# Heredity

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Photo Credits
Section Focus Transparency 1: Gail Meese/Meese Photo Research
Section Focus Transparency 2: Pete Saloutos/The Stock Market
Section Focus Transparency 3: (t) Natalie Fobes/CORBIS, (inset) Manfred Kage/Peter Arnold, Inc.
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Hands-On Activities
Comparing Common Traits

Procedure
1. Safely survey as many dogs in your neighborhood as you can for the presence of a solid color or spotted coat, short or long hair, and floppy or upright ears.
2. Record your data in the table below.

Data and Observations

<table>
<thead>
<tr>
<th>Traits</th>
<th>Coat</th>
<th>Hair</th>
<th>Ears</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Solid Color</td>
<td>Spotted</td>
<td>Short</td>
</tr>
<tr>
<td>Number of dogs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of variations</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Analysis
1. Compare the number of dogs that have one form of a trait with those that have the other form.

2. What can you conclude about the variations you noticed in the dogs?
Interpreting Polygenic Inheritance

Procedure
1. Measure the hand spans of your classmates.
2. Using a ruler, measure from the tip of the thumb to the tip of the little finger when the hand is stretched out. Read the measurement to the nearest centimeter.
3. Record the name and hand-span measurement of each person in the data table below.

Data and Observations

<table>
<thead>
<tr>
<th>Student</th>
<th>Hand Span (cm)</th>
<th>Student</th>
<th>Hand Span (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Analysis
1. What range of hand spans did you find?

2. Are hand spans inherited as a simple Mendelian pattern or as a polygenic or incomplete dominance pattern? Explain.
## Predicting Results

### Lab Preview

**Directions:** Answer these questions before you begin the Lab.

1. What do the beans in the experiment represent?

2. Why do you use two paper bags in this experiment?

---

Could you predict how many brown rabbits would result from crossing two heterozygous black rabbits? Try this investigation to find out. Brown color is a recessive trait for hair color in rabbits.

### Real-World Question

How does chance affect combinations of genes?

**Materials**
- paper bags (2)
- red beans (100)
- white beans (100)

**Goals**
- Model chance events in heredity.
- Compare and contrast predicted and actual results.

**Safety Precautions**

**WARNING:** Do not taste, eat, or drink any materials used in lab.

**Procedure**

1. Use a Punnett square to predict how many red/red, red/white, white/white bean combinations are possible. The combinations represent the coat colors in rabbit offspring.

2. Place 50 red beans and 50 white beans in a paper bag. Place 50 red beans and 50 white beans in a second bag. Red beans represent black alleles and white beans represent brown alleles.

3. Label one of the bags **Female** for the female parent. Label the other bag **Male** for the male parent.

4. Use Table 1 to record the combination each time you remove two beans. Your table will need to accommodate 100 picks.

5. Without looking, remove one bean from each bag. The two beans represent the alleles that combine when sperm and egg join. After recording, return the beans to their bags.

6. **Count** and record the total numbers for each of the three combinations in Table 2.

7. **Compile and record** the class totals in Table 2.

---

<table>
<thead>
<tr>
<th>Female parent</th>
<th>Male parent</th>
<th>R/R</th>
<th>R/W</th>
<th>W/W</th>
</tr>
</thead>
<tbody>
<tr>
<td>R/R 100%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R/W 50%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W/W 50%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Data and Observations

<table>
<thead>
<tr>
<th></th>
<th>Red/Red</th>
<th>Red/White</th>
<th>White/White</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red/Red</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Red/White</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White/White</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Conclude and Apply

1. **Name** the combination that occurred most often.

2. **Calculate** the ratio of red/red to red/white to white/white. What hair color in rabbits do these combinations represent?

3. **Compare** your predicted (expected) results with your observed (actual) results.

4. **Hypothesize** how you could get predicted results to be closer to actual results.

Communicating Your Data

Write a paragraph that clearly describes your results. Have another student read your paragraph. Ask if he or she could understand what happened. If not, rewrite your paragraph and have the other student read it again. **For more help, refer to the Science Skill Handbook.**
Design Your Own

Tests for Color Blindness

Lab Preview

Directions: Answer these questions before you begin the Lab.

1. What two types of color blindness can you test for in this lab?

2. What does a test for color blindness normally consist of?

What do color-blind people see? People who have inherited color blindness can see most colors, but they have difficulty telling the difference between two specific colors. You have three genes that help you see color. One gene lets you see red, another blue, and the third gene allows you to see green. In the most common type of color blindness, red-green color blindness, the green gene does not work properly.

Real-World Question

What percentages of males and females in your school are color-blind?

Form a Hypothesis

Based on your reading and your own experiences, form a hypothesis about how common color blindness is among males and females.

Goals

- **Design** an experiment that tests for a specific type of color blindness in males and females.
- **Calculate** the percentage of males and females with the disorder.

Possible Materials

white paper or poster board colored markers: red, orange, yellow, bright green, dark green, blue

*computer and color printer

*Alternate materials

Test Your Hypothesis

Make a Plan

1. Decide what type of color blindness you will test for—the common green-red color blindness or the more rare green-blue color blindness.

2. List the materials you will need and describe how you will create test pictures. Tests for color blindness use many circles of red, orange, and yellow as a background, with circles of dark and light green to make a picture or number. List the steps you will take to test your hypothesis.

3. Prepare a data table in your Science Journal to record your test results.

4. Examine your experiment to make sure all steps are in logical order.

5. Identify which pictures you will use as a control and which pictures you will use as variables.
Follow Your Plan
1. Make sure your teacher approves your plan before you start.
2. Draw the pictures that you will use to test for color blindness.
3. Carry out your experiment as planned and record your results in your data table.

Analyze Your Data
1. Calculate the percentage of males and females that tested positive for color blindness.

2. Compare the frequency of color blindness in males with the frequency of color blindness in females.

Conclude and Apply
1. Explain whether or not the results supported your hypothesis.

2. Explain why color blindness is called a sex-linked disorder.

3. Infer how common the color-blind disorder is in the general population.

4. Predict your results if you were to test a larger number of people.

Communicating Your Data
Using a word processor, write a short article for the advice column of a fashion magazine about how a color-blind person can avoid wearing outfits with clashing colors. For more help, refer to the Science Skill Handbook.
Genetic Traits

Have you ever been told you look like your parents? Parents pass genes that determine physical features to their children. These physical features are called genetic traits. Children receive half of their genes from each parent. The genes of one parent may be dominant over the genes of the other parent. A child usually looks most like the parent who supplies the most dominant genes.

Strategy
You will examine some of your genetic traits.
You will examine your parents for the same genetic traits.
You will compare how similar or different you and your parents are.

Materials
pencil

Procedure
1. Work with a partner during this activity.
   Complete the column marked “You” in Table 1 in Data and Observations for each of the genetic traits listed. Ask your partner to help you describe the traits you cannot see. Refer to Figure 1 for an explanation of traits you may not be familiar with.
2. Optional: Take the table home and complete it for each of your parents.

Figure 1
Hair Whorl
Clockwise
Counterclockwise
Ear Lobe
Free
Attached
Cheek
Dimples
No dimples
Tongue
Nonroller
Roller
Laboratory Activity 1 (continued)

Data and Observations
Record your results in the table.

Table 1

<table>
<thead>
<tr>
<th>Trait</th>
<th>Description</th>
<th>You</th>
<th>Father</th>
<th>Mother</th>
</tr>
</thead>
<tbody>
<tr>
<td>Handedness</td>
<td>Left or right</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sight</td>
<td>Nearsighted or normal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eye color</td>
<td>Blue or not blue</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dimples*</td>
<td>Yes or no</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freckles</td>
<td>Present or absent</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hair whorl*</td>
<td>Clockwise or counterclockwise</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Earlobe*</td>
<td>Free or attached</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tongue*</td>
<td>Roller or nonroller</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* See Figure 1.

Questions and Conclusions

1. How many traits do you and your mother share?

   You and your father?

2. How many traits do you share with both parents?

3. List all traits that you show but are not shown by either parent.

4. How might it be possible to show a trait when both parents do not show it?

5. What proof do you have that all of your genes did not come from only one parent?

Strategy Check

_____ Can you identify some genetic traits?

_____ Can you count how many traits are the same for each parent and you?

_____ Can you make any conclusions about the traits you received from each parent?
The chance of a flipped coin landing with the “heads” side up rather than the “tails” side is 50:50. Does that mean that for every two times a coin is flipped, heads will turn up once and tails will turn up once? The chance of a boy rather than a girl being born in a family is also 50:50. Does that mean that in a family with six children, three are boys and three are girls? You know the answer to both of these questions is no. What is the value, then, of saying the chances are 50:50?

**Strategy**
You will compare the chances of a boy or girl being born with the chances of a flipped coin landing on one side or the other.
You will flip a coin six times to represent the sexes of children in one family.
You will record your results and compare the sexes of the children in 15 families.

**Materials**
coin

**Procedure**
1. Let the heads side of the coin represent girls. Let the tails side represent boys. Flip the coin six times. How many times did girls turn up? How many times did boys turn up? Record these totals in Table 1 under Group 1.

2. Continue to flip the coin until you have a total of 15 groups of six flips each.

**Data and Observations**

<table>
<thead>
<tr>
<th>Group</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Girls (heads)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boys (tails)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

1. Use slash marks / to complete Table 2 using the data recorded in Table 1 for each group of six flips.
**Laboratory Activity 2 (continued)**

**Table 2**

<table>
<thead>
<tr>
<th>Possible combinations</th>
<th>6 girls 0 boys</th>
<th>5 girls 1 boy</th>
<th>4 girls 2 boys</th>
<th>3 girls 3 boys</th>
<th>2 girls 4 boys</th>
<th>1 girl 5 boys</th>
<th>0 girls 6 boys</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of combinations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Questions and Conclusions**

1. Why can you use coin flips to represent sex combinations that may occur in families?

2. According to your results, is it possible to have a family of exactly three boys and three girls?

   Do you know any family where there are exactly three boys and three girls?

3. According to your results, is it possible to have a family of six children where the ratio of boys to girls is not exactly 50:50?______

   Do you know of actual families where this is true?______

4. According to your results, which combination of boys and girls occurred the most often?

   Does this agree with what you had expected?______

5. Explain how one can make a statement that you expect three boys and three girls in every family of six children, but yet you may not get this ratio in an actual family.

6. Out of 90 total children (flips) counted, how many were males?______ Females?______

   Is your answer close to half boys and half girls?______ Explain

7. In a single family, the ratio may or may not be half boys and half girls. When do you begin to show that an equal number of boys and girls occurs in families?

**Strategy Check**

_____ Can you compare the chance of a boy or girl being born with the chance of a coin landing on one side or the other?

_____ Can you compare the sexes of the children in 15 families by flipping a coin?

_____ Can you explain how numbers, such as 50:50, can be used to show the likelihood of an occurrence?
Directions: Use this page to label your Foldable at the beginning of the chapter.

Personal Characteristics

Inherited

Not Inherited

- hair color
- hair length
- favorite book
- eye color
- blood type
- favorite food
Meeting Individual Needs
Overview

Heredity

Directions: Complete the concept map using the terms in the list below.

dominant  heterozygous organisms  alleles
recessive  homozygous organisms

Directions: Use the words in the concept map to fill in the missing words in the following sentences.

6. The study of how traits are inherited through the interaction of ______________ is the science of genetics.

7. An allele that is covered up by another allele is called ______________.

8. Organisms with two alleles that are the same are called ______________.
Directions: This diagram shows the joining of human male (XY) and human female (XX) sex cells. Use the diagram to answer the questions below.

1. What do the letters X and Y stand for?

2. Which chromosome is found only in the male?

3. Which person has two X chromosomes?

4. According to the diagram, what percentage of the offspring is female?

5. Do you think it is possible to accurately predict the sex of a particular offspring? Why or why not?
Directions: Use the following terms to complete the puzzle below. The letters in the dark vertical box complete question 8.

1. The long-term effects of consuming genetically ____________________ plants are not known.


3. Genetic engineering is used to help produce large volumes of _________________.

4. Selective breeding is done to improve the ____________________ of plants.

5. A normal allele can be introduced into a virus to ____________________ cystic fibrosis.

6. Recombinant DNA introduced into bacteria can cause the bacteria to produce ____________________.

7. Making ____________________ DNA is one method of genetic engineering.

8. Through ____________________ engineering, scientists are experimenting with biological and chemical methods to change the arrangement of DNA that makes up a gene.
Directions: Use the clues below to complete the crossword puzzle.

Across
1. Type of genetic engineering
4. Genetic makeup of an organism
6. Type of trait that masks another trait
7. How traits are inherited through alleles

Down
2. Worked with pea plants to study heredity
3. An organism that always produces the same traits in its offspring
5. Another name for an inherited characteristic
6. Material from which chromosomes are made
Instrucciones: Completa el mapa de conceptos usando los términos de la siguiente lista.

dominante  |  organismos heterocigotos  |  alelos
recesivo  |  organismos homocigotos

Los genes

1. tienen dos o más

2. que pueden ser

3. que pueden ser

4. y que se expresan en

5. y que se expresan en

Instrucciones: Llena la línea en blanco con la palabra que complete correctamente cada oración. Usa las palabras del mapa de conceptos.

6. El estudio de la herencia de los rasgos a través de la interacción de los (las) ______________ es la ciencia de la genética.

7. Un alelo que es cubierto por otro alelo se llama ______________.

8. Los organismos con dos alelos iguales se llaman ________________.
**Instrucciones:** Este diagrama muestra la unión de las células humanas masculinas (XY) y las células humanas femeninas (XX). Utiliza el diagrama para contestar las preguntas siguientes.

1. ¿Qué significan las letras X y Y?

2. ¿Cuál cromosoma se encuentra sólo en el hombre?

3. ¿Qué persona tiene dos cromosomas X?

4. De acuerdo con el diagrama, ¿qué porcentaje de la progenie es femenino?

5. ¿Piensas que es posible predecir de manera exacta el sexo de una progenie en particular? Explica tu respuesta.
Instrucciones: Utiliza los siguientes términos para completar el crucigrama. Las letras en la caja oscura vertical son la respuesta de la pregunta número 8.

Instrucciones: Completa la línea en blanco con el término correcto, utilizando las palabras de la parte superior.

1. Aún no se conocen los efectos a largo plazo de consumir plantas producidas mediante __________________ genética.

2. La ____________ genética puede convertirse en un método para curar trastornos genéticos en el futuro.

3. La ingeniería genética se utiliza para ayudar a producir grandes cantidades de ____________________.

4. Los cruces selectivos se realizan para mejorar el ________________ de las plantas.

5. Un alelo normal se puede introducir en un virus para ____________________ la fibrosis cística.

6. El DNA recombinante introducido dentro de una bacteria puede producir ____________________.

7. La producción de DNA ____________________ es un método de ingeniería genética.

8. A través de la ingeniería ____________________ , los científicos están experimentando con métodos biológicos y químicos para cambiar la distribución del DNA que forma los genes.
Términos clave
Herencia

Instrucciones: Usa los términos siguientes para completar el crucigrama.

<table>
<thead>
<tr>
<th>Horizontales</th>
<th>Verticales</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1. Otro nombre para una característica heredada.</td>
</tr>
<tr>
<td>2. Tipo de ingeniería genética.</td>
<td>3. Organismo que siempre produce los mismos rasgos en la progenie.</td>
</tr>
<tr>
<td>5. Estudió genética en plantas de arvejas.</td>
<td>4. Composición genética de un individuo.</td>
</tr>
<tr>
<td>7. Manera como se heredan las características por medio de alelos.</td>
<td>6. Material que compone los cromosomas.</td>
</tr>
<tr>
<td>8. Tipo de rasgo que oculta otro rasgo.</td>
<td></td>
</tr>
</tbody>
</table>
One of the traits of pea plants that Mendel observed was seed shape. The seeds were either round or wrinkled. Mendel observed that round seed shape (R) was dominant to the wrinkled shape (r).

**Directions:** Complete the Punnett square to show the possible offspring of two heterozygous pea plants. Then answer the questions that follow.

<table>
<thead>
<tr>
<th></th>
<th>R</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>R</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>r</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. What two forms of the trait for seed shape did Mendel observe?

2. What was the phenotype for seed shape of both parent plants?

3. What percentage of the possible types of offspring had the same genotype as the parents?

4. What percentage of the possible types of offspring were homozygous?

5. What percentage of the possible types of offspring had the same phenotype as the parents?

6. What was the genotype of the offspring that did not share the parents’ phenotype?

7. What is the probability that two heterozygous parents would have an offspring that produced round seeds? (Express your answer as a ratio.)

**Directions:** Answer the following questions on the lines provided.

8. What is genetics?

9. What role do genes play?

10. What 3 principles of heredity did Mendel discover?
Directions: Answer the following questions on the lines provided.

1. There are four phenotypes of human blood.
   a. Is it possible for two alleles to produce four phenotypes?

   b. What phenotype is produced by each of the following genotypes?
      
      | Genotype | Phenotype |
      |----------|-----------|
      | AA       | ______    |
      | AO       | ______    |
      | OO       | ______    |
      | BB       | ______    |
      | BO       | ______    |
      | AB       | ______    |

   c. How many alleles are there for blood type?

   d. When a trait has more than two alleles, how is that trait inherited?

   e. Which blood type is inherited by codominance? Explain your answer.

2. This pedigree shows the inheritance pattern of a sex-linked disorder, such as color blindness. Is the father, A, affected or not affected by the disorder? Explain your answer.

3. Name a sex-linked genetic disorder.

4. Name a homozygous recessive genetic disorder.
Direction: For each of the following, write the letter of the term or phrase that best completes the sentence.

1. _____ uses biological and chemical methods to change the DNA sequence of genes.
   a. Recombinant DNA  
   b. Genetic engineering  
   c. Gene therapy  
   d. Selective breeding

2. Genetic engineering can be accomplished in bacteria using _____.
   a. recombinant DNA  
   b. genetic engineering  
   c. gene therapy  
   d. selective breeding

3. Gene therapy has shown promise in controlling _____.
   a. high blood pressure  
   b. the common cold  
   c. cystic fibrosis  
   d. multiple sclerosis

4. Many stores _____ genetically engineered produce.
   a. provide pamphlets on  
   b. refuse to sell  
   c. label  
   d. carry only

5. _____ involves placing a normal allele in a cell that has a mutation and hoping that the normal allele begins to function.
   a. Chemical engineering  
   b. Selective breeding  
   c. Recombinant DNA  
   d. Gene therapy

Directions: Answer the following questions on the lines provided.

6. Explain how genetic engineering produces tomatoes that are ripe when they reach consumers?

7. How did knowledge of genotypes affect scientists’ efforts to improve plants used for food and clothing?

8. Identify a disease or disorder and explain how it might be controlled by genetic engineering.

9. Why do some people prefer to eat foods that are not genetically engineered?
As you have read, if an allele is paired with another one just like it, the name for the pair is homozygous. If the allele is paired with a different type, the pair is called heterozygous. You have also learned about how some alleles are dominant and some are recessive. A Punnett square shows how the pairs will possibly match up. Making a prediction about how the offspring will look is usually simple. If the pair is heterozygous or homozygous dominant, the dominant trait will be expressed. If the pair is homozygous recessive, the recessive trait will be expressed.

There are some alleles, however, that behave like normal dominant alleles when in a heterozygous pair, but are deadly in a homozygous pair. For example, the alleles that control fur color in wild mice are yellow and black. The yellow allele is dominant (Y) and the black is recessive (b). When a mating occurs and the alleles are paired together, the hairs have yellow and black bands. From a distance this makes the mouse appear brown or buff-colored.

However, the allele for yellow fur color is what scientists call a ‘lethal’ or deadly allele. If it is paired with itself, the two alleles kill the baby mouse before it can be born. Fortunately there are not many genes of this type.

Fill in the Punnett square below for a case in which two mice, each heterozygous for the dominant yellow allele, are mated. Then use the diagram to answer the following questions.

1. How many live offspring will have one dominant allele for yellow fur?

2. How many mice will die before birth?

3. How many brown mice will be born?

4. If you see a healthy living yellow mouse can you tell if it is heterozygous or homozygous? Explain your answer.
Many phenotypic traits in humans—such as height, eye color, skin color, some forms of cancer, mental illness and heart disease—are polygenic. Polygenic inheritance means that a particular genetic trait is controlled by more than one gene and that several different combinations of a set of genes are possible. The result will be a wide variety of phenotypes for the trait.

The multiple-gene inheritance hypothesis was first described accurately in 1913 by R. Emerson and E. East. They conducted a landmark experiment on corn plants. Two corn varieties, one with a long ear and the other with a short ear, were crossed. The next generation of corn ears showed a wide range of corn ear lengths from short to long. Emerson and East were the first to explain this continuous variation of inheritance by the hypothesis that there must be many different genes acting together for one trait. When these combinations of genes are mixed the result is a variety of phenotypes of the trait.

You will verify Emerson and East’s hypothesis by gathering data on the height of the students in your class. Determine the heights (in meters) of your classmates. Construct a table to record the heights of your classmates. Place your height data on a graph after all measurements have been taken.

1. Does your data show an even distribution between all possible heights, a grouping at two places, or a curved line?

2. Do your data and graph support polygenic inheritance?

3. How do you explain the data in terms of polygenic inheritance?
It may soon be possible to fight tooth decay by simply using a mouthwash. A new study of the decay-causing bacterium, *Streptococcus mutans*, or *S. mutans* has found a way to genetically alter this pesky resident of your mouth. Until now, *S. mutans* has lived quietly in your mouth feeding on sugars, along with 500 other bacteria that constantly live in your mouth. The waste product produced by this bacterium is lactic acid, a weak acid that, over time, destroys enamel and leads to cavities.

**Effector Strain**

Dr. Jeffery Hillman, a professor of oral biology at the University of Florida, recently announced a successful experiment in which the genes in *S. mutans* responsible for producing lactic acid were removed. The new strain is called an effector strain because its genes have been changed. The new *S. mutans* does not produce lactic acid and, therefore, will not cause decay, according to Dr. Hillman.

The effector strain was put into the mouths of rats, where it dominated the original strain and kept it from growing on tooth surfaces. The effector strain was fed a high-sugar diet, but tooth decay did not occur. In fact, the sugar helped the new strain to colonize in places the old decay-causing strain used to inhabit. The rats showed no health problems related to the new bacterium.

**No More Cavities**

Dr. Hillman and his team of researchers are hopeful that soon it will be safe to make a mouthwash containing the new strain which a dentist could squirt in a child’s mouth. The bacteria would colonize on the teeth and help prevent the child from developing cavities. More research needs to be done but the new, genetically altered bacteria may prove to be a major step in the fight against tooth decay. However, Dr. Hillman warns that nothing will ever replace a good toothbrushing.

1. Why is the naturally occurring strain of *Streptococcus mutans* harmful to teeth?

2. What was done to the new strain of *S. mutans* to make it harmless?

3. What is an “effector strain” of bacteria?

4. What happens to the old strain of *S. mutans* when the new effector strain is introduced into the mouth?
Section 1  Genetics

A. Heredity—the passing of traits from parent to offspring

1. Genes on chromosomes control the ________ that show up in an organism.

2. The different forms of a trait that a gene may have are ____________.

3. During __________ a pair of chromosomes separates and the __________ move into separate sex cells.

4. Each sex cell now contains _______ allele for each trait.

5. The study of how traits are inherited is ____________.

B. Gregor Mendel—the father of genetics

1. Mendel was the first to use __________________________ to explain heredity and to trace one trait for _________________________________.

2. Hybrid—receives ____________ genetic information for a trait from each parent
   a. ___________ allele—covers up or dominates the other trait
   b. ___________ allele—the trait seems to disappear

3. Probability helps you ______ the chance that something will happen.

4. A ____________ can help you predict what an offspring will look like.
   a. ____________ stand for dominant alleles.
   b. ____________ stand for recessive alleles.

5. Genotype—the _______________ of an organism
   a. homozygous—an organism with two alleles for one trait that are ____________
      (written T _____)
   b. heterozygous—an organism with two alleles for one trait that are ____________
      (written T _____)

6. Phenotype—the way an organism ________________ as a result of its genotype
# Section 2  Genetics Since Mendel

## A. Incomplete dominance
1. Neither allele for a trait is _____________.
2. The phenotype produced is ________________ between the two homozygous parents.

## B. Multiple Alleles
1. More than _____ alleles that control a trait are called multiple alleles.
2. Traits controlled by multiple alleles produce more than three _________________.

## C. Polygenic inheritance
1. A group of gene pairs acts together to ________________, which creates more variety in phenotypes.
2. Many human traits are controlled by _____________________, such as hair and eye color.

## D. ____________—genes that are altered or copied incorrectly
1. A mutation can be harmful, beneficial, or _________________.
2. Chromosome disorders—caused by _________________.
3. ________________—caused by _______________ of chromosome 21

## E. Recessive genetic disorders
1. Both parents have a _____________ allele responsible for the disorder and pass it to their child.
2. Because the parents are ________________, they don’t show _____________.
3. ________________ is a homozygous recessive disorder.

## F. Sex Determination
1. Chromosomes that determine the sex of an organism are XX in ___________ and XY in _____________.
2. Females produce eggs with ________________ only. Males produce sperm with ________________ chromosome.

## G. Sex-linked disorders
1. An allele inherited on an X or Y chromosome is a _________________.
2. ________________ is a sex-linked disorder caused by a recessive allele on the X chromosome.
3. A ____________ follows a trait through generations of a family.
Section 3 Advances in Genetics

A. Genetic engineering—___________ the arrangement of DNA that makes up a gene

1. ______________ DNA
   a. Insertion of a useful segment of DNA into a _____________
   b. __________ is made by genetically engineered organisms.

2. ______________
   a. A normal allele is placed into a ____________, which delivers the normal allele when it infects its target cell.
   b. May be used to control ________________ or other genetic disorders.

B. ______________________________—created by inserting the genes that produce desired traits in one plant into a different plant
Assessment
Part A. Vocabulary Review

Directions: Complete the following sentences using the terms listed below.

- alleles
- dominant
- genetic engineering
- genetics
- genotype
- heredity
- heterozygous
- homozygous
- hybrid
- incomplete dominance
- phenotype
- polygenic inheritance
- Punnett square
- recessive
- sex-linked gene

1. The allele for hemophilia is on the X chromosome and is a _____________________________.
2. ___________________________ is the passing of traits from one generation to another.
3. The different forms a gene may have for a trait are called _____________________________.
4. In ______________________________ both alleles are expressed in offspring.
5. A plant that receives different genetic information from each parent is a _________________________.
6. A ______________________________ trait covers up other traits.
7. In a Punnett square, a small letter (t) stands for a ______________________________ allele.
8. A tool used to predict the possible offspring of a mating is called a _________________________.
9. The genetic makeup of an organism is called its ______________________________.
10. ______________________________ is the way an organism looks and behaves a result of its genotype.
11. The study of how traits are inherited through the interactions of alleles is _________________________.
12. Through ______________________________ scientists are experimenting to change the arrangement of DNA in a gene.
13. An organism with two alleles that are exactly the same is _______________________________.
14. ______________________________ occurs when a group of gene pairs acts together to produce a single trait.
15. An organism that has two different alleles for a trait is _________________________________.

Chapter Review
Directions: Study the meanings of the prefixes listed below. Then write a word that contains a prefix from the list next to its definition.

<table>
<thead>
<tr>
<th>hetero—different</th>
<th>homo—same</th>
<th>poly—many</th>
</tr>
</thead>
</table>

16. _________________ an organism whose two alleles for a trait are exactly the same
17. _________________ an organism with two different alleles for a trait
18. _________________ a type of inheritance where more than one gene controls a trait

Part B. Concept Review

Directions: Answer the following questions using complete sentences.

In questions 1, 2, and 3 below, state the three main points of how traits are inherited.

1. ____________________________________________________________
2. ____________________________________________________________
3. ____________________________________________________________

4. Give an example of multiple alleles. _____________________________

5. Give an example of polygenic inheritance. _______________________

6. Describe a genetic disorder.
   _____________________________________________________________
   _____________________________________________________________

7. Describe genetic engineering and give one example of it.
   _____________________________________________________________

8. a. How could two parents with blood types A and B have a child with blood type O?
   _____________________________________________________________
   b. What would be the genotypes of these parents?
   _____________________________________________________________

Directions: Complete the Punnett square by writing the parental genotypes in the correct places and determining the possible genotypes of the offspring.

Dominant gene: curly hair (H)
Recessive gene: straight hair (h)
Parents: Hh × hh

9. What are the genotypes and phenotypes of the offspring? ________________________________
Transparency Activities
You may have noticed that tall parents often have tall children and dark-haired parents often have dark-haired children. Even though offspring are similar to their parents, they do not look exactly alike.

1. Do children ever look exactly the same? When?
2. How are the members of this family different? How are they the same?
3. Why can looking at a set of parents help you predict what their children might look like?
Humans have kept dogs for 12,000 to 14,000 years. At first, all dogs had jobs, such as herding or guarding. Today, some dogs have jobs, but many others are kept as pets.

1. What determines how big a dog can get?
2. Can a gray puppy and a brown puppy be littermates? How?
3. What environmental conditions could make one dog look different than its identical twin?
For many years, scientists have looked for ways to raise plants and animals with traits that people want most. At the same time they try to take away unwanted traits. But how can they make a better bacterium? Recently, scientists learned how to put new parts of DNA directly into cells. By doing this, they gave certain bacteria an appetite for oil!

1. What other advantages might there be to changing an organism in this way?
2. Are there any dangers in making these sorts of changes?
Pedigree

Female carrier of calico gene (XcX)

<table>
<thead>
<tr>
<th></th>
<th>Xc</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>Xc</td>
<td>XcXc</td>
<td>XcX</td>
</tr>
</tbody>
</table>

Male carrier of calico gene (XcY)

<table>
<thead>
<tr>
<th></th>
<th>Xc</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>XcY</td>
<td>XY</td>
</tr>
</tbody>
</table>

Genotypes: XcXc, XcX, XcY, XY
Phenotypes: One calico female, one carrier female, one carrier male, one normal male

Pedigree Key

- Normal female
- Normal male
- Carrier female
- Color-blind male
Teaching Transparency Activity (continued)

1. A pedigree is a visual tool for what purpose?

2. What is the most common form of color blindness?

3. Alleles are different forms of a trait. In which square of the Punnett square has a calico cat inherited the calico trait?

4. Why are no women in the family color blind?

5. In a pedigree, what symbol will always represent a male? A female?
**Assessment Transparency Activity**

**Heredity**

**Directions:** Carefully review the Punnett square and answer the following questions.

An AaBb plant is to be bred with itself.

<table>
<thead>
<tr>
<th>AB</th>
<th>Ab</th>
<th>aB</th>
<th>ab</th>
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<td>AaBB</td>
<td>AaBb</td>
<td>aaBB</td>
</tr>
<tr>
<td>ab</td>
<td>AaBb</td>
<td>Aabb</td>
<td>aaBb</td>
</tr>
</tbody>
</table>

A: Tall  
a: Short  
B: Fast-growing  
b: Slow-growing

1. Using the table above, you can hypothesize that the reason short, slow growing trees are rare is that ____.
   - A the tall, fast-growing trees will help them grow  
   - B water and sunlight will help them grow  
   - C only a few of the offspring will have the aabb genotype  
   - D most of the offspring are fast growing Aa and AA trees

2. According to the table, which genotype will not produce a tall, fast-growing tree?
   - F AaBB  
   - H Aabb  
   - G AABb  
   - J AABB

3. According to the information in the table, what characteristics do the parents have if their genotype is AAbb?
   - A Tall, fast-growing  
   - B Tall, slow-growing  
   - C Short, fast-growing  
   - D Short, slow-growing