■ Background

Monohybrid crosses are crosses in which only one characteristic/trait is considered. For example, attached earlobes verses unattached earlobes in humans. **Sex-Linked** crosses are crosses in which the characteristics being considered are related to genes on either the X or Y chromosome. Of all the chromosomes a given species may have, the **X** chromosome carries the genes for female sex determination and female characteristics, while the **Y** chromosome carries the genes for male sex determination and male characteristics. Additionally, the **X** chromosome carries a number of other genes from near sightedness and distichiasis (double eyelashes) in humans, to eye color in fruit flies. **Dihybrid crosses** involve tracking two traits simultaneously. For example, we can predict the outcome for offspring as the traits for both height and color are concerned.

Original parents in any given set of crosses are called the **parent generation or parentals**, while the two subsequent generations are denoted with the symbols **F1** and **F2** (a cross of two F1 individuals). Punnett Squares are one method for visually demonstrating genotypic crosses, the resulting **genotypes** of the offspring, and subsequent **phenotypes** as well. See the example below. Note the calculation and reporting of probabilities for the offspring.

■ Example 1: (Monohybrid Cross)

For humans, brown eyes are dominant (B) over blue eyes (b). A heterozygous brown-eyed man marries a blue-eyed female. What are the possible genotypes and phenotypes of the offspring? Give your answers in probabilities.

Parents: Male = Bb; Female = bb

> The separation of the parental genotype from Bb and bb on either side of the Punnett Square represents meiosis. Each single letter represents a possible haploid condition in either an egg or a sperm – whereas the double letters represent a diploid condition.

	B	b
b		
b		

Conventions

1. Male alleles on top of Punnett Square - female alleles on the left
2. Dominant allele (upper case) written before recessive allele (lower case)

Probabilities For F1 Offspring

Genotypes: Bb = 2/4 = 50%   Phenotypes: Brown eyed (Bb) = 2/4 = 50%
              bb = 2/4 = 50%   Blue eyed (bb) = 2/4 = 50%

Every time you complete a Punnett Square you must list and calculate the probabilities that the cross predicts for both genotypes and phenotypes. Remember, Punnett Squares predict the probability that a particular genotype or phenotype will be produced. These values may not always match a given set of offspring.

■ Monohybrid Problems

1   In guinea pigs rough coats are dominant over smooth coats. Let R = a rough coat and r = a smooth coat. *when the problem is not sex-linked and neither the male or female are identified – the convention is to consider the first individual as the male

If a homozygous rough-coated (RR) guinea pig is crossed with a smooth (rr) coated guinea pig, what will be the genotypes and phenotypes of both the F1 and F2 generations? **(recall that a F2 generation is the result of crossing two F1 individuals – hint: F2 problems can only be proposed when the F1 offspring all have the same genotype!)**

THIS PROBLEM REQUIRES TWO PUNNETT SQUARES: ONE FOR EACH GENERATION. IDENTIFY EACH PUNNETT SQUARE AS EITHER F1 OR F2.

Parentals: Male = RR; Female = rr

2. *This is a more challenging monohybrid problem*. A certain rough-coated guinea pig, when breed with a smooth-coated guinea pig gives 8 rough and 7 smooth offspring. What are the genotypes of both the parents and the offspring **most likely to be? Show all work.**

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■ **Example 2:** (Sex-Linked Cross)

The normal female condition is a result of the chromosomal pairing **XX**, while the normal male condition is **XY.** Certain genes located on the X chromosome, not associated with female sex characteristics, cause sex-linked recessive traits. As a result, females must receive two recessive alleles to exhibit any particular characteristic associated with one of these genes, while males need only receive one allele. The reason for the male anomaly is that the **Y** chromosome does not carry versions of the same genes as the **X** chromosome.

As you will see in this example, a dominance/recessive situation can occur. However, the fact remains that the male can carry only one allele for a given sex-linked trait. Likewise, only females can be a true heterozygote (one dominant allele and one recessive allele).

➢ Hemophilia is a rare heredity human disease of the blood. The blood of individuals with this condition does not clot properly. Without the capacity for blood clotting, even a small cut can be lethal. In a marriage of two non-hemophiliac parents, a bleeder son is born. What are the probabilities of these parents giving birth to sons being bleeders, and to daughters being bleeders? Use (H) for the normal "non-hemophiliac" allele and (h) for the hemophilia allele.

Parents: Male = $X^H Y$; Female = _____
Son Bleeder = $X^h Y$
Daughter Bleeder = $X^h X^h$

	Recall:	half of all sperm (which are haploid) carry the X chromosomes and half carry the Y chromosome

$$X^H \qquad\qquad Y$$

Recall: half of all sperm (which are haploid) carry the X chromosomes and half carry the Y chromosome

while 100% of all eggs (which are also haploid) carry only the X chromosome

Genotypes: Males = _____

Females = _____

Phenotypes: Males = _____

Females = _____

Answer to the question? _____

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■ Sex-Linked Problems

1. In humans colorblindness (b) is an example of a sex-linked recessive trait. In this problem, a male with colorblindness marries a female who is not colorblind but carries the (b) allele.
   Using a Punnett Square, determine the genotypic and phenotypic probabilities for their potential offspring.

2. In fruit flies red eye color (R) is dominant to white eyes (r). In a cross between two flies, 50% of the male and 50% of the female offspring had red eyes. The other half of the males and females had white eyes. What are the phenotype, and all possible genotypes, of the parents?
   Show All Work

■ Example 3: (Dihybrid Cross)

In garden peas, tallness (T) is dominant to shortness (t) and axillary flowers (A) are dominant to terminal flowers (a). What are the expected genotypes and phenotypes of the offspring if a heterozygous tall, heterozygous axillary plant is crossed with a heterozygous tall, terminal plant? Give your answers in probabilities, and ratios.

Parents: Male = TtAa; Female = Ttaa

Meiotic Distribution of Alleles

1. Purpose: to distribute the parental alleles into gametes (eggs and sperm or pollen and ovum) as would be predicted by meiosis.
2. Use the FOIL method from the binomial distributive property of multiplication.
3. ex: gamete distribution for AaBb

AB   Ab   aB   ab

F1 Offspring: Genotypes =

        Phenotypes =

        Genotypic ratio =

        Phenotypic ratio =

Mendelian Genetics Worksheet

■ Dihybrid Cross Problems

1. For certain cattle, (R) is the allele for red horns, and (r) is the allele for white horns. However Rr is the genotype for roan colored horns [this is an exception to the typical heterozygote condition where you might expect Rr cattle to have red horns]. Red horn cattle have the genotype RR. For these cattle shorthair (P) is dominant to longhair (p). Report a full set of data for the offspring resulting from a cross between a roan-horned homozygous shorthair bull and a red-horned heterozygote shorthaired cow. **Show all Work.**

2. In rabbits, spotted coats (S) are dominant to solid colored coats (s), and short hair is (L) is dominant to long hair (l). A homozygous spotted, longhaired male is mated to a fully solid-colored, homozygous shorthaired female rabbit. If the F1 offspring were allowed to interbreed and 64 offspring were produced, how many of the 64 would you predict would be spotted with long hair, and how many will be solid colored with short hair? **Show all Work.**