Biology
Mendel and Heredity
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Chapter 8: Mendel and Heredity

Use the glossary and don’t shorten the definition. If a page number is listed, use that page to define the term.

Section 1: The Origins of Genetics

1. heredity –

2. genetics –

3. monohybrid cross –

4. true-breeding –

5. P generation or parental generation –

6. F₁ generation or first filial generation –

7. F₂ generation or second filial generation –

Section 2: Mendel’s Theory

8. allele –

9. dominant (167) –

10. recessive –

11. homozygous –

12. heterozygous –

13. genotype –
14. phenotype –

15. law of segregation –

16. law of independent assortment –

Section 3: Studying Heredity
17. Punnett square –

18. test cross –

19. probability (173) –

20. pedigree –

21. sex-linked gene (175) –

Section 4: Complex Patterns of Heredity
22. polygenic inheritance –

23. incomplete dominance –

24. multiple alleles –

25. codominance –
PowerPoint Notes on Chapter 8 – Mendel and Heredity

Section 1: The Origins of Genetics

Objectives
- Identify the investigator whose studies formed the basis of modern genetics.
- List characteristics that make the garden pea a good subject for genetic study.
- Summarize the three major steps of Gregor Mendel’s garden pea experiments.
- Relate the ratios that Mendel observed in his crosses to his data.

Mendel’s Studies of Traits
- Many of your traits, including the ________________ and shape of your eyes, the ________________ of your hair, and even your height and weight, resemble those of your ____________________.
- The passing of traits from parents to offspring is called ____________________.

Mendel’s Breeding Experiments
- The scientific study of heredity began more than a century ago with the work of an Austrian monk named ____________________________________________.
- Mendel was the first to __________________________________________ that accurately ________________ patterns of heredity.
- The patterns that Mendel discovered form the basis of ____________________, the branch of biology that focuses on ______________________.
- Mendel experimented with ____________________ heredity by ____________-_________________________ plants with different characteristics.

Useful Features in Peas
- The garden pea is a good subject for studying heredity for several reasons:
  1. Several __________________ of the garden pea exist in two clearly _____________ forms.
  2. The male and female __________________ parts of garden peas are ________________ within the same flower. This allows you to easily ________________________________.
  3. The garden pea is ________________, grows __________________, matures __________________, and produces many ____________________.

Traits Expressed as Simple Ratios
- Mendel’s initial experiments were ____________________________________________.
- A __________________________ is a cross that involves one pair of ____________________________.
- For example, crossing a plant with ________________ flowers and a plant with ________________ flowers is a monohybrid cross.
- Mendel carried out his experiments in three steps:
  **Step 1** Mendel allowed each variety of garden pea to ____________________________
for several generations to ensure that each variety was____________________-
_________________________________ for a particular trait; that is, all the offspring would display only ____________________________
____________________________. These true-breeding plants served as the
____________________________ generation in Mendel’s experiments. The
parental generation, or _____________________________, are the first two
individuals that are ___________________________ in a breeding experiment.

**Step 2** Mendel then ____________________ - __________________ two P generation
plants that had __________________________ forms of a trait, such as purple
flowers and white flowers. Mendel called the offspring of the P generation the
________________________________, or ___________________________.

**Step 3** Mendel allowed the ___________________________ to __________
_________________________. He called the offspring of the F1 generation
plants the ____________________________, or ___________________________.

**Mendel’s Results**
- Each of Mendel’s __________________________ showed only ________ form of the trait.
- But when the F1 generation was allowed to __________ - _________________, the
  missing trait _______________________ in some of the plants in the _____ generation.
- For each of the seven traits Mendel studied, he found a ________ ratio of plants
  expressing the ___________________________ traits in the F2 generation.

**Section 2: Mendel’s Theory**

**Objectives**
- Describe the four major hypotheses Mendel developed.
- Define the terms homozygous, heterozygous, genotype, and phenotype.
- Compare Mendel’s two laws of heredity.

**A Theory of Heredity**

- Mendel correctly concluded from his experiments that each pea has _______ separate
  “_________________________________” for each trait—one from each _________.
- When _____________________ (sperm and egg cells) form, each receives only one of
  the organism’s ________ factors for each __________________.
- When gametes fuse during ____________________________, the offspring has two
  factors for each trait, one from each parent. Today these factors are called ________.

**Mendel’s Hypotheses**

- The four __________________________ Mendel developed as a result of his experiments
  now make up the Mendelian theory of heredity—the foundation of ____________________.
  1. *For each inherited __________________, an individual has two __________________ of
1. The gene—one from each _____________________.

2. There are alternative versions of _________________. Today the different versions of a gene are called its ___________________.

3. When two ___________________ alleles occur together, one of them may be completely ________________, while the other may have no ___________________________ effect on the organism’s _____________________________.

   Mendel described the __________________________ form of the trait as dominant.
   The trait that was ____________________________ when the dominant form of the trait was present was described as ____________________________.

4. When gametes are formed, the alleles for each gene in an individual separate ____________________________ of one another. Thus, gametes carry only ______ allele for each inherited trait. When gametes unite during ________________, each gamete contributes one allele.

Mendel’s Findings in Modern Terms

- _____________________ alleles are indicated by writing the _________________ letter of the trait as a _____________________ letter.
- _____________________ alleles are also indicated by writing the first letter of the _____________________ trait, but the letter is _____________________________.
- If the two ______________________ of a particular gene present in an individual are the _____________________, the individual is said to be ____________________________.
- If the ______________________ of a particular gene present in an individual are _________________, the individual is ____________________________.
- In ______________________ individuals, only the dominant allele is _________________; the recessive allele is present but ____________________________.
- The set of alleles that an individual has is called its ____________________________.

   Example:
   The physical appearance of a trait is called a _________________________.
   Example:
   _________________ is determined by which alleles are _________________________.

The Laws of Heredity

- The Law of Segregation
  - The first law of heredity describes the behavior of chromosomes during _______.
  - At this time, homologous chromosomes and then chromatids are _________________.
  - The first law, the ____________________________, states that the two __________________ for a trait ___________________ (separate) when gametes are formed.
The Law of Independent Assortment
- Mendel found that for the traits he studied, the ____________________________ of one trait ___________________ influence the inheritance of any other ____________________________.
- The **law of independent assortment** states that the alleles of ________________ genes separate _____________________________ of one another during gamete formation.

**Section 3: Studying Heredity**
**Objectives**
- Predict the results of monohybrid genetic crosses by using Punnett squares.
- Apply a test cross to determine the genotype of an organism with a dominant phenotype.
- Predict the results of monohybrid genetic crosses by using probabilities.
- Analyze a simple pedigree.

**Punnett Squares**
- A ________________________________ is a diagram that predicts the outcome of a genetic cross by considering all possible _____________________________ of __________________________ in the cross.
- The possible gametes that one parent can produce are written along the ________ of the square. The possible gametes that the other parent can produce are written along the ____________ side of the square.
- Each box inside the square is filled in with two letters obtained by combining the ________________ along the _____________ of the box with the ________________ along the _____________ of the box.

**One Pair of Contrasting Traits**
- Punnett squares can be used to __________________________ the outcome of a ________________________________ cross (a cross that considers one pair of contrasting traits between two individuals).
- Punnett squares allow direct and simple __________________________ to be made about the outcomes of genetic crosses.

**Determining Unknown Genotypes**
- Animal breeders, horticulturists, and others involved in breeding organisms often need to know whether an organism with a dominant phenotype is ___________________________ or __________________________ for a trait.
- In a ______________________________, an individual whose phenotype is ________________, but whose genotype is ________________________________, is crossed with a ________________________________ individual.
Outcomes of Crosses
- Like Punnett squares,.............................. can be used to predict the results of genetic crosses.
- ____________________________ is the likelihood that a specific event will occur.

\[
\text{Probability} = \frac{\text{number of one kind of possible outcome}}{\text{total number of all possible outcomes}}
\]

Probability of Specific Allele in a Gamete
- Consider the possibility that a coin tossed into the air will land on heads (one possible outcome). The total number of all possible outcomes is two—heads or tails. Thus, the probability that a coin will land on heads is ____________.
- The same formula can be used to predict the probability of an_______________ being present in a ____________________.

Probability of the Outcome of a Cross
- Because two parents are involved in a ____________________________, both parents must be considered when calculating the probability of the ____________________ of a genetic cross.
- To find the probability that a combination of two ____________________ events will occur, multiply the ______________________ probabilities of the two events.

Inheritance of Traits
- Geneticists often prepare a ____________________________, a family history that shows how a ________________ is inherited over several ____________________________.
- Pedigrees are particularly helpful if the trait is a ____________________________ and the family members want to know if they are ________________ or if their children might get the disorder.

Pedigree (Video clip)
- A pedigree is a diagram that shows the occurrences of genetic traits in several generations of a family.
  - □ = male
  - ○ = female
  - Lines connect parents to offspring.
  - Filled circles and squares indicate that the person has a certain trait. ■ ●
  - Half filled circles and squares indicate that the person is a carrier of the trait.
Scientists can determine several pieces of genetic information from a pedigree:

Autosomal?

Sex-linked?

Dominant?

Recessive?

Heterozygous?

Homozygous?

Section 4: Complex Patterns of Heredity
Objectives
- Identify five factors that influence patterns of heredity.
- Describe how mutations can cause genetic disorders.
- List two genetic disorders, and describe their causes and symptoms.
- Evaluate the benefits of genetic counseling.

Complex Control of Characters
Characters Influenced by Several Genes
- When several genes influence a trait, the trait is said to be a ___________________ ____________________
  ________________.
- The genes for a polygenic trait may be scattered along the ____________ chromosome or located on ________________ chromosomes.
- Familiar examples of polygenic traits in humans include ___________________, height, ________________, and hair and __________________________.

Intermediate Characters
- In some organisms, however, an individual displays a trait that is ___________________ between the two parents, a condition known as ________________________________.
- For example, when a snapdragon with __________ flowers is crossed with a snapdragon with ________________ flowers, a snapdragon with ________________ flowers is produced.
Characters Controlled by Genes with Three or More Alleles

- Genes with ____________ or more alleles are said to have ____________________________.
- Even for traits controlled by genes with _____________________ alleles, an individual can have only ___________ of the possible __________________ for that gene.

Characters with Two Forms Displayed at the Same Time

- For some traits, two _____________________ alleles are expressed at the __________ time.
- In this case, both forms of the trait are displayed, a phenomenon called ____________________________.
- _____________________________ is different from ______________________________ dominance because both traits are ______________________________.

Characters Influenced by the Environment

- An individual's __________________________ often depends on ____________________________ in the environment.
- Because identical ______________ have identical __________________, they are often used to study environmental ____________________________.
- Because identical twins are genetically ____________________________, any ____________________________ between them are attributed to environmental influences.

Genetic Disorders

Sickle Cell Anemia

- An example of a __________________________ genetic disorder is sickle cell ____________, a condition caused by a __________________________ allele that produces a defective form of the protein ____________________________.
- In sickle cell anemia, the defective form of ____________________________ causes many __________________________ to bend into a __________________________ shape.
- The recessive allele that causes sickle-shaped red blood cells helps ______________ the cells of heterozygous individuals from the effects of ____________________________.

Cystic Fibrosis (CF)

- Cystic fibrosis, a fatal __________________________ trait, is the most common fatal hereditary disorder among ____________________________.
- One in 25 Caucasian individuals has at least one copy of a defective gene that makes a ____________________________ necessary to pump __________________________ into and out of cells.
- The airways of the lungs become __________________________ with thick ____________________________, and the ducts of the liver and __________________________ become blocked.
Hemophilia

- Another recessive genetic disorder is hemophilia, a condition that impairs the blood’s ability to ________________.
- Hemophilia is a __________-________________ trait.
- A mutation on one of more than a dozen genes coding for the __________________ involved in blood clotting on the _____ chromosome causes the form of hemophilia called ____________________________.

Huntington’s Disease (HD)

- Huntington’s disease is a genetic disorder caused by a __________________ allele located on an ____________________________.
- The first symptoms of HD—mild ____________________________ and ____________________________ appear in victims in their __________ or ________________.
- In time, HD causes loss of muscle ________________________________, uncontrollable physical ____________________________, severe mental illness, and eventually ____________________________.

Treating Genetic Disorders

- Most genetic disorders ________________ be cured, although progress is being made.
- A person with a family history of genetic disorders may wish to undergo ____________________________ before becoming a ________________.
- In some cases, a genetic disorder can be treated if it is ____________________________ early enough.

Gene Therapy

- ____________________________ may soon allow scientists to correct certain ________________ genetic disorders by replacing ____________________________ genes with copies of ____________________________ ones, an approach called gene therapy.
- The essential first step in gene therapy is to ____________________________ a copy of the gene.
Chapter 8 Questions

Section 1 The Origins of Genetics – Pages 162-165

1. What species (scientific name) does the book say Mendel used for his experiments?

2. What was Mendel first to develop?

3. How were Mendel’s experiments different from T.A. Knights?

4. List 3 reasons why the garden pea is a good subject for studying heredity:
   a. 
   b. 
   c. 

5. What does true-breeding mean?

6. What is an example of true-breeding?

7. Explain what Mendel did in his breeding experiment and describe the results.
   **Step #1**
   
   Result:

   **Step #2**
   
   Result:

   **Step #3**
   
   Result:
8. **Math Lab: Calculating Mendel’s Ratios.** Calculate the ratio for each contrasting trait. Divide the larger number (2\text{nd} column) by the smaller number (3\text{rd} column).

<table>
<thead>
<tr>
<th>Contrasting traits</th>
<th>(F_2) generation results</th>
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<tbody>
<tr>
<td>Flower color</td>
<td>705 purple</td>
<td>224 white</td>
</tr>
<tr>
<td>Seed color</td>
<td>6,022 yellow</td>
<td>2,001 green</td>
</tr>
<tr>
<td>Seed shape</td>
<td>5,474 round</td>
<td>1,850 wrinkled</td>
</tr>
<tr>
<td>Pod color</td>
<td>428 green</td>
<td>152 yellow</td>
</tr>
<tr>
<td>Pod shape</td>
<td>882 round</td>
<td>299 constricted</td>
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<tr>
<td>Flower position</td>
<td>651 axial</td>
<td>207 top</td>
</tr>
<tr>
<td>Plant height</td>
<td>787 tall</td>
<td>277 dwarf</td>
</tr>
</tbody>
</table>

9. Interpret the results of the math lab. Do the data confirm a 3:1 ratio in the \(F_2\) generation for each of the traits he studied?

**Section 2 Mendel’s Theory – Pages 166-169**

1. Give an example of the blending hypothesis that Mendel disproved.

2. What are the four hypotheses of Mendel’s theory of heredity?
   a. .
   b. .
   c. .
   d. .

3. What are alleles?

4. Which allele is always expressed if present? Dominant or Recessive

5. How many alleles does each gamete contribute at fertilization?

6. How do geneticists represent dominant alleles?
7. How do geneticists represent recessive alleles?

8. What term is applied when 2 alleles of a particular gene in an individual are the same?

9. What term is applied when 2 alleles of a particular gene in an individual are different?

10. Which allele is expressed in heterozygous individuals?

11. What is the phenotype of a rabbit with a genotype Bb, where B = black coat and b = brown coat?

12. What is the phenotype of a rabbit with a genotype bb, where B = black coat and b = brown coat?

13. What does the Law of Segregation state?

14. What does the Law of Independent Assortment state?

Section 3 Studying Heredity – Pages 170-176.

1. For what are Punnett squares used?

2. How do animal breeders and horticulturists use Punnett squares?

3. Explain how a test cross is done.

4. What four ways are probability expressed?
   a. 
   b. 
   c. 
   d. 

5. What are carriers?

6. Why are Dalmatians sometimes born deaf? Real Life box on p. 175

7. On what chromosomes are sex-linked genes found?
8. Why do men tend to always exhibit sex-linked traits when they have them?

Section 4 Complex Patterns of Heredity – Pages 177-182.

1. What are 3 examples of polygenic traits?
   a. 
   b. 
   c. 

2. What is an example of incomplete dominance?

3. What is an example of codominance?

4. What are 3 characteristics influenced by the environment?
   a. 
   b. 
   c. 

5. How does sickle cell anemia affect people?

6. With what frequency does sickle cell anemia occur in human births? What race?

7. How does cystic fibrosis affect people?

8. With what frequency does cystic fibrosis occur in human births? What race?

9. How does Huntington’s disease affect people?
Section: The Origins of Genetics

Read the passage below. Then answer the questions that follow.

Mendel's initial experiments were monohybrid crosses. A monohybrid cross is a cross that involves one pair of contrasting traits. For example, crossing a plant with purple flowers and a plant with white flowers is a monohybrid cross. Mendel carried out his experiments in three steps.

**Step 1:** Mendel allowed each variety of garden pea plants to self-pollinate for several generations. This method ensured that each variety was true-breeding for a particular trait; that is, all the offspring would display only one form of a particular trait. For example, a true-breeding purple-flowering plant should produce only plants with purple flowers in subsequent generations.

These true-breeding plants served as the parental generation in Mendel’s experiments. The parental generation, or **P generation**, are the first two individuals that are crossed in a breeding experiment.

**Step 2:** Mendel then cross-pollinated two P generation plants that had contrasting forms of a trait such as purple and white flowers. Mendel called the offspring of the P generation the first filial generation, or **F₁ generation**. He then examined each F₁ plant and recorded the number of F₁ plants expressing each trait.

**Step 3:** Finally, Mendel allowed the F₁ generation to self-pollinate. He called the offspring of the F₁ generation plants the second filial generation, or **F₂ generation**. Again, each F₂ plant was characterized and counted.

**SKILL: READING EFFECTIVELY**

**Read each question, and write your answer in the space provided.**

1. The prefix *mono-* means “one.” How does this apply to the key term *monohybrid cross*?

2. What information does the third sentence tell the reader?
3. Describe the offspring of a true-breeding white-flowering plant.

4. What is the P generation?

5. What does the term $F_1$ generation refer to?

SKILL: INTERPRETING GRAPHICS

The figure below shows three generations of plants. Insert the following labels in the spaces provided: cross-pollination, $F_1$, $F_2$, $P$, self-pollination.

6. ______ generation  7. ______ generation  8. ______ generation

9. ______  10. ______

In the space provided, write the letter of the phrase that best completes the statement.

11. During the course of his experiment, Mendel studied traits in
   a. one generation of plants.
   b. two generations of plants.
   c. three generations of plants.
   d. more than five generations of plants.
Section: Mendel’s Theory

Read the passage below. Then answer the questions that follow.

Geneticists have developed specific terms and ways of representing an individual’s genetic makeup. Letters are often used to represent alleles. Dominant alleles are indicated by writing the first letter of the trait as a capital letter. Recessive alleles are also indicated by writing the first letter of the dominant trait, but the letter is lowercase.

If two alleles of a particular gene present in an individual are the same, the individual is said to be **homozygous** for that trait. If the alleles of a particular gene present in an individual are different, the individual is **heterozygous** for that trait.

**SKILL: READING EFFECTIVELY**

Read each question, and write your answer in the space provided.

1. How are dominant alleles often represented?

2. How are recessive alleles often represented?

3. A particular plant is said to be homozygous for seed color. What does this mean?

4. Another plant is said to be heterozygous for flower color. What does this mean?
5. The allele for yellow peas is dominant to the allele for green peas. How would you represent the alleles of a plant that is heterozygous for seed color?

6. The allele for purple flowers is dominant to the allele for white flowers. How would you represent the alleles of a plant that is homozygous recessive for flower color?

7. How would you represent the alleles of a plant that is heterozygous for flower color?

In the space provided, write the letter of the phrase that best completes the statement.

8. A plant with YY alleles for seed color is
   a. heterozygous dominant for this trait.
   b. homozygous dominant for this trait.
   c. homozygous recessive for this trait.
   d. Either (a) or (b)
Section: Studying Heredity

Read the passage below. Then answer the questions that follow.

A **Punnett square** is a diagram that predicts the expected outcome of a genetic cross by considering all possible combinations of gametes in the cross. Named for its inventor, Reginald Punnett, the Punnett square in its simplest form consists of four boxes inside a square. The possible gametes that one parent can produce are written along the top of the square. The possible gametes that the other parent can produce are written along the left side of the square. Each box inside the square is filled with two letters obtained by combining the allele along the top of the box with the allele along the side of the box. The letters in the boxes indicate the possible genotypes of the offspring.

**SKILL: READING EFFECTIVELY**

Read each question, and write your answer in the space provided.

1. What information does the first sentence tell the reader?

2. What do letters written along the top and left side of a Punnett square represent?

3. How is the combination of letters inside each square determined?

4. What do the letters in the boxes indicate?

5. What data did Mendel obtain when he examined each F₁ plant?
SKILL: ORGANIZING INFORMATION

The figure below shows a Punnett square. It shows a cross between two pea plants that are heterozygous for seed color. Use the Punnett square to answer the questions that follow. Write your answers in the spaces provided.

6. What pair of letters should appear in Box 1?

7. What pair of letters should appear in Box 4?

8. How many homozygous dominant offspring would be produced?

9. How many homozygous recessive offspring would be produced?

10. How many heterozygous offspring would be produced?

11. How many of the offspring would have green seeds?

12. How many of the offspring would have yellow seeds?

In the space provided, write the letter of the term or phrase that best completes the statement.

13. Each box inside a Punnett square represents one
   a. allele.                  c. dominant trait.
   b. parent.                d. offspring.
Section: Complex Patterns of Heredity

Read the passage below. Then answer the questions that follow.

Genes with three or more alleles are said to have multiple alleles. When traits are controlled by genes with multiple alleles, an individual can have only two of the possible alleles for that gene. For example, in the human population, the ABO blood groups (blood types) are determined by three alleles, \( I^A \), \( I^B \), and \( i \). The letters \( A \) and \( B \) refer to two carbohydrates on the surface of red blood cells. The \( i \) allele means that neither carbohydrate is present. The \( I^A \) and \( I^B \) alleles are both dominant over \( i \), which is recessive. But neither \( I^A \) nor \( I^B \) is dominant over the other. When \( I^A \) and \( I^B \) are both present in the genotype, they are codominant.

SKILL: READING EFFECTIVELY

Read each question, and write your answer in the space provided.

1. What information does the first sentence convey to the reader?

2. Why does the term blood types appear in parentheses in the third sentence of this passage?

3. What do the letters \( A \) and \( B \) refer to in the alleles \( I^A \) and \( I^B \)?

4. What allele is dominant for human blood type? What allele is recessive for this trait?

5. What causes an individual to show both the \( I^A \) and \( I^B \) forms of the trait for human blood type?
In the space provided, write the letter of the phrase that best completes the statement.

_____ 6. In humans, the $i$ allele for blood type means that
   a. one kind of carbohydrate is on the surface of red blood cells.
   b. two kinds of carbohydrates are on the surface of red blood cells.
   c. more than three kinds of carbohydrates are on the surface of red blood cells.
   d. neither carbohydrate is present on the surface of red blood cells.

In the space provided, write the letter of the term or phrase that best completes each statement or best answers each question.

_____ 1. When several genes influence a trait, the trait is said to be
   a. polygenic.
   b. incompletely dominant.
   c. codominant.
   d. completely dominant.

_____ 2. Which of the following patterns of heredity can result in an intermediate trait, such as pink snapdragon flowers?
   a. multiple alleles
   b. incomplete dominance
   c. codominance
   d. sex-linked alleles

_____ 3. Which of the following is responsible for the color of hydrangea flowers, which depends on the pH of the soil in which they are grown?
   a. multiple alleles
   b. incomplete dominance
   c. codominance
   d. environmental conditions

_____ 4. Which of the following genetic disorders is caused by a sex-linked allele?
   a. sickle cell anemia
   b. hypercholesterolemia
   c. hemophilia A
   d. Tay-Sachs disease

In the space provided, write the letter of the description that best matches the term or phrase.

_____ 5. sickle cell anemia
   a. determine the different ABO blood types
   b. caused by a mutated allele that results in a defective hemoglobin protein
   c. caused by a dominant allele located on an autosome
   d. changes in DNA that can cause genetic disorders
   e. informing people about genetic problems they or their offspring might have
   f. replacing defective genes with copies of healthy genes, using gene technology

_____ 6. Huntington's disease

_____ 7. gene therapy

_____ 8. genetic counseling

_____ 9. mutation

_____ 10. multiple alleles