Name: ________________Key________________________ Class: ____ Date: ______

Understanding the Genetics of Blood Groups

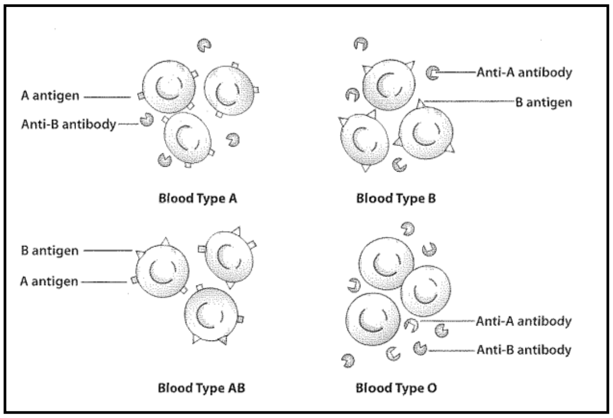
Objectives:

- *understand* the genetics of blood types
- *determine* the ABO blood type of unknown simulated blood samples
- *predict*, using punnett squares, all the possible ways blood type alleles can combine during fertilization.
- *Prepare* and examine a simulated blood smear under the microscope
- *estimate* the number of simulated blood cells in a given area.

Background:

Blood is a tissue comprised of four components: Plasma, red and white blood cells, and platelets. Plasma is a clear, straw-colored liquid portion that makes up 55% of the blood. It is composed of a mixture of water, sugar, fat, protein and various salts. In addition, plasma contains a number of blood-clotting chemicals that help to stop bleeding. Blood functions principally as a vehicle which transports gases, metabolic waste products and hormones throughout the body.

Surface proteins on red blood cells determine an individual's blood type. These surface proteins are called "antigens." The system used to classify human blood is called the "ABO System." Dr. Karl Landsteiner, an Austrian physician, received the Nobel Prize in physiology for this discovery in 1930.



With the ABO system, the kinds of antigens present on red blood cells determine the blood type. An individual with A antigens has Blood type A, one with B antigens has Blood Type B, one with both A and B antigens has Blood Type AB, and one with no antigens on the surface of his/her red blood cells has Blood Type O. As a result of these different antibodies different people can donate to only certain blood types and can only receive from different blood types. (See Table 1) Notice that if you have blood type "O" you are considered a universal donor. Blood type "AB" is a universal receptor.

Table 1: Blood Types Summary

Blood type	Antigen on Red Blood Cells	Antibodies in Plasma	Can receive blood from...	Can donate blood to...
A	**A**	**B**	**O,A**	**A,AB**
B	**B**	**A**	**O,B**	**B,AB**
AB	**A and B**	**None**	**O,AB,A,B**	**AB**
O	**None**	**A and B**	**O**	**`O,A,B,AB**

Blood plasma has circulating proteins called "antibodies". For example, individuals with A surface antigen have anti-B antibodies; those with B surface antigen have anti-A antibodies. Those with both A and B surface antigens have no antibodies. Individuals with no surface antigens have both anti-A and anti-B antibodies.

Blood typing is performed using "antiserum-blood that contains specific antibodies. "Anti-A Serum, which contains anti-A antibodies, and "Anti-B Serum," which contains anti-B antibodies, are used in ABO blood typing. To perform a blood typing test, anti-A and anti-B sera are each separately mixed with a drop of sample blood and observed for "agglutination," or clumping. (See Table 2)

Table 2: Agglutination Reactions in the ABO System

ABO Agglutination Reaction		
Anti- A Serum	**Anti-B Serum**	**Blood Type**
Agglutination	No Agglutination	A
No Agglutination	Agglutination	B
Agglutination	Agglutination	AB
No Agglutination	No Agglutination	O

In addition to the A and B antigens, another important antigen on the surface of red blood cells is the Rh protein, named for the rhesus monkey in which it was first studied. People who have this protein are 'Rh-positive," and those who do not are considered “Rh-negative.”

Table 3: Frequency of ABO Blood types and Rh Factor in the U.S.

Blood Type	Frequency Percentage	Blood Type & Rh Factor	Frequency Percentage
A	42	A+	37
		A-	8
B	10	B+	8
		B-	2
AB	4	AB+	3
		AB-	1
O	44	O+	35
		O-	9

Genotype	Phenotype (Blood Type)
I^AI^A or I^Ai	Type A
I^BI^B or I^Bi	Type B
I^AI^B	Type AB
ii	Type O

The presence of antigens on the red blood cells is determined by co-dominant alleles. An allele is one of several different forms of a gene that is present as a specific location on a specific chromosome. Human blood type is independent on three different alleles, known as “I^A”, “I^B” and “i.” The I^A and I^B are co-dominant, whereas the “i” allele is recessive. Each of us has two ABO blood type alleles. We inherit one allele from our biological mother and another from our biological father. The pair of alleles in our DNA that codes for a particular blood type is called the “genotype,” while the characteristics of the trait that an individual displays is referred to as the “phenotype.” Since there are three different alleles, there are six different genotypes for blood types, as shown in Table 4.

Biologists us a diagram called a “Punnet Square” to predict all the possible ways alleles can combine during fertilization. The parents' genotypes are placed on the out of the square. Letters inside show the possible allele combinations for an offspring. For example, if both parents' genotypes are I^A I^A, then the Punnett square will show that there is 100% chance that all of the offspring will have the alleles, I^AI^A and inherit type A blood.

		Mother	
		I^A	I^A
Father	I^A	I^AI^A	I^AI^A
	I^A	I^AI^A	I^AI^A

However, it is also possible to have blood type A if you inherit an “I^A” allele (A antigen) from one parent and an “i” allele (no antigen) from the other. Remember that the I^A allele is dominant and the i allele is recessive. In the following Punnett square, whille all of the offspring will have blood type A there is a 50% chance that they will inherit the I^AI^A or the I^Ai genotype.

		Mother	
		I^A	i
Father	I^A	I^AI^A	I^Ai
	I^A	I^AI^A	I^Ai

However, if both parents have blood type A but have I^ai genotypes, then there is a 25% chance that one of their offspring will have type O blood (ii genotype) as shown in the Punnett square below.

		Mother	
		I^A	i
Father	I^A	I^AI^A	I^Ai
	i	I^Ai	ii

Similarly, if you inherit an I^B allele from each parent, or an I^B allele from one parent and an i allele from the other, you will have Blood Type B.

Offspring will have Blood Type AB, if they inherit an I^A allele from one parent and an I^B allele from the other. The following Punnett Square shows the possible offspring genotype combinations resulting from two parents with I^AI^A and I^AI^B genotypes. Under this scenario, there is a 50 % chance that offspring will have Blood Type A and a 50% chance that they will have blood type AB.

Mother

Father	I^A	I^A
I^A	I^AI^A	I^AI^A
I^B	I^AI^B	I^AI^B

Mother

Father	I^A	I^B
I^A	I^AI^A	I^AI^B
I^B	I^AI^B	I^BI^B

However if both parents have Blood Type AB (genotypes), then there is a 25% chance that the offspring will have Blood Type A, and a 50% chance that they will have Blood Type AB, and a 25% chance that they will have Blood Type B.

Purpose:

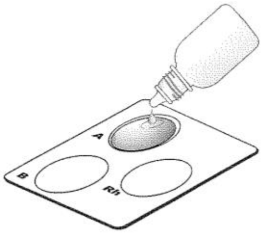
Under certain circumstances, blood typing can be used to rule out a potential father, but it is not an exact method that can be used to establish a parental link. Based on the typing results of the simulated blood samples provided and your knowledge of the inheritance of human blood groups, you will determine which of the two alleged fathers could possibly be excluded as the biological father.

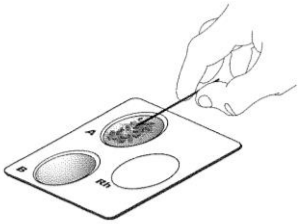
Materials:

- Anti-A Serum (simulated)
- Anti-B Serum (simulated)
- 4 blood samples (simulated)
    - Mother
    - Child
    - Alleged Father 1
    - Alleged Father 2
- 1 blood typing tray
- Paper towels
- 1 set stirring sticks (Blue and Yellow)

Procedure:

1) Place 5 drops of the "mother" simulated blood sample in the A and B wells on your blood typing tray.
2) Place 3 drops of Anti-A Simulated Serum in Well A.
3) Place 3 drops of Anti-B Simulated Serum in Well B.
4) Use a separate stirring stick to mix the simulated blood and serum in each well for about 10 seconds.
5) Carefully examine each well to determine if the simulated blood in each well has clumped or agglutinated. Record your results and observations in Data Table 1.
6) Thoroughly rinse the tray and stirring sticks and repeat steps 1-6 to type the remaining, simulated blood samples- "Child," "Alleged Father 1," and "Alleged Father 2."





Data:

Simulated Blood Sample	Agglutination in Well A (+/-)	Agglutination in Well B (+/-)	Blood Type (Phenotype)	Genotypes	Observations
Mother	+	-	A	I^AI^A or I^Ai	Answers will vary
Child	-	-	O	ii	Answers will vary
Alleged Father 1	-	+	B	I^BI^B or I^Bi	Answers will vary
Alleged Father 2	+	+	AB	I^AI^B	Answers will vary

Data Analysis:

Clumping indicates that the simulated blood sample contains antigens that reacted against the antibodies in the typing serum that you mixed it with. If the blood in **Well A** is the only blood that *agglutinates, or clumps*, then the blood *sample you tested is Type A blood*. IF the blood in **Well B** is the only blood that *agglutinates or clumps*, then the blood sample you tested is **type B** blood. If the blood in both **Well A and Well B** *agglutinate or clumps*, then the blood sample you tested is **type AB** blood. If the blood in both **Well A and Well B** *does not agglutinate or clump*, then the blood sample you tested is **Type O** blood.

1. Based upon your blood typing results, could either of the alleged fathers possibly be the biological father of the child? Alleged Father 1's blood type is B, while the mother's blood type is A. Based upon this Alleged Father 1 could possibly be the biological father of the child with type O blood, provided his genotype is I^Bi.
2. Would you definitely exclude either of the two alleged fathers as the biological father of the child? Explain. Alleged Father 2 could definitely be excluded as the biological father, since the child is blood type O (ii genotype) and must have received an "I" allele from each parent. The genotype of an individual with blood type AB is I^AI^B and therefore, Alleged Father 2 could not have passed on an "I" allele to the child.
3. In this activity, what are the possible blood types of the biological father? Genotypes? The possible blood types of the biological father are A, B or O. The genotypes of the possible blood types of the biological father would have to be I^Ai, I^Bi or ii.
4. Could a man with Type A blood and a woman with type AB blood produce a child with type O blood? Explain. No. A child with blood type O (ii genotype) receives an "I" allele from each parent. The genotype of an individual with blood type AB is I^AI^B and therefore, a mother with type AB blood could not pass on an "i" allele to the child.
5. What would a child's blood type be if the mother is type O and the father is type A? Under this scenario, the mother's blood type genotype is ii, whereas the father's blood type genotype could be either I^AI^A or I^Ai. The possible blood type outcomes could be determined using the Punnett squares as shown .

Mother

Father

	i	i
I^A	I^A i	I^A i
I^A	I^A i	I^A i

All children would have blood type A

Mother

Father

	i	i
I^A	I^A i	I^A i
i	ii	ii

There is a 50% chance that the children would have type O and 50% chance for type A

6. What would the biological father's blood type be if the child's type is A and the mother's is O? The biological father's blood type would have to be A or AB

7. What would the father's blood type be if both the mother and the child have blood type A The Biological father's blood type would have to be A, AB or O.

8. Use a Punnett Square to determine the possible blood types of the children if the biological mother's blood type is A (genotype I^AI^A or I^Ai) and the biological father's blood type is AB (genotype I^AI^B)

Mother

Father

	I^A	I^A
I^A	$I^A I^A$	$I^A I^A$
I^B	$I^A I^B$	$I^A I^B$

There is a 50% chance that the children will be Blood type A and a 50% chance that the children would be Blood Type AB.

Mother

Father

	I^A	i
I^A	$I^A I^A$	$I^A i$
I^B	$I^A I^B$	$I^B i$

There is a 50% chance that the children would have type A blood, a 25% chance they would have Type AB blood, and a 25% chance they would have type B blood.