Name ______________________________ Date __________

ENRICHMENT ACTIVITY

Genetics Problem Solving

CHAPTER 25

Crosses Involving 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 gene 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.

As you know, a diploid individual can carry only two alleles for any gene. This is because for each gene one allele is carried on each of the two chromosomes that constitute a pair of homologous chromosomes. But in a population of individuals, more than two alleles of a gene can exist. For example, one individual may have alleles 1 and 2 of a particular gene while another individual may have alleles 2 and 5 of that same gene. The best 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 of which exist in all human body cells. The alleles of this gene are designated as follows:

I^A—codes for type A blood
I^B—codes for type B blood
i —codes for type O blood

I^A and I^B are each dominant over i, but are not dominant over each other. The possible genotypes and corresponding blood types are as follows:

genotype	*phenotype (blood type)*
ii	O
I^Ai	A
I^AI^A	A
I^Bi	B
I^BI^B	B
I^AI^B	AB

SAMPLE PROBLEM

A woman with type A blood whose father was type O married a man with type AB blood. What will be the possible genotypes and phenotypes of their children?

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

Step 5 State the genotype and phenotype ratios of the offspring.
$1\ I^AI^A : 1\ I^Ai : 1I^AI^B : 1I^Bi = \frac{1}{4}\ I^AI^A, \frac{1}{4}\ I^Ai, \frac{1}{4}\ I^AI^B, \frac{1}{4}\ I^Bi$
2 type A: 1 type AB: 1 type B = ½ type A, ¼ type AB, ¼ type B

EXERCISES

For each exercise draw the Punnett square when appropriate and answer the questions in the spaces provided.

1. A woman homozygous for type B blood marries a man who is heterozygous type A. What will be the possible genotypes and phenotypes of their children?

____

____

2. A man with type O blood marries a woman with type AB blood. What will be the possible genotypes and phenotypes of their children?

____

____

3. A type B woman whose mother was type O marries a type O man. What will be the possible genotypes and phenotypes of their children?

____

____

4. A type A woman whose father was type B marries a type B man whose mother was type A. What will be their childrens' possible genotypes and phenotypes?

____

____

____

____

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

____

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

____

Name ______________________________ Date __________

ENRICHMENT ACTIVITY

Genetics Problem Solving

CHAPTER 26

Sex-Linked Traits

Sex-linked traits are those whose genes are found on the X chromosome but not on the Y chromosome. In humans the X chromosome is much larger than the Y chromosome and contains thousands of genes more than the Y chromosome. For each of the genes that are exclusively on the X chromosome, females, who are XX, would obviously have two alleles. Males, who are XY, would have only one allele. Thus, females with one recessive allele and one dominant allele for a gene that is unique to the X chromosome will display the dominant phenotype. However, a male with a recessive allele for a gene unique to the X chromosome will always exhibit that recessive trait because there is no other corresponding allele on the Y chromosome.

In humans, each of three different sex-linked genes has a defective recessive allele that causes a disease. The diseases are hemophilia, color-blindness, and Duchenne's muscular dystrophy, a condition wherein muscles begin to degenerate in childhood. In hemophilia, the defective allele prevents the synthesis of a factor needed for blood clotting. In the example below, hemophilia is used to illustrate how sex-linked traits are designated.

X^H X chromosome with normal dominant allele (nonhemophilia)
X^h X chromosome with recessive hemophilia allele
Y Y chromosome (does not contain comparable gene)

SAMPLE PROBLEM

A man with hemophilia marries a homozygous normal woman. Predict the genotypes and phenotypes of their children.

Step 1 Determine the genotypes of the parents.
hemophiliac male X^hY, normal female X^HX^H
$X^hY \times X^HX^H$

Step 2 Determine the gamete genotypes produced by each 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		

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

	X^h	Y
X^H	**X^HX^h**	**X^HY**

Step 5 State the genotype and phenotype ratios of the offspring.
$1\ X^HX^h : 1\ X^HY = \frac{1}{2}X^HX^h, \frac{1}{2}\ X^HY$
1 normal female: 1 normal male = ½ normal females, ½ normal males

EXERCISES

For each exercise write out the Punnett square where appropriate, and answer the questions in the spaces provided.

1. A woman who is heterozygous for hemophilia marries a normal man. What will be the possible phenotype ratio of their children?

______

2. A woman who is a carrier for hemophilia marries a hemophiliac man. What will be their childrens' possible phenotypes?

______

______

3. A hemophiliac woman has a phenotypically normal mother. What are the genotypes of her mother and father?

______

______

4. A phenotypically normal woman has phenotypically normal parents. However, she has a hemophiliac brother. (a) What are her chances of being a carrier for hemophilia? (b) If she is a carrier and marries a normal male, what is the chance of a child being a hemophiliac?

a. ______

b. ______

5. A phenotypically normal man who has a hemophiliac brother marries a homozygous normal woman. What is the probability that any of their children will be hemophiliac?

______

6. If a normal-sighted woman whose father was color-blind marries a color-blind man, what is the probability that they will have a son who is color-blind? What is the probability that they will have a color-blind daughter?

______

7. What is the probability that a color-blind woman who marries a man with normal vision will have a color-blind child?

______

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

______