SECTION 7.1

CHROMOSOMES AND PHENOTYPE

Study Guide

KEY CONCEPT
The chromosomes on which genes are located can affect the expression of traits.

VOCABULARY

| carrier  |
| sex-linked gene |
| X chromosome inactivation |

MAIN IDEA: Two copies of each autosomal gene affect phenotype.

1. What are sex chromosomes?

2. What are autosomes?

3. How is a carrier different from a person who has a genetic disorder?

Complete the two Punnett squares below to compare autosomal recessive disorders with autosomal dominant disorders. Fill in the possible genotypes for offspring, and write in the phenotype (no disorder, carrier, or disorder) for each.

**Autosomal Recessive**

<table>
<thead>
<tr>
<th></th>
<th>D</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Autosomal Dominant**

<table>
<thead>
<tr>
<th></th>
<th>D</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

MAIN IDEA: Males and females can differ in sex-linked traits.

4. What are sex-linked genes?
Fill in the Punnett square below to show the pattern of inheritance for sex chromosomes.

**Sex Chromosome Inheritance**

<table>
<thead>
<tr>
<th></th>
<th>X</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Y</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5. In humans, how does a gamete from a male determine the sex of offspring?

6. For what are genes on the Y chromosome responsible?

7. How are sex-linked genes expressed differently in the phenotypes of males and females?

**Vocabulary Check**

8. The verb *carry* means “to transport.” How is the everyday meaning of *carry* related to the meaning of the term *carrier* in genetics?

9. What is X chromosome inactivation?
# SECTION 7.1 | CHROMOSOMES AND PHENOTYPE

## Power Notes

<table>
<thead>
<tr>
<th><strong>Autosomes</strong></th>
<th><strong>Sex Chromosomes</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Autosomes are:</strong></td>
<td><strong>Sex chromosomes are:</strong></td>
</tr>
<tr>
<td><strong>Autosomal gene expression:</strong></td>
<td><strong>Inheritance of sex chromosomes:</strong></td>
</tr>
<tr>
<td><strong>Inheritance of autosomes:</strong></td>
<td><strong>Expression of sex-linked genes in males:</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Expression of sex-linked genes in females:</strong></td>
</tr>
</tbody>
</table>
SECTION 7.1 CHROMOSOMES AND PHENOTYPE

**Reinforcement**

**KEY CONCEPT** The chromosomes on which genes are located can affect the expression of traits.

There are two types of chromosomes: autosomes and sex chromosomes. Genes on the sex chromosomes determine an organism’s sex. Autosomes are all of the other chromosomes, and they do not directly affect sex determination. Gene expression can differ depending on the type of chromosome on which a gene is located.

- **Autosomal genes**: There are two copies of each autosome, which means that there are two copies of each autosomal gene. However, the two copies of a gene may be different alleles. Both copies of a gene can affect phenotype. Much of what has been learned about human genes comes from studies of genetic disorders. Many genetic disorders are caused by recessive alleles on autosomes. People who have one dominant allele and one recessive, disorder-causing allele, do not have the disorder, but can pass it on because they are **carriers** of the disorder.

- **Sex-linked genes**: Genes on the sex-chromosomes (the X and Y chromosomes in many species) are **sex-linked genes**. In mammals, including humans, and some other animals, XX individuals are female and XY individuals are male. Because males have only one copy of each sex chromosome, all of the genes on each chromosome will be expressed. Expression of sex-linked genes in females is similar to the expression of autosomal genes: two copies of each gene can affect phenotype. However, one X chromosome in each cell is randomly turned off by a process called **X chromosome inactivation**.

1. What is the pattern of expression for autosomal genes?

2. What is a carrier?

3. What are sex-linked genes?

4. What are the patterns of expression for sex-linked genes?
SECTION 7.2 | COMPLEX PATTERNS OF INHERITANCE

Study Guide

KEY CONCEPT
 Phenotype is affected by many different factors.

VOCABULARY
 incomplete dominance
 codominance
 polygenic trait

MAIN IDEA: Phenotype can depend on interactions of alleles.

1. How is incomplete dominance different from a dominant and recessive relationship?

2. How is codominance different from a dominant and recessive relationship?

3. What is a multiple-allele trait?

In the table below, describe how phenotypes appear in incomplete dominance and codominance. Then sketch an example of each.

<table>
<thead>
<tr>
<th>Interaction</th>
<th>Phenotype</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incomplete dominance</td>
<td>4.</td>
<td>5.</td>
</tr>
<tr>
<td>Codominance</td>
<td>6.</td>
<td>7.</td>
</tr>
</tbody>
</table>
MAIN IDEA: Many genes may interact to produce one trait.
Use the chart below to take notes on polygenic traits and epistasis.

Many genes may interact to produce one trait.

Polygenic Traits

Epistasis

MAIN IDEA: The environment interacts with genotype.

8. Why is genotype not the only factor that affects phenotype?

9. List and explain two examples of how environment and genotype can interact.

Vocabulary Check

10. The prefix in- means “not.” How is the meaning of this prefix related to the meaning of incomplete dominance?

11. The prefix co- means “together.” How is the meaning of this prefix related to the meaning of codominance?

12. The prefix poly- means “many,” and the term genic means “related to genes.” How do these word parts combine to give the meaning of polygenic?
SECTION 7.2
COMPLEX PATTERNS OF INHERITANCE

Complex Patterns of Inheritance

Incomplete dominance:

Codominance:

Multiple alleles:

Polygenic traits:

Epistasis:

Interaction of environment and genotype:
KEY CONCEPT Phenotype is affected by many different factors.

Although some genetic traits are produced by one gene with dominant and recessive alleles, most genetic traits are the result of more complex relationships among genes and alleles. In many cases phenotype comes from more than just one gene, and many genes have more than just two alleles.

- **Incomplete dominance**: In incomplete dominance, neither of two alleles is completely dominant or completely recessive. Instead, the alleles show incomplete dominance, where the heterozygous phenotype is somewhere between the homozygous dominant and homozygous recessive phenotypes. The heterozygous phenotype is a third, distinct phenotype.

- **Codominance**: In codominance, two alleles of a gene are completely and separately expressed, and both phenotypes are also completely expressed. Human blood type is an example of both codominance and a multiple allele trait. The alleles for blood types A and B are codominant, which can be expressed as an AB blood type. The allele for type O blood is recessive to the other two alleles.

- **Polygenic traits**: Traits that are produced by two or more genes are polygenic traits. Because many different gene interactions can occur with polygenic traits, these traits often have a wide, continuous range of phenotypes.

- **Epistasis**: An epistatic gene is a gene that can affect the expression of all of the other genes that affect a trait.

The environment can influence gene expression, which then affects phenotype. Human height is a trait that is partially due to environment. Another example is how temperature affects sex determination of sea turtles.

1. What is incomplete dominance?

2. What is codominance?

3. What is a polygenic trait?


5. Give an example of how genotype and the environment can interact.
KEY CONCEPT
Genes can be mapped to specific locations on chromosomes.

VOCABULARY
linkage map

MAIN IDEA: Gene linkage was explained through fruit flies.
1. What is gene linkage?

2. Why were fruit flies useful in Morgan’s research?

3. What is the difference between a wild type and a mutant type?

4. What did Morgan conclude from his research on fruit flies?

Complete the sequence below to take notes about the discovery of gene linkage.

**Mendel:**
Genes assort independently of one another.

**Punnett, Bateson:**

**Morgan:**
MAIN IDEA: Linkage maps estimate distances between genes.

5. How is the distance between two genes related to the chance they are inherited together?

6. What hypothesis was the basis of Sturtevant’s research?

7. What is a linkage map?

8. How are cross-over frequencies related to linkage maps?

9. What do linkage maps show about genes on a chromosome?

Use the cross-over frequencies given below to draw a linkage map for the four genes listed. Think about the relationship between cross-over frequency and distance in linkage map units. Use Figure 7.11 to help you make the linkage map. Put gene A on the far left of the map, then work through the distances between the gene pairs.

<table>
<thead>
<tr>
<th>Cross-over Frequencies:</th>
<th>Linkage Map</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-B 20%</td>
<td></td>
</tr>
<tr>
<td>B-C 5%</td>
<td></td>
</tr>
<tr>
<td>A-C 25%</td>
<td></td>
</tr>
<tr>
<td>A-D 7%</td>
<td></td>
</tr>
<tr>
<td>D-B 13%</td>
<td></td>
</tr>
<tr>
<td>D-C 18%</td>
<td></td>
</tr>
</tbody>
</table>
Mendel's experiments:

Conclusions:

Punnett and Bateson:

Conclusions:

Morgan:

Conclusions:

Sturtevant's hypothesis:

Sturtevant's experiments:

Making a linkage map:
KEY CONCEPT  Genes can be mapped to specific locations on chromosomes.

One of Mendel’s conclusions from his work on inheritance in pea plants was the law of independent assortment, which stated that genes assort independently of each other during meiosis. However, later experiments suggested that some genes were linked together and did not assort independently. Eventually, research with fruit flies demonstrated that chromosomes, not genes, assort independently and that during meiosis chromosomes could exchange homologous genes.

The chance that two genes on a chromosome will be inherited together is related to the distance between the genes. If two genes are close together, it is very likely that they will be inherited together. If two genes are far apart, it is much more likely that they will be separated by the crossing over that occurs during meiosis. Crossing over takes place when segments of sister chromatids are exchanged.

The frequency of cross-overs is related to the distance between genes on a chromosome. By finding the percentage of times that cross-overs occur from observations of phenotypes in offspring, it is possible to make a map of the locations of the genes. A linkage map is a map of the relative locations of genes on a chromosome.

The distance between two genes on a linkage map is expressed in “map units.” Two genes that cross over one percent of the time are one map unit apart. Two genes that cross over 20 percent of the time are 20 map units apart. Linkage maps can be made for several different genes at one time if all of their cross-over frequencies are known.

1. How was Mendel’s law of independent assortment inaccurate?

2. What is the relationship between the distance between two genes and the chance that they will be inherited together?

3. What is a linkage map?

4. How are the distances between genes determined for a linkage map?
SECTION 7.4  HUMAN GENETICS AND PEDIGREES

Study Guide

KEY CONCEPT
A combination of methods is used to study human genetics.

VOCABULARY
- pedigree
- karyotype

MAIN IDEA: Human genetics follows the patterns seen in other organisms.
1. How does genetic inheritance follow similar patterns in all sexually reproducing organisms?

2. How are single-gene traits useful in studying human genetics?

MAIN IDEA: Females can carry sex-linked genetic disorders.
3. Who can be carriers of autosomal disorders?

4. Why can females, but not males, be carriers of sex-linked genetic disorders?

MAIN IDEA: A pedigree is a chart for tracing genes in a family.
5. What is a pedigree?

6. How are phenotypes used in pedigree analysis?

7. What information on a pedigree can tell you whether a gene is on an autosome or on a sex chromosome?
8. Complete the chart to follow the logic necessary to fill out a pedigree for a sex-linked gene. Use $X^D$ and $X^d$ for the dominant and recessive X-linked genes, respectively.

### Tracing Sex-Linked Genes

<table>
<thead>
<tr>
<th>Phenotype</th>
<th>Genotype</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female, recessive phenotype</td>
<td></td>
</tr>
<tr>
<td>Male, recessive phenotype</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parental Phenotype</th>
<th>Parental Genotype</th>
<th>Offspring Genotypes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female carrier, normal male</td>
<td>$X^D$</td>
<td>could have $X^D$X^d, $X^D$X_d, $X^d$X^d, $X^d$X_d</td>
</tr>
<tr>
<td>Female carrier, male with recessive phenotype</td>
<td>could have</td>
<td></td>
</tr>
<tr>
<td>Female with recessive phenotype, normal male</td>
<td>could have</td>
<td></td>
</tr>
<tr>
<td>Female with recessive phenotype, male with recessive phenotype</td>
<td>could have</td>
<td></td>
</tr>
</tbody>
</table>

**MAIN IDEA:** Several methods help map human chromosomes.

9. What are two methods that are used to directly study human chromosomes?

10. What does a karyotype show about chromosomes?

**Vocabulary Check**

11. What is a karyotype?
## 7.4 HUMAN GENETICS AND PEDIGREES

### Power Notes

<table>
<thead>
<tr>
<th>Sex-Linked Disorders</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Males:</strong></td>
</tr>
<tr>
<td><strong>Females:</strong></td>
</tr>
</tbody>
</table>

A pedigree chart is:

<table>
<thead>
<tr>
<th>TracingAutosomalGenes</th>
<th>TracingSex-LinkedGenes</th>
</tr>
</thead>
<tbody>
<tr>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>•</td>
<td>•</td>
</tr>
</tbody>
</table>

A karyotype is:

A karyotype shows:
**KEY CONCEPT**  A combination of methods is used to study human genetics.

The patterns of inheritance in humans are the same as the patterns of inheritance in other sexually reproducing organisms. Phenotypes are often the result of varying degrees of dominance, several genes, multiple alleles, or sex-linked genes.

Only females can be carriers of sex-linked disorders. Females, who have an XX genotype for their sex chromosomes, must have two recessive alleles to show a recessive phenotype, such as for a recessive sex-linked disorder. Males, on the other hand, have an XY genotype. They will show all of the phenotypes from the genes on their X chromosome, even the recessive alleles, because they cannot have a second, dominant allele that could mask the recessive allele.

The potential for a genetic disorder to be passed on through a family can be studied using pedigree analysis. A **pedigree** is a chart that is used to trace phenotypes and genotypes within a family. It can help show whether someone in a family may have recessive alleles that cause a genetic disorder.

Known phenotypes in a family are used to infer genotypes. Both autosomal genes and sex-linked genes can be traced with pedigrees.

- **Tracing autosomal genes**: Equal numbers of males and females will have the recessive phenotype. Anyone with the recessive phenotype must be homozygous recessive. Two heterozygous parents can have children who are homozygous dominant, heterozygous, or homozygous recessive.

- **Tracing sex-linked genes**: More males than females will have the recessive phenotype. Males with a recessive allele will pass it on to all of his daughters. Females can be carriers of a recessive allele and pass it on to either sons or daughters.

In addition to pedigrees, other methods of studying human genetics are used. **Karyotypes**, for example, are pictures of all of a person’s chromosomes that can show any large changes in the chromosomes.

1. Why can only females be carriers of sex-linked disorders?

2. What is a pedigree?

3. What is one major difference in pedigrees between autosomal and sex-linked genes?
Bar graphs are used to display data collected during an investigation. Bar graphs are used to compare groups of data that are independent of each other.

The temperature at which sea turtle eggs mature helps determine the sex of the turtles. Evidence suggests that black sea turtle eggs that mature at temperatures below 27.1ºC result in all males. In contrast, black sea turtle eggs that mature above 31ºC result in all females. Suppose a team of scientists studied the effect of a range of temperatures between those two extremes by incubating different groups of black sea turtle eggs at different temperatures in an incubator. Each group contained 20 eggs. The scientists collected the data shown in the table below.

**EFFECT OF TEMPERATURE ON SEA TURTLE SEX DETERMINATION**

<table>
<thead>
<tr>
<th>Incubation Temperature (ºC)</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>27.0</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>27.5</td>
<td>18</td>
<td>2</td>
</tr>
<tr>
<td>28.0</td>
<td>14</td>
<td>6</td>
</tr>
<tr>
<td>28.5</td>
<td>11</td>
<td>9</td>
</tr>
<tr>
<td>29.0</td>
<td>12</td>
<td>8</td>
</tr>
<tr>
<td>29.5</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>30.0</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>30.5</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>31.0</td>
<td>0</td>
<td>20</td>
</tr>
</tbody>
</table>

1. **Graph** On the next page, construct a bar graph that shows the data in the table. Be sure to include labels on each axis and a title for the graph.
2. **Analyze**  Describe the relationship shown in the graph between incubation temperature and sex determination in sea turtles.
In Chapter 7, you have learned that when a homozygous red-flowered four o’clock plant is crossed with a homozygous white-flowered four o’clock plant, the offspring all have pink flowers. This is an example of incomplete dominance, a type of non-Mendelian genetics.

DOMINANCE AT THE MOLECULAR LEVEL

One of the traits Mendel studied in pea plants was flower color. When he crossed a purple-flowered plant, $PP$, with a white-flowered plant, $pp$, all flowers in the first generation of offspring ($F_1$) had purple flowers. The allele for purple flowers was completely dominant to white flowers.

Each gene holds the genetic information for the production of a particular protein, usually an enzyme. When the dominant allele for purple flower color is present, a series of enzymatic reactions results in the flower cells making a purple pigment. When no dominant allele is present, as in the $pp$ homozygous recessive plant, no purple pigment is made, and the flowers are white. The recessive allele most likely codes for an enzyme that is defective and unable to catalyze the reaction that leads to the production of the purple pigment. In the $Pp$ heterozygote, only half the amount of pigment is produced, but it is enough to make the flowers purple. The flowers of a $Pp$ plant cannot be distinguished from those of a $PP$ plant.

INHERITANCE PATTERN OF INCOMPLETE DOMINANCE

Why does the heterozygote four o’clock have pink flowers? The allele for red flower color causes a red pigment, called anthocyanin, to be produced. If only one copy of the allele is present, only half the amount of red pigment is made, which effectively dilutes the coloring so that the flowers appear pink, not red.

<table>
<thead>
<tr>
<th>White four o’clock $R_1R_1$</th>
<th>$R_1$</th>
<th>$R_1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R_2$</td>
<td>$R_1R_2$ Pink</td>
<td>$R_1R_2$ Pink</td>
</tr>
<tr>
<td>$R_2$</td>
<td>$R_1R_2$ Pink</td>
<td>$R_1R_2$ Pink</td>
</tr>
</tbody>
</table>

$F_1$ generation: four pink four o’clocks

What is the inheritance pattern of a trait that is controlled by incomplete dominance? To find out, you will diagram the self-fertilization of one heterozygous $F_1$ plant and then the self-fertilization of all the resulting genotypes of the $F_2$ generation.
1. In the Punnett squares below, diagram the self-fertilization, a self-cross, of one pink-flowered F₁ heterozygous plant \((R₁R₂)\). Then use the second series of Punnett squares to diagram the self-fertilization of each genotype of the F₂ generation. Include both the genotype and phenotype in the cells of the Punnett Square. If you have colored pencils available, you can color in the squares with the appropriate flower colors.

2. Describe the pattern of inheritance for incomplete dominance.

3. As described in Chapter 6, Mendel’s work with pea plants demonstrated that the factors that control heritable traits exist as discrete units, what we now call genes. Yet the cross of a red four o’clock plant with a white four o’clock clearly shows a blend in the phenotype: red plus white equals pink. How are the Punnett squares you completed evidence that heritable factors are discrete units, despite the blending of colors?
In Chapter 7, you have learned how sex-linked traits are inherited, and how to analyze a pedigree. You also learned how to make and analyze a pedigree. Hemophilia, a condition that results in excessive bleeding after injury due to an abnormal blood clotting factor, is a sex-linked trait. By analyzing a pedigree of Queen Victoria’s family, you will learn more about this genetic disorder.

**QUEEN VICTORIA’S FAMILY**

The most famous example of hemophilia occurred in the family of Victoria, Queen of England from 1837 to 1901. She was England’s longest reigning monarch.

Victoria married her cousin, Prince Albert, and they had nine children—five girls and four boys. As you can see in the pedigree on the next page, three of her children inherited the allele for hemophilia. Because it was common for members of European royal families to marry into other royal families, the defective allele was carried into the royal families of Russia, Germany, and Spain. The disease has been called the royal disease, or royal hemophilia. Ten of Victoria’s male descendants had hemophilia.

Answer the following questions on a separate sheet of paper.

1. Victoria’s youngest child, Beatrice, had one daughter, one normal son, and two sons with hemophilia. Beatrice’s daughter, Eugenie, married King Alfonso XIII of Spain. They had six children, one of whom was the father of Juan Carlos, the current King of Spain. What is Juan Carlos’s phenotype—normal, carrier, or hemophilic? Explain.

2. Victoria’s daughter Alice had a daughter, Alix, who carried the defective allele into the royal Russian family when she married Tsar Nicholas II. They had four daughters and one son, Alexis. Alexis had hemophilia. The entire family was murdered during the Russian Revolution. What is the probability that one of Alexis’s sisters was a carrier? What is the probability that all four of Alexis’s sisters were carriers? Explain.

3. If Alexis had lived and married a normal woman, what is the probability that he would have had a daughter with hemophilia? Explain.

4. Is it possible for a female to have hemophilia? Explain.

5. What is the probability that the next generation of the present British royal family—Charles, Andrew, Edward, and Ann—will have hemophilia? Explain.
### A. Compound Word Puzzle

Read the phrase and write the word that it most closely describes. Then write another phrase that describes the same word in a different way.

<table>
<thead>
<tr>
<th>PHRASE 1</th>
<th>WORD</th>
<th>PHRASE 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>picture of all human chromosomes</td>
<td>Example karyotype</td>
<td>can show large changes in chromosomes</td>
</tr>
<tr>
<td>genes located on the sex chromosomes</td>
<td>1.</td>
<td></td>
</tr>
<tr>
<td>it shows the relative locations of genes on a chromosome</td>
<td>2.</td>
<td></td>
</tr>
<tr>
<td>one X chromosome is randomly turned off</td>
<td>3.</td>
<td></td>
</tr>
<tr>
<td>a chart that is used to trace phenotypes and genotypes in a family</td>
<td>4.</td>
<td></td>
</tr>
<tr>
<td>many genes interact to produce a single trait</td>
<td>5.</td>
<td></td>
</tr>
<tr>
<td>an “in-between” phenotype</td>
<td>6.</td>
<td></td>
</tr>
</tbody>
</table>
VOCABULARY PRACTICE, CONTINUED

B. Words in Context  Answer the questions to show your understanding of the vocabulary words.

1. Which is like a karyotype, a satellite weather map, or the temperature on one street corner?

2. Is incomplete dominance like a glass of cranberry-raspberry juice or a pizza with everything?

3. Is X chromosome inactivation like an electrical generator or a power failure?

4. Would a pedigree be used to trace genes in a family or to send a dog to obedience school?

5. Is codominance like doing your homework or two people talking at the same time?

6. Which is like a carrier, a ferry crossing a lake, or a door opening?

7. Are exact directions or a general idea of where you are going more like a linkage map?

8. Is a polygenic trait more like a basketball team or a figure skater?

C. Do-It Yourself Matching  In a random order, write short definitions for each term on the blank lines to the right. Then give your paper to a classmate who should write the number of the term next to the correct definition.

1. sex-linked gene

2. incomplete dominance

3. carrier

4. linkage map

5. codominance

6. karyotype
D. Who Am I? Choose among these terms to answer the riddles below:

<table>
<thead>
<tr>
<th>carrier</th>
<th>karyotype</th>
<th>polygenic trait</th>
</tr>
</thead>
<tbody>
<tr>
<td>codominance</td>
<td>linkage map</td>
<td>X chromosome inactivation</td>
</tr>
<tr>
<td>incomplete dominance</td>
<td>pedigree</td>
<td></td>
</tr>
</tbody>
</table>

1. I am the process that randomly turns off one X chromosome in a human female’s cells.

2. I am an interaction between two alleles in which both alleles are fully and separately expressed.

3. I am a chart that can be used to trace genes through a family.

4. I am a picture that shows the overall structure of chromosomes.

5. I am an interaction between two alleles that produces a phenotype that is between the phenotypes of homozygotes.

6. I am a person who does not show a genetic disorder, but I can pass it on to my offspring.

7. I am a map of genes on a chromosome, but I do not show the exact locations of the genes.

8. I am a trait that is the result of many genes.

E. Find the Odd Word  Put a checkmark next to the word that does not belong.

1. ___ karyotype  Explanation______________________________
   ___ linkage map  ________________________________
   ___ X chromosome inactivation

2. ___ sex-linked gene  Explanation______________________________
   ___ polygenic trait  ________________________________
   ___ carrier
3. ____ linkage map
   ____ incomplete dominance
   ____ codominance

4. ____ incomplete dominance
   ____ karyotype
   ____ pedigree

F. Analogies Read each analogy. Decide which term is most like it.

<table>
<thead>
<tr>
<th>carrier</th>
<th>codominance</th>
<th>linkage map</th>
</tr>
</thead>
<tbody>
<tr>
<td>X chromosome inactivation</td>
<td>polygenic trait</td>
<td>karyotype</td>
</tr>
<tr>
<td>incomplete dominance</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Airport baggage handler ________________________________
2. Blending the ingredients of a fruit smoothie ________________________________
3. Randomly flipping switches in an electrical panel ________________________________
4. A still-life painting ________________________________
5. All of the people who make up the United States ________________________________
6. Mixing the ingredients of a fruit salad ________________________________
7. A train schedule that shows the stops made by the train ________________________________

Write your own analogies to show the meaning of these terms:

8. sex-linked gene ________________________________

9. pedigree ________________________________