Exceptions to Mendelian Genetics

Standard B-4.7
Summarize the chromosome theory of inheritance and relate that theory to Gregor Mendel’s principles of genetics.
Key Concepts

- Chromosome theory of inheritance
- Gene linkage, crossing over
- Incomplete dominance, Codominance
- Multiple alleles, Polygenic traits
- Sex-linked traits, Sex-linked genes
What You Already Know...

This concept has NOT been addressed in previous grades. Therefore it is BRAND NEW INFORMATION.
You MUST Understand

• The Chromosome Theory of Inheritance.
• The principles of Mendelian Genetics support this theory.
• There have been new discoveries since Mendel’s time, which are covered in this lesson.
OBJECTIVES

- **Describe** patterns of inheritance in sex-linked traits.
- **Describe** different types of allele interactions.
- **Explain** how linkage maps can be used to estimate distance between genes.
Vocabulary

1. Sex-linked genes
2. Incomplete dominance
3. Codominance
4. Polygenic trait
According to Mendel...

- Genes can be either dominant or recessive.

- They do not mix to form the phenotype.
Since Mendel’s Time...

Due to advances in technology since Mendel’s time, inheritance patterns and genetic variations that could not be explained by Mendelian genetics are now understood using the Chromosome Theory of Inheritance. There are many new developments.

- Incomplete Dominance
- Gene Linkage
- Crossing Over
- Codominance
- Multiple Alleles
- Polygenic Traits
- Sex-linked Traits
1. Gene expression is often related to whether a gene is located on an **autosome** or on a **sex chromosome**.

2. **Sex chromosomes** determines an organism’s sex but **autosomes** do not play a direct role in sex determination.

3. Many human genetic disorders are also caused by **autosomal genes**.

4. The genes that affect your hair texture are **autosomal genes**.

5. Many human **genetic disorders** are caused by autosomal genes.
6. Is a carrier homozygous or heterozygous?

7. Dominant genetic disorders are far less common than recessive disorders.

8. The expression of genes on the sex chromosomes differs from the expression of autosomal genes.

9. Genes located on the sex chromosomes are sex linked genes.

10. Genes on the Y chromosome are responsible for the development of male offspring. The x chromosome has much more influence over phenotype.
1. Incomplete dominance occurs when a heterozygous phenotype is somewhere between the two homozygous phenotypes. Give an example and describe the cross.

a. Four o’clock plants – red flower crossed with white flower – offspring is a pink flower

b. Beta fish – green fish crossed with steel blue – offspring is a royal color.
Incomplete Dominance

- There are 2 different dominant genes.
- A heterozygote is intermediate b/w the two homozygotes.
- Genotypes designated as:
  \[ BB = \text{blue} \quad B' B' = \text{green} \quad BB' = \text{blue-green} \]
Phenotype can depend on interactions of alleles.

- In incomplete dominance, neither allele is completely dominant nor completely recessive.
  - Heterozygous phenotype is intermediate between the two homozygous phenotypes
  - Homozygous parental phenotypes not seen in F1 offspring
2. Alleles show **codominance** in which both traits are fully and separately expressed. A and B blood types is an example of **codominance**.

3. This trait is also considered a **multiple allele** trait.

4. A pair of codominant alleles or multiple alleles can produce **3** different phenotypes.

**Blood types can produce 4 phenotypes and 6 genotypes**
Codominance

- There are 2 different dominant genes.
- A heterozygote shows both other possible phenotypes in a pattern.
- Genotypes designated as:
  - PP=pink
  - OO=orange
  - PO=pink & orange
Codominant alleles will both be completely expressed.

- Codominant alleles are neither dominant nor recessive.
- The ABO blood types result from codominant alleles.

<table>
<thead>
<tr>
<th>PHENOTYPE (BLOOD TYPE)</th>
<th>GENOTYPES</th>
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<tbody>
<tr>
<td>A</td>
<td>$I^A I^A$ or $I^A i$</td>
</tr>
<tr>
<td>B</td>
<td>$I^B I^B$ or $I^B i$</td>
</tr>
<tr>
<td>AB</td>
<td>$I^A I^B$</td>
</tr>
<tr>
<td>O</td>
<td>$ii$</td>
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Many genes have more than two alleles. This is called Multiple Alleles and bloodgroup is also an example of this pattern of inheritance.
Multiple Alleles

- Unlike those studied by Mendel, some traits are controlled by more than one gene (allele).

- These genes may be dominant or recessive, or dominant to different degrees.

Ex: ABO Human Blood Groups

- Human Blood types may be A, B, AB or O.
- Codominant blood types: A and B
- Recessive blood type: O
- How would a person have blood type AB?
Use the letter I to indicate variations of the same gene.

- $I^A I^A$, $I^A i = \text{type } A$
- $I^B I^B$, $I^B i = \text{type } B$
- $I^A I^B = \text{type } AB$
- $i i = \text{type } O$

Universal Receiver

Universal Donor

1. Suppose a woman homozygous for blood type A marries a man with blood type AB. What are all the possible blood types their children could be?

A or AB

2. If a woman with blood type AB marries a man with the same blood type, what are the chances, they will have a child that is blood type A?

25%

3. If a couple, both blood type O, have children, what percent can be something besides type O?

none (0%)

4. A child is born with type O blood, and his mother has type A blood? Is it possible that his father can have type B blood?

Yes, if both parents heterozygous
5. Traits produced by two or more genes are called **polygenic** traits. What are two examples?
   a. Human skin color
   b. Eye color
Many genes may interact to produce one trait.

- Polygenic traits are produced by two or more genes.

Order of dominance: brown > green > blue.

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<thead>
<tr>
<th>GENE NAME</th>
<th>DOMINANT ALLELE</th>
<th>RECESSIVE ALLELE</th>
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<tbody>
<tr>
<td>BEY1</td>
<td>brown</td>
<td>blue</td>
</tr>
<tr>
<td>BEY2</td>
<td>brown</td>
<td>blue</td>
</tr>
<tr>
<td>GEY</td>
<td>green</td>
<td>blue</td>
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1. If genes are considered to be linked, it means that they are close together on the same chromosome.
2. Both males and females can be carriers of an autosomal disorder.
3. Only females can be carriers of sex linked disorders.
4. An example of a historical sex-linked disorder is called hemophilia.
5. Which offspring would have the hemophilia and which would be the carrier? Son – hemophilia daughter – carrier.
6. An example of a sex-linked trait is red green colorblindness.
Linkage maps estimate distances between genes.

- The closer together two genes are, the more likely they will be inherited together.
- Cross-over frequencies are related to distances between genes.
- Linkage maps show the relative locations of genes.
Sex-Linked Inheritance

XX=female    XY=male

• The X and Y chromosomes are NOT HOMOLOGOUS. They have DIFFERENT GENES.

• A male having XY can exhibit a recessive trait if it is on the X or Y chromosome because there is no other gene to counter it.

Examples of sex-linked genes:
• Red-green colorblindness
• Hemophilia
• Muscular Dystrophy
Hemophilia is due to a recessive gene on the X chromosome. $X^h$

If mom is $X^H X^h$, and dad is $X^H Y$

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Girls with hemophilia
- 0
Boys with hemophilia
- 1

Girls without hemophilia
- 2
Boys without hemophilia
- 1