

VANDERBILT STUDENT VOLUNTEERS FOR SCIENCE

<http://studentorgs.vanderbilt.edu/vsvs>

Inheritance and Blood Typing

2018-2019 VINSE/VSVS Rural

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

Fits TN standards:

GLE 0507.4.1: Recognize that information is passed from parent to offspring during reproduction

GLE 0707.4.3: Explain the relationship among genes, chromosomes and inherited traits

SPI 0707.4.4: Interpret a Punnett Square to predict possible genetic combinations passed from parents to offspring during sexual reproduction

VSVSer LESSON OUTLINE

I. Introduction

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

II. Red blood cell demonstration

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

III. The Kidney Problem

Students will perform an experiment to determine the blood types of family members to see if they qualify as kidney donors for their mother/wife.

IV. Analysis

Using the data obtained from part III, the students will analyze their results.

V. Optional: Blood genetics and Punnett squares

Explain how blood type is determined genetically and show how Punnett squares can be used to determine genotype. Provide definitions for genotype, phenotype, dominant, and recessive.

MATERIALS

1 liter bottle (empty)

2 Red blood cell model with antigens and antibodies

4 red Styrofoam balls

2 pink pipe cleaners

2 blue 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 plates

1 binder containing training presentation, 30 Punnett square worksheets and 15 blood testing worksheets, 15 Blood Types handouts.

30 safety goggles

LOOK AT THE VIDEO BEFORE YOU GO OUT TO YOUR CLASSROOM

<https://studentorg.vanderbilt.edu/vsvs/lessons/>

USE THE PPT AND VIDEO TO VISUALIZE THE MATERIALS USED IN EACH SECTION.

Students will work in pairs for the activity.

2. During the Lesson:

Here are some Fun Facts for the lesson – for VSVSers

- Usually a person has one blood type for their whole life, but infection, malignancy (like cancer), or autoimmune diseases can cause a change. A blood marrow transplant may also do this; the patient will eventually convert to the blood donor's blood type.
- Blood typing is important during pregnancies; if the father has an incompatible blood type to the mother, care must be taken so that the mother doesn't develop antibodies against the baby's blood that attack the baby's RBCs (hemolytic disease of the newborn (HDN) - has to do with Rh + and -, but not covered in lesson). Mothers often receive shots (Rho(D) immune globulin) to prevent this from happening.
- Blood typing also used to be heavily used for paternity tests and in criminal investigation. Actual blood isn't always necessary; about 80% of the population secretes the antigens/proteins/antibodies/enzymes characteristic of their blood type in other bodily fluids and tissues. A serologist could, for example, be able to tell if the source of a sample of blood came from the victim or the criminal. DNA testing, though, is used for detailed analysis.
- Type O is generally considered the "universal donor" type because it does not contain A or B antigens that would be rejected by A, B, or AB blood types. (However, there are other antigens that come into play, so in real life situations, hospitals categorize blood type on a more detailed level.)
- Even though Type O is recessive, it is the most common blood type because it is the ancestral form; the A and B antigens are mutations.
- Infants get antibodies passively from their mothers but start making them independently when they are three months old.
Clinical trials are being done on a bacterial enzyme that can convert RBCs of A, B, and AB types into O by stripping away their antigens. This could have profound implications for blood transfusions

UNPACKING THE KIT – what you will need for each part

FOR PART I. INTRODUCTION:

- 1 1 liter bottle (empty or containing liquid with red dye)

FOR PART II RED BLOOD CELL DEMONSTRATION:

- 3 red Styrofoam balls, 2 pink pipe cleaners, 2 blue pipe cleaners, 15 Blood Types handouts.

FOR PART III. THE KIDNEY PROBLEM:

- 15 24-well plates, 15 plates, 15 blood testing worksheets, 30 safety goggles
- 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"

I. INTRODUCTION

Learning Goals:

- Students describe the composition of blood, including how antigens and antibodies determine blood type in different individuals.
- Students understand the relationship between antigens and antibodies, and identify which blood types are compatible as donors and receivers

Your Notes:

Write the following vocabulary words on the board:

Antibodies, antigen, Punnett square, blood cell, ABO blood type

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

Explanation: About 5 liters of blood. At this point, show the students the 1-liter bottle and tell them that their bodies contain about 5 bottles of blood.

Ask students: *What is in blood? (What makes up blood?)*

Explanation:

Blood is composed of a liquid (plasma) and solids (red and white blood cells and platelets).

Plasma—yellow-colored liquid that is primarily (92%) water; makes up most of blood volume (55%). It carries metabolites, nutrients, hormones, wastes, salts and proteins throughout the body and contains the anti-A and anti-B antibodies

Red blood cells (RBCs)—shaped like a donut, but without a hole; carry oxygen; give blood the red color; make up 40-45% of blood.

White blood cells (WBCs)—cells that are a part of the immune system. There are several types of white blood cells; one can produce **antibodies** which can help destroy bacteria and viruses.

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

Tell the students that this activity will focus on characteristics of red blood cells.

Ask students: *What are the different blood types?*

Explanation:

There are four blood types: A, B, AB, and O.

Blood typing is one way of characterizing what kind of blood someone has. It is determined by the type of **antigen** that is present on the surface of the red blood cells.

II. RED BLOOD CELL DEMONSTRATION

MATERIALS

4 red Styrofoam balls

2 pink pipe cleaners – “A” antigen

2 blue pipe cleaners – “B” antigen

1. The red blood cell has proteins on its surface that determines what blood type a person is. These proteins are called “**antigens.**”
2. Tell students that the ball is a model for a red blood cell. The pipe cleaners are the antigens (pink is the “A” antigen, blue is the “B” antigen).
3. Tell students that you will focus on two antigens in this activity. Jab the Styrofoam ball with the pink pipe cleaner. This red blood cell now has an “**A**” **antigen.**
4. Take the second Styrofoam ball and jab it with the blue 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 red blood cell with the A antigen is an **A blood cell.** The red blood cell with the B antigen is a **B blood cell.**
6. Jab the third red blood cell with both a pink and blue pipe cleaners. Ask the students what type of blood cell this is. **Answer: an AB blood cell**

Your Notes:

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. Tell students to look at the handout to see a comparison of the different types of blood cells side-by-side, and the relative representation of blood types in the American population.
9. The A-B-O blood typing system classifies blood by the antigens on the red blood cell surface and the antibodies in the plasma.
10. **Antibodies** help in removing unwanted things from the blood. 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.
 - a) 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**.
 - b) If someone has blood cells with the **B antigen**, that person has antibodies against cells with the A antigen.
 - c) People with AB blood cells do not have antibodies to either type of antigen, while people with O blood cells have antibodies to both.

Tell students to look at the Table in the handout.

ABO Blood Type	Contains Antigen A	Contains Antigen B	Contains Antibody anti-A	Contains Antibody anti-B
A	yes	no	no	yes
B	no	yes	yes	no
AB	yes	yes	no	no
O	no	no	yes	yes

http://anthro.palomar.edu/blood/ABO_system.htm

11. If a person has blood type A, he cannot receive Type B or Type AB blood because the Anti-B antibodies will bind to the B antigen and tell the body to destroy these cells.
12. Ask students if they can determine what types of blood a person with Type B blood **can receive? O and B.**
13. Ask students if they can determine what types of blood a person with Type AB blood **can receive? A, B, AB, O. This person is called a universal recipient.**
14. Ask students if they can determine what types of blood a person with Type O blood **can receive? Only O. But this person can give blood to anyone and is called a universal donor.**

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.

Your Notes:

III. THE KIDNEY PROBLEM

Learning Goals:

- Students understand the relationship between antigens and antibodies, and identify which blood types are compatible as donors and receivers
- With support, students identify a method for determining blood type

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 plates

15 blood testing worksheets

30 safety goggles

Tell students that they will work to determine the blood type of the members of a “family” so that a donor match can be found.

Scenario: Mrs. Sanderson developed a rare kidney disease that causes the kidney to lose function over time. She had been doing well for the past few years, but it seems that her kidney is starting to decline rapidly. Her doctors suggest that the best way for her to live a long life is for her to receive a kidney transplant. Her family has just been informed of her health situation and they are asked to undergo a blood test. If a family member shares her blood type and is willing to donate a kidney to her, Mrs. Sanderson 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 one kidney in order to live normally.

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.

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.

a. If the blood clumps in the anti-A serum and not the anti-B serum, then the blood type is A.

b. If it clumps for the anti-B and not for the anti-A, then the blood type is B.

c. If it clumps for both, the blood type is AB.

d. If there is no clumping, then the blood type is O.

Your Notes:

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

Tell the students:

1. Put on the goggles and wear them until after they finish using the dropper bottles.
2. Look at the 24-well plate and find the column labels 1-6 (across the top) and the row labels (A-D) (along the side). You will be using columns 1-4 and rows A and B.
3. Add a squirt of Mrs. Sanderson's samples to 1A and 1B (the first two wells in Column 1).
Replace the cap on the bottle labelled Mrs Sanderson.
Add a squirt of anti-A (blue) to the first well in row A(1A). Observe whether a precipitate (or cloudiness) occurs. If a precipitate or cloudiness occurs, enter a "+" in square A-1 in the table below. If nothing happens, enter a "-".
Add a squirt of anti-B (yellow) to 1B, recording a "+" or a "-" in the appropriate square of the table.
4. Repeat for Mr. Sanderson's samples in 2A and 2B (the first two wells under Column 2) and enter your results. Replace the cap on the bottle labelled Mr Sanderson.
5. Repeat for Jill's samples to 3A and 3B (the first two wells under Column 3). Record the results. Replace the cap on the bottle labelled Jill.
6. Repeat for Jack's samples to 4A and 4B (the first two wells under column 4). Replace the cap on the bottle labelled Jack. Replace the caps on the bottles labelled anti -A and anti-B.
7. Determine the blood type:
 - **Type A** will clump only in anti-A serum
 - **Type B** will clump only in anti-B serum
 - **Type AB** will clump in both anti-A and anti-B serum
 - **Type O** does not clump when either serum is added.

IV. ANALYSIS

Learning Goals: Students understand the relationship between antigens and antibodies, and identify which blood types are compatible as donors and receivers

1. From the data that was obtained, tell the students to figure out what the blood type of each family member is. The instructions on how to determine the blood type of each individual are written in the last step of the handout. Write these answers on the board and/or share with the class.
2. From the data tables, ask the students if any of Mrs. Sanderson's family will be able to donate their kidney to her.

Because Mrs. Sanderson's blood clumps in the anti-A serum, she is blood type A. In the same way, Mr. Sanderson has type B blood and Jill has type AB blood and they will not be able to donate. However, Jack, with type O blood, can and does donate a kidney, saving his mother's life.

V. BLOOD GENETICS AND PUNNETT SQUARES

Learning Goals: Students use Punnett squares and basic genetics to construct an explanation for why people have certain blood types

Your Notes:

We can tell what blood type someone has by analyzing their red blood cells for their antigens.

Ask the students: *Can we tell what possible blood types an offspring will have just by knowing what his or her parents' blood types are?* Accept answers. Yes, by using a Punnett square.

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

Tell students that antigens and thus, blood type, are determined by the genes (on chromosome 9!) that get passed on from parents.

An individual's ABO type is determined by the inheritance of 1 of 3 alleles (A, B, or O) from each parent.

Explain that each parent has two blood type alleles. This is what's known as a **genotype**.

Each parent will pass on one of these genes (remember that they have two!) to their child.

These alleles are for the A antigen (blood type A), the B antigen (blood type B) or no antigens (blood type O). The combination of two of these alleles will determine what the blood type will be.

Ask students to determine the possible genotypes of offspring? If they do not know how to use Punnett squares, briefly explain by drawing the square on the board:

1. Draw a Punnett square (Figure 1.) 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.
2. 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). In this example, the mother has an AA blood genotype, while the father has an AB blood genotype.

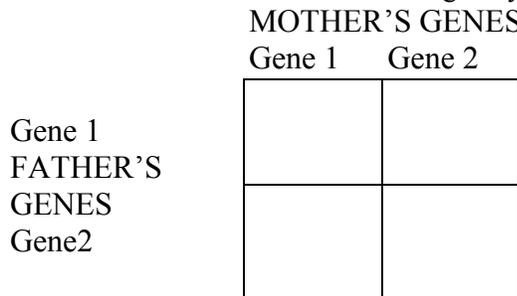


Figure 1. Punnett Square

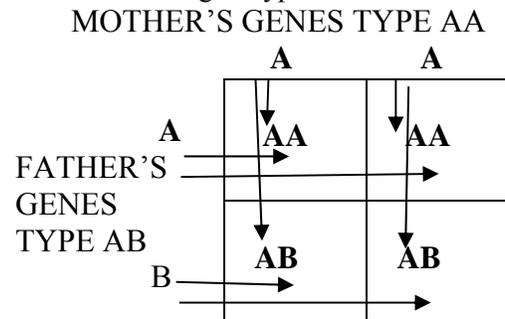


Figure 2. Filling in the Punnett Square

3. 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 their offspring will either have an AA genotype or an AB genotype.
4. Review the terms **dominant** and **recessive** with the students.
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 and the phenotype will be AB.
Individuals who have an AO genotype will have an A phenotype.
People who are type O have OO genotypes. In other words, they inherited a recessive O allele from both parents.
5. Tell students to fill out the last line in the observation sheet, assigning possible genotypes to the family members.

Your Notes:

6. Tell students to look at the Punnett square on the Handout.

The possible ABO alleles for one parent are in the top row and the alleles of the other are in the left column. Offspring genotypes are shown in black. Phenotypes are red in the brackets.

Parent Alleles 	A	B	O
A	AA (A)	AB (AB)	AO (A)
B	AB (AB)	BB (B)	BO (B)
O	AO (A)	BO (B)	OO (O)

http://anthro.palomar.edu/blood/ABO_system.htm

Ask students: If Jack has type O blood, what are the genotypes for his mother and father.

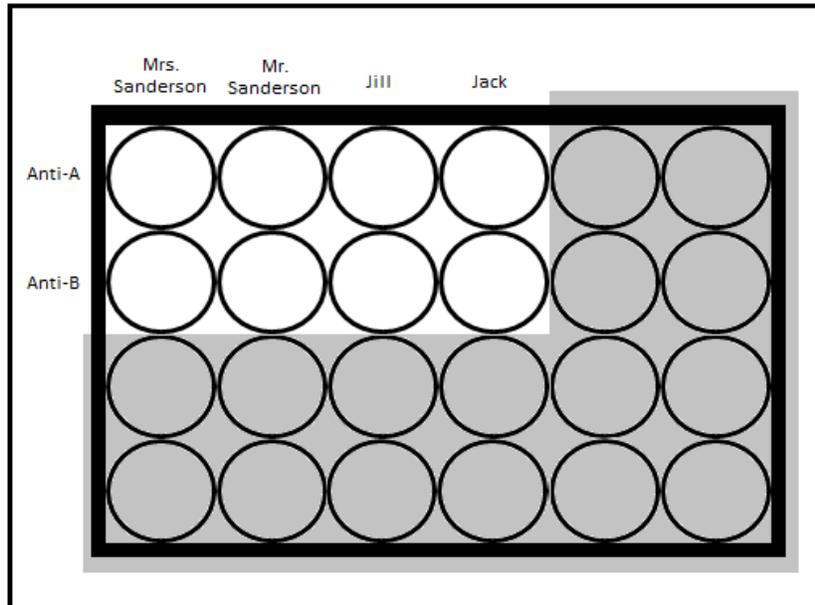
Have the students fill out their Punnett square using all the possible genotypes for Mr. and Mrs. Sanderson.

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Answer sheet
Blood Typing Lab Data Sheet

	Column 1	Column 2	Column 3	Column 4
	Mrs. Sanderson	Mr. Sanderson	Jill	Jack
Row A Anti-A serum	+ Yes	- No	+ Yes	- No
Row B 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

Blood Typing Lab Data Sheet NAME _____



	Column 1	Column 2	Column 3	Column 4
	Mrs. Sanderson	Mr. Sanderson	Jill	Jack
Row A Anti-A serum clumping occurs = + nothing happens = -				
Row B Anti-B serum clumping occurs = + nothing happens = -				
Blood Type (Phenotype) (A, B, AB or O)				
Possible Genotype (AA, AB, BB, AO, BO, OO)				

Mrs Sanderson

Mrs Sanderson

Mr Sanderson

Mr Sanderson

Blood Typing Lab Instruction Sheet

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 1-6 (across the top) and the row labels (A-D) (along the side).
3. Add a squirt of Mrs. Sanderson's samples to 1A and 1B (the first two wells in Column 1).
Slowly add 2-3 drops of anti-A (blue) to the first well in row 1(1A). Observe whether a precipitate (or cloudiness) occurs. If a precipitate or cloudiness occurs, enter a "+" in square A-1 in the table below. If nothing happens, enter a "-".

Slowly add 2-3 drops of anti-B (yellow) to 1B, recording a "+" or a "-" in the appropriate square of the table.
4. Repeat for Mr. Sanderson's samples in 2A and 2B (the first two wells under Column 2) and enter your results.
5. Repeat for Jill's samples to 3A and 3B (the first two wells under Column 3). Record the results.
6. Repeat for Jack's samples to 4A and 4B (the first two wells under column 4).
7. Determine the blood type:
 - **Type A** will clump only in anti-A serum
 - **Type B** will clump only in anti-B serum
 - **Type AB** will clump in both anti-A and anti-B serum
 - **Type O** does not clump when either serum is added

	Mrs. Sanderson	Mr. Sanderson	Jill	Jack		
Anti-A						
Anti-B						

