Antigens and Antibodies

Bloodless Transfusion Activity

Introduction

A blood transfusion with a mismatched blood type usually has serious consequences for the recipient of the donated blood. To ensure mismatching does not occur, complete blood analysis is now done with sophisticated instruments before transfusions are performed. The basic principles of blood type matching will be simply and easily demonstrated in this activity.

Concepts

- Antigens
- Antibodies
- Multiple alleles
- Transfusion
- Dominant vs. recessive

Background

Early attempts to transfer blood from one person to another produced varied results. Sometimes it seemed to help the recipient, while at other times it produced severe illness or death. Eventually, it was discovered that every individual has a unique combination of chemical substances in the blood. Some of these substances may be compatible with one person’s blood type but not another’s. These findings led to the development of procedures for determining an individuals’ blood type. Safe transfusions of blood depend upon properly matching the blood types of the donors and the recipients.

A person’s blood type is determined by the presence or absence of specific proteins located on their red blood cells. An individual’s inherited genes determine which proteins are produced by the body. Red blood cells may contain proteins, known as antigens, attached to the cell membrane. The presence or absence of these antigens (labeled A and B) on the surface of red blood cells determines the individual’s blood type in the ABO typing system. (Another well-known red blood cell antigen is Rh and a person may be either Rh+ or Rh–.) A person whose red blood cells contain antigen A and lack antigen B have type A blood. Those with antigen B but not antigen A have type B blood. Individuals with both antigen A and B have type AB blood and individuals with neither of the antigens are referred to as having blood type O.

ABO blood typing provides a genetic example of multiple alleles. There are three forms (alleles) of the gene responsible for making these blood proteins. These alleles are known as \( I^A \), \( I^B \), and \( i \). The \( I^A \) allele causes the body to make red blood cells (RBCs) with antigen A, and \( I^B \) causes the body to make RBCs with antigen B. However, if a person inherits two \( i \) alleles (\( ii \)), their RBCs contain neither A nor B antigens. Interactions between these inherited alleles illustrate both simple dominance as well as codominance. (Remember that every individual has at least two alleles for each trait they possess regardless of the number of alleles in the gene pool.) When the \( I^A \) allele combination occurs, the individual is blood type A. When the \( I^A I^B \) combination occurs, the \( I^A \) and \( I^B \) alleles are codominant and the individual has type AB blood. The accompanying table illustrates the allele combinations, resulting blood types and the antigens on the red blood cells.

<table>
<thead>
<tr>
<th>Phenotype</th>
<th>Genotype</th>
<th>Protein on RBC (antigen)</th>
<th>Antibodies in blood plasma</th>
</tr>
</thead>
<tbody>
<tr>
<td>type A</td>
<td>( I^A I^A ) or ( I^A i )</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>type B</td>
<td>( I^B I^B ) or ( I^B i )</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>type AB</td>
<td>( I^A I^B )</td>
<td>A and B</td>
<td></td>
</tr>
<tr>
<td>type O</td>
<td>( ii )</td>
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Blood groups are critically important with respect to transfusions. If someone with type A blood is given a transfusion of blood type B, the blood will clot, clog arteries, and usually cause death. The clumping is caused by the interaction of the antigens on the RBC’s surface with other proteins (called antibodies) present in the recipient’s plasma, which is the liquid part of the blood containing no cells. This clumping phenomenon is similar to what happens when a large amount of cornstarch is added to water—it thickens or “clumps” up. Although antibodies are necessary components of our immune system, they cannot distinguish a disease antigen (protein) from an RBC antigen. Why then does an individual’s blood not clot? Complete the following Pre-Lab Activity and Questions to try and discover the answer. Have your instructor check that this part is complete before continuing on to the procedures.

Pre-Lab Activity and Questions

All must be completed and checked by the instructor before obtaining the materials to begin the activity.

1. Complete Table 1 above by filling in the correct antibody(ies) for each blood type.
2. If a person has blood type B, which type of antibodies are present in their plasma?
3. If a person has no RBC antibodies in their blood, which type of blood do they have?
4. If a person has blood type A, why does their blood flow freely through their veins and arteries and not clot?

Materials

- RBC model cutouts: type O, type A, type B, type AB
- Marker, black
- Zipper-lock bag
- Scissors
- Transfusion Worksheet

Safety Precautions

This laboratory activity is considered nonhazardous. Follow all normal laboratory safety rules and be careful when using scissors.

Procedure

1. Select a model RBC with its antibodies, if any. Use scissors to carefully cut out the parts. Do not cut off any shape labeled antigen(s)—cut around it.
2. Use a marker to label a zipper-lock bag—“Type A,” “Type B,” “Type O,” or “Type AB”—depending on the chosen RBC model.
3. Create a “bag of blood” for the blood type by placing the RBC and any accompanying antibodies in the bag.
4. Make this blood type your first donor blood and write the blood type on line #1 of the Transfusion Worksheet. Record the antigen(s) on the worksheet, if any.
5. Find another student in the room with a different blood type to be the recipient of your “blood.” Donors remove only the RBC from the bag, but the recipient must remove all blood components. Lay the model blood components for both blood types on a counter, desk, or table top.
6. Match up the blood components to determine compatibility. Fill in the recipient columns on the Transfusion Worksheet for this first blood type and indicate if clotting will occur. Return all components to each labeled bag.
7. Repeat steps 5 and 6 twice more with the remaining two blood types as recipients. Examine each set of components to determine if clotting will occur. Fill in lines 2 and 3 for both donor and recipient on the worksheet.
8. On line 4, of the worksheet, record the results of a transfusion with a recipient who has the same blood type as your donor blood.
9. Switch blood bags with another student to obtain a new type of donor blood. Use the blood bag components to visualize what would happen if this new blood type was transfused into recipients with the other three blood types.
10. Complete the worksheet by “transfusing” your blood to other students until every possible combination of donor and recipient blood type is represented.
11. Upon completion of this activity, answer the Discussion Questions.
Discussion Questions

1. Which blood combinations clotted? (Write each blood type with the donor blood type on the left and the recipient’s on the right, i.e., A and B.)

2. Which combinations did not clot?

3. Why is the knowledge of donor blood antigens critical for successful transfusions?

4. Which blood type could be considered the “universal donor”? Why? (Be specific.)

5. Which blood type could be considered the “universal recipient”? Why? (Be specific.)

6. In determining if blood types are compatible, why did students who were “donors” only remove RBCs from the bag and not antibodies?

7. Which blood type(s) is/are considered the recessive blood type(s)? Explain.
# Transfusion Worksheet

<table>
<thead>
<tr>
<th>Donor</th>
<th>Recipient</th>
<th>Clot?</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Blood Type</td>
<td>Antigen</td>
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<td>16</td>
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</tbody>
</table>
Teacher’s Notes
Antigens and Antibodies

Materials Included in Kit
Master sheets for four blood types–A, B, AB, and O  Zipper-lock bags, 32
Master sheets of Transfusion Worksheet  Instructions

Additional Materials Needed
Markers, black  Scissors

Safety Precautions
Normal safety procedures should be followed during this laboratory exercise. Caution students about the safe use of scissors.

Disposal
Please consult your current Flinn Scientific Catalog/Reference Manual for general guidelines and specific procedures governing the disposal of laboratory waste. Save the “bags of blood” for each class to use throughout the day. All items can be reused many times.

Connecting to the National Standards
This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12
Systems, order, and organization
Evidence, models, and explanation

Content Standards: Grades 5–8
Content Standard C: Life Science, structure and function in living systems
Content Standard F: Science in Personal and Social Perspectives; personal health

Content Standards: Grades 9–12
Content Standard C: Life Science, matter, energy, and organization in living systems
Content Standard F: Science in Personal and Social Perspectives, personal and community health

Tips
• Enough materials are provided in this kit for 32 students. There are eight copies of each of the four blood types. This activity may be completed in one 50-minute class period depending on the time spent discussing the background material.
• If more than 32 students are in the class, those without “blood bags” may pair up. However, make enough copies of the Transfusion Worksheet (page 5) so that each student has his or her own copy.
• Prior to doing this activity, students should have a basic understanding of genetics and the difference between dominant and recessive alleles. It should also be explained to students that antigens do not stick out from cell membranes but are actually embedded within them. Showing them sticking outward is only to illustrate their presence.
• Instructor may want to demonstrate the clumping action that occurs when cornstarch is added to water as discussed in the first paragraph on page 2.
• Instructor should make enough copies of each blood type so that every student can choose one type to cut out.
• If additional copies are needed and red copy paper is not available, have students color the RBCs before cutting. Antibodies could be colored different colors.
Teacher’s Notes continued

Answers to Pre-Lab Activity and Questions

1. Complete Table 1 above by filling in the correct antibody(ies) for each blood type.

   The last column in Table 1 should be completed as follows:
   Type A = B antibodies
   Type B = A antibodies
   Type AB = 0 (zero) antibodies
   Type O = A and B antibodies

2. If a person has blood type B, which type of antibodies are present in their plasma?
   Type A antibodies

3. If a person has no RBC antibodies in their blood, which type of blood do they have?
   Type AB

4. If a person has blood type A, why does their blood flow freely through their veins and arteries and not clot?
   Because they have B antibodies which will not cause blood type A to clot.

Answers to Discussion Questions

1. Which blood combinations clotted? (Write each blood type with the donor blood type on the left and the recipient’s on the right, i.e., A and B.)
   A + O, A + B, B + O, B + A, AB + O, AB + A, AB + B.

2. Which combinations did not clot?
   O + A, O + B, O + AB, O + O, A + AB, A + A, B + AB, B + B, AB + AB

3. Why is the knowledge of donor blood antigens critical for transfusion considerations?
   Introduced antigens will stimulate antibody production and potential clotting reactions.

4. Which blood type could be considered a “universal donor”? Why? (Be specific.)
   Type O seems to be able to be donated to all blood types without clotting occurring because the RBCs have no surface antigens.

5. Which blood type could be considered a “universal recipient”? Why? (Be specific.)
   Type AB seems to be able to receive blood from all blood types without clotting because the plasma contains no A or B antibodies.

6. In determining if blood types are compatible, why did students who were “donors” only remove RBCs from the bag and not antibodies?
   Blood transfusions only involve the RBCs of the donor and not the plasma, where the antibodies are located.

7. Which blood type(s) is/are considered the recessive blood types? Explain.
   O blood type is recessive to all the others because two ii alleles must be inherited from the parents. If an i allele is combined with I^A or I^B, the blood type will be either A or B.
### Sample Worksheet

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<tr>
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<tbody>
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<td>Antigen</td>
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<td>16</td>
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Antigens and Antibodies—Bloodless Transfusion Activity is available from Flinn Scientific, Inc.

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<th>Description</th>
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