Genetics
The Principles of Mendel

Objectives
By the end of this exercise you should be able to:
1. Describe simple genetic dominance, incomplete dominance, and lethal inheritance.
2. Describe possible genotypes for some of your personal traits inherited as dominant and recessive genes.
4. Distinguish between an organism’s phenotype and genotype.

Published papers are the primary means of communicating scientific discoveries. One of the most famous of these papers, entitled “Experiments in Plant Hybridization,” was written in 1866 by Gregor Mendel, an Austrian monk. Although this paper later became the basis for genetics and inheritance, it went largely unnoticed until it was rediscovered independently by several European scientists in 1900. The experiments and conclusions in Mendel’s paper now form the foundation of Mendelian genetics, the topic of today’s exercise.

Mendel’s greatest contribution was to replace the blending theory of inheritance, which stated that all traits blend with each other, with the particulate theory. Mendel’s particulate theory states that (1) inherited characters are determined by particular factors (now called genes), (2) these factors occur in pairs (i.e., genes occur on maternal and paternal homologous chromosomes), and (3) when gametes form, these genes segregate so that only one of the homologous pair is contained in a particular gamete. Recall from Exercise 15 (Meiosis) that each gamete has an equal chance of possessing either member of a pair of homologous chromosomes. This part of the particulate theory is collectively known as Mendel’s First Law, or the Law of Segregation. Mendel’s Second Law, or the Law of Independent Assortment, states that genes on nonhomologous or different chromosomes will be distributed randomly into gametes (fig 17.1).

Before you start this exercise, briefly review in your textbook some principles and terms pertinent to today’s exercise. A gene is a unit of heredity on a chromosome. A gene has alternate states called alleles, contributed to an organism by its parents. Alleles for a particular gene occur in pairs. Alleles that mask expression of other alleles but are themselves expressed are dominant; these alleles are usually designated by a capital letter (for example, P). Alleles whose expression is masked by dominant alleles are recessive, and they are designated by a lowercase letter (for example, p). The genotype of an organism includes all the alleles present in the cell, whether they are dominant or recessive. The physical appearance of the trait is the phenotype. Thus, if purple flowers (P) are dominant to white flowers (p), a plant with purple flowers can have a genotype PP or Pp. A plant with white flowers can only have a genotype pp. When the paired alleles are identical (PP or pp), the genotype is homozygous. Heterozygous refers to a pair of different (Pp) alleles. With this minimal review, you’re prepared to apply this information to solve some genetics problems.

**SIMPLE DOMINANCE**

Assume that purple flowers are dominant to white flowers. If a homozygous purple-flowered plant is crossed (mated) with a homozygous white-flowered plant, what will be the phenotype (physical appearance) and genotype of the offspring?

Parents: PP (homozygous dominant = purple flowers) × pp (homozygous recessive = white flowers)

Gametes: P from the purple-flowered parent
          p from the white-flowered parent

Offspring: genotype = Pp
          phenotype = purple flowers

This first generation of offspring is called the first filial or F₁ generation (fig. 17.2).

Each of the F₁ offspring can produce two possible gametes, P and p. Mendel noted that the gametes from each of
**Figure 17.1**

Independent assortment increases genetic variability. Independent assortment contributes new gene combinations to the next generation because the orientation of chromosomes on the metaphase plate is random. For example, in cells with three chromosome pairs, eight different gametes can result, each with different combinations of parental chromosomes.

**Figure 17.2**

In Mendel's cross of purple by white flowers, the original parents each only make one type of gamete. The resulting F₁ generation are all Pp heterozygotes with purple flowers. These F₁ then each make two types of gametes that can be combined to produce three kinds of F₂ offspring: PP homoygotes (purple flowers); Pp heterozygotes (also purple flowers); and pp homoygotes (white flowers). The ratio of dominant to recessive phenotypes is 3:1. The ratio of genotypes is 1:2:1 (1 PP: 2 Pp: 1 pp).
TABLE 17.1
RESULTS OF COIN-FLIPPING EXPERIMENT
SIMULATING RANDOM MATING OF HETEROZYGOUS (Pp) INDIVIDUALS

<table>
<thead>
<tr>
<th>Response</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heads-heads = PP = purple flowers</td>
<td></td>
</tr>
<tr>
<td>Heads-tails = Pp = purple flowers</td>
<td></td>
</tr>
<tr>
<td>Tails-tails = pp = white flowers</td>
<td></td>
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</tbody>
</table>

the parents combine with each other randomly. Thus, you can simulate the random mating of gametes from the F1 generation by flipping two coins simultaneously. Assume that heads designates the purple-flower allele (P), and tails designates the white-flower allele (p). Flipping one coin will determine the type of gamete from one parent and flipping the other will determine the gamete from the other parent. To demonstrate this technique, flip two coins simultaneously 64 times and record the occurrence of each of the three possible combinations in table 17.1.

**Question 1**
What is the ratio of purple-flowered (PP or Pp) to white-flowered (pp) offspring?

Keep these results in mind and return to the original problem: What are the genotypes and phenotypes of the offspring of the F1 generation?

Parents: Pp × Pp
Gametes: (P or p) × (P or p)
Offspring: PP, Pp, Pp, pp

Thus, the theoretical genotypic ratio for the offspring of the F1 generation is 1 PP : 2 Pp : 1 pp, and the phenotypic ratio is 3 purple : 1 white.

**Question 2**

a. How do these ratios compare with your data derived from coin flipping?

b. Would you have expected a closer similarity if you had flipped the coins 64,000 times instead of 64 times? Why or why not?

**Procedure 17.1**
Determine genotypic and phenotypic ratios for albinism
Albinos are homozygous recessive for the pair of alleles that produce pigments of skin, hair, and eyes. Suppose a woman having normal colored skin and an albino mother marries an albino man. Record the genotypic and phenotypic ratios of their children.

Genotype of children's mother
Genotype of children's father
Possible gametes of mother
Possible gametes of father
Possible offspring
Genotypic ratio of children
Phenotypic ratio of children

**Procedure 17.2**
Determine color and height ratios for corn plants
Color of grains (karyopses) and height of Zea mays (corn) plants are often determined by a single gene.

1. Examine (a) the ears of corn having red and yellow grains and (b) the tray of tall and dwarf plants on demonstration.
2. Record your observations here and determine the probable genotypes of the parents of each cross. Probable genotypes of parents:

   **Color of Corn Grains**
   Number of red grains
   Number of white grains
   Ratio of red : white grains
   Probable genotypes of parents

   **Height of Plants**
   Number of tall plants
   Number of dwarf plants
   Ratio of tall : dwarf plants
   Probable genotypes of parents
3. The preceding crosses involved only one trait and thus are termed monohybrid crosses. Let’s now examine a cross involving two traits; that is, a dihybrid cross. Your instructor will review with you the basis for working genetics problems involving dihybrid crosses.

In corn, red (R) seed color is dominant to white (r) seed color, and smoothness (S) is dominant to wrinkled (s) seed. Observe the cobs of corn derived from a cross between parents having genotypes RRSS and rrss.

**Question 3**

a. What is the expected genotype for the F₁ generation?

b. Will all F₁ offspring (seeds) have the same genotype?

**Question 4**

a. What are the predicted genotypes for the F₂ (i.e., second) generation?

b. In what ratio will they occur?

4. To test your prediction in Question 4 count the number of kernels for five rows for each of the following phenotypes:

   - Red, smooth
   - Red, wrinkled
   - White, smooth
   - White, wrinkled

**Question 5**

a. What are the genotypes of the F₁ generation?

b. How did your data compare with those that you predicted?

**INCOMPLETE DOMINANCE**

Some traits such as flower color are controlled by incomplete dominance. In this type of inheritance, the heterozygous genotype results in an intermediate characteristic. For example, if a plant with red flowers (RR) is crossed with a plant having white flowers (rr), all of the offspring in the first filial (F₁) generation will have pink flowers (Rr).

Parents: RR (red) × rr (white)
Gametes: R × r
Offspring: Rr (pink)

**Question 6**

What are the expected ratios of red, pink, and white flowers in a cross involving two pink-flowered parents?

**LETHAL INHERITANCE**

Lethal inheritance involves inheriting a gene that kills the offspring. Observe the tray of green and albino seedlings of corn. The albino plants cannot photosynthesize and therefore die as soon as their food reserves are exhausted.

**Question 7**

a. What is the ratio of green to albino seedlings?

b. Based on this ratio, what might you expect were the genotypes of the parents?

**Question 8**

Why is it impossible to cross a green and an albino plant?

**OTHER SOURCES OF GENETIC DIVERSITY**

Genetic diversity can also result from multiple alleles, gene interactions (epistasis), continuous variation, pleiotropy, environmental effects, linkage, and sex linkage. Although time limitations prohibit exercises about these topics, be sure to review them in your textbook.

**BLOOD TYPE**

Blood type of humans provides an excellent example of codominance, another type of Mendelian inheritance. In codominance, both alleles contribute to the phenotype of a heterozygote. For example, all individuals have one of four blood types: A, B, AB, and O (fig. 17.3). These blood groups are determined by the presence of compounds called
antigens on the surfaces of their red blood cells. If antigen A or B is present, no antibodies against this antigen are produced. Thus, if a person has antigen-A on his or her blood cells, then the person has type A blood and possesses blood antibodies (proteins) that agglutinate type B blood cells. Similarly, a person having antigen-B on his or her blood cells has type B blood and has antibodies that agglutinate type A blood cells. If a person has antigen-A and antigen-B on his or her blood cells, then the person has type AB blood and lacks A and B antibodies. If a person has no A or B antigens on his or her blood cells, the blood type is O and the person possesses antibodies against both A and B antigens (table 17.2). This system is rather unusual in that individuals have antibodies against the blood antigens that they do not possess.

Blood typing is often important for establishing the possible identity of an individual in forensic work and paternity suits. For example, assume that a woman with type O blood has a child having type O blood. The suspected father has type AB blood.

Could the suspected father with type AB blood be the child's father? The answer is no, because the cross would have the following results:

Parents:  \( ii \) (type O) \( \times I^A I^B \) (type AB)
Gametes:  \( i \) and \( i, I^A \) and \( I^B \)
Offspring:  \( I^A i \) or \( I^B i \)

Half of the offspring from the mother and the suspected father would have type A blood (genotype = \( I^A i \)), and the other half would have type B blood (genotype = \( I^B i \)). Thus, the suspected father could not have fathered a child with blood type AB or with type O blood with this mother.

ABO blood typing can be used to eliminate a person as a potential parent, but not to prove paternity. To appreciate this, suppose there is a mix-up of children in the maternity ward of a hospital after the genotypes of the children are determined from the parents' blood types. The following unidentified children have these blood types:

Child 1: type A (genotype \( I^A I^A \) or \( I^A i \))
Child 2: type B (genotype \( I^B I^B \) or \( I^B i \))
Child 3: type AB (genotype \( I^A I^B \))
Child 4: type O (genotype \( ii \))
Question 9
Which child or children could belong to a couple having AB and O blood types?

Blood typing is also important for determining the safety of blood transfusions. Your body automatically produces antibodies for antigens you do not carry (fig. 17.3). For example, people with type A blood have antibodies against B antigens, and people with type B blood produce antibodies against A antigens. If someone having type B blood received blood from someone having type A blood, the recipient's antibodies would react with and agglutinate the red blood cells received from the donor (fig. 17.3b). As a result, the recipient would die.

Question 10
a. Can a person with type O blood safely donate blood to a person having type A blood? Why or why not?

b. Which blood type would be a universal donor?

c. Which blood type would be a universal recipient?

Procedure 17.3
Determine blood type for ABO system

1. You will be provided with various samples of synthetic blood. This material is designed to simulate the blood type characteristics of human blood, and it is safe. Also obtain two bottles of antiserums.

2. Obtain a clean slide and label the ends A and B. Near one end of the slide place a drop of antiserum A (containing antibodies against antigen-A), and near the other end of the slide place a drop of antiserum B (containing antibodies against antigen-B).

3. Place drops of blood near (but not touching) the two drops of antiserum.

4. Mix one of the drops of blood with antiserum A and one with antiserum B. Use a different toothpick to mix each antiserum.

5. Dispose of all used materials properly.

6. Observe any agglutination of blood cells in either of the two antiserums.

Agglutination of blood mixed with an antiserum is indicated by a grainy appearance. Agglutination indicates the presence of the respective antigen on red blood cells (fig. 17.3). Determine and record the blood type from your sample based on the presence of antigens.

Question 11
a. What antigens are present on the artificial red blood cells that you tested?

b. What is the blood type of your sample?

You are probably familiar with another characteristic of blood called Rh factor. Although more than two alleles determine Rh, we'll use "positive" and "negative" for simplicity and convenience.

Procedure 17.4
Determine Rh

1. Place a drop of anti-Rh serum on a clean slide.

2. Using the procedure just described, mix a drop of blood from the synthetic blood sample provided with the antiserum.

3. Label the slide with your initials and place it on the warming plate in the lab.

4. The blood sample will agglutinate within a few minutes if it is Rh-positive. The absence of agglutination indicates the blood is Rh-negative.

5. Dispose of all materials properly.

Rh Incompatibility

You've probably heard of the incompatibility (agglutination) problems that Rh-negative women may have with their Rh-positive babies (the Rh-positive trait is inherited from the child's father). This problem usually occurs with the second and subsequent children, because women with the Rh blood system must be sensitized to the antigen before antibody production begins. This sensitization usually occurs during birth of the first child.

If you are a woman having Rh-negative blood, you should be concerned but not alarmed. Rh incompatibility is handled routinely by injections of anti-Rh antibodies. These antibodies destroy Rh-positive red cells and thus eliminate the Rh-associated risk of subsequent childbirth.
<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Your Phenotype</th>
<th>Your Genotype*</th>
<th>Phenotypes of Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Widow's peak</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Bent little finger</td>
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<td></td>
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<td>Albinism</td>
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<tr>
<td>Pigmented iris</td>
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<td>Attached earlobes</td>
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<tr>
<td>Hitchhiker's thumb</td>
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<td></td>
<td></td>
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<tr>
<td>Interlacing fingers</td>
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<td></td>
</tr>
<tr>
<td>PTC tasting</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Middigital hair</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dimpled chin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Six fingers</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

*Homozygous dominant, heterozygous, or homozygous recessive

**OTHER HUMAN TRAITS**

The following traits are determined by a single gene. List your phenotype for each trait in table 17.3 and, if possible, list your genotype. If you have the recessive trait for gene G, for example, your genotype is homozygous recessive (gg). If you have the dominant trait, your genotype could be GG or Gg, in which case you should enter G in table 17.3. If you have the dominant trait and one of your parents shows the recessive trait, you must be heterozygous (Gg) for that trait. Give your results to your instructor so that she or he can provide you with the phenotypic results for your class.

**Widow's peak**—The W allele for widow's peak (i.e., a pointed hairline) is dominant to the w allele for a straight hairline (fig. 17.4).

**Bent little finger**—Lay your hands flat on the table and relax them. If the last joint of your little finger bends toward the fourth finger, you have the dominant allele B (fig. 17.5).

**Albinism**—The A allele is dominant and leads to production of melanin, a pigment. Individuals with an aa genotype lack pigment in their skin, hair, and iris.

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**Figure 17.4**

Widow's peak hairline (top). People lacking a widow's peak have a relatively straight hairline (bottom).
Pigmented iris—If you are homozygous for the recessive allele $p$, you do not produce pigment in the front layer of your iris, and your eyes are either blue or gray (i.e., your eyes are the color of the back layer of the iris). The $P$ allele produces pigment in the front layer of the iris (green, hazel, brown, or black), which masks the blue or gray color of the back layer of the iris.

Attached earlobes—The $A$ allele for free earlobes is dominant to the recessive $a$ allele for attached earlobes (fig. 17.6).

Hitchhiker’s thumb—Bend your thumb backward as far as possible. If you can bend the last joint of the thumb back at an angle of 60° or more, you are showing the recessive allele $h$ (fig. 17.7).

Interlacing fingers—Casually fold your hands together so that your fingers interlace. The $C$ allele for crossing the left thumb over the right thumb when you interlace your fingers is dominant over the $c$ allele for crossing your right thumb over your left.

PTC tasting—Obtain a piece of paper impregnated with phenylthiocarbamide (PTC). Taste the paper by chewing on it for a few seconds. If you detect a bitter taste, you have the dominant allele $T$.

Middigital hair—The allele $M$ for hair on the middle segment of your fingers is dominant to the $m$ allele for no middigital hair. If hair is present on the middigit of any finger you have the dominant allele.

Dimpled chin—A dimpled chin is caused by a dominant allele $M$. People who have a dimpled chin are either homozygous dominant (MM) or heterozygous (Mm) for this trait. Homozygous recessive (mm) individuals do not have a dimpled chin.

Six fingers—In humans, the occurrence of six fingers results from a dominant allele $S$. People who have six fingers are either homozygous dominant (SS) or heterozygous (Ss). People who have only five fingers are homozygous recessive (ss) for this trait.
Several diseases are inherited as single-gene traits. These include:

- **Cystic fibrosis**, a disease characterized by chronic bronchial obstruction and growth reduction. This disease is inherited as a recessive trait; people who are heterozygous or homozygous dominant do not have this disease.

- **Galactosemia**, an inability to metabolize galactose, a sugar in human milk. Inherited as an autosomal recessive trait. Approximately five cases occur per million births. Prenatal diagnosis can be performed on cells obtained through amniocentesis or chorionic villi sampling. This disease is inherited as a recessive trait; people who are heterozygous or homozygous dominant do not have this disease.

- **Phenylketonuria (PKU)**, an inability to metabolize the amino acid phenylalanine. Approximately 100 cases occur per million births. If untreated, this disease produces mental retardation. This disease is inherited as a recessive trait; people who are heterozygous or homozygous dominant do not have this disease.

- **Juvenile retinoblastoma**, a cancer of the retina. The allele is located on chromosome 13. This disease is inherited as a recessive trait; people who are heterozygous or homozygous dominant do not have this disease.

- **Huntington’s disease**, a mental disorder involving uncontrollable, involuntary muscle movements. The disease occurs relatively late in life, so many affected individuals bear children before they realize that they are carriers. Approximately 100 cases occur per million births. Unlike most other genetic diseases, Huntington’s disease is inherited as a dominant trait; people who are homozygous recessive (hh) do not have the disease, and people who are heterozygous (Hh) or homozygous dominant (HH) have the disease.

**Question 12**
What conclusion about your genotype is evident if one of your siblings, but neither parent, shows the recessive trait?

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### ANALYZING PEDIGREES

Many human traits display both dominant and recessive inheritance (table 17.4). Researchers cannot control crosses in humans the way Mendel did with pea plants, so to analyze human inheritance, geneticists study crosses that have been performed already—in other words, family histories. The methodology used is a **pedigree**, a consistent graphical presentation of matings and offspring over multiple generations for a particular trait. Information in a pedigree allows geneticists to deduce the mode of inheritance of the trait.

If you understand the simple patterns of inheritance presented in this lab, you can trace a trait in a pedigree (i.e., family tree) to determine if it is inherited in a dominant or recessive pattern of inheritance.

**Question 13**

a. What features would characterize pedigrees of dominant traits?

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### TABLE 17.4

<table>
<thead>
<tr>
<th>Some Dominant and Recessive Traits in Humans</th>
<th>Dominant Traits</th>
<th>Phenotypes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Recessive Traits</strong></td>
<td><strong>Phenotypes</strong></td>
<td></td>
</tr>
<tr>
<td>Albinism</td>
<td>Lack of melanin pigmentation</td>
<td>Middigital hair</td>
</tr>
<tr>
<td>Alkaptonuria</td>
<td>Inability to metabolize homogentisic acid</td>
<td>Brachydactyly</td>
</tr>
<tr>
<td>Red-green color blindness</td>
<td>Inability to distinguish red or green wavelengths of light</td>
<td>Huntington disease</td>
</tr>
<tr>
<td>Cystic fibrosis</td>
<td>Abnormal gland secretion, leading to liver degeneration and lung failure</td>
<td>Phenylthiocarbamide (PTC) sensitivity</td>
</tr>
<tr>
<td>Duchenne muscular dystrophy</td>
<td>Wasting away of muscles during childhood</td>
<td>Camptodactyly</td>
</tr>
<tr>
<td>Hemophilia</td>
<td>Inability of blood to clot properly, some clots form but the process is delayed</td>
<td>Hypercholesterolemia (the most common human Mendelian disorder)</td>
</tr>
<tr>
<td>Sickle cell anemia</td>
<td>Defective hemoglobin that causes red blood cells to curve and stick together</td>
<td>Polydactyly</td>
</tr>
</tbody>
</table>
b. What features would characterize pedigrees of recessive traits?

Biologists use the following symbols in pedigrees:

- **Male**
- **Female**
- **Affected male**
- **Affected female**

**Procedure 17.5**

Analyze a pedigree of inheritance of cystic fibrosis

1. Among Caucasians, about 1 of every 2500 newborn infants is born with cystic fibrosis. In these individuals, a defective membrane protein results in the production of unusually thick and dry mucus that lines organs such as the tubes in the respiratory system. People having cystic fibrosis often have recurrent and serious infections, and most die in their 20s or 30s.

2. Determine whether the allele for cystic fibrosis is inherited as a dominant or recessive allele.

**Question 14**

- **a.** What is the inheritance pattern for the cystic fibrosis allele? What is your reasoning for this conclusion?

- **b.** Can you determine the genotypes of any individuals in the pedigree? If so, which ones? Explain your reasoning.

**Procedure 17.6**

Analyze a pedigree of inheritance of Huntington's disease

1. Huntington's disease is a severe disorder of the nervous system that usually causes death.

2. Determine whether the allele for Huntington's disease is inherited as a dominant or recessive allele.

**Question 15**

- **a.** What is the inheritance pattern for the Huntington's disease allele? What is your reasoning for this conclusion?

- **b.** Can you determine the genotypes of any individuals in the pedigree? If so, which ones? Explain your reasoning.

- **c.** Examine fig. 17.8. Shana's mother has Huntington's disease, and Shana has a 50-50 chance of developing Huntington's disease. Explain the genetic basis for Shana's chances of inheriting Huntington's disease.

**Procedure 17.7**

Analyze a pedigree of inheritance of phenylketonuria

1. Phenylketonuria, or PKU, results from an inability to metabolize the amino acid phenylalanine. If untreated, PKU leads to mental retardation.

2. Determine whether the allele for phenylketonuria is inherited as a dominant or recessive allele.
THE FACE OF HUNTINGTON'S

"All my life I've worked hard to be mentally and physically strong. Still, there's a 50-50 chance that I'll develop HD — the disease that's taking my mother. Watching Mom's struggle hurts. I sure miss the way she was... but I'll always love her for who she is. Always."

Shana Martin
ATHLETE

HUNTINGTON'S DISEASE IS A FATAL ILLNESS THAT AFFECTS ONE IN EVERY 10,000 AMERICANS. Another 250,000 are at risk. But, sadly, this disease's disruptive and devastating effects touch many more lives. Besides the emotional trauma to victims and their families, there is a financial one, as well. Care is costly and needed for many years. Please help us ease the suffering and continue the research. Together, we can make this the last generation with Huntington's Disease.

Figure 17.8
Huntington's disease is a degenerative disease inherited as a dominant trait. What is the genetic basis for Shana's statement that she has a 50-50 chance of getting Huntington's disease?
Question 16

a. What is the inheritance pattern for the phenylketonuria allele? What is your reasoning for this conclusion?

b. Can you determine the genotypes of any individuals in the pedigree? If so, which ones? Explain your reasoning.

TRANSPOSONS

For much of this century, geneticists thought that genes do not move in cells. However, in 1947 Barbara McClintock proposed that genes could move within and between chromosomes. McClintock based her conclusion on a series of experiments involving genetic crosses in corn. Specifically, McClintock showed that there is a fragment of DNA that can move to and be inserted at the locus for the production of pigments in corn kernels. Because this insertion renders the cell unable to make the purple pigment, the resulting kernel is yellow or white. However, subsequent removal of the DNA fragment results in the cell resuming production of the purple pigment; therefore, the resulting kernel is purple. Thus, Indian corn often has kernels with varying pigmentation, depending on when the DNA fragment was inserted or removed.

A similar phenomenon occurs with the production of other pigments in corn kernels. The translocation to and from the locus for production of these pigments several times during kernel development produces the red-orange swirls characteristic of many kernels of Indian corn.

INVESTIGATION

The Frequency of Homozygous Recessive Traits in Humans

Observation: In humans, traits such as widow's peak, attached earlobes, and a dimpled chin are homozygous recessive traits. In many people, these traits are easily observed.

Question: How common are homozygous recessive traits such as widow's peak, attached earlobes, and a dimpled chin among your classmates?

a. Establish a working lab group and obtain Investigation Worksheet 17 from your instructor.
b. Discuss with your group well-defined questions relevant to the preceding observation and question. Choose and record your group’s best question for investigation.
c. Translate your question into a testable hypothesis and record it.
d. Outline on Worksheet 17 your experimental design and supplies needed to test your hypothesis. Ask your instructor to review your proposed investigation.
e. Conduct your procedures, record your data, answer your question, and make relevant comments.
f. Discuss with your instructor any revisions to your questions, hypothesis, or procedures. Repeat your work as needed.
1. When reclusive billionaire Howard Hughes died in 1976, a variety of people claimed that they were entitled to Hughes' estate because they were his children. Hughes had type AB blood. One man who claimed that Hughes was his father had type 0 blood, and the man's mother had type A blood. If you were the judge in the case, what would you rule? Explain your answer.

2. Suppose that flower color is inherited by simple dominance and that purple flowers are dominant to white flowers. If a homozygous recessive individual is crossed with a homozygous dominant individual, what is the probability of obtaining a purple-flowered offspring?
   a. 100%
   b. 75%
   c. 50%
   d. 25%
   e. 0%

3. Bob is heterozygous for phenylketonuria, and Loretta is homozygous recessive for phenylketonuria. What is the probability that their first child will have phenylketonuria?
   a. 100%
   b. 75%
   c. 50%
   d. 25%
   e. 0%

4. Suppose that (1) Randy is heterozygous for the allele that causes Huntington's disease, (2) Susan is homozygous recessive for the allele that causes Huntington's disease, and (3) Randy and Susan decide to have a child. What is the probability that their child will get Huntington's disease?
   a. 100%
   b. 75%
   c. 50%
   d. 25%
   e. 0%

5. In question 4, what is the probability that their first daughter will get Huntington's disease?
   a. 100%
   b. 75%
   c. 50%
   d. 25%
   e. 0%

6. Suppose that someone having type AB blood has a child with someone having type O blood. What is the probability that their child will have type A blood?
   a. 100%
   b. 75%
   c. 50%
   d. 25%
   e. 0%

7. Suppose that you cross a red-flowered carnation with a white-flowered carnation. All of the offspring have pink flowers. What can you conclude?
   a. Flower color in carnations is inherited by incomplete dominance, and the red-flowered carnation is homozygous dominant for the trait.
   b. At least one of the parents is heterozygous for flower color.
   c. Flower color is inherited by simple dominance.
   d. Half of the offspring are heterozygous and half are homozygous for flower color.
   e. None of the above statements are true.

8. Suppose that a trait is inherited by simple dominance. If two heterozygotes are mated, what is the probability of having a homozygous recessive offspring?
   a. 100%
   b. 75%
   c. 50%
   d. 25%
   e. 0%

9. Tay-Sachs disease is characterized by the inability to produce an enzyme needed to metabolize lipids in brain cells. If this enzyme is not present, lipids accumulate in the brain and gradually destroy its ability to function (homozygous recessive children usually die by the age of four or five). Suppose that you are a carrier for Tay-Sachs disease and that your partner is not. What is the probability that you and your partner will have a child with Tay-Sachs disease?
   a. 100%
   b. 75%
   c. 50%
   d. 25%
   e. 0%

10. A normally pigmented man marries a normally pigmented woman. Their second child is an albino.
   a. What is the genotype of the man? _______
   b. What is the genotype of the woman? _______
   c. What is the genotype of the albino child? _______
   d. What is the probability that their next child will be an albino? _______

11. Darrell and Matilda each have type O blood. If they start a family, the probability that they will have a child having type A blood is _______
   a. 100%
   b. 75%
   c. 50%
   d. 25%
   e. 0%

12. Suppose that a person having type B blood is married to someone having type A blood. Is it possible for this couple to have a child having type O blood? Explain your answer.

13. Wanda, who has type O blood, gives birth to a baby having type O blood. The woman then claims that the child's father is Randy, who has type A blood.
   a. Could Randy be the father?
   b. Can this information alone prove that Randy is the father? Explain your answer.

14. Suppose that two people having free earlobes marry and start a family. Their first child has free earlobes and their second has attached earlobes.
   a. What are the genotypes of the parents? _______
   b. What is the genotype of their first child? _______
   c. What is the genotype of their second child? _______

15. Suppose that a trait is inherited by simple dominance. If two heterozygotes are mated, what is the probability of having an offspring that has the same phenotype as the parents?
   a. 100%
   b. 75%
   c. 50%
   d. 25%
   e. 0%

16. Suppose that a trait is inherited by incomplete dominance. If two heterozygotes are mated, what is the probability of having an offspring that has the same phenotype as the parents?
   a. 100%
   b. 75%
   c. 50%
   d. 25%
   e. 0%
Answers to Genetics Problems

1. The man could not be Hughes' son. Hughes had type AB blood. Regardless of the blood type of the mother, a child of Hughes could not have type O blood.

2. a
3. c
4. c
5. c
6. c
7. a
8. d
9. e
10a. Aa
10b. Aa
10c. aa

10d. 25%
11. e
12. Yes, but only if the person having type B blood has a BO genotype, and if the person having type A blood has an AO genotype.
13a. Yes, if he has an AO genotype.
13b. No, information about blood type cannot prove that anyone is the parent of a child; it can only eliminate people who are not parents of the child.
14a. Ee
14b. EE or Ee
14c. ee
15. b
16. c

Questions for Further Thought and Study

1. What determines how often a phenotype occurs in a population?

2. Are dominant characteristics always more frequent in a population than recessive characteristics? Why or why not?

3. Is it possible to determine the genotype of an individual having a dominant phenotype? How?

4. Why is hybrid seed so expensive to produce?

5. What blood types are not expected for children to have if their parents have AB blood? O blood?

WRITING TO LEARN BIOLOGY
Organisms heterozygous for a recessive trait are often called carriers of that trait. What does this mean?