**VANDERBILT STUDENT VOLUNTEERS FOR SCIENCE**

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**Inheritance and Blood Typing**

**Spring, 2006**

**GOAL** To introduce the students to the study of genetics through an activity dealing with blood typing

**LESSON OUTLINE**

**I. Introduction**

Give a brief introduction to the volume of blood in the body and the components of blood.

**II. Red blood cell demonstration**

Provide a model of a red blood cell and explain what an antigen is and how it relates to blood type.

**III. Blood genetics and Punnett squares**

Explain how blood type is determined genetically and show how Punnett squares are used to help in determining genotype. Provide definitions for genotype, phenotype, dominant, and recessive.

**IV. The Kidney Problem**

Students will perform an experiment to determine whether family members can donate a kidney to another family member.

**V. Analysis**

Using the data obtained from part IV and from a Punnett square, the students will analyze their results.

**MATERIALS**

 2-liter bottle containing fake blood

 red blood cell model with antigens and antibodies

 4 red Styrofoam balls

 2 straight pipe cleaners

 2 forked pipe cleaners

 15 24-well plates

 15 ziploc bags with

1 dropping bottle containing fake blood labeled “Mrs. Sanderson”

 1 dropping bottle containing fake blood labeled “Mr. Sanderson”

 1 dropping bottle containing fake blood labeled “Jill”

 1 dropping bottle containing fake blood labeled “Jack”

 1 dropping bottle containing “Anti-A serum”

1 dropping bottle containing “Anti-B serum”

 15 aluminum pans

 30 Punnett square worksheets

 15 blood testing worksheets

 30 safety goggles

**Students will work in pairs for the activity.**

**I. INTRODUCTION**

Ask students: *How much blood do you think is in the human body?*

 Accept responses.

Explanation: About 5 liters of blood. At this point, show the students the 2-liter bottle filled with fake blood. Tell the students that it would take about two-and-one-half bottles to equal 5 liters.

Ask students: *What is in blood? (What is contained in blood?)*

 Accept responses.

Explanation: Red blood cells (RBCs)—shaped like a donut, but without a hole; carry oxygen; give blood the red color

 White blood cells (WBCs)—cells that are a part of the immune system and that can attack germs that enter the bloodstream

 Plasma—yellow-colored liquid that is primarily water; makes up most of the volume of blood

 Platelets—cell fragments that are responsible for clotting and scab formation

Tell the students that this activity will focus on characteristics of RBCs.

Ask students: *What are blood types?*

 Accept responses.

Explanation: Blood typing is one way of characterizing what kind of blood someone has. Specifically, it tells what kinds of proteins are present on someone’s red blood cells.

**II. RED BLOOD CELL DEMONSTRATION**

**MATERIALS**

 **4 red Styrofoam balls**

 **2 straight pipe cleaners**

 **2 forked pipe cleaners**

1. Tell students that the ball is a model for a red blood cell.

2. The red blood cell has proteins on its surface that determines what blood type a person is. These proteins are also called “**antigens**”.

3. Tell students that you will focus on two antigens in this activity. Jab the Styrofoam ball with the straight pipe cleaner. This red blood cell now has an “A” antigen.

4. Take the second Styrofoam ball and jab it with the forked pipe cleaner. This red blood cell has a “B” antigen.

5. These blood cells are named by the type of antigen on its surface. The RBC with the A antigen is an A blood cell. The RBC with the B antigen is a B blood cell.

6. Jab the third RBC with both a straight and a forked pipe cleaner. Ask the students what type of blood cell this is. **Answer: an AB blood cell**

7. Show the students the fourth RBC that does not have any antigens on its surface. Ask the students what type of blood cell this is. **Answer: an O blood cell** (if the students are confused, tell them to think of the cell has having zero (O) antigens on its surface)

8. You may want to pass out the models to each pair of students. Also, you can show the students figure 3 to compare the different types of blood cells side-by-side. Figure 4 shows the relative representation of blood types in the American population.

9. Tell students that if a person’s blood cells have one type of antigen, then that person’s blood will contain **antibodies** to the antigen that is lacking. So if a person has blood cells with the A antigen, that person will have antibodies against the B antigen and any cells with that antigen. People with AB blood cells do not have antibodies to either type of antigen, while people with O blood cells have antibodies to both.

10. Antibodies help in removing unwanted things from the blood. Remember that if someone has blood cells with the B antigen, that person has antibodies against cells with the A antigen. If that same person receives blood with cells that have the A antigen, the antibodies that are already in the blood will attack and destroy the cells with the A antigen.

11. This **reactivity** demonstrates why people have their blood tested prior to a transfusion or transplantation. If blood types are not compatible, any transferring of blood can have negative consequences.

**II. BLOOD GENETICS AND PUNNETT SQUARES**

Ask the students: *What do you think determines which antigens end up on the red blood cells?* Accept answers.

Tell students that antigens and thus, blood type, are determined by the genes that get passed on from someone’s parents. Explain that each parent (and each person) has two blood type genes. This is what’s known as a **genotype**, or what genes are in someone’s body. Each parent will pass on one of these genes (remember that they have two!) to their child. These genes are for the A antigen, the B antigen or no antigen at all. The combination of two of these genes is what blood type one will be.

(You may want to diagram this out for the students on the board)

Ask the students: *We can tell what blood type someone is by analyzing their red blood cells for their antigens. But can we tell what a baby’s blood type will be, just by knowing what his or her parents’ blood types are?* Accept answers.

Yes. Obviously, you can test the baby’s blood, but you can also figure out the baby’s blood type by drawing a Punnett square.

Draw a Punnett square and compare it to a four-square court. The mother’s genes are on top and the father’s genes are on the left side (figure 1). The empty boxes are filled by writing the each of the mother’s genes in the boxes directly below it and each of the father’s genes in the boxes directly to the right of it (figure 2).

MOTHER’S GENES

|  |  |
| --- | --- |
|  |  |
|  |  |

Gene 1 Gene 2

Gene 1

FATHER’S GENES

 Gene 2

 **Figure 1. Punnett square**

|  |  |
| --- | --- |
|  **AA**  |  **AA** |
|  **AB** |  **AB** |

MOTHER’S GENES

A A

A

FATHER’S GENES

 B

 **Figure 2. Filling in the Punnett square**

In this example, the mother has an AA blood genotype, while the father has an AB blood genotype. After filling in the empty boxes by bringing down both A genes contributed by the mother and bringing over the A and B genes contributed by the father, we find that a baby will either have an AA genotype or an AB genotype.

After demonstrating how to fill in the Punnett square, tell students that the cells that are filled in are the possible blood types of the children for the given mother and father.

Pass out the Punnett square worksheets to the students (one per student).

Review the terms **dominant** and **recessive** with the students. Dominant in this case means stronger and recessive means weaker. The dominant gene will be “seen” if it is passed on along with a recessive gene. An example involves the dominant gene for brown hair and the recessive gene for blonde hair. If a child inherits both genes from her parents, her hair will be brown, as she has a dominant brown hair gene.

In the case of blood, the A and B genes are **co-dominant**. This means that if a child inherits both an A gene and a B gene, both A and B antigens will be found on the surface of an RBC.

**III. THE KIDNEY PROBLEM**

**MATERIALS**

15 24-well plates

 15 ziploc bags with

1 dropping bottle containing fake blood labeled “Mrs. Sanderson”

 1 dropping bottle containing fake blood labeled “Mr. Sanderson”

 1 dropping bottle containing fake blood labeled “Jill”

 1 dropping bottle containing fake blood labeled “Jack”

 1 dropping bottle containing “Anti-A serum”

1 dropping bottle containing “Anti-B serum”

 15 aluminum pans

 15 blood testing worksheets

 30 safety goggles

**Scenario:**  Jack Sanderson was born with a rare kidney disease that causes the kidney to degenerate (lose function) over time. He had been doing well for the past few years, but it seems that his kidney is not functioning properly. His doctors suggest that the best way for him to live a long life is if he receives a kidney transplant. His family has just been informed of his health situation and they are asked to undergo a blood test. If a family member shares his blood type and is willing to donate part of his or her kidney to Jack, Jack will probably be able to get better.

(OPTIONAL INFO) The major function of the kidney is to filter the blood to get rid of various wastes such as urea. People only need a small part of their kidney in order to live normally. However, people with limited kidney function would be cautioned to watch what they eat and drink, since the kidney would not be able to filter the blood as efficiently.

In order to donate a kidney (or blood), there must be a match of blood types between the donor and the recipient to prevent the recipient’s immune cells and antibodies from attacking the donor cells.

Tell the students that they will be blood test specialists. **Remind the students that the blood samples are not really blood.** In this case, they will be testing the samples for each person by combining sera that reacts with A or B antigens on the surfaces of red blood cells. They will be able to tell if a sample is positive for an antigen by observing whether agglutination (clumping) occurs. If the blood clumps for the anti-A serum and not the anti-B serum, then the blood type is A. If it clumps for the anti-B and not for the anti-A, then the blood type is B. If it clumps for both, the blood type is AB. If there is no clumping, then the blood type is O.

**Divide the students into pairs. Pass out safety goggles and one set of materials to each pair of students.**

1. Tell the students they will have to put on their goggles until after they finish using the dropper bottles.

2. Orient the students to where the columns (going down) and the rows (going across) are located. They will be using columns A-D and rows 1 and 2.

3. Tell students to use labeled dropper bottles for steps 4 - 7.

4. Have students add 15 drops off the following samples in the columns indicated.

* 1. Mrs. Sanderson’s samples to the first two wells in column A
	2. Mr. Sanderson’s samples to the first two wells in column B
	3. Jill’s samples to the first two wells in column C.
	4. Jack’s samples to the first two wells in column D.

5. Have students add 5 drops of anti-A (blue) to the first well (A-1). They should observe whether a precipitate (or cloudiness) occurs If a precipitate or cloudiness occurs, they should enter a “+” in square A-1. If nothing happens, they should enter a “\_“.

6. They should then proceed to add 5 drops of anti-A to wells B-1, C-1, and D-1, recording a “+” or “− “ as soon as they have added Anti-A. They should replace the cap on the Anti-A bottle before proceeding.

6. Have students add 5 drops of anti-B (yellow) to each well in column 2, recording a “+” or a “− “ in the appropriate square after each addition.

**IV. ANALYSIS**

1. From the data that was obtained, tell the students to try to figure out what the blood type of each family member is. Write these answers on the board and/or share with the class.

2. Ask students what each family member’s possible genotype is. Write these answers on the board and/or share with the class.

3. From the data tables, Jack does not have the same blood type as any of his family members. Thus, they won’t be able to donate a part of their kidney to him. However, as a result of a Tennessee Titans fundraiser and kidney awareness day, they were able to find someone who had the same blood type as Jack and who was willing to donate part of her kidney.

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2005

**PUNNETT SQUARE PRACTICE**

MOTHER’S GENES

|  |  |
| --- | --- |
|  |  |
|  |  |

FATHER’S GENES

MOTHER’S GENES

|  |  |
| --- | --- |
|  |  |
|  |  |

FATHER’S GENES

MOTHER’S GENES

|  |  |
| --- | --- |
|  |  |
|  |  |

FATHER’S GENES

**Blood Typing Lab Data Sheet**

**NAME \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

1. Put on your goggles and wear them until after you finish using the dropper bottles.

2. Look at the 24-well plate and find the column labels A-D (across the top) and the row labels (1-6) (along the side). You will be using columns A-D and rows 1 and 2.

3. Use the labeled dropper bottles for steps 4 - 7.

4. Add 15 drops of the following as indicated below.

a. Mrs. Sanderson’s samples to A-1 and A-2 (the first two wells under Column A).

b. Mr. Sanderson’s samples to B-1 and B-2 (the first two wells under Column B).

c. Jill’s samples to C-1 and C-2 (the first two wells under Column C).

1. Jack’s samples to D-1 and D-2 (the first two wells under column D).

5. Add 5 drops of anti-A (blue) to the first well in row 1(A-1). Observe whether a precipitate (or cloudiness) occurs If a precipitate or cloudiness occurs, enter a “+” in square A-1in the table below. If nothing happens, enter a “−“.

6. Proceed to add 5 drops of anti-A to the rest of the wells in row 1 ( B-1, C-1, and D-1), recording a “+” or “− “ as soon as you have added Anti-A. Replace the cap on the Anti-A bottle before proceeding.

7. Add 5 drops of anti-B (yellow) to each well in row 2, recording a “+” or a “− “ in the appropriate square of the table after each addition.

**Determining Blood Type:** If the blood clumps for the anti-A serum and not the anti-B serum, then the blood type is A. If it clumps for the anti-B and not for the anti-A, then the blood type is B. If it clumps for both, the blood type is AB. If there is no clumping, then the blood type is O.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Column A** | **Column B** | **Column C** | **Column D** |
| **Mrs. Sanderson** | **Mr. Sanderson** | **Jill** | **Jack** |
| **Row 1****Anti-A serum****(+ / -)** |  |  |  |  |
| **Row 2****Anti-B serum****(+ / -)** |  |  |  |  |
| **Blood Type****(A, B, or O)** |  |  |  |  |
| **Possible Genotype** |  |  |  |  |

**Answer sheet**

**Blood Typing Lab Data Sheet**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Column A** | **Column B** | **Column C** | **Column D** |
| **Mrs. Sanderson** | **Mr. Sanderson** | **Jill** | **Jack** |
| **Row 1****Anti-A serum****(+ / -)** | **Yes** | **No** | **Yes** | **No** |
| **Row 2****Anti-B serum****(+ / -)** | **No** | **Yes** | **Yes** | **No** |
| **Blood Type****(A, B, or O)** | **A** | **B** | **AB** | **O** |
| **Possible Genotype** | **AA or AO** | **BB or BO** | **AB** | **OO** |

Four Basic Blood Types



Figure 3% Blood Types in the Population



Figure 4

