ENRICHMENT ACTIVITY
Genetics Problem Solving

Crosses Involving Two Traits

Predicting the outcome of crosses involving two traits requires basically the same procedure as that for crosses involving one trait. Keep in mind that in these crosses the genes controlling the two different traits are located on nonhomologous chromosomes. During meiosis nonhomologous chromosomes assort randomly, or independently. This means that each of the chromosomes of any pair of homologous chromosomes has an equal probability of ending up in a gamete with either chromosome from any other pair of homologous chromosomes. For example, assume that chromosomes A' and A'' are one pair of homologous chromosomes and chromosomes B' and B'' are another pair of homologous chromosomes. Therefore, A and B chromosomes are nonhomologous with respect to each other. During meiosis there is equal probability that chromosome A' will assort with chromosome B' or B''. Likewise chromosome A'' is equally likely to assort with chromosome B' or B''. This results in equal numbers of gametes with the nonhomologous chromosome combinations A'B', A'B'', A''B', and A''B''. Obviously then, genes that occur on nonhomologous chromosomes will also assort independently with respect to each other during meiosis.

To illustrate this situation, consider a plant that is heterozygous tall (Tt) and heterozygous green (Gg). This plant has the genotype TtGg. The T and t alleles (for height) are located on one pair of homologous chromosomes while the G and g alleles (for color) occur on another pair of homologous chromosomes. Since the genes for these traits are on nonhomologous chromosomes, during meiosis they will assort independently. This means that each allele for height, T and t, has an equal probability of assorting in the same gamete with either allele for color, G or g. To determine the possible gamete genotypes that this plant will produce, you must combine each height allele with each color allele. This can be done as follows:

$$T\ t\ G\ g \rightarrow TG,\ Tg,\ tG,\ tg$$

Thus this plant will produce equal numbers of gametes with the genotypes TG, Tg, tG, and tg.

SAMPLE PROBLEM 1

Using the allele symbols from the activity on pp. 25-7—25-9, predict the results of a cross between two pea plants both of which are homozygous round, homozygous tall.

Step 1   Determine the genotypes of the parents.
homozygous round   RR, homozygous tall   TT: RRTT
RRTT × RRTT

Step 2   Determine the gamete genotypes produced by each parent.
RRTT → RT, RT, RT, RT = RT

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

	RT
RT	

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ENRICHMENT ACTIVITY (continued)

Genetics Problem Solving Crosses Involving Two Traits

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

	RT
RT	RRTT

Step 5 State the genotype ratio and the phenotype ratio.
genotype ratio all RRTT   phenotype ratio all round tall

SAMPLE PROBLEM 2

Predict the results of a cross between a heterozygous round, homozygous tall plant and a homozygous round, short plant.

Step 1 Determine the genotype of the parents.
heterozygous round Rr, homozygous tall TT: RrTT
homozygous round RR, short tt: RRtt   RrTT × RRtt

Step 2 Determine the gamete genotypes produced by each parent.
RrTT → RT, RT, rT, rT = RT, rT; RRtt → Rt, Rt, Rt, Rt = Rt

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

	RT	rT
Rt		

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

	RT	rT
Rt	RRTt	RrTt

Step 5 State the genotype and phenotype ratios of the offspring.
genotype ratio 1 RRTt:1 RrTt = ½ RRTt, ½ Rr Tt   phenotype ratio all round tall

SAMPLE PROBLEM 3

Predict the results of a cross between two heterozygous green, heterozygous tall plants.

Step 1 heterozygous green Gg, heterozygous tall Tt: GgTt   **Step 2** GgTt → GT, Gt, gT, gt
GgTt × GgTt

Step 3

	GT	Gt	gT	gt
GT				
Gt				
gT				
gt				

Step 4

	GT	Gt	gT	gt
GT	GGTT	GGTt	GgTT	GgTt
Gt	GGTt	GGtt	GgTt	Ggtt
gT	GgTT	GgTt	ggTT	ggTt
gt	GgTt	Ggtt	ggTt	ggtt

BIOLOGY: The Study of Life

Step 5 genotype ratio 1 GGTT:2 GGTt:2 GgTT:4 GgTt:1 GGtt:2 Ggtt:1 ggTT:2 ggTt:1 ggtt =
$\frac{1}{16}$ GGTT, $\frac{1}{8}$ GGTt, $\frac{1}{8}$ GgTT, $\frac{1}{4}$ GgTt, $\frac{1}{16}$ GGtt, $\frac{1}{8}$ Ggtt, $\frac{1}{16}$ ggTT, $\frac{1}{8}$ ggTt, $\frac{1}{16}$ ggtt
phenotype ratio 9 green tall:3 green short:3 yellow tall:1 yellow short =
$\frac{9}{16}$ green tall, $\frac{3}{16}$ green short, $\frac{3}{16}$ yellow tall, $\frac{1}{16}$ yellow short

EXERCISES

For each exercise, (a) show the parental genotypes, (b) draw out the Punnett square, and (c) answer the question, in the spaces provided.

In mice, the ability to run normally is a dominant trait. Mice with this trait are called running mice (R), The recessive trait causes mice to run in circles only. Mice with this trait are called waltzing mice (r). Hair color is also inherited in mice. Black hair (B) is dominant over brown hair (b).

1. Cross a heterozygous running, heterozygous black mouse with a homozygous running, homozygous black mouse. What is the probable phenotype ratio?

a. —————————— b.   c. ——————————

2. Cross a homozygous running, homozygous black mouse with a heterozygous running, brown mouse. What is the probable phenotype ratio?

a. —————————— b.   c. ——————————

3. Cross a waltzing brown mouse with a waltzing brown mouse. What is the probable phenotype ratio?

a. —————————— b.   c. ——————————

4. Cross a homozygous running, heterozygous black mouse with a waltzing brown mouse. What is the probable phenotype ratio?

a. —————————— b.   c. ——————————

5. Cross a heterozygous running, brown mouse with a heterozygous running, homozygous black mouse. What is the probable phenotype ratio?

a. —————————— b.   c. ——————————

6. Cross a heterozygous running, heterozygous black mouse with a heterozygous running, heterozygous black mouse. What is the probable phenotype ratio?

a. —————————— b.   c. ——————————

BIOLOGY 1 LEVEL 2/3
GENETICS PROBLEMS /DIHYBRID CROSSES

1. A man homozygous for widow's peak (dominant) marries a woman homozygous for continuous hairline (recessive). What is the genotype of the man? What is the genotype of the woman? Using a Punnett square, determine the genotype and phenotype ratio of their offspring.

2. In humans, the allele for short fingers is dominant over that for long fingers. If a person with short fingers who had one parent with long fingers marries a person with long fingers, what will be the genotype and phenotype ratios of the offspring?

3. In horses, black coat is dominant to brown coat, and being a trotter is dominant to being a pacer. A black horse who is a pacer is crossed with a brown horse who is a trotter. The offspring is a brown pacer. Give the genotypes of all these horses.

4. In rabbits, black fur is dominant and brown fur is recessive. Short fur is dominant over long fur. A homozygous black long haired rabbit is crossed with a brown homozygous short-haired rabbit. Give the genotype and phenotype ratio of the offspring.

5. In humans, widow's peak is dominant to continuous hairline and short fingers are dominant to long fingers. If an individual who is heterozygous for both traits is married to an individual who is recessive for both traits, what are the chances that a child will also be recessive for both traits?

6. In plants, tallness is dominant over shortness and purple flowers are dominant over white ones.

   a. What is the genotype of the parents if a tall plant with purple flowers is crossed with a dwarf plant with white flowers and the offspring are 1/2 tall with purple flowers and 1/2 tall with white flowers?

   b. What is the genotype of the parents if a tall plant with white flowers is crossed with a dwarf plant with purple flowers and all offspring are tall with purple flowers.

   c. What is the genotype of the parents if a tall plant with purple flowers is crossed with a dwarf plant with white flowers and the offspring are: 1/4 tall purple; 1/4 dwarf purple; 1/4 dwarf white; 1/4 tall white?

   d. A tall purple crossed with a tall purple produced 3/4 tall purple and 1/4 tall white. What is the genotype of the parents?