Genotypes and Phenotypes

Use the following information to answer the questions below.

R – round seeds  
C – colored seed coat  
G – green pods  
r – wrinkled seeds  
c – white seed coat  
g – yellow pods  
T – tall plants  
I – inflated pods  
B – blue flowers  
t – short plants  
i – constricted pods  
b – black flowers  
Y – yellow seeds  
A – axial flowers  
P – purple stems  
y – green seeds  
a – terminal flowers  
p – pink stems  

Give the Genotype.

1) Heterozygous inflated pods  
   6) Homozygous constricted pods  
2) Homozygous white seed coat  
   7) Homozygous green seeds  
3) Homozygous round seeds  
   8) Heterozygous yellow seeds  
4) Heterozygous green pods  
   9) Homozygous colored seed coat  
5) Heterozygous purple stems  
   10) Homozygous blue flowers  
11) Homozygous black flowers and heterozygous tall plants  
12) Heterozygous round seeds and homozygous pink stems  

Give the Complete Phenotype.

1) Cc  
   6) Bb  
2) gg  
   7) YY  
3) rr  
   8) Pp  
4) II  
   9) RR  
5) Aa  
   10) Gg  
11) Tt Cc  
12) Bb Rr
Monohybrid Crosses

1. In cabbage butterflies, white wings (W) are dominant to yellow wings (w). If a heterozygous white butterfly is crossed with a yellow butterfly, what are the possible genotypes and phenotypes of the offspring and the percent chance for each?

2. In dogs, there is a hereditary type of deafness caused by a recessive gene (d). Two dogs are mated, both carry the gene for deafness but have normal hearing. What are the possible genotypes and phenotypes of their offspring and the percent chance for each?

3. In guinea pigs, short hair (H) is dominant over long hair (h). If a pure short haired guinea pig is crossed with a long haired guinea pig, what are the possible genotypes and phenotypes of their offspring and the percent chance of each?

4. Can you curl your tongue up on the sides? Tongue-curling (T) in humans is a dominant genetic trait. Suppose a man who is hybrid for tongue-curling marries a woman who is also hybrid for this trait. What are the possible genotypes and phenotypes of their children and the percent chance for each?

5. In guinea pigs, rough coats with lots of swirly cowlicks (R) are dominant over smooth coats (r). If a pure rough coat guinea pig is crossed with a heterozygous rough coat guinea pig, what are the possible genotypes and phenotypes of the offspring? What are the chances of each?
ALIEN GENETICS
Pictured at the right is an alien who displays all of the dominant characteristics of its species. Below is a chart listing various traits found in this alien race. Use the information in the chart to solve the genetics problems that follow. Use Punnett Squares to show your work.

<table>
<thead>
<tr>
<th>Trait</th>
<th>Dominant Phenotype</th>
<th>Recessive Phenotype</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body color</td>
<td>(Y) Yellow</td>
<td>(y) Orange</td>
</tr>
<tr>
<td>Number of Antennae</td>
<td>(A) 2</td>
<td>(a) 1</td>
</tr>
<tr>
<td>Eye color</td>
<td>(P) Purple</td>
<td>(p) White</td>
</tr>
<tr>
<td>Eyesight</td>
<td>(E) Glasses needed</td>
<td>(e) Glasses not worn</td>
</tr>
<tr>
<td>Number of Body Rings</td>
<td>(R) 3</td>
<td>(r) 5</td>
</tr>
</tbody>
</table>

*Note: “pure” refers to a homozygous genotype and “hybrid” refers to a heterozygous genotype.*

1. A male heterozygous for body color mates with a pure yellow female. What is the chance this couple will produce an orange baby?

2. Two purple-eyed aliens mate. Both aliens are hybrid for the eye color trait. What is the chance this couple will produce a baby with a homozygous recessive genotype?

3. A 5-ringed female mates with a 5-ringed male. The 5-ringed female had parents with 3 body rings. What is the chance that this couple will have a baby that looks like its maternal grandparents?
4. A pure male alien displaying the dominant body color mates with a female that is homozygous recessive for this characteristic. What is the chance that this couple will have a baby with a hybrid genotype?

5. A male alien, with 1 antenna, mates with a female alien who has 2 antennae. The female is heterozygous for the antenna trait. What is the chance that this couple will produce a baby with the recessive phenotype?

6. An alien couple, both of which wear glasses, is having a baby. The male's genotype is heterozygous. The female is phenotypically dominant but does carry the recessive allele. What is the chance that this couple's baby will have to wear glasses?

7. A three-ring female mates with a homozygous male. The female has been genetically tested and is carrying both the dominant and the recessive allele for this trait. The male displays the recessive phenotype. What is the chance that this couple will have a genetically pure baby?
Extra Practice Problems:

1. Woodrats are medium sized rodents with lots of interesting behaviors. You may know of them as packrats. Let's assume that the trait of bringing home shiny objects (H) is dominant to the trait of carrying home only dull objects (h). Suppose two heterozygous individuals are crossed. How many of each genotype would be expected if only 4 offspring were produced? How many of each phenotype?

2. Saguaro cacti are very tall cylindrical plants that usually have two L-shaped arms, one on each side. Suppose you lived in southern Arizona where the Saguaro cactus is common and you happen to have one growing in your yard. Your Saguaro has two arms but one is longer than the other. Now, assume that arm length in these cacti is controlled by a single gene with arms of the same length (A) being dominant to arms of different lengths. What is the genotype of your cactus? Could one of the parents of your cactus have had a phenotype with arms the same length? If so, what would have been the genotype of that parent?

3. The common grackle is a species of robin-sized blackbirds that are fairly common (hence the name) over most of the United States. Suppose that long tails (T) were dominant to short tails in these birds. A female short-tailed grackle mates with a male long-tailed grackle who had one parent with a long tail and one parent with a short tail. What is the male's genotype? How many of each genotype will be found in the F1 generation? How many of each phenotype will be found in the F1 generation?

4. In cattle, the polled (hornless) condition is caused by a dominant allele (H), while the recessive allele causes horns to grow. A polled cow and a polled bull produce a calf which grows horns as it matures. Show the genotypes of all three. What is the probability that the pair's next calf will also grow horns?

5. In dogs, wire hair (W) is dominant to smooth (w). In a cross of a homozygous wire-haired dog with a smooth-haired dog, what will be the phenotype of the offspring (F1 generation)? What would the genotype be? What would be the ratio of wire-haired to smooth-haired dogs in the F2 generation? Hint: think of Mendel’s experiments to determine the cross for the F2 generation.
Dihybrid Crosses

1. Tall plants (T) are dominant over short plants. Round seeds (R) are dominant over wrinkled seeds. What would be the results of a cross between two pea plants that were heterozygous for both tall and round seeds? Show a Punnett square and state the phenotypic ratios.

2. Parent 1 is heterozygous for skin color (green (G) is dominant over purple) and homozygous for eating people (eating (E) is dominant over non-eating). Parent 2 is purple and does not eat people. Give the genotype and phenotypes of the possible offspring.

3. In lizards, yellow (Y) belly is dominant over white and sap sucking is recessive to non-sap sucking (S). If one lizard is heterozygous non-sap sucking with a white belly and the other lizard is heterozygous non-sap sucking with a yellow belly, what are the genotype possibilities and phenotypes of the offspring?
4. Gray (G) is dominant over pink in elephants. No polka dots (D) is dominant over polka dots. If the father is homozygous for both traits (gray and no polka dots) and the mother is homozygous recessive for both traits, will any of the offspring look like the mother? Give the genotypes of the parents and the genotypes and phenotypes offspring.

5. Cross a heterozygous gray with no dots with the mother in the previous question. Give the genotypes and phenotypes possible in the children.

6. In rabbits, black is due to a dominant factor (B), brown to its recessive allele (b). Short hair (S) is dominant over long hair (s). In a cross between a homozygous black, short haired female and a homozygous brown long haired male, what would be the genotypic constitution and appearance of the F₁ generation? Of the F₂ generation?
7. In horses, black is dependent upon a dominant factor (B), and chestnut on its recessive allele (b). The trotting gait is due to a dominant factor (T), pacing gait to its recessive allele (t). If a homozygous black pacer is mated to a homozygous chestnut trotter, what will be the appearance of the F₁ generation?

8. If two F₁ individuals from problem 7 were mated, what kinds of offspring could they have and in what proportion?

9. If an F₁ male from problem 7 were mated to a homozygous black female pacer, what kinds of offspring could they have and in what proportions?
10. In watermelons, the skin color may be green or striped, and the fruit shape can be long or short. A homozygous long, green plant was crossed with a homozygous short, striped variety. The F₁ generation plants were all green, short. The F₂ generation plants were all four types – 9 short green, 3 short striped, 3 long green, and 1 long striped. **How many pairs of genes are concerned in this cross? Which genes are dominant?** Use a Punnet square to show your work.

11. Rough coat in guinea pigs is dominant (R) over smooth (r). Short hair (L) is dominant to long hair (l) and black hair (B) is dominant to white hair. A homozygous rough, short, black hair is crossed with a smooth, long, white hair. **What are the phenotypes of the F₁?**

12. If an F₁ from question 11 is mated to a smooth, long, white hair guinea pig, **what will be the appearance of the offspring?**
Incomplete Dominance, Codominance, Multiple Alleles

Dominance is the simplest example of how genes interact with each other. Earlier, you learned that the effects of the dominant allele are seen even when the recessive allele is present. But what causes dominance?

Remember that a gene is a section of DNA, and DNA codes for a polypeptide, or string of amino acids. In many cases, the dominant allele codes for a polypeptide that works, whereas the recessive allele codes for a polypeptide that does not work. For example, suppose that the allele $B$ codes for an enzyme that makes a black pigment in a mouse’s fur and allele $b$ codes for a defective enzyme that cannot make the pigment. A mouse that has the genotype $bb$ will have white fur because it lacks the enzyme that makes the black pigment. But a mouse that has the genotype $BB$ or $Bb$ will have black fur because it possesses the enzyme that makes the black pigment. Although each cell in the $Bb$ animal has just one copy of the functioning allele, that single copy can code for thousands of mRNA molecules. And each mRNA molecule can code for thousands of enzymes, which are special proteins. This is the reason the $B$ allele is dominant over the $b$ allele.

In some cases, this simple interaction between the dominant and recessive alleles is not seen. Instead, the resulting phenotype of the heterozygous individual is somewhere in between the two homozygous phenotypes. Incomplete dominance (aka “intermediate inheritance”) and co-dominance are examples of such situations.

1. In 4-o’clock flowers, red flower color (R) is incompletely dominant to white flower color (W).
   a. What is the color of the offspring when a red flowered plant and a white flowered plant are crossed?

   b. If a pink flower and a white flower are crossed, what is the chance of getting a red flowered offspring?

   c. If two pink flowered plants are crossed, what are the genotypic and phenotypic ratios?

2. Certain breeds of cattle show a codominance pattern in coat color. When pure breeding red cows are bred with pure breeding white cows, the offspring are roan (red and white coat color). The allele for red is $C^R$ and the allele for white is $C^W$. Summarize the genotypes & phenotypes of the possible offspring when a roan cow is mated with a roan bull.
3. A pure-breeding red (R) radish crossed with a pure-breeding white (W) radish makes a purple radish. What are the genotypic and phenotypic ratios when you cross a purple radish with a red radish? *Is this incomplete dominance or codominance?*

4. There are four rabbit colors: full color (wild type) – C, chinchilla – c<sup>ch</sup>, himalayan – c<sup>h</sup>, and albino – c. The order of dominance is as follows: C > c<sup>ch</sup> > c<sup>h</sup> > c. What are the possible genotypes for the following rabbit colors?
   a. full color (wild): ____________, ____________, ____________, ____________
   b. chinchilla (black speckled white): ____________, ____________, ____________
   c. himalayan: ____________, ____________
   d. albinism: ____________

5. Cross a chinchilla (c<sup>ch</sup> c<sup>h</sup>) with an albino rabbit. What are the phenotypic ratios.

6. **Dihybrid review:** In a certain type of flower, yellow petals are dominant to red petals, and round petals are dominant to pointed petals.
   a. Make a key of the alleles and the traits.
   b. A heterozygous yellow, pointed flower is crossed with a red, pointed flower. Make sure to show your work in a punnett square.
   c. What fraction of the offspring will have pointed flowers?
   d. What fraction of the offspring will be yellow?
**Human Blood Cell Typing – POGIL**

**Why do blood types matter?**

An organism monitors its internal environment to stay healthy and to carry out its life functions. Recognizing when foreign cells or other potentially harmful substances are in the body is one way to prevent damage and fight off infection by pathogens. Human red blood cells have a system for being recognized so that cells that belong in the body are kept safe while cells that do not belong can be destroyed.

### Model 1 – Red Blood Cells and Antibodies

<table>
<thead>
<tr>
<th></th>
<th>Person with Blood Type A</th>
<th>Person with Blood Type B</th>
<th>Person with Blood Type AB</th>
<th>Person with Blood Type O</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cell with attached antigen</strong></td>
<td>A</td>
<td>B</td>
<td>AB</td>
<td>O</td>
</tr>
<tr>
<td><strong>Antibody produced</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Anti-A</td>
<td>Anti-B</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td><strong>Cells in the presence of anti-A antibody</strong></td>
<td>A</td>
<td>B</td>
<td>AB</td>
<td>O</td>
</tr>
<tr>
<td><strong>Cells in the presence of anti-B antibody</strong></td>
<td>A</td>
<td>B</td>
<td>AB</td>
<td>O</td>
</tr>
</tbody>
</table>

1. Blood types in the human population are characterized by the presence or absence of antigens on the surface of the red blood cells.
   a. According to Model 1, how many blood types are found in the human population?

   
   b. What shape is used in Model 1 to represent an A antigen?

   c. What distinguishes a type A red blood cell from a type B red blood cell?

   d. What distinguishes a type A red blood cell from a type O red blood cell?

2. Refer to the antibodies shown in Model 1.
   a. How many different types of antibodies are shown?

   b. What antibodies are produced by a person with type A blood?

   c. Which antigen would these antibodies fit?
3. Model 1 illustrates what happens when red blood cells are in the presence of the two antibodies. Write a description that explains the complementary relationships between antigens and antibodies.

4. Refer to the second part of Model 1 that illustrates what happens when blood types are mixed. What happens to red blood cells when they are mixed with complementary antibodies?

5. The term agglutination is used to describe what happens to red blood cells when incompatible blood types are mixed.
   a. Define agglutination according to Model 1.
   b. What adverse effects might agglutinated red blood cells have on the body as they travel through veins, arteries, and capillaries?

An antibody is a protein made by the immune system of an organism in response to an antigen (foreign substance). The ability to produce antibodies protects animals from infections due to viruses, bacteria, and other microbes. In the case of blood, the body recognizes other blood types as foreign. For example, a person with type A blood produces anti-B antibodies. This process depends upon the body’s ability to recognize self- and nonself-antigens.

6. Refer to Model 1.
   a. What antigens are self-antigens for a person with type A blood?
   b. What antigens are nonself-antigens for a person with type A blood?
   c. What antigens are self-antigens for type AB blood?

7. A person with type A blood typically would not produce anti-A antibodies. Why is this a benefit to the person?

8. Suppose a person with type A blood needs a blood transfusion after an accident. Blood is received from a donor. Note that the antibodies in the donor blood are not significant. Only the antibodies in the recipient’s blood will be considered. Use the diagrams in Model 1 to complete the following illustrations.
   a. What happens if the donor blood was also type A.
   b. What happens if the donor blood was type B.
   c. What happens if the donor blood was type O.
9. Why would hospitals and blood banks need to be absolutely certain that blood is typed correctly before being used for transfusions?

10. In emergency situations when the supply of blood runs short or when the need for blood is critical, type O blood can be given. Use your knowledge of blood typing from Model 1 to explain why persons with type O blood are called universal donors.

11. Persons with type AB blood, which is rarest, are often referred to as universal recipients. Use your knowledge from Model 1 to explain why people with type AB blood can receive any blood type.

12. People with type O blood are universal donors but can only receive blood from other type O donors. Use your knowledge of blood typing from Model 1 to explain why they cannot receive blood of any other types.

**Extension Questions**

13. People may need a replacement body part for a number of reasons. Currently, the main sources of “new” organs are other human beings. One of the first steps in determining if an available organ will be a match is to know the blood types of the donor and the recipient. Predict what would happen to the recipient and the new organ if this critical step was skipped or done incorrectly. Use the terms antigen and antibody in your explanation.

14. Another marker, Rh factor, is also used to type blood because it, too, is found on human red blood cells and causes antigen/antibody reactions. These reactions are separate from the so-called ABO reactions described in this activity. In the Rh-factor system, the Rh antigen is either present or absent, leading to designations of Rh-positive (Rh+, antigen present) or Rh-negative (Rh−, antigen absent). Thus, a person can be O+ or O−, A+ or A−, and so on. A person with O-negative blood can only receive O− blood. Explain this limitation.
Blood Types – Multiple Alleles and Codominance

Write all possible genotypes for A blood.

Write all possible genotypes for B blood.

Write all possible genotypes for AB blood.

Write all possible genotypes for O blood.

1. Mom has type A blood. Dad has type AB blood. What possible blood types could their children inherit? (Show all possibilities).

2. Mom has type O blood. Dad has type AB blood. What percentage of their kids will inherit type B blood?

3. Mom has type B blood. Dad has type O blood. They have a child with type O blood. Make a punnett square to show what Mom’s genotype must be to have a child with type O blood.
4. A woman sues a man for child support, claiming he is the father of her illegitimate child. The woman is type A blood, the man is type B blood, and the child is type O blood. Show how it is possible for this man to be the father of this child.

5. A woman sues a man for child support, claiming that he is the father of her illegitimate child. The woman is type A, the child is type O, and the man is type AB. Could he be the father of her child? Show why or why not.

6. A wealthy elderly couple dies together in an accident. A man comes forward, claiming that he is their long lost son and is entitled to their fortune. The couple was of blood types AB and O. The man has type O blood. Could he be the heir to the fortune? Show why or why not.

7. John has type O blood. He knows his mother had type B blood. He does not know the identity of his father, however. What possible blood types could his father have had? Show your work.
Inheritance Patterns Review

1. Petal color in carnations is an example of incomplete dominance. In these flowers, the R allele, which codes for an enzyme that makes red pigment, is incompletely dominant over the W allele, which codes for a defective enzyme that cannot make pigment. The heterozygous phenotype is pink flowers. A pink flower is allowed to self-pollinate. What percentage of the offspring is predicted to be pink? Show all of your work.

2. A curly haired (C) person and a straight haired (S) person mate and all their offspring have wavy hair. What would be the result of a cross between two wavy haired individuals? Is this incomplete dominance or codominance?

3. Certain breeds of cattle show a specific pattern in coat color. When pure breeding red cows (C<sup>R</sup>) are bred with pure breeding white cows (C<sup>W</sup>), the offspring are roan (red hairs mixed with white). Summarize the genotypes and phenotypes of the possible offspring when a roan bull is mated with a white cow. Is this incomplete dominance or codominance?

4. Palomino horses are a hybrid showing a golden coat color with a lighter mane and tail. A pair of codominant alleles, D<sub>1</sub> and D<sub>2</sub> is known to be involved in this trait. Horses with D<sub>1</sub>D<sub>1</sub> genotype are chestnut colored, horses with D<sub>1</sub>D<sub>2</sub> genotype are palomino, and horses with D<sub>2</sub>D<sub>2</sub> genotype are white in color.
   a. Two palomino horses are mated, what types of offspring could be produced?
   b. If a palomino horse and a white horse are mated, what types of offspring could be produced?

5. Achondroplasia (dwarfism) is caused by a dominant gene. A woman and a man both with dwarfism marry. If homozygous achondroplasia results in death of embryos, list the genotypes and phenotypes of all potential live-birth offspring. What is the expected ratio of dwarfism to normal offspring?

6. Back fins are dominant on this species of salamander. Could this couple have had this baby? Explain.
7. Mr. Spock’s father, Sarek, was a Vulcan, while his mother was an earth woman. Vulcanians have pointed ears and right sided hearts. Pointed ears (E) are dominant over regular earth-like ears. Right sided hearts (R) are dominant over the earth center heart.
   a. Sarek (assume homozygous dominant) mated with an earth woman, hence Spock! What is the genotype of Spock?
   b. After Spock joined the Enterprise, he became involved in an affair with Ohura, an earth woman. They mated and had a child. What are the possible phenotypes of their child?
   c. If Spock and Ohura continued their hidden romance and had 10 children, how many out of 10 are expected to have pointy ears?

8. Mike has type AB blood. Paul has type O blood. Mike knows that his Mom had type B blood. Show how it could be possible for Mike and Paul to be brothers.

9. Alice has type O blood. Jessica has type B blood. Jessica’s mom had type O blood. Show how it is possible that Jessica and Alice are not sisters.

10. Mom has curly hair and Dad has wavy hair. What kind of hair will their kids have?

11. In a family of four, 1 child has curly hair, 1 child has straight hair, and 2 children have wavy hair. Show what the genotypes of the parents would have to be.

12. Show how it is possible to get a red four o’clock plant and a white four o’clock plant from two pink parents.

13. What are the odds of getting a white four o’clock plant if the parents are pink and white?
11.1 The Work of Gregor Mendel

*Match the term with its definition.*

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. genes</td>
<td>A. Specific characteristics that vary among individuals</td>
</tr>
<tr>
<td>2. hybrids</td>
<td>B. Process in which male and female gametes join to produce a new cell</td>
</tr>
<tr>
<td>3. traits</td>
<td>C. The offspring of true-breeding parents with different traits</td>
</tr>
<tr>
<td>4. alleles</td>
<td>D. Separation of alleles during formation of sex cells</td>
</tr>
<tr>
<td>5. gametes</td>
<td>E. Factors that determine traits</td>
</tr>
<tr>
<td>6. fertilization</td>
<td>F. Sex cells, egg or sperm</td>
</tr>
<tr>
<td>7. principle of dominance</td>
<td>G. Some alleles are dominant, and others are recessive.</td>
</tr>
<tr>
<td>8. segregation</td>
<td>H. The different forms of a gene.</td>
</tr>
</tbody>
</table>

9. Why are peas a good model system for studying heredity? 

10. How did Mendel cross-pollinate flowers? 

11. What is the difference between a gene and an allele? 

12. State the principle of dominance.
The table shows some crosses between true-breeding parents that carry pairs of dominant alleles (such as SS) or pairs of recessive alleles (such as ss). Complete the table to show the combination of alleles in the offspring.

<table>
<thead>
<tr>
<th>Trait</th>
<th>Parent Plants (P Generation)</th>
<th>Offspring (F₁ Generation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed Color</td>
<td>Yellow (YY) X Green (yy)</td>
<td>Yellow</td>
</tr>
<tr>
<td>Seed Coat Color</td>
<td>White (gg) X Gray (GG)</td>
<td>Gray</td>
</tr>
<tr>
<td>Pod Shape</td>
<td>Constricted (ss) X Smooth (SS)</td>
<td>Smooth</td>
</tr>
<tr>
<td>Pod Color</td>
<td>Green (CC) X Yellow (cc)</td>
<td>Green</td>
</tr>
</tbody>
</table>

13. What is the dominant shape of a pea pod? How do you know? ________________________________

14. What symbol represents the recessive allele for pod color? ________________________________

Segregation

15. What is segregation? What is the result of segregation? ________________________________
16. The capital letter \( G \) represents the allele in peas that causes the dominant trait, gray seed coat. The lowercase letter \( g \) represents the recessive allele that causes the recessive trait, white seed coat. *In the circles, show the alleles in the gametes of the parent generation. Show how the alleles recombine in the \( F_1 \) plants.*

The following table shows some Mendelian traits exhibited by Julia and her parents.

<table>
<thead>
<tr>
<th>Trait</th>
<th>Julia’s Dad</th>
<th>Julia’s Mom</th>
<th>Julia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freckles</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Cheek dimples</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Free ear lobes</td>
<td>yes</td>
<td>no</td>
<td>no</td>
</tr>
</tbody>
</table>

*Use the table to answer the questions.*

17. Which statement is true about Julia and her parents? Circle the correct answer.
   a. They all have at least one dominant allele for freckles.
   b. They all have at least one dominant allele for cheek dimples.
   c. They all have at least one dominant allele for free ear lobes.

18. In the future, Julia will marry a man with freckles. However, her daughter will not have freckles. How is that possible?  

__________________________________________________________________________

__________________________________________________________________________
Probability Questions:

19. The diagram shows a spinner made up of a piece of card in the shape of a regular pentagon, with a toothpick pushed through its center. The five triangles are numbered from 1 to 5.

   The spinner is spun until it lands on one of the five edges of the pentagon. What is the probability that the number it lands on is odd?

20. Each of the letters of the word MISSISSIPPI are written on separate pieces of paper that are then folded, put in a hat, and mixed thoroughly. One piece of paper is chosen (without looking) from the hat. What is the probability it is an I?

21. There are 10 counters in a bag: 3 are red, 2 are blue and 5 are green. The contents of the bag are shaken before Maxine randomly chooses one counter from the bag. What is the probability that she doesn't pick a red counter?

22. A special die is made in the shape of an octahedron. The die has 8 equal faces marked with the numbers 1 to 8. If the die is thrown once, what is the probability that the face that lands uppermost has a prime number?

23. A card is chosen at random from a deck of 52 playing cards. What is the probability it is a Queen or a King?
11.2 Applying Mendel’s Principles

The chart below shows key terms from the lesson with their definitions.

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genetic makeup</td>
<td>Organism that has different alleles for a gene</td>
</tr>
<tr>
<td>Organism</td>
<td>Organism that has two identical alleles for a gene</td>
</tr>
<tr>
<td>Genes for different traits</td>
<td>Genes for different traits segregate independently when gametes are formed</td>
</tr>
<tr>
<td>segregate</td>
<td>Physical traits</td>
</tr>
<tr>
<td></td>
<td>The likelihood that a particular event will occur</td>
</tr>
<tr>
<td></td>
<td>Diagram that can be used to predict the offspring of a genetic cross</td>
</tr>
</tbody>
</table>

**Probability and Punnett Squares**

1. What is probability?

2. In a parent pea plant with genotype *Gg*, what is the probability that one gamete will have the *G* allele? ____

3. Complete the table to define the characteristics of homozygous and heterozygous genotypes and phenotypes.

<table>
<thead>
<tr>
<th></th>
<th>Homozygous</th>
<th>Heterozygous</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Genotype</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Phenotype</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*For the following questions, match the term with its description.*

______ 4. Determine traits

______ 5. Can be two of these in one gene

______ 6. Allele that is expressed

______ 7. Where genes come from

______ 8. What genes do during gamete formation

A. parents

B. alleles

C. dominant

D. segregate

E. genes
Table A lists some characteristic of pea plants. Write Ph in the right column if the characteristic describes a phenotype. Write Ge if the characteristic is a genotype. Table B lists some genotypes of pea plants. Write He in the right column if the genotype is heterozygous. Write Ho if the genotype is homozygous.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Phenotype or Genotype?</th>
</tr>
</thead>
<tbody>
<tr>
<td>tall</td>
<td></td>
</tr>
<tr>
<td>short</td>
<td></td>
</tr>
<tr>
<td>Tt</td>
<td></td>
</tr>
<tr>
<td>TT</td>
<td></td>
</tr>
<tr>
<td>yellow seed</td>
<td></td>
</tr>
<tr>
<td>color</td>
<td></td>
</tr>
<tr>
<td>yy</td>
<td></td>
</tr>
<tr>
<td>Yy</td>
<td></td>
</tr>
<tr>
<td>rr</td>
<td></td>
</tr>
</tbody>
</table>

Table B

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Heterozygous or Homozygous?</th>
</tr>
</thead>
<tbody>
<tr>
<td>RR</td>
<td></td>
</tr>
<tr>
<td>tt</td>
<td></td>
</tr>
<tr>
<td>Rr</td>
<td></td>
</tr>
<tr>
<td>Tt</td>
<td></td>
</tr>
<tr>
<td>YY</td>
<td></td>
</tr>
<tr>
<td>Yy</td>
<td></td>
</tr>
<tr>
<td>Gg</td>
<td></td>
</tr>
<tr>
<td>gg</td>
<td></td>
</tr>
</tbody>
</table>

9. The dominant allele for smooth pod shape in peas is S. The recessive allele for constricted pod shape is s. In the Punnett square, show the result of crossing two heterozygous parents (Ss). Write the genotype and the phenotype of each type of offspring in the space provided.

<table>
<thead>
<tr>
<th></th>
<th>S</th>
<th>s</th>
</tr>
</thead>
</table>
| S | Genotype: _______ | Genotype: _______
|   | Phenotype: _______ | Phenotype: _______
| s | Genotype: _______ | Genotype: _______
|   | Phenotype: _______ | Phenotype: _______

For the following questions, refer to the Punnett square above.

10. What is the probability of a heterozygous offspring? ________________________________

11. What is the probability of a homozygous offspring? ________________________________

12. What is the probability of a homozygous recessive offspring? __________________________

13. What is the probability of a smooth phenotype? ________________________________

14. What is the probability of a homozygous recessive individual (ss) producing a gamete with a dominant allele (S)? Explain. __________________________________________________________________________
Independent Assortment

15. State the principle of independent assortment: ____________________________________________

16. Using the principle of independent assortment, complete the Punnett square to show the results of an F1 cross between two individuals heterozygous for both seed color (G = green and g = yellow) and seed shape (R = round and r = wrinkled). The gametes and some of the genotypes of the F2 offspring are given.

<table>
<thead>
<tr>
<th></th>
<th>GR</th>
<th>gR</th>
<th>Gr</th>
<th>gr</th>
</tr>
</thead>
<tbody>
<tr>
<td>GR</td>
<td>GRR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>gR</td>
<td></td>
<td></td>
<td>ggR</td>
<td></td>
</tr>
<tr>
<td>Gr</td>
<td></td>
<td>GGrr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>gr</td>
<td></td>
<td>ggR</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For the following questions, refer to the Punnett square above.

17. Which genotype belongs to an offspring that is homozygous recessive for both traits? What is the probability of that genotype? ____________________________________________

18. What is the phenotype of an individual heterozygous for both traits? __________________________

19. What is the probability of an F2 offspring having the green seed color and round seed shape? Show all possible genotypes. __________________________

20. The Punnett square predicts a 9:3:3:1 ratio for phenotypes. Explain what that ratio means. ________________

Summary of Mendel’s Principles

For the following questions, complete each statement by writing the correct word or words

21. The units that determine the inheritance of biological characteristics are __________________________.

22. A form of a gene is a(n) __________________________.

23. If two or more forms of a gene exist, some may be dominant and others may be __________________________.

24. The offspring of most sexually reproducing organisms have two copies of each gene. One comes from each __________________________.

25. Alleles from different genes usually __________________________ independently from each other when gametes form.
11.3 Other Patterns of Inheritance

Beyond Dominant and Recessive Alleles

1. Complete the graphic organizer to summarize exceptions to Mendel's principle.

Mendel’s experiments cannot predict the outcome of traits that involve

- Incomplete dominance  
  Example: Speckled chicken feathers from solid-color-feather parents

- Multiple alleles  
  Example: Variety of skin color in humans

For Questions 2–8, write True if the statement is true. If the statement is false, change the underlined word to make the statement true.

2. When offspring show a blend of the parents’ traits, one allele is dominant over the other.

3. In complete dominance, the heterozygous phenotype lies somewhere between the two homozygous phenotypes.

4. A heterozygous individual that exhibits the traits of both parents is an example of codominance.

5. Many genes exist in several forms and are said to have codominant alleles.

6. While multiple alleles may exist in a population, an individual usually carries only two alleles for each gene.

7. Traits produced by two or more genes are codominant.

8. Polygenic traits often show a wide range of phenotypes.

9. A plant breeder produced a purple flower by crossing a red parent with a blue parent. Use $RR$ as the genotype for the red parent and $BB$ for the blue parent. Complete the Punnett square to show the resulting genotypes and phenotypes of the offspring.

<table>
<thead>
<tr>
<th>Gamete allele</th>
<th>Gamete allele</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gamete allele:</strong></td>
<td><strong>Gamete allele:</strong></td>
</tr>
<tr>
<td>$RR$</td>
<td>$BB$</td>
</tr>
<tr>
<td>Genotype: ________</td>
<td>Genotype: ________</td>
</tr>
<tr>
<td>Phenotype: ________</td>
<td>Phenotype: ________</td>
</tr>
</tbody>
</table>
For Questions 10–11, refer to the Punnett square above.

10. What type of inheritance is the example in Question 9?

11. If the offspring had been red and blue spotted flowers, what kind of inheritance would be most likely?

12. Explain the difference between multiple alleles and polygenic traits.

Genes and the Environment: complete each statement by writing in the correct word or words.

13. An organism’s results from its genotype and its environment.

14. Some produce variable traits depending on environmental conditions.

15. Western white butterflies vary in their wing color because their varies depending on when they hatch.

16. is an environmental variable that affects wing color in western white butterflies.

For each of the following examples, write G if the trait is determined by genotype, and E if it is by environment.

17. Turtles whose eggs hatch at higher temperatures tend to be female.

18. A blue-eyed girl is born to two blue-eyed parents.

19. Bees in a colony are assigned different jobs. As they develop, workers begin to look dramatically different.

20. A pair of twins is separated at birth. They grow up in different countries and speak different languages.

21. A litter of puppies is born. They are all gray except one, which is brown.

22. Tall pea plant seeds are planted in different locations around a yard. They produce plants of different heights.

23. A kitten is born with six toes.
## Chapter 11 Word Game

1. Organism produced by crossing parents that have different traits
2. Genetic make-up
3. Containing a single set of chromosomes
4. Structures in chromosomes that control characteristics
5. Fertilization of egg cells by pollen from the same plant
6. Biological inheritance
7. Diagram that indicates all possible genotypes of a genetic cross
8. Containing two sets of chromosomes
9. Different forms of a gene
10. The study of heredity
11. Separation of alleles
12. Another word for characteristics
13. Allele that is hidden by a dominant allele
14. Exchange of genes between homologous chromosomes
15. Fertilization of egg cells by pollen from a different plant
16. Another word for homozygous
17. Reproductive cells
18. Allele that prevents the expression of a recessive allele
19. Process of reduction division
20. Physical characteristics that result from heredity
21. Having two different alleles for the same trait

**Arrange the letters that are in the colored boxes to complete this statement:**

The principle that states that the inheritance of a gene for one trait does not affect the inheritance of the gene for another trait.