STUDY GUIDE - Ch. 15.1 - Morgan Showed that Mendelian Inheritance has its Physical Basis in the Behavior of Chromosomes
- Ch. 15.2 - Sex-Linked Genes Exhibit Unique Patterns of Inheritance

NAME: _____

- **PHYSICALLY PRINT OUT this PDF and HANDWRITE (with a black or blue pen) your answers directly on this PDF.** *Typed or digitally-written work is **not** accepted. Do **not** answer questions on separate paper.*
- **Importantly, study guides are NOT GROUP PROJECTS!!!** *You, and you alone, are to answer the questions as you **read** your assigned textbook. You are **not** to share answers with other students. You are **not** to copy any answers from any other source, including the internet.*
- **Get in the habit of writing LEGIBLY, neatly, and in a medium-sized font.** *AP essay readers and I will skip grading anything that cannot be easily read so start perfecting your handwriting, and don't write so large you can't add all the relevant details and key elaborations in the space provided.*
- **SCAN physical documents in color and with good resolution. Then, upload your final work as PDFs to Archie.** *Avoid uploading dark, shaded, washed-out, sideways, or upside-down scans of homework. Keep completed physical study guides organized in your biology binder to use as future study and review tools.*
- **READ FOR UNDERSTANDING and not merely to complete an assignment.** ***First**, read a section quickly to get an overview of the topic covered. Then, read it a **second** time slowly, paraphrasing each paragraph **out loud** and analyzing every figure. Finally, read it a **third** time as you answer the study guide questions if assigned and start building your memory. Try to write answers out in your own words, when possible, and try to purposefully and accurately use all new terminology introduced.*

1. Mendel never knew chromosomes existed. Nonetheless, he hypothesized that there were "**heredity factors**" that were passed from parent to child **(these "heredity factors" being the information for the traits of characters)**. Mendel never knew how the process of passing down these pieces of discrete information actually occurred. This started to change in the early 1900s, when researchers proposed the '**chromosomal theory of inheritance.**' What did this new hypothesis state?

2. List three reasons why Morgan's choice of the fruit fly was a good one for genetic experiments?
   1.
   2.
   3.

3. Explain the difference between what Thomas H. Morgan called the **wild type phenotype** versus the **mutant phenotype**?

   Wild Type Phenotype =

   Mutant Phenotype =

BE CAREFUL with the way the letters represent the different traits of a character. *With Morgan's allele notation, the gene is named after the mutant phenotype.* **The "+" superscript means the mutant trait is ABSENT. So vg^+ means normal wings, not vestigial wings (*vg*) and w^+ means normal red eye color, not white eyes (*w*)!** This is counterintuitive and appears backwards. Be careful with it until you get the hang of it to avoid getting very confused.

4. **Study the Figure 15.3 inquiry.** When Morgan started his experiments, he thought inheritance always worked like it did with Mendel. Each organism contained two copies of information for each character (either two of the same copies of the character's information, two of the same alleles, or two different copies of the character's information, two different alleles). He also thought the phenotype that resulted was **not** tied in any way to the sex (female/male) of the organism. This proved to not always be true. Explain exactly how **Morgan determined that a fruit flies eye color IS linked to its sex chromosome** and, therefore, the flies sex by answering the following questions.

a. What were the **phenotypes of the flies that Morgan mated in his P generation** to create his F1 generation?

b. Based on Mendel's work, **what eye-color phenotype did Morgan EXPECT to see in all the F1 generation flies** (regardless of whether they were males and females)? *This is what Mendel would have expected given that red eyes is dominant over white eyes.*

c. What **eye-color phenotypes did he OBSERVE among all flies in the F1 generation**?

d. What **eye-color phenotypes were OBSERVED in male vs in female flies in the F1 generation**? *This is what Mendel would have expected too.*

e. What were the **phenotypes of the flies that Morgan mated in his F1 generation** to create his F2 generation?

f. Based on Mendel's work, **what eye-color phenotype RATIO** *(x red : x white)* **did Morgan EXPECT to see in the F2 generation flies** (regardless of whether they were males and females)? *This is what Mendel would have expected too.*

g. What **eye-color phenotype RATIO** *(x red : x white)* **did he actually OBSERVE among all flies combined in the F2 generation**?

This is what Mendel would have expected too, but, upon closer examination, Morgan noted something unusual when he looked at the sex of the flies and their corresponding eye color.

h. Curiously, how were the **eye-color phenotypes OBSERVED distributed among male vs among female flies in the F2 generation**? *Mendel would **not** have expected this.*

5. a. Study Figure 15.4 **well** first, which highlights one of the matings Mendel performed between his pea plants. Then, describe Mendel's **Law of Segregation** in terms of what happens to the alleles for **one** type of gene for a character in a diploid organism. **KNOW THIS BY HEART!**

b. What **stage of Meiosis accounts for the Law of Segregation**?

c. Describe Mendel's **Law of Independent Assortment** in terms of what happens to the alleles of **different** types of genes for two different characters in a diploid organism. **KNOW THIS BY HEART!**

d. What **stage of Meiosis accounts for the Law of Segregation**?

6. The system different sexually-reproducing species use to determine sex (male vs female anatomy) varies by organism.

MAMMALS

a. What are the **two sex chromosomes that mammals (like humans) have**?

b. What is the **genotype of a human female** in terms of her sex chromosomes?

c. What is the **genotype of a human male** in terms of his sex chromosomes?

d. What is/are the **genotype(s) of the possible eggs** that a female can make in terms of sex chromosomes? *(Remember eggs are haploid not diploid)*

e. What is/are the **genotype(s) of the possible sperm** that a male can make in terms of sex chromosomes? *(Remember sperm are haploid not diploid)*

f. Does the human father or the human mother determine the sex of a couple's offspring? As part of your explanation, draw a Punnet Square, tracing the sex chromosomes from the mammalian father vs mother when mating.

SOME INSECTS

g. Study Figure 15.6. As you see, ***not all sexually reproducing organisms use the mammalian X-Y system for determining sex anatomy.*** What type of **sex chromosomes do some insects like grasshopper have**?

h. What is the **genotype of a female grasshopper** in terms of her sex chromosomes?

i. What is the **genotype of a male grasshopper** in terms of is sex chromosomes?

j. Grasshoppers are diploid so they contain two of every type of chromosome, **except for the males which have two of every autosomal chromosome, but only one sex chromosome. Females, however, still have two sex chromosomes.** What is/are the **genotype(s) of the possible eggs** that a female grasshopper can make in terms of sex chromosomes *(remember eggs are haploid not diploid)*?

k. What is/are the **genotype(s) of the possible sperm** that a male grasshopper can make in terms of sex chromosomes?

l. Does the grasshopper father or the grasshopper mother determine the sex of a couples offspring? As part of your explanation, draw a Punnet Square, tracing the sex chromosomes from the insect father vs mother when mating.

BIRDS, SOME FISH, & SOME INSECTS

m. Some organisms use yet another chromosomal system of sex determination. What **type of sex chromosomes do birds have**?

n. What is the **genotype of a female bird** in terms of her sex chromosomes?

o. What is the **genotype of a male bird** in terms of is sex chromosomes?

p. **Birds are diploid so they contain two of every type of chromosome and have two of every autosomal chromosome and two sex chromosomes.** What is/are the **genotype(s) of the possible eggs** that a female birds can make in terms of sex chromosomes?

q. What is/are the **genotype(s) of the possible sperm** that a male bird can make in terms of sex chromosomes?

r. Does the bird father or the bird mother determine the sex of a couples offspring? As part of your explanation, draw a Punnet Square, tracing the sex chromosomes from the avian (bird) father vs mother when mating.

SOME INSECTS LIKE ANTS & BEES

s. Insects like bees and ants use yet another system of determining an organism's sex. What **type of sex chromosomes do bees and ants have**?

t. What **determined if a bee or an ant is a female**?

u. What **determines if a bee or an ant is a male**?

7. What is a **sex-linked gene**?

8. What is the **SRY gene** and what role does it play?

9. **Study Figure 15.7.** The X chromosome has 1,100 genes for making various proteins both males and females use in various tissues. The Y only codes for about 25 proteins. Therefore, **most sex-linked genes are X-linked genes (and not Y-linked genes).** Notice that we write the allele of a sex-linked gene as the sex chromosome symbol with the gene symbol as a superscript. **Alleles of an X-linked gene would be written as X^A or X^a depending on if the allele is dominant or recessive** (instead of Aa which implies that these alleles are found on one of the autosome instead of a sex chromosome). Referring back to question 6 and how sex is determined in mammals....

   a. When does a **female express a X-linked recessive trait (phenotype)**?

   b. When does a **male express a X-linked recessive trait (phenotype)**?

   c. Which parent does the **male inherit an X-linked trait from**?

d. When does a **female express a Y-linked trait (phenotype)**?

e. When does a **male express a Y-linked trait (phenotype)**?

f. Which parent does the **male inherit an Y-linked trait from**?

10. Why do we say that males are **hemizygous**, instead of homozygous or heterozygous, for an X-linked trait?

11. a. What is **X-Inactivation**?

b. What do we **call the condensed, inactivated X chromosome** in a female's cell?

c. **When does X-Inactivation occur**?

d. When an X chromosome becomes inactivated, the same X chromosome will be inactivated in all the descendent cells produced during embryological development from this one cell by mitosis. In an embryo, cluster of dividing cells that formed from the zygote, **which of the two X chromosomes in a female's cells become inactivated AND** what is the **consequence of X-inactivation in females** that have two copies of the X chromosome with two different alleles for one or more X-linked genes?

12. Why are most tortoiseshell cats female?

13. *Think:* During early embryonic development of female carriers for **color blindness (an X-linked recessive disorder)**, the normal allele is inactivated by chance in about 1/2 the cells of all tissue involved with seeing and interpreting color (just like all the cells of the female's body). Why aren't 50% of female carriers color blind?

14. **Duchenne Muscular Dystrophy** involved the progressive weakening of the muscles and loss of coordination due to the absence of functional muscle protein dystrophin. **Hemophilia** is a disease that involves the absence of one or more of the normal blood clotting proteins, causing a person, who is inured, to bleed for a prolonged time. Both of these traits involve **recessive mutations** in **X-linked genes**.

a. Two parents, Tim and Shonda, who exhibit no disease have a firstborn son that has Duchenne muscular dystrophy. What is the probability that a second child of this couple will have the disease? Do remember...

!!! AS ALWAYS (and on the AP exam) you must:

1. **state the genotypes of the parents first.** Then...
2. **show the Punnett Square** showcasing the reproductive cells each parent can make via meiosis and the offspring that can result from all possible fertilization events between parents' gametes,
3. **report or calculate the probability requested.** So...let's walk through this step by step below.

Both Parents' Genotypes:

Punnett Square Showing Results of Parent Mating:

Probability Calculation of Offspring of a Certain Phenotype:

b. Based on your work above, what is the probability if the second child is a boy?

c. What is the probability if the second child is a girl?

*(Check your answers to a-c above by going to the **Ch.15.2 Concept Check Question #2** answer in Appendix A)*

15. Remember, **eye color in Drosophila is an X-linked gene**. A white-eyed female Drosophila is mated with a red-eyed (wild-type) male. What phenotypes and genotypes do you predict for the offspring? **Again, remember the MUST DO's when answering such questions listed in 14.a. above.**

Parents' Genotypes:

Punnett Square Showing Results of Parent Mating:

Genotype Distribution of Offspring:

Phenotype Distribution of Offspring:

*(Check your answers to a-c above by going to the **Ch.15.2 Concept Check Question #1** answer in Appendix A)*

P.S. Here is the answer to #13: The cells in the eye responsible for color vision must come from multiple cells in the early embryo. The descendants of half of those cells express the allele for normal color vision and half the allele for color blindness. Having half the number of mature eye cells expressing the normal allele in the eye must be sufficient for normal color vision.