B-4.7 Summarize the chromosome theory of inheritance and relate that theory to Gregor Mendel's principles of genetics

The *Chromosome theory of inheritance* is a basic principle in biology that states genes are located on chromosomes and that the behavior of chromosomes during meiosis accounts for patterns of inheritance, which closely parallels predicted Mendelian patterns.

The principles of Mendelian genetics:

segregation
independent assortment
dominance

Due to advances in technology, the following are new developments since Mendel's principles of genetics:

Gene Linkage and Crossing-over

- *Gene linkage* simply means that genes that are located on the same chromosome will be inherited together. These genes travel together during gamete *formation* (MEIOSIS)
  - This is an exception to the Mendelian principle of independent assortment because linked genes do not segregate independently.

- *Crossing-over* is a process in which alleles in close proximity to each other on homologous chromosomes are exchanged, resulting in new combinations of alleles. **INCREASES GENETIC VARIATION**
  - When chromosomes pair up during meiosis I, sometimes sections of the two chromosomes become crossed. The two crossed sections break off and usually reattach.
  - When the genes are rearranged, new combinations of alleles are formed
- Crossing-over explains how linked genes can be separated resulting in greater genetic diversity that could not be explained by Mendel's principles of genetics.

Incomplete Dominance and Codominance

- *Incomplete dominance* is a condition in which one allele is not completely dominant over another. The phenotype expressed is somewhere between the two possible parent phenotypes.
- *Codominance* occurs when both alleles for a gene are expressed completely. The phenotype expressed shows evidence of both alleles being present.
- These conditions go beyond Mendel's principle of dominance.

Multiple Alleles and Polygenic Traits

- *Multiple alleles* can exist for a particular trait even though only two alleles are inherited. For example, three alleles exist for blood type (A, B, and O), which result in four different blood groups.

- *Polygenic traits* are traits that are controlled by two or more genes. These traits often show a great variety of phenotypes, e.g. skin color.
- Mendel's principles of genetics did not explain that many traits are controlled by more than one gene.

Sex-Linked Trait

Sex-linked traits are the result of genes that are carried on either the X or the Y chromosome.

- This is an exception to the Mendel's principle of independent assortment, which does not explain sex-linked traits.
- In organisms that undergo sexual reproduction, the gametes, or the sex chromosomes, determines the sex of the organism.

	X	Y
X		
X		

- Complete the Punnett square for the cross showing chance of offspring being male (XY) or female (XX).

- In humans, the Y chromosome carries very few genes; the X chromosome contains a number of genes that affect many traits. Genes on sex chromosomes are called *sex-linked genes*. Sex-linked genes are expressed differently from an autosomal gene.

    - If a gene is linked on the X chromosome (X-linked),
        - Female offspring will inherit the gene as they do all other chromosomes (X from the father and X from the mother). The principles of dominance will apply.

        - Male offspring will inherit the gene on their X chromosome, but not on the Y chromosome.

        - Since males have one X chromosome, they express the allele whether it is dominant or recessive; there is no second allele to mask the effects of the other allele.

    - For example, the trait for color blindness is located on the X chromosome:

	X^c	Y
X^c		

X^c		

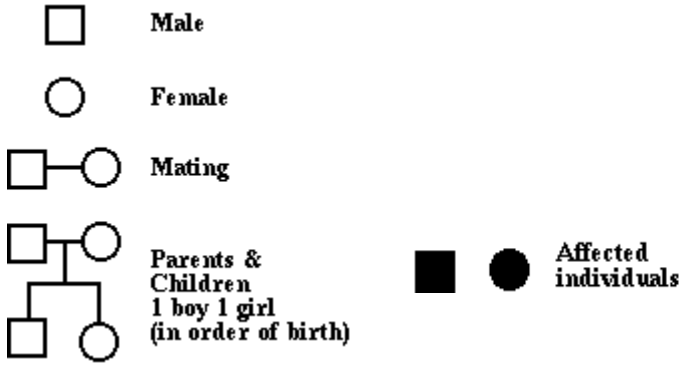
- X chromosomes carrying a gene for normal vision can be coded X^C
- X chromosomes carrying a gene for color-blindness can be coded X^c
- Y chromosomes that all lack this gene can be coded Y
- Only offspring that have the X^C gene will have normal vision.
- Complete the PUNNETT SQUARE showing the probability of offspring with normal/affected vision.

- Hemophilia is also a sex-linked trait.
- In rare cases, a female can express the sex-linked, recessive trait.

Pedigree

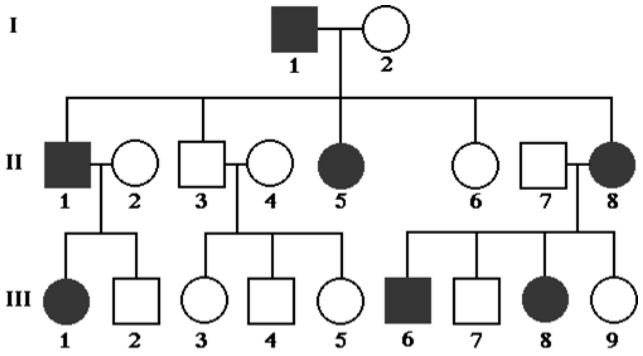
A *pedigree* is a chart showing an inheritance pattern (trait, disease, disorder) within a family through multiple generations. Through the use of a pedigree chart and key, the genotype and phenotype of the family members and the genetic characteristics (dominant/recessive, sex-linked) of the trait can be tracked.

An example of a pedigree key:



Pedigree Example I:

(Family with a dominant autosomal genetic trait)



The gene for this particular genetic trait does not occur on the sex chromosomes; it occurs on an autosomal chromosome because both males and females have the trait. This information can be inferred from two facts:

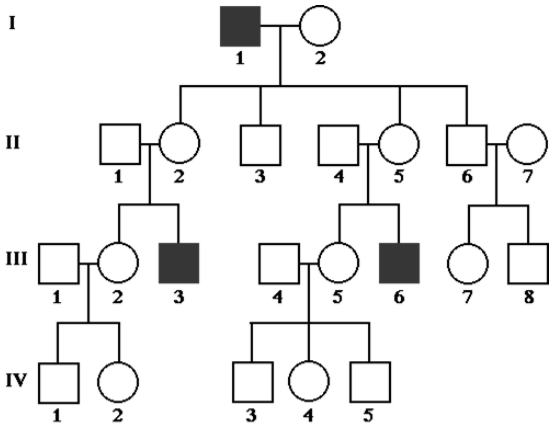
(1) Because the father has the trait, if the trait were sex-linked (on the father's X chromosome), then all females would have the trait. However, because some females do not have the trait, it is not a sex-linked trait.

(2) Individual III-7 who is a male did not inherit the trait from his mother, who has the trait. He received his only X chromosome from his mother.

- This particular gene is a dominant gene because

- each of the people who have the trait has only one parent who has the trait.
- if only one parent has the trait and the trait is not sex-linked, then the individuals who have the trait must be heterozygous for the gene.

<u>Pedigree Example II</u>
(Family with a recessive sex-linked genetic trait)



The gene for this particular trait is <u>sex-linked</u> and recessive. This information can be inferred because <u>only males</u> have the trait.

- This is common in X-linked, recessive traits because females who receive the gene for the trait on the X chromosome from their fathers also receive an X chromosome from their mothers which <u>hides</u> the expression of the trait.
- The trait <u>skips</u> a generation.
  - In generation <u>II</u>, all of the offspring receive an X chromosome from their mother.

- Because the males only receive the X chromosome from their mother, they do not receive the gene carrying the trait.
- Because the females receive an X chromosome from their mother and father, they are heterozygous and do not express the recessive trait, but they are carriers.

- In generation III, the offspring of all of the females from generation II have a 50/50 chance of passing a trait-carrying gene to their children.
  - If the males receive the trait-carrying gene, they will express the trait.
  - If the females receive the trait-carrying gene, they will again be carriers.