Non-Mendelian Inheritance

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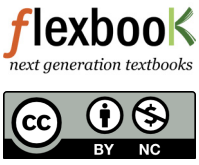

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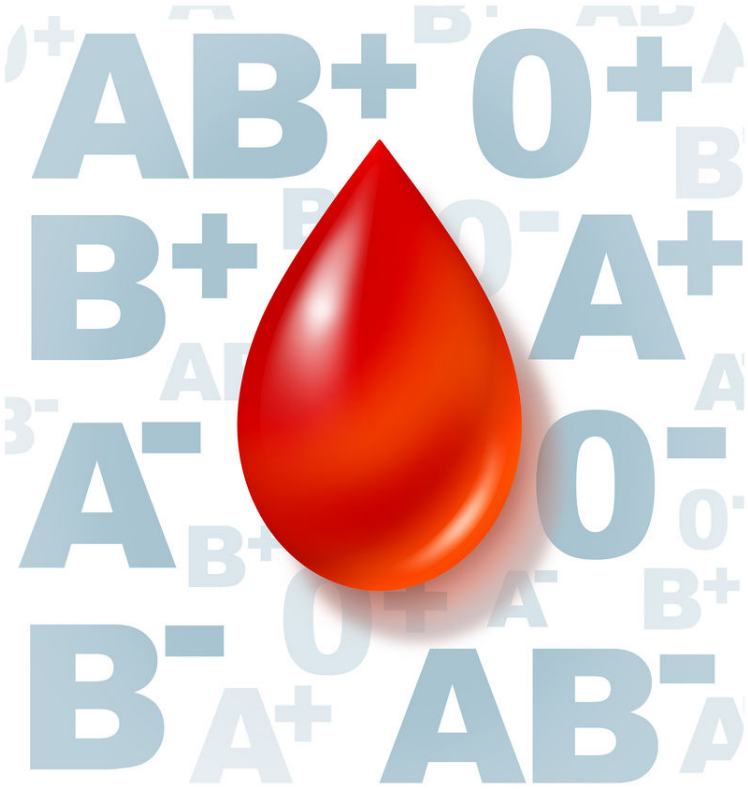
CHAPTER 1 Non-Mendelian Inheritance

- Distinguish incomplete dominance from codominance.
- Describe the genetics of ABO blood types in humans.



How would Mendel explain blood types?

The inheritance of traits is not always as simple as Mendel's rules. Each characteristic Mendel investigated was controlled by one gene that had only two possible alleles, one of which was completely dominant over the other. We now know that inheritance is often more complicated than this. In blood types, for example, there are actually three alleles instead of two. And some traits even have more than three alleles.

Exceptions to Mendel's Rules

In all of Mendel's experiments, he worked with traits where a single gene controlled the trait. Each also had one allele that was always dominant over the recessive allele. But this is not always true.

There are exceptions to Mendel's rules, and these exceptions usually have something to do with the dominant allele. If you cross a homozygous red flower with a homozygous white flower, according to Mendel's laws, what color flower should result from the cross? Either a completely red or completely white flower, depending on which allele is dominant. But since Mendel's time, scientists have discovered this is not always the case.

Incomplete Dominance

One allele is NOT always completely dominant over another allele. Sometimes an individual has a phenotype between the two parents because one allele is not dominant over another. This pattern of inheritance is called

incomplete dominance. For example, snapdragon flowers show incomplete dominance. One of the genes for flower color in snapdragons has two alleles, one for red flowers and one for white flowers.

A plant that is homozygous for the red allele (*RR*) will have red flowers, while a plant that is homozygous for the white allele will have white flowers (*WW*). But the heterozygote will have pink flowers (*RW*) (**Figure** 1.1) as both alleles are expressed. Neither the red nor the white allele is dominant, so the phenotype of the offspring is a blend of the two parents.

FIGURE 1.1

Pink snapdragons are an example of incomplete dominance.

Another example of incomplete dominance is with sickle cell anemia, a disease in which a blood protein called hemoglobin is produced incorrectly. This causes the red blood cells to have a sickle shape, making it difficult for these misshapen cells to pass through the smallest blood vessels. A person that is homozygous recessive (*ss*) for the sickle cell trait will have red blood cells that all have the incorrect hemoglobin. A person who is homozygous dominant (*SS*) will have normal red blood cells.

What type of blood cells do you think a person who is heterozygous (*Ss*) for the trait will have? They will have some misshapen cells and some normal cells (**Figure** 1.2). Both the dominant and recessive alleles are expressed, so the result is a phenotype that is a combination of the recessive and dominant traits.

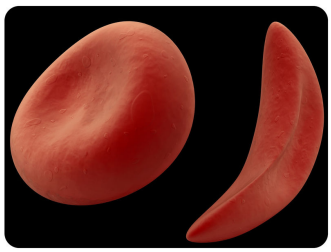


FIGURE 1.2

Sickle cell anemia causes red blood cells to become misshapen and curved unlike normal, rounded red blood cells.

Codominance

Another exception to Mendel's laws is a phenomenon called **codominance**. For example, our blood type shows codominance. Do you know what your blood type is? Are you A? O? AB? Those letters actually represent alleles. Unlike other traits, your blood type has three alleles, instead of two!

The ABO blood types (**Figure** 1.3) are named for the protein attached to the outside of the blood cell. In this case, two alleles are dominant and completely expressed *(I^A and I^B),* while one allele is recessive *(i).* The I^A allele encodes for red blood cells with the A antigen, while the I^B allele encodes for red blood cells with the B antigen. The recessive allele *(i)* does not encode for any proteins. Therefore a person with two recessive alleles *(ii)* has type O blood. As no dominant *(I^A and I^B)* allele is present, the person cannot have type A or type B blood. What are the genotypes of a person with type A or type B blood?

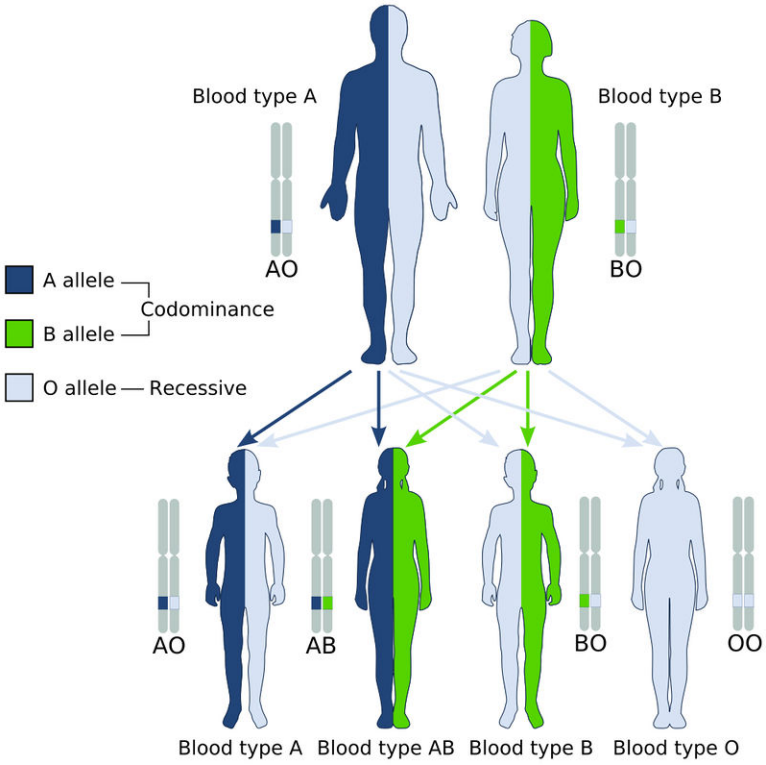


FIGURE 1.3

An example of codominant inheritance is ABO blood types.

There are two possible genotypes for type A blood, homozygous (I^AI^A) and heterozygous (I^Ai), and two possible genotypes for type B blood, (I^BI^B and I^Bi). If a person is heterozygous for both the I^A and I^B alleles, they will express both and have type AB blood with both proteins on each red blood cell.

This pattern of inheritance is significantly different than Mendel's rules for inheritance, because both alleles are expressed completely, and one does not mask the other.

Summary

- Incomplete dominance, as seen in sickle cell anemia, is a form of inheritance in which one allele is only partly dominant over the other allele, resulting in an intermediate phenotype.
- Codominance, as in human blood type, is a form of inheritance in which both alleles are expressed equally in the phenotype of the heterozygote.

Explore More

Use the resources below to answer the questions that follow.

Explore More I

- **Incomplete Dominance** at http://www.ksu.edu/biology/pob/genetics/incom.htm

1. A species exists with three color types, (blue, yellow and green). You breed a yellow (*bb*) individual with a blue (*BB*) individual, and all the offspring are green. Which trait is dominant? Explain your reasoning.
2. You now breed the green offspring with a yellow individual. What will their offspring look like? Explain your answer.
3. You now breed a green individual with a blue individual. What will their offspring look like? Explain your answer.

Explore More II

- **Incomplete Dominance and Codominance** at http://www2.edc.org/weblabs/incompletedom/incompletedominance.html

1. When one trait is said to cancel out another trait, what kind of relationship is said to exist?
2. What is an allele?
3. If a trait is said to show incomplete dominance, can it be a simple trait? Explain your answer fully.
4. What is found on the surface of red blood cells in humans that determines blood type?
5. Is blood type an example of incomplete dominance or codominance? Explain your reasoning and be as specific as you can.

Review

1. A dark purple flower is crossed with a white flower of the same species, and the offspring have light purple flowers. What type of inheritance does this describe? Explain.
2. What is the inheritance pattern in which both alleles are expressed?
3. What is the genotype of a person with type O blood?
4. What is the genotype(s) of a person with type AB blood?

References

1. Rochelle Hartman. Pink snapdragons are an example of incomplete dominance . CC BY 2.0
2. Image copyright Sebastian Kaulitzk, 2013. Image of blood cell caused by sickle-cell anemia . Used under license from Shutterstock.com
3. Yassine Mrabet, based on image by the National Institutes of Health. An example of codominant inheritance is ABO blood types . Public Domain