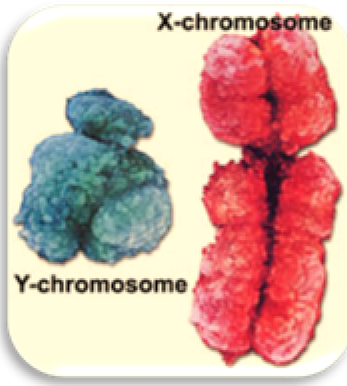
PDF File

HEREDITY – SEX-LINKED



In this unit, we will discuss Sex-Linked Traits. Sex-Linked traits are carried on the X and Y chromosomes of the sex chromosomes. The two previous crosses you learned, monohybrid and dihybrid, dealt with the autosomes. Remember that autosomes are chromosomes 1-22. The sex chromosomes are the 23rd pair. Also, remember that the **sex chromosomes for a female are "XX"** and the **sex chromosomes for a male are "XY".** Even though sex-linked traits may be carried on the X or Y of the sex chromosomes, most sex-linked traits are located on the X chromosome, because the Y is shorter and holds fewer genes.

Thomas Hunt Morgan

	In the early 1900s, Thomas Hunt Morgan helped discover the role of chromosomes in heredity. Morgan worked with *Drosophila melanogaster* (fruit	

	fly), and the fruit fly's 8 chromosomes, to demonstrate that genes are carried on chromosomes and are the basis of heredity. He won the Nobel Prize in Physiology or Medicine in 1933 for his discoveries. Morgan made the link between chromosomes and heredity by demonstrating the X chromosome is related to gender and eye color in fruit flies.	
		

Sex Determination

Sex determination in Fruit Flies, as in humans, results from the arrangement of sex chromosomes. *Reminder, the female sex chromosomes are "XX" and the male sex chromosomes are "XY".* As you know, chromosome pairs are separated when forming the gametes (sperm and egg) through the process of meiosis. As a result, the gametes that are produced have either an "X" sex chromosome or a "Y" sex chromosome, depending on the gamete type.

When a female forms gametes, the only possible chromosomes that can be separated

Male Parent	
X	Y

into two different gametes is an "X" and another "X", because her sex chromosome pair is "XX". When a male forms gametes, it is possible for one gamete to pick up an "X" chromosome and another gamete to pick up a "Y" chromosome, because his sex chromosome pair is "XY". Setting up a Punnett square to show these gametes crossing displays why, on every birth, there is a 50/50 chance of male or female. It also displays how the father's gametes determine the gender of the offspring, because he offers either an "X" chromosome to a future female offspring or a "Y" chromosome to a future male offspring.

Female Parent	X	XX *Female*	XY *Male*
	X	XX *Female*	XY *Male*

Morgan's Experiment

Thomas Hunt Morgan confirmed the existence of X-linked (sex-linked) traits by crossing the eye color of fruit flies. Most fruit flies have red eyes while a few have white eyes. Morgan originally crossed a white-eye male with a red-eye female and the F_1 generation included all red-eye offspring of both genders just as Mendel would have predicted.

F_1		*Male Fruit Fly with White Eyes*	
		X^r	Y
Female Fruit Fly with Red Eyes	X^R	X^RX^r	X^RY
	X^R	X^RX^r	X^RY

****Notice that the alleles for eye color are only carried on the "X" chromosomes. Red eye (R) is dominant and white eye (r) is recessive.***

Morgan then crossed two members of this F_1 generation. The F_2 generation then showed the expected ratio of 3 red eye fruit flies to 1 white eye fruit fly, however, he found that the white eye fruit flies were all male.

F_2		*Male Fruit Fly with White Eyes*	
		X^R	Y
Female Fruit Fly with Red Eyes	X^R	X^RX^R	X^RY
	X^r	X^RX^r	X^rY

After these F_2 generation results, Morgan then concluded that the gene for eye color is carried on the “X” chromosome.

Concerning sex-linked traits carried on the “X” chromosome, it is important to realize that males have a 50% chance of having a recessive sex-linked trait, while females have only a 33% chance of having a recessive sex-linked trait. In the case of fruit flies with sex-linked eye color, males are either red-eye, X^RY, or white-eye, X^rY (1/2, 50%). Females are red-eye, X^RX^R or X^RX^r, or white-eye, X^rX^r (1/3 = 33%).

Terminology: *The term* ***Carrier*** *can be used for a heterozygous female (example:* X^RX^r). *A carrier female will still exhibit the dominant trait but “carry” the recessive trait.*

Sex-Linked Cross Example

Hemophilia is a recessive sex-linked genetic disorder that impairs the body’s ability to clot the blood when a blood vessel is broken. We will use “H” for the dominant allele which represents normal blood clotting. We will use “h” for the recessive allele which represent the hemophiliac condition.

Parents: Hemophiliac Female x Normal Male

***Little Note:** In all of the other types of hereditary crosses the gender of the parents never matters, however, in sex-linked crosses the gender of the parents and offspring must be made known.

1. Genotypes of Parents: $\underline{X^hX^h}$ x $\underline{X^HY}$

Due to the law of segregation, the alleles will now separate into gametes. The alleles separate with the “X” chromosome to which they are attached.

2. Gametes of Parents: $\underline{X^h}$, $\underline{X^h}$ x $\underline{X^H}$, $\underline{Y}$

One parent’s alleles (gametes) will be placed on top of the Punnett square. The other parent’s alleles will be placed on the side of the Punnett square.

	X^h	X^h
X^H		
Y		

3. Crossing the Parents’ Alleles:

Now, we will cross the two parents by first dragging the “X”s with their allele attached, above each column, down into the two lower boxes.

	X^h	X^h
X^H	X^h	X^h

Y	X^h	X^h

Next, we will drag the “X” with its attached allele, beside one row, across into the next two boxes and then the “Y” in the same fashion.

	X^h	X^h
X^H	$X^H X^h$	$X^H X^h$
Y	$X^h Y$	$X^h Y$

***Little Note:** Whenever you have a capital letter (dominant allele) and a lowercase letter (recessive allele) together, list or write the capital letter first then the lowercase. Hh and hH are the same genotype, just write it as Hh.

After completing the Punnett square, we can now determine the genotypic and phenotypic probabilities. The genotypic probability will provide us with a calculation of the chance of having a particular genotype. The phenotypic probability will provide us with a calculation of the chance of having a particular phenotype. However, with sex-linked traits, offspring can be analyzed by gender or by the overall group.

4. Genotypic Probability (Gender-based)

Record the genotype of the upper left box of the Punnett square ($X^H X^h$). Then count how many boxes out of 2 have the same genotype. Out of 2 because only two out of the four boxes are designated for females (XX). In this cross we have a probability of **2/2 X^HX^h**. We then determine the next possibility which is X^hY and count how many boxes have that same genotype. In this cross we have a probability of **2/2 X^hY.**

5. Phenotypic Probability (Offspring-based)

Phenotypic probability can be determined two ways: by offspring or by gender. We will first look at offspring phenotype. When considering offspring, we need to look at all four boxes, disregarding gender. In this cross, we have a phenotypic probability of **2/4 Normal** (which happens to be the two females)**; 2/4 Hemophiliac** (which happens to be the two males).

6. Phenotypic Probability (Gender-based)

We will now look at gender phenotype. When considering genders, we need to look at the two female boxes separate from the two male boxes. In this cross, we have a phenotypic probability of **2/2 Female Carriers** (remember, these females are normal, but carry the hemophilia allele)**; 2/2 Hemophiliac Males**.

Unit 23 Worksheet Heredity – Sex-Linked

UNIT VOCABULARY REVIEW

Click card to see term 👆

Male sex chromosomes.

View this study set

Choose a Study Mode