

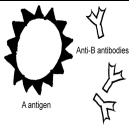
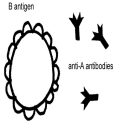
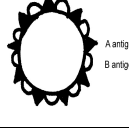
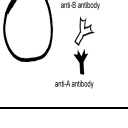
Using Blood Tests to Identify Babies and Criminals

I. Were the babies switched?

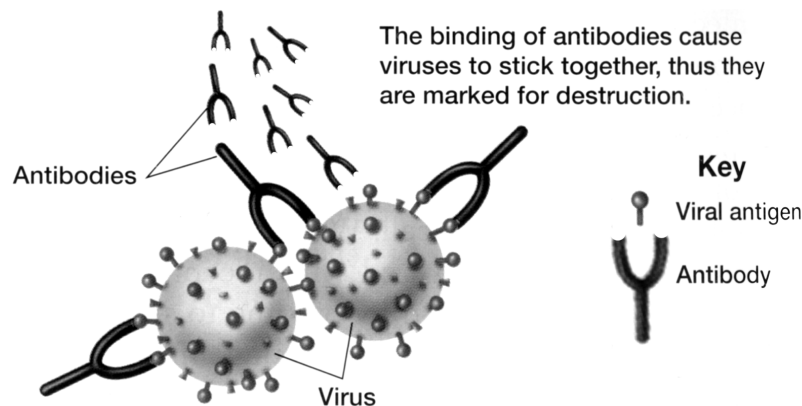
Two couples had babies on the same day in the same hospital. Denise and Earnest had a girl, Tonja. Danielle and Michael had twins, a boy, Michael, Jr., and a girl, Michelle. Danielle was convinced that there had been a mix-up and she had the wrong girl, since Michael Jr. and Tonja were both light-skinned, while Michelle had darker skin. Danielle insisted on blood type tests for both families to check whether there had been a mix-up. In order to interpret the results of the blood type tests, you will need to understand the basic biology of blood types.

Blood Types

There are many different ways to classify blood types, but the most common blood type classification system is the ABO (said "A-B-O") system. There are four blood types in the ABO system: Type A, Type B, Type AB, and Type O. These blood types refer to different versions of carbohydrate molecules (complex sugars) which are present on the surface of red blood cells.

People with:	Have:	
Type A blood	Type A carbohydrate molecules on their red blood cells	
Type B blood	Type B carbohydrate molecules on their red blood cells	
Type AB blood	Type A and B carbohydrate molecules on their red blood cells	
Type O blood	Neither A nor B carbohydrate molecules on their red blood cells	

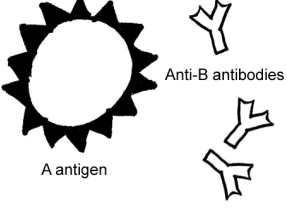
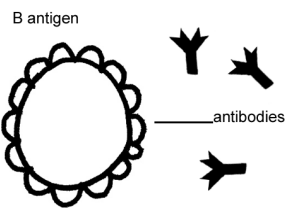
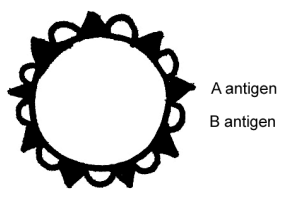
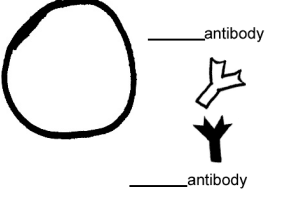
The Type A and Type B carbohydrate molecules are called **antigens** because they can stimulate the body to produce an immune response, including antibodies. **Antibodies** are special proteins that travel in the blood and help our bodies to destroy viruses or bacteria that may have infected our bodies.



Normally, our bodies do not make antibodies against any molecules that are part of our own bodies. Thus, antibodies help to defend against invading viruses and bacteria, but normally antibodies do not attack our own body cells.

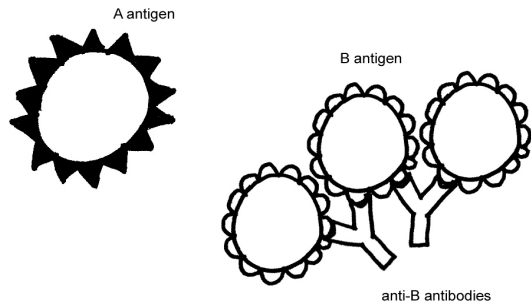
For example, people with Type A blood do not make antibodies against the Type A antigen which is present on their red blood cells. However, they do make antibodies against the Type B antigen (called anti-B antibodies).

1. Test your understanding of blood groups by filling in the blanks in the chart below.

 <p>A antigen</p> <p>Anti-B antibodies</p>	<p>Blood group A</p> <p>If you belong to the blood group A, you have A antigens on the surface of your red blood cells and _____ antibodies in your blood.</p>
 <p>B antigen</p> <p>_____antibodies</p>	<p>Blood group B</p> <p>If you belong to the blood group B, you have B antigens on the surface of your red blood cells and _____ antibodies in your blood.</p>
 <p>A antigen</p> <p>B antigen</p>	<p>Blood group AB</p> <p>If you belong to the blood group AB, you have both A and B antigens on the surface of your red blood cells and no anti-A or anti-B antibodies in your blood.</p>
 <p>_____antibody</p> <p>_____antibody</p>	<p>Blood group O</p> <p>If you belong to the blood group O, you have neither A nor B antigens on the surface of your red blood cells, but you have both _____ and _____ antibodies in your blood.</p>

Blood transfusions — Who can receive blood from whom?

If you are given a blood transfusion that does not match your blood type, antibodies present in your blood can react with the antigens present on the donated red blood cells. For example, if a person who has Type A blood is given a Type B blood transfusion, then this person's anti-B antibodies will react with the Type B antigens on the donated red blood cells and cause a harmful reaction. This transfusion reaction can cause the donated red blood cells to burst and/or clump together and block blood vessels.



Transfusion reactions can be fatal. To prevent this from happening, doctors test whether a person's blood is compatible with the donated blood before they give a transfusion. A person can only be given donated blood with red blood cells that do not have any antigen that can react with the antibodies in the person's blood.

2. Test your understanding of blood groups by completing the table below.

Blood Group	Antigens on red blood cells	Antibodies in plasma	Can receive blood from	Can give blood to
A	A	Anti-B	A and O	A and AB
B	B			
AB	A and B			
O	None			

3. Which blood type would be considered a universal donor (someone who can give blood to anyone)?

Genetics of Blood Types

The ABO blood types result from the alleles of a gene that can code for two different versions of a protein enzyme or an inactive protein as shown in this table:

Allele	Codes for a protein that is
I^A	a version of the enzyme that puts Type A carbohydrate molecules on the surface of red blood cells
I^B	a version of the enzyme that puts Type B carbohydrate molecules on the surface of red blood cells
i	inactive; doesn't put either type of carbohydrate molecule on red blood cells

4. Each person has two copies of this gene, one inherited from his/her mother and the other inherited from his/her father. Complete the following table to relate genotypes to blood types.

Genotype	This person's cells make	Blood Type
$I^A I^A$	the version of the enzyme that puts Type A carbohydrate molecules on the surface of red blood cells	
ii	the inactive protein	
$I^A i$	the version of the enzyme that puts Type A carbohydrate molecules on the surface of red blood cells and the inactive protein.	A

In a person with the $I^A i$ genotype, which allele is dominant, I^A or i ? Explain your reasoning.

5. Complete the following table to describe each of the three genotypes listed.

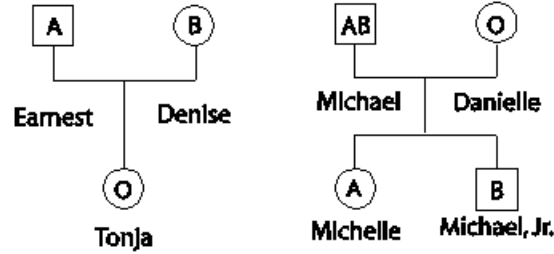
Genotype	Will this person's cells make the version of the enzyme needed to attach this carbohydrate on the surface of his or her red blood cells?	Blood Type
$I^B I^B$	Type A __yes __ no; Type B __yes __ no	
$I^B i$	Type A __yes __ no; Type B __yes __ no	
$I^A I^B$	Type A __yes __ no; Type B __yes __ no	

Codominance refers to inheritance in which two alleles of a gene each have a different observable effect on the phenotype of a heterozygous individual. Thus, in codominance, neither allele is recessive — both alleles are dominant.

6. Which of the genotypes results in a blood type that provides clear evidence of codominance? Explain your reasoning.

Were the babies switched?

Now you are ready to evaluate whether Earnest and Denise's baby girl was switched with Michael and Danielle's baby girl. The following family trees show the blood types for each person in both families.



7. What allele for the blood type gene will be present in each egg produced by Danielle?

Michael can produce sperm with either the _____ allele or the _____ allele.

Draw the Punnett Square that shows the possible genotypes for Danielle and Michael's children. Write in the blood type for each genotype to show the possible blood types for Danielle and Michael's children.

Is it possible for Danielle and Michael to have a child who has type O blood?

8. To check whether Earnest and Denise could have a baby with Type O blood, draw a Punnett square for a father who has blood Type A and $I^A i$ genotype and a mother who has blood Type B and $I^B i$ genotype. Write in the blood type for each child's genotype.

9. Were Earnest and Denise the parents of Tonja or had the hospital made a mistake? Explain your reasoning.

10. How could fraternal twins be as different in appearance as Michelle and Michael, Jr., including one having light skin and the other having dark skin?

