Name: _____ Date: _____ Block: _____

Honors Biology: Genetics Packet #2

Incomplete and Codominance, Multiple Alleles, Sex-linked traits, Pedigrees

Please bring this packet with you to class every day.

Genetics Focus Questions (Con't) _____

Read pages 164-169

1. What forms of genetic testing are available for parents? What are some ethical considerations to genetic testing?
2. Define incomplete dominance. Compare and contrast codominant alleles with alleles that show incomplete dominance. Provide examples of each.
3. Blood groups in humans are an example of both codominance *and* multiple alleles. Explain why.
4. Define pleiotropy. Describe an example in the human population.
5. What is polygenic inheritance? Provide an example.

Read pages 170-177

6. Carefully read section 9.16 and look at figure 9.16. Summarize the chromosome theory of inheritance. Connect ideas of meiosis and fertilization in your answer.
7. What does it mean when genes are linked?
8. Genes on the same chromosome tend to get inherited together. Which of Mendel's laws does this violate? Explain.
9. Differentiate between an autosome and a sex chromosome.
10. What are 'sex-linked' genes?
11. Why do human sex-linked conditions affect mostly males?

Incomplete Dominance and Codominance

In the traits considered previously, an organism heterozygous for a trait has been indistinguishable from a homozygous dominant individual. This is because a dominant allele prevents the expression of a recessive allele. For example, Mendel's peas were either tall or short. If a pea plant had one tall allele and one short allele, it was as tall as a pea having two tall alleles.

There are some genes for which this is not true. For example, in Japanese four-o'clock flowers, the gene controlling flower color has alleles that are neither dominant nor recessive (they show incomplete dominance). Plants that have two red alleles (designated RR or C^RC^R) have red flowers. Plants with two white alleles (WW or C^WC^W) have white flowers. However, plants with one red allele and one white allele (RW or C^RC^W) are pink. This type of inheritance in which the phenotype of a heterozygous individual is an intermediate between the two types of homozygotes is called **incomplete dominance**.

Codominant genes differ slightly from genes that show incomplete dominance but the problems are solved in the same manner. When the heterozygote expresses the distinct trait of both alleles equally, the gene is said to be Codominant. Incomplete dominant and codominant genes differ in the way the genes are expressed (blending vs. both genes expressed equally) but the problems are tackled in the same way.

The outcome of crosses involving traits that show incomplete and codominance are determined in the same way as those involving dominant traits. However, keep in mind that each allele of a gene showing incomplete or codominance is represented by its own capital letter (R or W in the case of 4 o'clocks) or as a gene loci and superscript (C^RC^W). Also, with these 2 variations the heterozygote has a phenotype different from that of either homozygote.

SAMPLE PROBLEM

In Japanese four-o'clock flowers, predict the outcome of a cross between a red-flowered plant and a pink-flowered plant

Step 1 Determine the genotypes of the parents.
The red flowered plant is homozygous (RR); the pink plant is heterozygous (RW)
RR x RW

Step 2 Determine the gamete genotypes produced by each parent.
RR → R and R *RW → R and W*

Step 3 Set up a Punnett Square using the gamete genotypes.

	R	*W*
R		
R		

Step 4 Combine the gamete genotypes of one parent with those of the other parent to show all possible offspring genotypes.

	R	*W*
R	***RR***	***RW***
R	***RR***	***RW***

Step 5 State the genotype and phenotype proportions of the offspring.
½ RR ½ RW
½ Red ½ pink

EXERCISES

In each exercise draw a Punnett Square and write the phenotypic proportions in the space provided.

1. In Japanese four-o'clock flowers, predict the phenotypes and their proportions of a cross between

   a. a white plant and a pink plant _____

   b. Two pink plants _____

2. In some cates the gene for tail length shows incomplete dominance. Cates with long tails and those with no tails are homozygous for the respective alleles. Cats with one long-tail allele and one no-tail allele have short tails. Predict the phenotypes and their proportions of a cross between

   a. A long-tail cat and a cat with no tail _____

   b. A short-tail cat and a cat with a long tail _____

   c. Two short-tailed cats _____

3. The Andalusian fowl is a breed of chicken that shows codominance in the gene for feather pattern. Homozygous individuals either have black or white feathers and heterozygous individuals are speckled (both the white and black gene is expressed). Predict the phenotypes and their proportions of a cross between

   a. A white-feathered chicken with a speckled _____

   b. A black-feathered chicken with a speckled _____

   c. Two speckled chickens _____

Multiple Alleles

In previous activities, every gene was considered to have only two possible alleles. For example, the alleles of the gene for plant height in peas are either tall or short, and the alleles of the gen for fruit color in squash are either yellow or white. However, there are genes for which more than two different alleles exist. When this is the case, the alleles are referred to as **multiple alleles**.

A diploid individual can carry only two alleles for any given gene. This is befacu for each gene, one allele is carried on each of the two chromosomes that constitute a pair of homologous chromosomes (one from each parent). But in a population of individuals, more than two alleles of a gene can exist. For example, one individual may have allele versions 1 and 2 of a particular gene while another individual may have alleles 2 and 5 of that same gene. A well-known example of multiple alleles involves the gene for blood type in humans. This gene has three different alleles and is located on chromosome 9, two copies which exist in all human body cells. The alleles of this gene are designated as follows:

$I^A \rightarrow$ codes for type A blood
$I^B \rightarrow$ codes for type B blood
$i \rightarrow$ codes for type O

I^A and I^B are each dominant over *i* but are codominant to each other. The possible genotypes are corresponding blood types are as shown:

Genotype	***Phenotype***
ii	Type O
I^AI^A, I^Ai	Type A
I^BI^B, I^Bi	Type B
I^AI^B	Type AB

SAMPLE PROBLEM

A woman with type A blood whose biological father was type O has offspring with a man with type AB blood. What will be the possible genotype and phenotypes of their offspring and in what proportions?

Step 1 Determine the genotypes of the parents.
Type A woman with father type O $\rightarrow I^Ai$
Type AB man $\rightarrow I^AI^B$
$I^Ai \times I^AI^B$

Step 2 Determine the gamete genotypes produced by each parent.
$I^Ai \rightarrow I^A, i$
$I^AI^B \rightarrow I^A, I^B$

Step 3 Set up a Punnett Square using the gamete genotypes.

	I^A	i
I^A		
I^B		

Step 4 Combine the gamete genotypes of one parent with those of the other parent to show all possible offspring genotypes.

	I^A	i
I^A	$\boldsymbol{I^AI^A}$	$\boldsymbol{I^Ai}$
I^B	$\boldsymbol{I^AI^B}$	$\boldsymbol{I^Bi}$

Step 5 State the genotype and phenotype proportions of the offspring.
¼ I^AI^A, ¼ I^Ai, ¼ I^AI^B, ¼ I^Bi
½ type A, ¼ type B, ¼ type AB

EXERCISES

For each exercise, write out the Punnett Square where appropriate, and answer the questions in the spaces provided. Please express the probabilities as fractions.

1. A female who is homozygous for type B blood has children with a male who is heterozygous type A. What will be the possible genotypes and phenotypes of the offspring and in what proportions?

2. A male with type O blood has children with a female with type AB. What will be the possible genotypes and phenotypes of the offspring and in what proportions?

3. A type A male whose biological father was type B has children with a type B female whose biological father was type A. What will be the possible genotypes and phenotypes of the offspring and in what proportions?

4. What is the probability that 2 individuals whose blood types are AB and O will have a type A child?

5. A couple as a child with type A blood. If one biological parent is type O, what are the possible genotypes of the other parent?

Sex-Linked Traits

Most humans are born with 46 chromosomes in 23 pairs. The X and Y chromosomes determine the sex of an individual. Most females have 46 chromosomes, including an XX pair. Most males have 46 chromosomes, including an XY pair. In the practice problems, you will assume these combinations of chromosomes for males and females. However, there are other possible outcomes for sex chromosomes. For example, Turner Syndrome results when an individual has 45 chromosomes, including one X chromosome, but lacks a second sex chromosome. Humans can also have three sex chromosomes with the combinations XXX, XXY, or XYY. For the XXY and XYY individuals, the presence of the Y chromosome typically leads to the development of male sex organs. It is important to note that the combination of sex chromosomes indicates the sex of an individual and not necessarily the gender. Gender is a social construct that varies between cultures and over time.

Sex-linked traits are those whose genes are found on the X chromosome, but not the Y chromosome. For individuals with two X chromosomes, they are less likely to have sex-linked traits because if they inherit one recessive allele, there is still a chance that they would also inherit a dominant allele. Thus, sex-linked traits are more common in individuals with only one copy of the X chromosome. Two examples of sex-linked conditions are color-blindess and hemophilia. Hemophilia is caused by a recessive allele that prevents the synthesis of a factor necessary for blood-clotting. For sex-linked traits, carriers are defined as individuals who are heterozygous. They do not have the condition, but it is possible for them to pass it on to their offspring. In the example below, hemophilia is used to illustrate the designation of sex-linked traits:

H = dominant allele h = recessive allele

X^HX^H = a female without hemophilia

X^HX^h = a female carrier

X^hX^h = a female with hemophilia

X^HY = a male without hemophilia

X^hY = a male with hemophilia

**Note that the allele is not shown on the Y chromosome.*

SAMPLE PROBLEM

A man with hemophilia has offspring with a homozygous woman without hemophilia. Predict the genotypes and phenotypes of their offspring.

Step 1 Determine the genotypes of the biological parents.

Male with hemophilia: X^hY

Homozygous female without hemophilia: X^HX^H

Step 2 Determine the gamete genotypes produced by each biological parent.

$X^hY \rightarrow X^h, Y$ $X^HX^H \rightarrow X^H$

Step 3 Set up a Punnett Square using the gamete genotypes.

	X^h	Y
X^H		
X^H		

Step 4 Combine the gamete genotypes of one parent with those of the other parent to show all possible offspring genotypes. *Note that sometimes these questions ask about all offspring, but sometimes they will just ask about the male or female offspring.

	X^h	Y
X^H	$\boldsymbol{X^HX^h}$	$\boldsymbol{X^HY}$
X^H	$\boldsymbol{X^HX^h}$	$\boldsymbol{X^HY}$

Step 5 State the genotype and phenotype proportions of the offspring.

½ X^HX^h ½ X^HY

½ carriers ½ non-hemophiliac males

EXERCISES

For each exercise, write out the Punnett Square where appropriate, and answer the questions in the spaces provided. Please express the probabilities as fractions.

1. A female who is heterozygous for hemophilia has offspring with a man without hemophilia. What will be the possible phenotype proportions?

2. A female who is a carrier for hemophilia reproduces with a man with hemophilia. What will be their offsprings' possible phenotypes and in what proportions?

3. A hemophiliac woman has a non-hemophiliac biological mother. What are the genotypes of her biological mother and biological father?

4. A woman without hemophilia has parents without hemophilia. However, she has a brother with hemophilia. What are the possible genotypes of the parents?

5. If a female who is not color-blind whose biological father was color-blind reproduces with a color-blind male, what is the probability that they will have a male offspring who is color-blind? What is the probability that they will have a female offspring that is color-blind?

6. What is the probability that a color-blind female who has offspring with a man who is not color-blind will have a color-blind child?

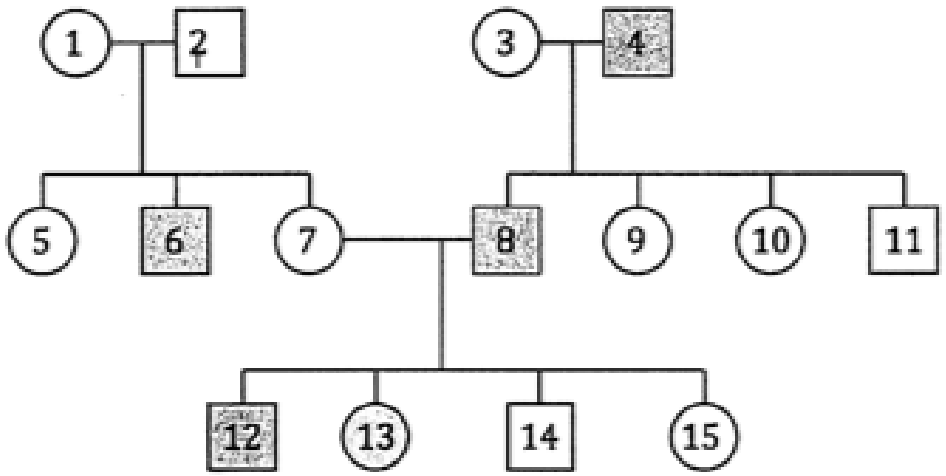
7. In fruit flies, the dominant eye color is red and white eyes is a sex-linked trait. If a white-eyed male is crossed with a heterozygous female, what proportion of the offspring will have red eyes?

Pedigrees

A pedigree is a diagram showing the inheritance pattern of a particular gene throughout the generations of a single family. Each row is typically indicated by a number or Roman numeral and represents a generation. For example, the top row of the pedigree would be labeled with "I" and would represent the first generation. Circles represent females and squares represent males. The shading typically indicates that an individual has a certain condition or trait. Pedigrees often come with a key to indicate the meaning of the shading.

EXERCISES

1. The pedigree seen below is for colorblindness. Remember that coloblindness is a sex-linked trait. Shaded individuals are coloblind.



   a. Determine the probable genotypes of individuals #1-15.
   b. How did you determine the genotype of Individual 3?

   c. Individual 8 was colorblind, just like his biological father. Where did Individual 8 get his allele for colorblindness?

   d. Neither Individual 1 nor 2 were colorblind. How did they have a colorblind child (Individual 6)?

   e. What genotypes are required for a set of biological parents if one of the female offspring is colorblind?

   f. If Individual 13 marries a male who is not colorblind, what is the probability that their male offspring would be colorblind?