Background

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 the probability of offspring **genotypes** and offspring **phenotypes**.

Example 1: (*Monohybrid Cross*)

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

Parents: Male = Bb; Female = Bb

	B	b
B		
b		

> 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.

> **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)*

Record the probabilities for genotypes and phenotypes of the offspring (F_2 generation) as percents and ratios. *Use the following format to write genotypic ratios: homozygous dominant: heterozygous: homozygous recessive. Use the following format to write phenotypic ratios: dominant phenotype: recessive phenotype.*

Genotypic Percents	Phenotypic Percent
25% BB	75% brown eyes
50% Bb	25% blue eyes
25% bb	

Monohybrid Practice Problems

1. Cystic fibrosis is a recessive genetic disorder. Ron is homozygous dominant (FF) and Nancy is a carrier (Ff) of cystic fibrosis. Use a Punnett square to predict the probability that one of their children will have cystic fibrosis? **Show all work and box your final answer.**

Genotypic Percents	Phenotypic Percents

2. Patty is homozygous dominant for freckles (SS), while Charlie is homozygous for no freckles (ss). Draw a Punnett square predicting the probability if their children will have freckles.

Genotypic Percents	Phenotypic Percents

3. Eddie has brown eyes, while Cybil has blue. If brown eyes are known to be dominant, and blue eyes are recessive, use a Punnett square to predict their offspring. Assume Eddie doesn't carry a recessive allele.

Genotypic Percents	Phenotypic Percents

4. Larry and Lola Little have achondroplasia, a form of dwarfism. Both are heterozygotes. Their son, Big Bob Little, is 7'1". Use a Punnett square to show how Big Bob got his genotype.

Genotypic Percents	Phenotypic Percents

5. Woody Guthrie, who wrote *This Land is Your Land*, was heterozygous for Huntington's disease (Hh). His wife was homozygous recessive and perfectly normal (hh). Huntington's disease is caused by a latent dominant gene, meaning that it is not phenotypically (physically) expressed until later in life. Dominant disease genes are expressed in homozygous dominant and heterozygous people (HH or Hh). Draw a Punnett square for Woody ad his wife.

Genotypic Percents	Phenotypic Percents

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. Consequently, only females can be true heterozygotes (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^HY; Female = _____
Son Bleeder = X^hY
Daughter Bleeder = X^hX^h

Recall:
Half of all sperm (haploid) carry the X chromosome and half carry the Y chromosome, while 100% of all eggs (haploid) carry only the X

X^H Y

	Genotypic Percents	Phenotypic Percents
male		
female		

Monohybrid and Sex-Linked Worksheet

Sex-Linked Practice 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.

	Genotypic Percents	Phenotypic Percents
male		
female		

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 offspring?

	Genotypic Percents	Phenotypic Percents
male		
female		

Example 3: (*Dihybrid Cross*)

Dihybrid crosses use Punnett squares to distribute parental alleles from *two* genes into gametes (eggs and sperm or pollen and ovum) as would be predicted by meiosis.

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

Guidelines for Dihybrid Punnett Squares

1. Dihybrid crosses - use the *FOIL* method from the binomial distributive property of multiplication.
   ex: gamete distribution for AaBb:
   AB   Ab   aB   ab

2. Dominant alleles (upper case) are written before recessive allele (lower case) - except for distributing alleles in dihybrid crosses.

3. Alleles of the same gene always stay together (important in dihybrid problems)

Genotypes:

	Genotypic Ratios	Phenotypic Ratios

Phenotypes:

Monohybrid and Sex-Linked Worksheet

Dihybrid Practice Problems

1. In horses, the coat color black is dominant (B) over chestnut (b). The trotting gait is dominant (T) over the pacing gait (t). If a homozygous black pacer is mated to a homozygous chestnut, heterozygous trotter, what will be the ratios for genotype and phenotype of the F_1 generation?

Genotypes:

Phenotypes

Genotypic Ratios	Phenotypic Ratios

2. In rabbits, the coat color black dominant (B) over brown (b). Short hair is dominant (S) over long (s). In a cross between a homozygous black short-haired male and a brown homozygous long-haired female, what would be the ratios for genotype and phenotype of the F_1 generation?

Genotypes:

Phenotypes

Genotypic Ratios	Phenotypic Ratios

3. Imagine that a couple is planning to have children. The male is heterozygous for Huntington's disease and homozygous dominant for Tay-Sachs. The female is homozygous recessive for Huntington's disease and heterozygous for Tay-Sachs. The couple is curious about the possibility and probability of their offspring inheriting Tay-Sachs and/or Huntington's. For humans, Huntington's disease is dominant (H) over the "normal" condition (h), and the "normal" condition is dominant (T) over Tay-Sachs (t). Complete a Punnett square for this cross and record the probabilities for genotypes and phenotypes of the offspring as ratios.

Genotypes:

Phenotypes

Genotypic Ratios	Phenotypic Ratios

Monohybrid and Sex-Linked Worksheet