Born of Blood: Inheritance of Blood Types

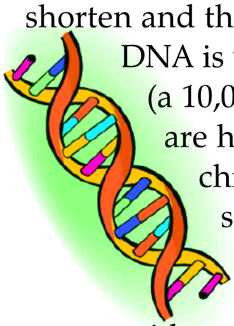
Student Activity 3C

Activity Introduction:

You have probably heard people talk about their blood type and you may even know your own. But do you know how you inherited that blood type? In this activity, you will learn how the ABO blood types are passed from parents to offspring.

Activity Background:

Our blood type is a trait coded into our DNA, just as our eye color or hair color. All of our human traits are coded into genes found on 23 pairs (46) of chromosomes (strands of DNA and protein) kept in the nucleus of every cell in our body except red blood cells. Most of the time, our DNA is stretched out into long, thin strands and intertwined much like a bowl of spaghetti. The largest human chromosome would extend to 8.5 cm, the smallest 1.7 cm. When a cell gets ready to divide, it must prepare so that each of the 2 cells resulting from the split receive a complete set of DNA. In preparation for cell division, the chromosomes shorten and thicken and make exact copies of themselves. The shortening and thickening of DNA is very efficient, changing from 8.5 cm to approximately 5 micrometers in length (a 10,000 fold reduction in length). After an exact copy is made, the 2 chromosomes are held together at the centromere (DNA) by a kinetochore (protein). When the chromosomes are in this form, they are visible under a compound microscope, see ***Figure 1 Chromosome Pairs (Dyads)***. Notice that each chromosome has a short arm and a long arm. When the cell divides, the duplicate strands of each chromosome separate and each cell gets one copy. This process occurs with each of our 46 chromosomes, so each daughter cell receives a full set of 46 chromosomes.



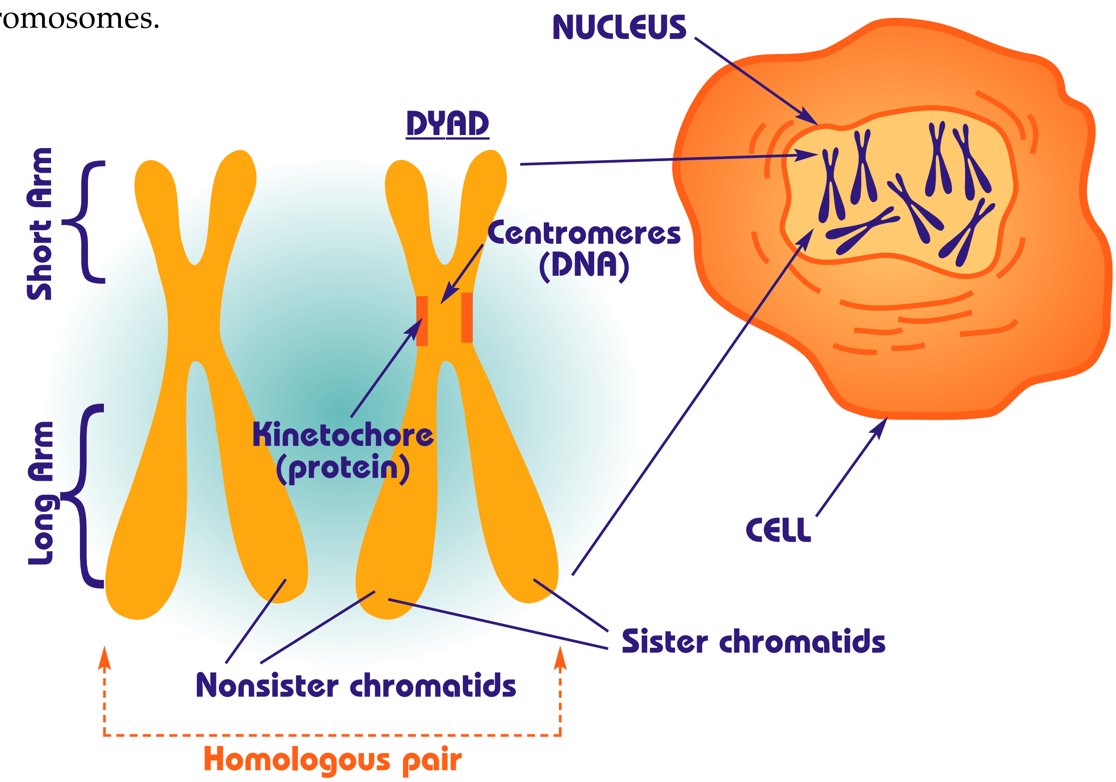


Figure 1 Chromosome Pairs (Dyads)

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Our chromosomes exist as similar pairs (homologous), each containing genes for hundreds of traits. These pairs of chromosomes have genes for the exact same traits, but the information in the genes may differ. For example, if eye color is a trait located on the chromosome, both chromosomes in a pair will have a gene for eye color, but one gene may code for blue eyes and the other gene may code for brown eyes. This means that every trait in our body is controlled by 2 genes, one inherited from our father and the other inherited from our mother. Genes are located in a particular sequence along the chromosomes.

In this activity, we are particularly interested in the ***ABO gene***, found on the long arm of chromosome 9. It was not until 1990 that this gene was discovered and the mapping of chromosome 9 was not completed until 2002; we now know it has approximately 1400 genes. There are three main variations of this blood type gene; A, B, and O.

- The A gene changes the antigens on our red blood cells into A antigens by adding a molecule of ***GaINAC*** to the H antigens found on almost everyone's red blood cells. This change creates Type A blood.
- The B gene changes the antigens on our red blood cells into B antigens by adding a molecule of ***galactose*** to the H antigens found on almost everyone's red blood cells. This change creates Type B blood.
- The O gene does not alter the H antigens found on almost everyone's red blood cells. This means that neither A nor B antigens are present, resulting in Type O blood.
- Most of the time, Type AB blood results from inheriting an A gene and a B gene so that both A and B antigens are produced.

Activity Materials: (per group)

- 1 copy ***Student Information Page***
- 1 copy ***Student Data Page*** *per student*
- 80 cm blue curling ribbon*
- 80 cm yellow curling ribbon*
- 80 cm red curling ribbon*
- Permanent marker
- Ruler
- Scissors
- (24) 3/8" diameter Velcro dots (Alternately cut six small pieces off of Velcro tape)
- Yellow, Blue and Red map pencils

**Note: Any three colors of curling ribbon can be used*

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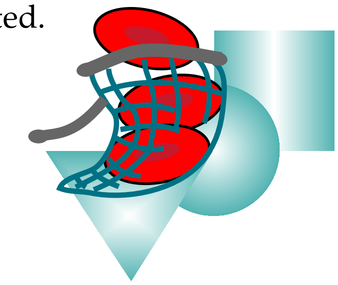
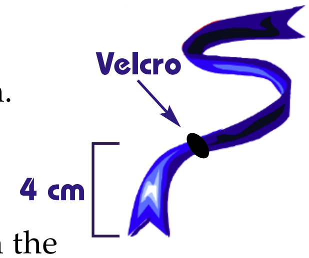
Activity Instructions: Read each step and check off when completed.

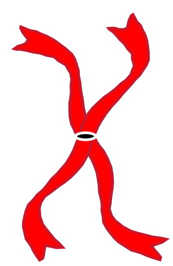


Part I. Making Chromosome Models

- ☐ 1. Carefully measure ***10 cm*** of curling ribbon using your ruler. Cut carefully using the scissors so you have a piece of curling ribbon exactly 10 cm long.
- ☐ 2. Repeat Step 1 using the rest of the curling ribbon. When you finish, you will have 24 pieces of curling ribbon measuring ***10 cm***; 8 blue, 8 yellow and 8 red.



- ☐ 3. Measure exactly ***4 cm*** from one end of a piece of curling ribbon. Attach the sticky side of the Velcro to the curling ribbon.
- ☐ 4. Repeat for all other pieces of curling ribbon in your group. These pieces of curling ribbon represent ***chromosomes*** found in the nuclei of our body cells (except red blood cells).
- ☐ 5. On the longest part of a piece of curling ribbon, measure ***3. 6 cm*** from the end and make a mark on the curling ribbon using the permanent marker. The mark you made represents the ***gene*** that determines the ABO blood type.
- ☐ 6. You have just made a model of ***chromosome 9***, which is found in every cell of your body, with the exception of red blood cells. Red blood cells do not have a nucleus and therefore do not contain the chromosomes found in cells ***with*** a nucleus.
- ☐ 7. Repeat Step 5 and 6 for each remaining piece of curling ribbon.
- ☐ 8. You now have 8 ***Chromosome 9*** models in blue, 8 ***Chromosome 9*** models in yellow, and 8 ***Chromosome 9*** models in red.
- ☐ 9. As you learned from reading the background information, when a cell gets ready to divide, every chromosome shortens, thickens, and makes a copy of itself.
  - a. Use your scissors to curl the chromosome 9 models.
  - b. Using the Velcro pieces, attach two blue "chromosomes" to represent the new chromosome pair waiting to split when their cell divides. They attach so that they resemble an "X" under the microscope.



- ☐ 10. Repeat step 9 for all other blue pieces.
- ☐ 11. Repeat steps 9 and 10 for the red curling ribbon.
- ☐ 12. Repeat steps 9 and 10 for the yellow curling ribbon.
- ☐ 13. You are now ready for the next part of the activity.

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Part II. How Gene Pairs Determine ABO Blood Types

1. Each color represents a different variety of the ABO gene on Chromosome 9:

   a. The ***red*** *Chromosome 9* will represent a chromosome with the ***"A"*** gene.

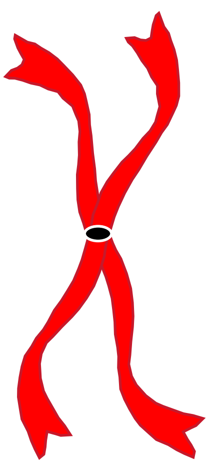
   b. The ***blue*** *Chromosome 9* will represent a chromosome with the ***"B"*** gene.

   c. The ***yellow*** *Chromosome 9* will represent a chromosome with the ***"O"*** gene

2. As you learned in ***"What's Your Type?,"*** the "A" gene changes the antigens on each red blood cell (RBC), turning them into "A" antigens and thus type A blood. The "B" gene changes the antigens on each red blood cell, turning them into "B" antigens and thus type B blood. The "O" gene does not change the antigens into either A or B antigens.

3. The ABO genes are not dominant or recessive as are many other genes. They are co-dominant, meaning that when one of these genes is present, it expresses itself.

4. Use your ***Chromosome Models*** to make each blood type described below and draw your combinations on the ***Student Data Page***.



   a. **Type A** blood with an *A gene from each parent*:

      1. Choose 2 red *Chromosome 9* models from ***Part I***. Remember that each chromosome has 2 identical copies attached in the middle waiting for their cell to divide. You have picked up two red models, because one way to have type A blood is to have 2 A genes. Using a red map pencil, draw this combination of genes on your ***Student Data Page***.

      2. Look at ***Table 1*** on the following page and create all other possible combinations for *Type A* blood. Draw each on ***Part II of your Student Data Page***.

   b. Repeat Steps 1 and 2 for each of the other blood types.

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Table 1 Gene Pairs for Each Possible Blood Type

Type A Blood	Type B Blood	Type O Blood	Type AB Blood
A gene from each parent (AA) **A gene = Red ribbon**	***B*** gene from each parent (BB) **B gene = Blue ribbon**	***O*** gene from each parent (OO) **O gene = Yellow ribbon**	***A*** gene from 1 parent and ***B*** gene from 2^{nd} parent **A gene = red ribbon,** **B gene = blue ribbon**
A gene from 1 parent and "O" gene from 2^{nd} parent (AO) **A gene = red ribbon** **O gene = yellow ribbon**	***B*** gene from one parent and O gene from 2^{nd} parent (BO) **B gene = Blue ribbon** **O gene = yellow ribbon**		

Part III. Determining How Blood Types are Inherited

- ☐ 1. Read the descriptions on ***Part III of your Student Data Page***. Determine the ABO genes for each parent using ***Table 1 Gene Pairs for Each Possible Blood Type***.
- ☐ 2. Follow the instructions on your ***Student Data Page*** for predicting the possible blood types of children from each set of parents described on your ***Student Data Page.***

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