11.3 Other Patterns of Inheritance

THINK ABOUT IT Mendel's principles offer a tidy set of rules with which to predict various patterns of inheritance. Unfortunately, biology is not a tidy science. There are exceptions to every rule, and exceptions to the exceptions. What happens if one allele is not completely dominant over another? What if a gene has several alleles?

Beyond Dominant and Recessive Alleles

What are some exceptions to Mendel's principles?

Despite the importance of Mendel's work, there are important exceptions to most of his principles. For example, not all genes show simple patterns of inheritance. In most organisms, genetics is more complicated, because the majority of genes have more than two alleles. Also, many important traits are controlled by more than one gene. Understanding these exceptions allows geneticists to predict the ways in which more complex traits are inherited.

Incomplete Dominance A cross between two four o'clock (*Mirabilis jalapa*) plants shows a common exception to Mendel's principles. **Some alleles are neither dominant nor recessive.** As shown in **Figure 11–12,** the F_1 generation produced by a cross between red-flowered (*RR*) and white-flowered (*WW*) *Mirabilis* plants consists of pink-colored flowers (*RW*). Which allele is dominant in this case? Neither one. Cases in which one allele is not completely dominant over another are called **incomplete dominance.** In incomplete dominance, the heterozygous phenotype lies somewhere between the two homozygous phenotypes.

Codominance A similar situation arises from **codominance,** in which the phenotypes produced by both alleles are clearly expressed. For example, in certain varieties of chicken, the allele for black feathers is codominant with the allele for white feathers. Heterozygous chickens have a color described as "erminette," speckled with black and white feathers. Unlike the blending of red and white colors in heterozygous four o'clocks, black and white colors appear separately in chickens. Many human genes, including one for a protein that controls cholesterol levels in the blood, show codominance, too. People with the heterozygous form of this gene produce two different forms of the protein, each with a different effect on cholesterol levels.

Key Questions

What are some exceptions to Mendel's principles?

Does the environment have a role in how genes determine traits?

Vocabulary

incomplete dominance • codominance • multiple allele • polygenic trait

Taking Notes

Outline Make an outline using the green and blue headings. As you read, write bulleted notes below each heading to summarize its topic.

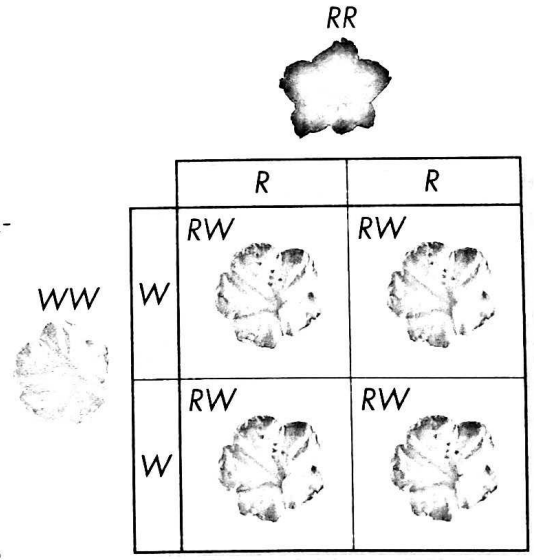


FIGURE 11–12 Incomplete Dominance In four o'clock plants, the alleles for red and white flowers show incomplete dominance. Heterozygous (*RW*) plants have pink flowers—a mix of red and white coloring.

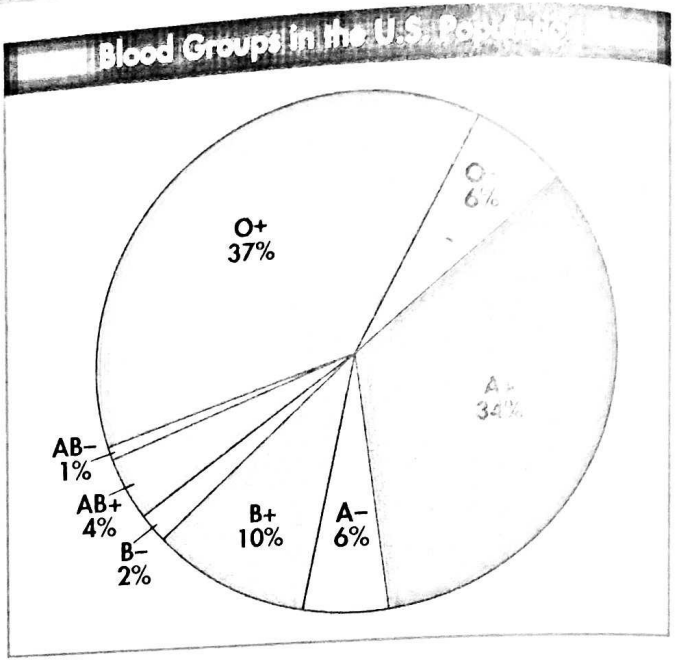
Analyzing Data

Human Blood Types

Red blood cells carry antigens, molecules that can trigger an immune reaction, on their surfaces. Human blood type A carries an A antigen, type B has a B antigen, type AB has both antigens, and type O carries neither antigen. The gene for these antigens has three alleles; A, B, and O.

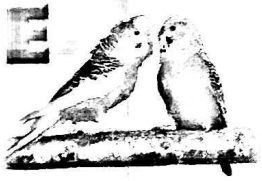
For a transfusion to succeed, it must not introduce a new antigen into the body of the recipient. So, a person with type A blood may receive type O, but not vice versa.

Another gene controls a second type of antigen, known as Rh factor. Rh^+ individuals carry this antigen, while Rh^- ones don't. This chart of the U.S. population shows the percentage of each blood type.



1. **Interpret Graphs** Which blood type makes up the greatest percentage of the U.S. population?
2. **Calculate** What percentage of the total U.S. population has a positive Rh factor? What percentage has a negative Rh factor?
3. **Infer** Which blood type can be used for transfusion into the largest percentage of individuals? Which type has the smallest percentage of possible donors available?
4. **Predict** Could a person with O^+ blood have two parents with O^- blood? Could that person have a daughter with AB^+ blood? Explain your answers.

MYSTERY CLUE



Green feathers don't actually contain green pigments. Rather, they contain a mixture of blue and yellow pigments. Could feather color be controlled by more than one gene?

Multiple Alleles So far, our examples have described genes for which there are only two alleles, such as *a* and *A*. In nature, such genes are the exception rather than the rule. **Many genes exist in several different forms and are therefore said to have multiple alleles.** A gene with more than two alleles is said to have **multiple alleles.** An individual, of course, usually has only two copies of each gene, but many different alleles are often found within a population. One of the best-known examples is coat color in rabbits. A rabbit's coat color is determined by a single gene that has at least four different alleles. The four known alleles display a pattern of simple dominance that can produce four coat colors. Many other genes have multiple alleles, including the human genes for blood type.

Polygenic Traits **Many traits are produced by the interaction of several genes.** Traits controlled by two or more genes are said to be **polygenic traits.** *Polygenic* means "many genes." For example, at least three genes are involved in making the reddish-brown pigment in the eyes of fruit flies. Polygenic traits often show a wide range of phenotypes. The variety of skin color in humans comes about partly because more than four different genes probably control this trait.

In Your Notebook *In your own words, describe multiple alleles and polygenic traits. How are they similar? How are they different?*

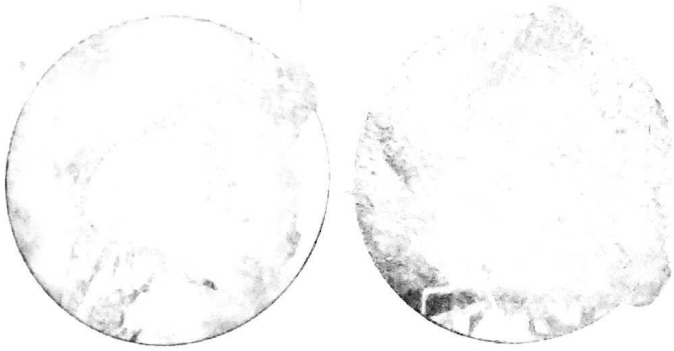
Genes and the Environment

Does the environment have a role in how genes determine traits?

The characteristics of any organism—whether plant, fruit fly, or human being—are not determined solely by the genes that organism inherits. Genes provide a plan for development, but how that plan unfolds also depends on the environment. In other words, the phenotype of an organism is only partly determined by its genotype.

Consider the buckeye butterfly, *Precis coenia*. It is found throughout North America. Butterfly enthusiasts had noted for years that buckeyes hatching in the summer had different color patterns on their wings than those hatching in the fall. Scientific studies suggested a reason—butterflies hatching in the shorter days of autumn had greater levels of pigment in their wings, making their markings appear darker than those hatching in the longer days of summer. In other words, the environment in which the butterflies develop influences the expression of their genes for wing coloration. **Environmental conditions can affect gene expression and influence genetically determined traits.** An individual's actual phenotype is determined by its environment as well as its genes.

Studies on another species, the western white butterfly, have shown the importance of changes in wing pigmentation. In order to fly effectively, the body temperature of the butterfly must be 28°C–40°C (about 84°F–104°F) as shown in **Figure 11–13.** Since the spring months are cooler in the west, greater pigmentation helps them reach the body temperature needed for flight. Similarly, in the hot summer months, less pigmentation enables the butterflies to avoid overheating.



Environmental Temperature and Butterfly Needs

Temp. Needed for Flight	Average Spring Temp.	Average Summer Temp.
28–40°C	26.5°C	34.8°C

FIGURE 11–13 Temperature and Wing Color Western white butterflies that hatch in the spring have darker wing patterns than those that hatch in summer. The dark wing color helps increase their body heat. This trait is important because the butterflies need to reach a certain temperature in order to fly. The buckeye butterflies shown above are darker in the autumn than they are in the summer. **Calculate** *What is the difference between the minimum temperature western white butterflies need to fly and the average spring temperature? Would the same calculation apply to butterflies developing in the summer?* MATH

11.3 Assessment

Review Key Concepts

1. a. Review What does *incomplete dominance* mean? Give an example.

b. Design an Experiment Design an experiment to determine whether the pink flowers of petunia plants result from incomplete dominance.

2. a. Review What is the relationship between the environment and phenotype?

b. Infer What might be the result of an exceptionally hot spring on wing pigmentation in the western white butterfly?

PRACTICE PROBLEM

3. Construct a genetics problem to be given as an assignment to a classmate. The problem must test incomplete dominance, codominance, multiple alleles, or polygenic traits. Your problem must have an answer key that includes all of your work.