Lecture Activity - GENETICS WORKSHEET

In the following problems, you will review the basics of solving genetics problems. Before you begin, review the following basic concepts:

A. The problems in this activity deal with **Mendelian** genetic traits. Mendelian genetics traits are determined by a **single gene locus** with exactly **two (2) alleles.** One allele is **DOMINANT** and the other allele is **recessive**.

B. Dominant alleles are represented by capital letters while recessive alleles are represented by the corresponding small letter. Actual letter choices are a matter of personal preference but common practice uses the first letter of the dominant trait.

e.g., Brown hair is dominant to red hair.
B = Brown hair
b = red hair

C. Organisms can be described by their **GENOTYPES** or **PHENOTYPES**:

1. Genotypes - represent actual allelic composition

heterozygous = alleles are different - eg. Bb, Aa
homozygous dominant = alleles are both dominant - BB, AA
homozygous recessive = alleles are both recessive - bb, aa

2. Phenotypes - represent the physical manifestation of the allelic composition

	DOMINANT phenotype	vs.	**recessive** phenotype
e.g.,	BROWN HAIR	vs.	red hair
	TALL	vs.	short

Note: Homozygous dominant & Heterozygotes individuals express the **DOMINANT** phenotype. Homozygous recessive individuals express the **recessive** phenotype.

D. Organisms are diploid and have 2 alleles at each gene locus. Therefore, each trait is represented by two letters (BB, Bb, bb). This represents the organism's **GENOTYPE** for that trait.

E. Gametes are haploid and have one allele at each gene locus. Therefore, each trait is represented by one letter (B, b). This represents the gamete's **GENOTYPE** for that trait

F. When determining the gametes that an organism can produce, take one allele (letter) from each gene locus (trait) for each gamete. It is not necessary to duplicate gamete genotypes.

e.g., BB - # of unique gametes: 1 = B
Bb - # of unique gametes: 2 = B, b

AaBB - # of unique gametes: 2 = AB, aB
AaBb - # of unique gametes: 4 = AB, Ab, aB, ab

G. The initial cross in a problem is called the PARENTAL GENERATION (P). The subsequent generations are called FILIAL GENERATIONS and indicated by subscripted numbers (F_1, F_2). The F_2 generation comes from crossing two F_1 offspring.

H. In any cross, each offspring will receive one allele (letter) from each parent. It is usually helpful to set-up a Punnent square to determine the genotypes of each offspring.

e.g., Bb x BB
→ gametes for Bb parent = B, b
→ gamete for BB parent = B

Note: Each gamete from each parent is placed in the first row or column. The genotype of each offspring is determined by combining one gamete from each parent

	B	b
B	BB	Bb

I. TEST CROSSES

Some of the problems that follow use test crosses. In a test cross, an individual expressing the dominant phenotype is crossed with an individual expressing the recessive phenotype. The recessive individual is the "tester", since its genotype is known (a recessive phenotype can only be expressed in an individual with a homozygous recessive genotype).

By analyzing the offspring of such a cross, the genotype of the phenotypically DOMINANT individual can be determined with some certainty. The phenotypically DOMINANT individual may be homozygous dominant or heterozygous. In a cross with a recessive individual, each of these dominant phenotypes will yield characteristic offspring ratios. The punnent squares are done below.

BB x bb

	b
B	Bb

All offspring are phenotypically dominant

Bb x bb

	b
B	Bb
b	bb

Half the offspring are phenotypically dominant & the other half are phenotypically recessive.

1:1 phenotype ratio

NOTE: Problems 4,6,7, & 8 in Section 1 and Problems 5-8 in Section 2 involve Test Cross Data

EACH SECTION THAT FOLLOWS CONTAINS SEVERAL WARMUP EXERCISES FOLLOWED BY ACTUAL PROBLEMS.

Section I: Monohybrid Crosses

1. In tomatoes, red fruits are dominant over yellow fruits.

   A. What letter would you choose to represent the red and yellow alleles.

   RED ALLELE = _____ YELLOW ALLELE = _____

2. Using your answers from #1, determine the genotypes of these organisms (remember, 2 letters for each trait).

   A. homozygous red fruited plant = _____
   B. heterozygous plant = _____
   C. yellow fruited plant = _____
   D. What is the phenotype (appearance) of plant B ? _____
   E. Why is it unnecessary to call plant C homozygous yellow fruited ?

   _____

3. For each of the answers in #2, list all the unique gametes that could be produced.

   A. _____
   B. _____
   C. _____

USE THE INFORMATION IN #1 - #3 ABOVE TO SOLVE THIS PROBLEM:

1. If you cross a homozygous red-fruited plant with a yellow-fruited plant, what is the appearance (phenotypes) and genotypes of the F_1 generation ?

2. What will be the phenotypes and genotypes of the F_2 generation.

NOTE: Monohybrid crosses involving 2 Heterozygotes always produce the same PHENOTYPE and GENOTYPE RATIOS

- **PHENOTYPE RATIO**
  - **3 dominant :1 recessive**
- **GENOTYPE RATIO**
  - **1 homozygous dominant: 2 heterozygotes: 1 homozygous recessive**

MORE MONOHYBRID PROBLEMS:

3. In squash, white color is dominant over yellow. Pollen (male gametes) from a heterozygous white fruited plant is placed on the pistil (female organ) of a yellow fruited plant. Determine the genotypes of the parents and the genotypes and phenotypes of the F_1 generation.

4. A hornless bull is bred to three cows, A,B, and C. Cow A is horned and produces Calf D, which is also horned. Cow B is hornless and produces Calf E, which is horned. Cow C is horned and produces Calf F which is hornless. Note: Hornless is dominant to horned.

   - Determine the genotypes of all seven animals.

   Bull:_____

   Cow A: _____ Calf D: _____

   Cow B: _____ Calf E: _____

   Cow C: _____ Calf F: _____

5. The gene for brown hair is dominant over that for blond hair. If two heterozygotes mated, what proportions of these two traits would you expect in their children ?

6. In humans the gene for farsightedness is inherited as a dominant (therefore normal vision is recessive). What fraction of children will have normal vision if a normal man mates with a woman who is farsighted and had a normal father ?

7. Two short-haired female guinea pigs are mated to a short-haired male guinea pig. Several litters are produced. The first female produces 25 short-haired offspring and no long-haired ones. The second female produces 15 short-hairs and 5 long-hairs. Based on this information, what deductions can be made concerning hair-length inheritance ? List the genotypes of all the parents and offspring.

8. In horses, trotter is dominant over pacer. A trotter is mated to a pacer. Over the course of several matings, 5 pacers are produced along with 4 trotters. What were the genotypes of each original parents ?

9. Silky feathers in fowl is recessive to normal feathers. If 96 birds were raised from a cross between two heterozygotes, how many would you expect to be normal ? silky ?

Section 2: DiHybrid Crosses

Dihybrid crosses examine two unlinked (on different chromosomes) gene loci. The following problem uses many of the skills you learned in the section on monohybrid crosses.

In peas, a single gene codes for stem length and another single gene codes for seed shape. Each gene has two alleles, one dominant and one recessive. For stem length, tall plants are dominant over short plants. For seed shape, smooth peas are dominant over wrinkled peas.

A. Choose letters to represent each gene and its alleles.

Seed shape: Smooth:_____ wrinkled:_____
Stem length: Tall:_____ short:_____

B. In the Table below is a list of all the possible phenotypes for this pair of traits. Determine the genotypes for these plants, in some cases there will be multiple possible genotypes. When we worked with one gene locus, each individual genotype was represented by 2 letters since individual organisms are diploid. Now we are working with two gene loci, so each individual genotype will be represented by 4 letters, 2 letters for each gene locus. The first genotype is given.

C. For each of the individuals in part B, list all the unique gametes that can be produced. Remember, each gamete will have 1 allele from each gene locus. When we worked with a single gene, each gamete genotype was represented by 1 letter. Now we are working with 2 gene loci, so each gamete genotype will be represented by 2 letters, one from each gene locus. Fill in the rest of the Table with all the possible gamete genotypes for each parent genotype listed. The first gamete genotype is given.

Table of Genotypes for Two Loci

Phenotype	Possible Genotypes	Possible Unique Gamete Genotypes
SMOOTH,TALL	SSTT	ST
wrinkle, TALL		
SMOOTH, short		
wrinkled, short		

USE THE TABLE OF INFORMATION ON THE PRECEDING PAGE TO SOLVE THE NEXT 2 PROBLEMS.

1. Determine the F_1 genotypes and phenotypes resulting from a cross of a homozygous Smooth and homozygous Tall plant with a wrinkled, short plant.

2. What are the F_2 genotypes and phenotypes (crossing two F_1 from problem #1)

MORE DIHYBRID PROBLEMS:

3. In fruit flies, the genes for wing length and body hair each have two alleles. Long wings and a hairless body are dominant to alleles for vestigial (functionally useless) wings and a hairy body.

   A. Calculate the genotypes and phenotypes of the offspring from the cross between a vestigial winged, hairy male and a homozygous dominant female.

   B. Calculate the genotypes and phenotypes of the F_2 offspring.

TAKE NOTE OF THE PHENOTYPE RATIO OF THE OFFSPRING FROM THE CROSS IN #3B. THE 9:3:3:1 RATIO IS THE RATIO FROM CROSSING TWO DOUBLE HETEROZYGOTES.

4. In snerds, matted-hair is dominant to frizzled-hair and buck-toothed is dominant to snaggle-toothed.

   A. A frizzled-hair, snaggle-tooth snerd is mated to a pure breeding matted-hair, buck-toothed snerd. What is/are the genotypes and phenotypes of the F_1.

   B. Without doing any calculations, what will be the phenotype ratio of the F_2.

5. In rabbits, black fur and normal length fur are dominant to brown fur and short fur. The litter from a mating of a black, normal fur rabbit with a brown, short rabbit contains 6 black, shorts and 7 black, normals. What are the genotypes of the parents ?

6. After eating asparagus, some individuals excrete the strongly odorous substance, methanethiol. The excretion of this substance is due to a recessive gene. After eating red beets, some individuals excrete the red pigment, betamin. This is due to a dominant gene. A man and a woman both excrete betamin but do not excrete methanethiol. Their son excretes methanethiol but does not excrete betamin. Give the genotypes of the man, woman, and their son. What genotype and phenotypes and in what proportions can be expected in subsequent progeny ?

7. On the planet Zion, you have discovered two interesting plants. These plants exhibit several traits, two of which you decide to study genetically. The two traits are singing (production of a perfect "C" note upon touching) vs. non-singing and smelly (exude a odor of manure) vs. fragrant (exude an odor similar to earth roses). You manage to isolate a pure breeding singer, smelly and a pure breeding non-singer, fragrant. When you cross these two individuals all the progeny are non-singersm smelly. Based in this information, what can you conclude about the nature of these two genes ? What are the genotypes of your pure-breeding stock ?