Use the antibodies for Rh to show how clotting can occur.

9. Answer #10, #11, #12, and #13 in "Blood Types: What Did I Discover?"

10. From the handout "Matching Blood Types," read aloud the section "How Is Blood Type Used to Solve Crimes?" and answer #14 in "Blood Types: What Did I Discover?"

Handout 2-B
Matching Blood Types

Name _____ Date _____

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The history of blood research and the role of blood in medicine are marked by trial and error. In 1799, an elderly George Washington was treated by a team of physicians who recommended bloodletting to remove the impurities making him ill. Over a nine-hour period, they removed approximately 3.75 liters—over half the blood in his body! He died the next day (Vadakan 2004).

From its earliest attempts in the 1600s and over hundreds of years following, blood transfusions between people did not have a high rate of success due to the lack of knowledge about the concept of different blood types. It was not until the early 20th century, when Austrian physician Karl Landsteiner announced he had discovered three main types of human blood groups (he was awarded the Nobel Prize for Medicine for this discovery), that people began to understand the vital importance of blood types (EBC 2002).

Today, blood-type identification has uses outside the hospital walls. It can help forensic scientists narrow suspect pools and point to probable suspects involved in crimes, and it can help match parents with children when parentage is in question.

What Does the Forensic Scientist Need to Know?

Forensic scientists distinguish between blood types and know what will happen if different blood types are mixed. In the lab, they can recognize and explain the chemical reactions observed in testing for blood types. Finally, they understand how blood typing can be used as evidence in a crime investigation.

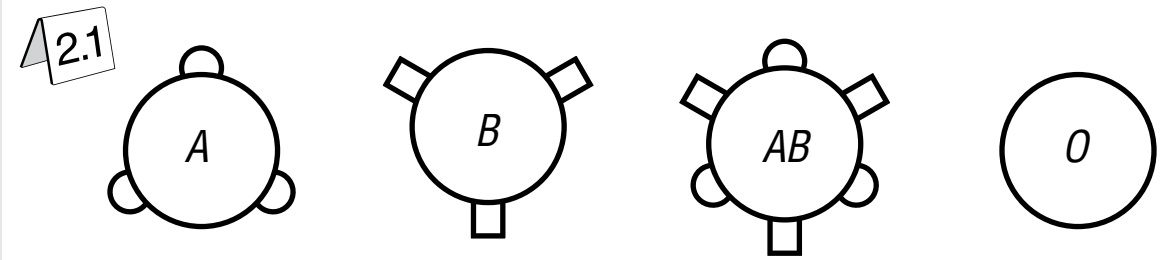
What Determines Blood Type?

A person has the same blood type throughout his or her lifetime. The four different types of human blood (A, B, AB, and O) each have a different combination of proteins attached to the red blood cell (RBC) (Figure 2.1). The two proteins (called antigens or agglutinogens) are called antigen A and antigen B. The type of antigens present give the name of the blood type. Antigen A is found in type A blood; antigen B is found in type B blood; type AB RBCs have both antigens; and type O RBCs have no antigens.

What Are Blood Antibodies?

Blood antibodies are like bodyguards flowing through the plasma in our

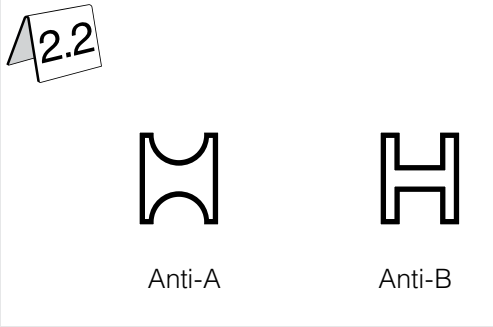
Handout 2-B
Matching Blood Types



RBCs with antigens attached (except for Type O, which has no antigens).

blood vessels. Part of the immune system, they attack foreign RBC antigens by locking onto them like a lock and key (Figure 2.2). This causes the blood to clot and can lead to death. These antibodies begin to form in a baby's blood plasma shortly after birth.

The body makes antibodies for any antigen that is not found naturally on the body's RBCs (Figure 2.3). For example, if the blood has antigen A (type A), the person would make antibody B to attack any foreign antigen Bs that might enter the blood stream. If the blood has antigen B (type B), the person would make antibody A to attack foreign antigen As. If the blood has both antigens A and B (type AB), the person would make *no* blood antibodies. Type O RBCs have no antigens, so the person would make both antibodies A and B.

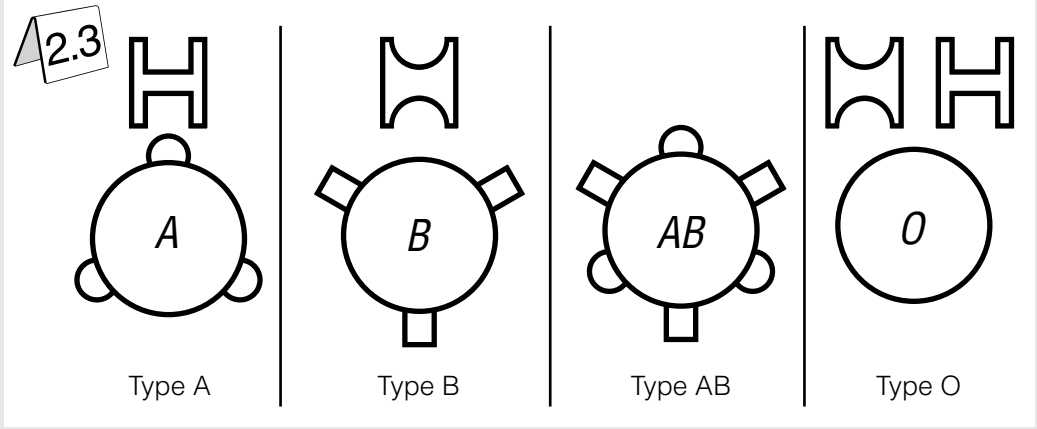


The two antibody shapes.

Is This Blood Friend or Foe?

A blood transfusion means blood is taken from one person and put directly into another person's blood vessels. Before 1900 many patients mysteriously died from blood transfusions, while others lived. Doctors had no way of determining the blood types of the donor and the recipient of a transfusion, but they knew that transfusions were more successful when the donor

Handout 2-B
Matching Blood Types



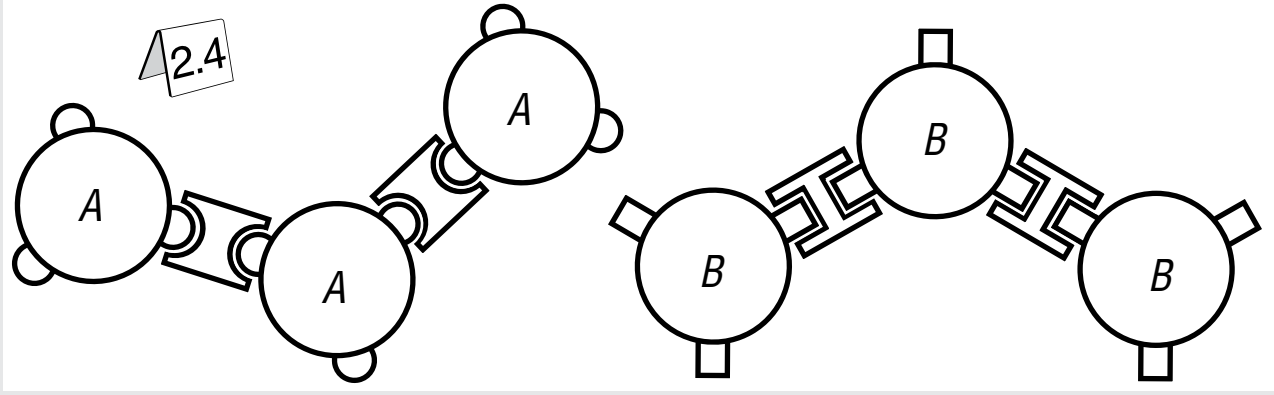
Antigens and antibodies for the four blood types.

was a close relative. In fact, blood type is inherited from parents.

Eventually, technology and lab tests gave doctors and scientists a way to identify the antigens and antibodies in blood. They found that if the donor's red blood cells had antigens that matched the antibodies in the recipient's blood, the antibodies would lock onto the foreign antigens, causing the blood to clot (Figure 2.4). The result was often the death of the person receiving the blood.

Who Can a Person Donate Blood to?

The discovery of the structure and function of blood antigens and antibodies helped doctors to safely match donors and recipients. The type of antigens on the donor's red blood cells is the important factor in



Anti-A locks together (clots) type A RBCs.

Anti-B locks together (clots) type B RBCs.

Handout 2-B
Matching Blood Types

deciding who can donate blood. For instance, a person with antigen A (type A) can donate blood to another person with antigen A (type A and type AB) (Figure 2.5). The donor's antibodies are minimal in a transfusion and do not cause life-threatening harm to the recipient. Type O has no antigens, so no antibodies can lock onto antigen A or antigen B to cause clotting. Type O is called the "universal donor" because it is safe for all recipients.

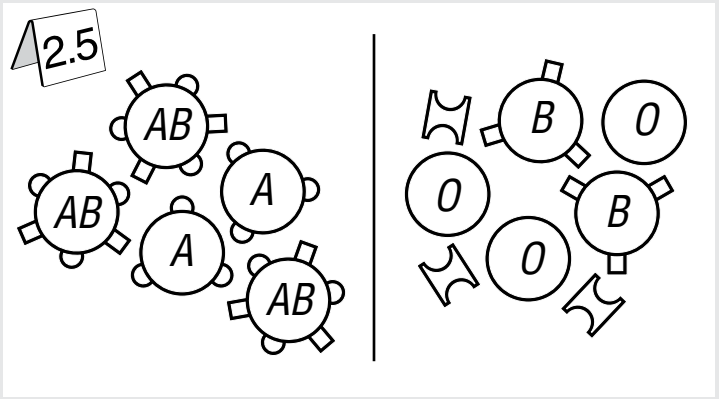
Who Can a Person Receive Blood From?

A person who needs a blood transfusion can safely receive blood with antigens that match his or her own blood or blood with no antigens (type O). If the patient receives blood with antigens that match his or her plasma antibodies, the blood will clot and the patient could die (Figure 2.6). For example, if a person has type A (antigen A and antibody B), she can receive type A because the donor's antigen A will not clot with her antibody B. She can also receive type O because it has no antigens to react with her antibodies (Figure 2.7).

If a person has type AB blood (antigens A and B), he can receive any type of blood because his plasma has no antibodies. If a person has type O, he has both antibody A and B in the plasma. The only safe donor is another type O with no antigens.

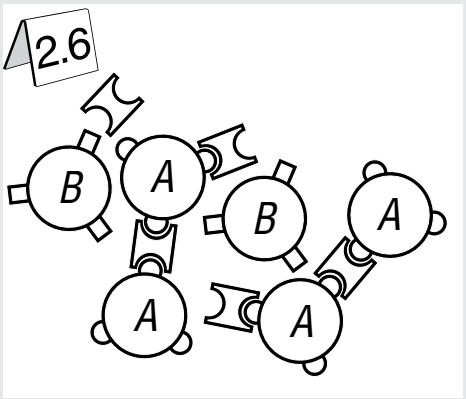
What Is the Rh Factor of Blood?

The Rh factor is another protein antigen found on the surface of red blood cells. It is either present (+) or absent (-). It was first discovered in, and then



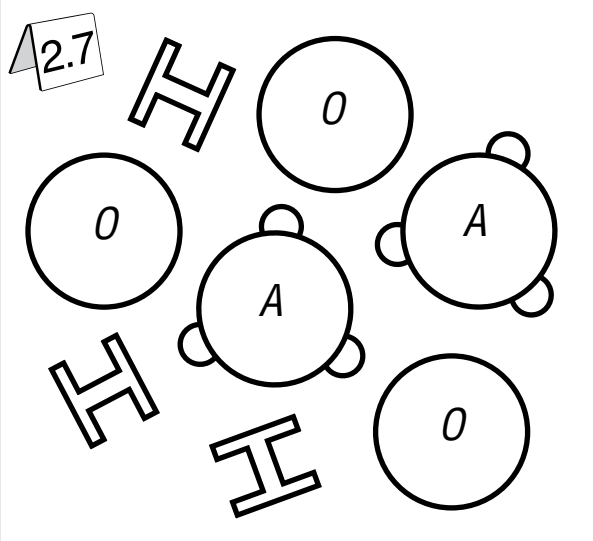
No clotting when type A antigens are donated to type AB.

No clotting when type O antigens are donated to type B.



Clotting when type A antigens are donated to type B.

Handout 2-B
Matching Blood Types



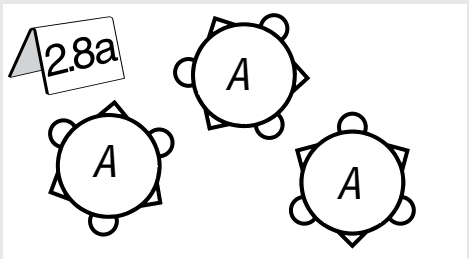
Type A can receive blood from type O.

named after, the rhesus (RH) monkey. There is no relationship between a person's blood type and the presence of the Rh-antigen. Each blood type is either Rh+ or Rh-, with 85% of the U.S. population being Rh+.

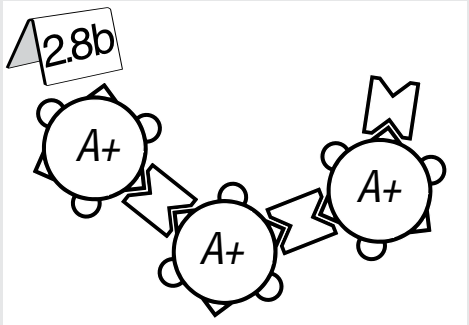
If a person has the Rh antigen (Rh+), he will not have the Rh antibody in his plasma (Figure 2.8a). An Rh- (no antigen) woman who is pregnant with an Rh+ baby will begin making Rh antibodies if her blood mixes with the baby's. These antibodies will lock onto the baby's Rh antigens and cause the blood to clot. This serious medical condition, called Rh disease, can threaten the lives of her future children (Figure 2.8b). This is also a problem if an Rh- person receives a transfusion of Rh+ blood.

How Is Blood Type Used to Solve Crimes?

All people fit into one of four blood-type categories. In the United States, 45% of people have type O, 39% have type A, 12% have type B, and 4% have type AB. In terms of forensics, this means blood type can only be used as indirect or circumstantial evidence to classify a suspect with a larger group of people who have the same blood type. It cannot be matched to one individual. For example, if the blood at the crime scene is type O and the suspect's blood is type O, all that can be concluded is that the suspect is in the group of individuals having the blood type of the evidence. If the blood type from



Rh+ (type A+).



Rh blood antigens exposed to Rh antibodies.

Handout 2-B
Matching Blood Types

the scene of a crime is different from that of the suspect, however, it could support a plea of innocence.

A stronger identification test using blood would be to isolate the DNA from the blood and create a DNA fingerprint. These results could be reliably matched to a single individual.

REFERENCES

Educational Broadcasting Corporation (EBC). 2002. Blood history: Discovery and exploration timeline. From the PBS program "Red Gold: The Epic Story of Blood." Timeline available online at *www.pbs.org/wnet/redgold/history/timeline3.html*

Vadakan, V. V. 2004. The asphyxiating and exsanguinating death of President George Washington. *The Permanente Journal* 8 (2): 76–79.

Handout 2-C

Blood Types: What Did I Discover?

Name _____ Date _____

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1. How is blood typing helpful?

2. What are antigens and where are they found?

3. What are antibodies and where are they found?

4. Draw RBCs with antigen(s) for each blood type. Draw and name the antibodies that will lock onto each blood antigen.

Type A	Type B	Type AB	Type O

5. What would happen if your blood had matching RBC antigens and antibodies, as shown in #4?

6. Draw the combination of antigens and antibodies found naturally in each blood type. (They cannot lock together to cause clotting.)

	Type A	Type B	Type AB	Type O
RBC antigen(s)				
Antibodies naturally found in blood plasma				

Handout 2-C
Blood Types: What Did I Discover?

7. If you have antigens A and B, what is your blood type?

   If you have antibodies A and B, what is your blood type?

8. Each blood type can donate to _____. Mark donor matches with a "yes." *Reminder:* The donor's antigens should not clot with the recipient's antibodies.

	Type A	Type B	Type AB	Type O
Type A can donate to___.				
Type B can donate to___.				
Type AB can donate to___.				
Type O can donate to___.				

9. Each blood type can receive blood from _____. Mark recipient matches with a "yes." *Reminder:* The recipient's antibodies should not clot with the donor's antigens.

	Type A	Type B	Type AB	Type O
Type A can receive blood from ___.				
Type B can receive blood from ___.				
Type AB can receive blood from ___.				
Type O can receive blood from ___.				

Handout 2-C

Blood Types: What Did I Discover?

10. What is the Rh factor?

11. Complete this table on Rh factor reactions in blood by putting an X in the correct boxes.

Blood type	Has antigen Rh	Can make antibody Rh	Will clot if antigen Rh is donated
Rh+			
Rh-			

12. Draw the RBC antigens for

- B+
- AB+
- O+

13. Write the blood types, including Rh, for the first set of blood cards you worked with.

14. Blood typing has its limits in identifying an individual in a crime.

a. Why can't a blood sample be matched to a specific person after comparing blood types?

b. What additional blood test could give a match to a specific individual?

Handout 2-D
Are You My (Blood) Type? Student Lab Investigation

Name _____ Date _____

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Your Job

Use simulated blood of four fictitious people to test for blood type and Rh factor.

What You Need to Know

A person's blood type is tested by mixing samples of blood with laboratory solutions that contains anti-A serum (antibody A), anti-B serum (antibody B), and anti-Rh serum (antibody Rh). Clotting proves that a particular antigen was in the blood. For example, if blood clotted with anti-A serum and anti-Rh serum, but did not clot with anti-B serum, then antigens A and Rh were in the blood. The blood type would be A+.

Blood typing is based on a chemical reaction that causes precipitates (solids) to form in specific ionic solutions. In blood typing tests, a precipitate (clot) forms when a particular antigen is present in the blood.

Your Steps

1. Work in pairs to complete the following reference table. Use it to determine blood types from your results.

Reference Table

Complete the table by putting an X in boxes to show when clotting will occur for each blood type. These are the results you should expect to see during the blood typing activity.

Blood type	Add anti-A serum	Add anti-B serum
Type A		
Type B		
Type AB		
Type O		

2. Set the spot plate on a larger-sized paper towel. Trace around the spot plate and label the rows and columns as shown in the "Blood Type Results" diagram.

Handout 2-D
Are You My (Blood) Type? Student Lab Investigation

Blood Type Results

Record test results by writing "clot" in the cups that clotted. Based on the three anti-sera tests, determine the blood type for each individual.

Blood Sample	Antibody Serum: Anti-A	Anti-B	Anti-Rh	Blood Type
_____	◯	◯	◯	_____
_____	◯	◯	◯	_____
_____	◯	◯	◯	_____
_____	◯	◯	◯	_____

3. Draw this lab set-up in your Investigator Notebook or lab notes as a diagram or a data table.

4. Put 2–3 drops of the first person's simulated blood in each of the three anti-sera wells for that individual.

5. Test the blood's reaction to each anti-serum by putting 2 drops of anti-A serum into the first well, 2 drops of anti-B serum into the second, and 2 drops of anti-Rh serum into the third.

6. Complete steps 4 and 5 for the other three blood samples.

7. Stir with a toothpick and let the blood mixture sit for 3–5 minutes. Use a magnifying lens to determine if a precipitate has formed. A positive result will show a darkened clumping at the bottom or a crystallized web on the top. (The precipiate appearance will vary depending on the type of blood test kit used.)

8. Record the results and determine the blood type of each individual.

Handout 2-D
Are You My (Blood) Type? Student Lab Investigation

What Did You Discover About Blood and Blood Typing?

1. Why do some blood types form precipitates when mixed with anti-sera, while others do not?

2. What type antigen is present if a precipitate forms with
   - anti-A serum?
   - anti-B serum?
   - anti-Rh serum?

3. Pick one blood sample and summarize in several sentences your procedure and interpretation of the results. Use the words *antigen, antibodies, anti-serum,* and *precipitate.*

4. Read your comments on blood typing in your Investigator Notebook (*What do I know about blood typing? What do I want to know about blood typing?*). Respond to the following question: *What have I learned about blood typing?*