70-0107

Blood Group Genetics With Synthetic Blood Kit

Teacher's Manual

CAROLINA

World-Class Support for Science & Math

The ABO blood group illustrates several basic genetic concepts including multiple alleles, co-dominance, and the relationship of genotype to phenotype. While the test procedures used in this kit are used to test real blood, this kit contains synthetic blood and synthetic antisera. This eliminates any risk associated with exposure to actual blood or blood products. The materials in this kit may be discarded after use. There are no biological materials in the synthetic blood or synthetic antisera that would cause any health hazard when discarded.

Materials

Included in the kit

30 blood typing slides
synthetic blood
mixing sticks (blue and yellow)
synthetic anti-A serum
synthetic anti-B serum
30 Student Instructions

Objectives

- Perform standard tests used for blood type identification
- Interpret test results and draw conclusions
- Demonstrate understanding of Mendelian genetics and the monohybrid cross
- Use prior knowledge to solve a problem
- Learn about the form and function of blood components

National Science Standards

This kit can be used to address the following National Science Education Content Standards:

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry
- Reproduction and heredity
- Structure and function in living systems
- Understanding of the cell

Preparation

Set up a workstation where students can obtain the synthetic blood and synthetic anti-serum samples they will need to complete this activity. Students must be familiar with basic Mendelian genetics concepts and terminology before attempting these activities. Review the ABO blood groups and their inheritance patterns. Each student will need a copy of the student instructions and a blood typing slide. Have the students proceed to the workstation and follow the instructions to test each synthetic blood.

Final Activities

After the results of all four blood types have been completed and the results recorded, students should clean their blood typing slides. Be certain that all mixing sticks have been discarded.

Have the students compare their results. If a student has a result that differs from that obtained by the rest of the class, discuss what may have happened, such as

- contamination of the sample
- sample not sufficiently mixed
- not enough time to view the reaction
- wrong anti-serum in the well
- wrong blood sample in the well

Sample Questions for Assessment

The following questions can be used to check for student understanding of the ABO and Rh blood groups and their inheritance. Answers are in italics.

1. Give the phenotype (blood type) for each of the following genotypes:

Genotype	Phenotype
I^A/I^A	*A*
I^B/I^B	*B*
I^A/i	*A*
I^B/i	*B*
I^A/I^B	*AB*
i/i	*O*

2. Jane is blood type A and her husband is blood type B. Jane is puzzled because their daughter is type O. Explain how the daughter inherited a blood type that neither of her parents has.

Jane and her husband are heterozygous for their blood type. Both carry the recessive allele for type O blood. Their daughter has inherited the recessive allele from each parent and expresses the recessive allele in her phenotype.

3. (Continued from Question 2) If Jane and her husband are both type AB, could they have a type O daughter?
No.

Explain your answer.
Both parents have the genotype I^A/I^B and cannot pass on the recessive allele i.

4. An archeologist discovers an unopened tomb in Egypt. Inside the tomb, he finds the mummies of two adults and two children. Inscriptions identify the two adults as the chief scribe and his wife. The inscriptions tell how their son and his best friend drowned in the Nile River when their boat overturned. The mummies are so well preserved that lab technicians are able to type their blood. Both adults are type B. Child 1 is type A. Child 2 is type B. Which child is not the son?
Child 1.

How do you know?
Neither parent had the allele for type A blood. (The allele I^B would have been expressed in the parents' blood types.)

5. (Continued from Question 4) Based on blood type, you know that one of the children could not have been a son of the two adults. Does this prove that the other child is their son?
No. Type B blood is (and was) a common blood type. The blood type evidence is consistent with Child 2 being an offspring of the two adults. Some students may correctly assert that the blood types combined with the inscriptions strongly support Child 2 as being an offspring of the adults. Perceptive students may notice that the gender of the children is not given. What if Child 2 is a girl?

6. Jim is blood type A and his mother is blood type O. What is the blood type of Jim's father?
Either A or AB.

7. (Continued from Question 6) Jim has a sister who is blood type O. What does this make their father's blood type?
A.

8. (Continued from questions 6 and 7) Is their father's genotype I^A/I^A or I^A/i?
   I^A/i.

   Explain your answer.
   The father has type A blood. The sister is i/i and must have received one of the recessive alleles from her father. This would make his genotype I^A/i.

9. After graduating from high school, Amanda decides to join the Navy. She knows that her father's blood type is A and her mother's is O. Amanda's blood is typed as part of her physical exam and she is blood type B. Amanda returns home and asks her parents if she is adopted. Why does Amanda ask this question?
   The allele for blood type B blood is always expressed, and neither parent carries the allele for type B. They could not have produced a child of blood type B.

10. A baby is kidnapped from a couple's home. Police capture two suspects with a baby that fits the age and gender of the missing child. The suspects claim that the baby is theirs. From their driver's licenses you learn that their blood types are A and AB. The parents of the kidnapped child have blood types A and B. You type the baby's blood and discover that it is type O. Can the suspects be the biological parents of the baby, and if not, could this be the kidnapped child? Explain your answers.
    The baby had to receive the recessive allele for type O blood from both parents. The type AB suspect does not have the recessive allele. The suspects cannot be the baby's biological parents. The parents of the kidnapped baby could be heterozygous for A and B blood types. If so, they could have a type O child. They could be the biological parents of the baby.

Optional Activities

The main activity in this kit could be followed by a mock trial with students playing the roles of attorneys for Daryl and the Deans (see story in Student Instructions). The remainder of the class can serve as jurors and vote on whether to accept or deny Daryl's claim.

You may wish to have students observe the different kinds of blood cells. This is easily done with prepared blood smears and the following instructions.

Materials

Needed, but not provided

compound microscopes

human blood film, smear (Carolina Catalog #31-3158)

human sickle cell anemia, smear (Carolina Catalog #31-7374)

human acute granulocytic leukemia, smear (Carolina Catalog #31-7404)

Have students examine the normal human blood film under 400–450× magnification. They will immediately see the red blood cells. Careful examination of these cells may enable the students to infer their basic shape as being biconcave disks. They should also see red blood cells in various degrees of flexure. There will be fewer white blood cells, and it will take some searching to find them.

With Wright Stain, several types of white blood cells can be distinguished. Students can simply observe that there are different types of white blood cells, or they can try to identify them. Textbooks often contain illustrations of the different white blood cell types, which will aid in their identification.

Basophils have cytoplasmic granules that stain blue. The cytoplasmic granules of eosinophils stain bright red, and those of neutrophils stain paler than those of basophils. Lymphocytes have a nucleus that stains blue. Monocytes also have a blue nucleus, but it is distinctly bi-lobed. Platelets are much smaller than any of these cells. They tend to form blue-stained clusters.

Once students are familiar with the appearance of a normal blood film, they can examine sickle cell anemia and granulocytic leukemia smears. How do they differ from the normal smear? Students can be assigned to research and report on these and other disorders that cause changes to the forms or relative abundance of the different blood cells.

Discussion

It will aid their understanding of blood group genetics if students are familiar with the **Fluid Mosaic Model** of the cell membrane. The cell membrane of a red blood cell, like that of other cells, has molecules that project from its surface. Some of these molecules function like identification badges. They allow the immune system to recognize the cell as a normal component of an individual's body. If red blood cells from another person are introduced into the bloodstream, they may have surface molecules that are different. These molecules, which are

recognized as foreign to the body, are called **antigens**. The immune system then attacks these antigens and attempts to destroy them and the cells that carry them. This results in clumping or agglutination of the blood cells.

The ABO blood groups result from the presence or absence of two antigens, A and B, on the surface of the red blood cells. The immune system produces an **antibody** in the plasma for the antigen not present. Usually it is necessary for exposure to an antigen to occur before antibodies are produced; however, in this instance the antibodies are already present. Type A blood has the A antigen on its red blood cells and anti-B antibodies in the plasma. Type B blood has the B antigen on its red blood cells and anti-A antibodies in the plasma. Type AB blood has both A and B antigens on the red blood cells and no antibodies in the plasma. Finally, Type O blood has neither A or B antigens on the red blood cells and there are both A and B antibodies in the plasma.

These blood groups (or more properly, the A and B antigens) are inherited. There are three alleles: $\mathbf{I^A}$, $\mathbf{I^B}$, and **i** (also designated $\mathbf{I^O}$).

When present, the alleles I^A and I^B are always expressed in the **phenotype**. Both I^A and I^B alleles are dominant to i. The O phenotype always indicates that the **genotype** is **homozygous**. The A and B phenotypes may be homozygous or **heterozygous**, and the AB phenotype is always heterozygous. These relationships are summarized in the table below.

The ABO Blood Groups

Blood Group (Phenotype)	Blood Group Genotype	Red Cell Antigen	Serum Antibody
A	I^A/I^A or I^A/i	A	Anti-B
B	I^B/I^B or I^B/i	B	Anti-A
AB	I^A/I^B	A and B	Neither
O	i/i	Neither	Anti-A and Anti-B

Because they are inherited, knowledge of these blood groups can be useful in cases of disputed parentage.

Student Instructions Key *(answers in italics)*

You are a blood geneticist at a medical laboratory and are often called upon to serve as an expert witness in court cases. Your help is needed to resolve a case involving a disputed inheritance.

Here are the facts: John and Andrea Dean, an elderly couple, went to an attorney to make their will. For many years, John and Andrea had visited flea markets and yard sales looking for antique toys and other items that they collected. They wished to leave all their possessions to their only child, Marline.

When Marline had her parents' collections appraised, she was shocked to discover that the collections were worth over $300,000. At this point, Daryl, a man from another state, demands to be included in the will. He claims that Andrea had become pregnant in high school while she and John were dating, and that Andrea's parents sent her to another state, where she gave birth to a son. Daryl claims to be that son. John and Andrea deny his allegations.

Knowing that the blood groups are inherited, you decide to try solving the case by typing the blood of John, Andrea, Marline, and Daryl. Go to your workstation where you will find the blood samples and materials for ABO blood group testing. Use the following instructions:

1. Using the dropper vial, place a drop of John's blood in each well of the blood typing slide. Replace the cap on the dropper vial. Always replace the cap on one vial before opening the next vial to prevent cross contamination.
2. Add a drop of synthetic anti-A (blue) to the well labeled A. Replace the cap.
3. Add a drop of synthetic anti-B serum (yellow) to the well labeled B. Replace the cap.
4. Using a different color mixing stick for each well (blue for anti-A, yellow for anti-B), gently stir the synthetic blood and anti-serum drops for 30 seconds. Discard each mixing stick after a single use to avoid contamination of your samples and inaccurate results.
5. Carefully examine the thin films of liquid mixture left behind. If a film remains uniform in appearance, there is no agglutination. If the sample appears granular, agglutination has occurred. Determine the blood type of the sample using the chart below. Answer yes or no as to whether agglutination occurred in each sample. A positive agglutination reaction indicates the blood type.

6. Record the results for John's blood sample in the data table below.
7. Thoroughly rinse the blood typing slide, then repeat steps 1 through 6 for the other blood samples.

Data Table

	John	Andrea	Marline	Daryl
Anti-A	*No*	*Yes*	*No*	*No*
Anti-B	*No*	*No*	*No*	*Yes*
Blood Type	*O*	*A*	*O*	*B*

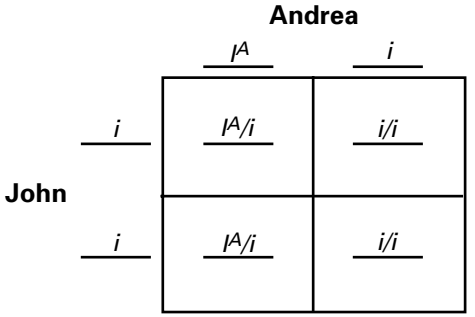
What is John's genotype? *i/i*

What is Marline's genotype? *i/i*

Knowing Andrea's blood type and John and Marline's genotypes, what is Andrea's genotype? I^A/i

Now fill in the Punnett square (genetic square) to show the possible genotypes for John and Andrea's children.

Punnett Square



Using the Punnett square, give the possible blood types (phenotypes) of John and Andrea's children. Blood type *A* and blood type *O*.

Based on your results, could Daryl be John and Andrea's son? *No*.

How do you know this? (Remember that as an expert witness, you may have to defend your finding in a court of law.)

Daryl has type B blood, so he must have inherited the allele for type B from at least one of his parents. Neither John nor Andrea have the allele for B and could not have had a child with type B blood. ***Note:*** *Daryl could change his story and claim that he is Andrea's son by someone other than John.*

Student Instructions

70-0107

Name _____

Date _____

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Data Table

	John	Andrea	Marline	Daryl
Anti-A				
Anti-B				
Blood Type				

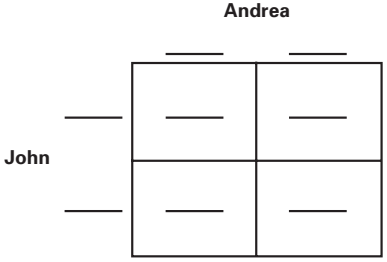
What is John's genotype? _____

What is Marline's genotype? _____

Knowing Andrea's blood type and John and Marline's genotypes, what is Andrea's genotype? _____

Now fill in the Punnett square (genetic square) to show the possible genotypes for John and Andrea's children.

Punnett Square



Using the Punnett square, give the possible blood types (phenotypes) of John and Andrea's children. Blood type _____ and blood type _____ .

Based on your results, could Daryl be John and Andrea's son? _____.

How do you know this? (Remember that as an expert witness, you may have to defend your finding in a court of law.)

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