Genetic Crosses

In this lesson, you will learn how to predict the probable genetic makeup and appearance of offspring resulting from specific crosses.

Probability

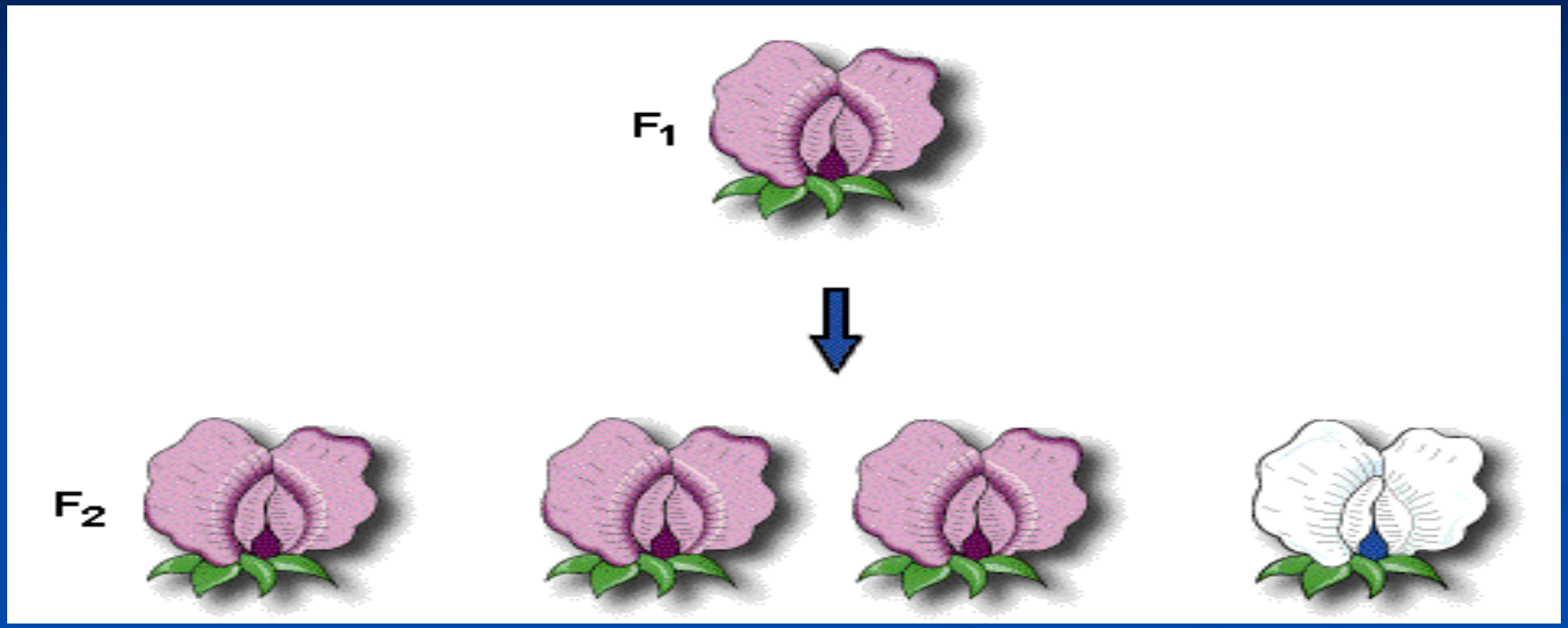
- Predicts the likelihood that a specific event will occur.
- May be expressed a a decimal, a percentage, or a fraction.
- Determined by the following formula:

$$\text{Probability} = \frac{\text{number of times an event is expected to happen}}{\text{number of opportunities for an event to happen}}$$

Why probability is important to genetics

- Mendel used probability to determine how likely the dominant trait would appear over the recessive trait.
- The yellow pea appeared 6,022 times in the F_2 generation. The green pea appeared 2,001 times.
  - The total number of individual was 8023 (6022+2001)
  - Using the formula:
    - 6022 ÷ 8023 = 0.75
    - 2001 ÷ 8023 = 0.25
      - Percentage: 75% green peas 25% yellow peas
      - Ratio: 3:1 ratio of yellow to green peas
      - Fraction: 1/4 chance of green peas and 3/4 chance of yellow peas

Results of the F1 generation



PP **Pp x 2** **pp**

ratio: 1:2:1 or 3:1 purple to white

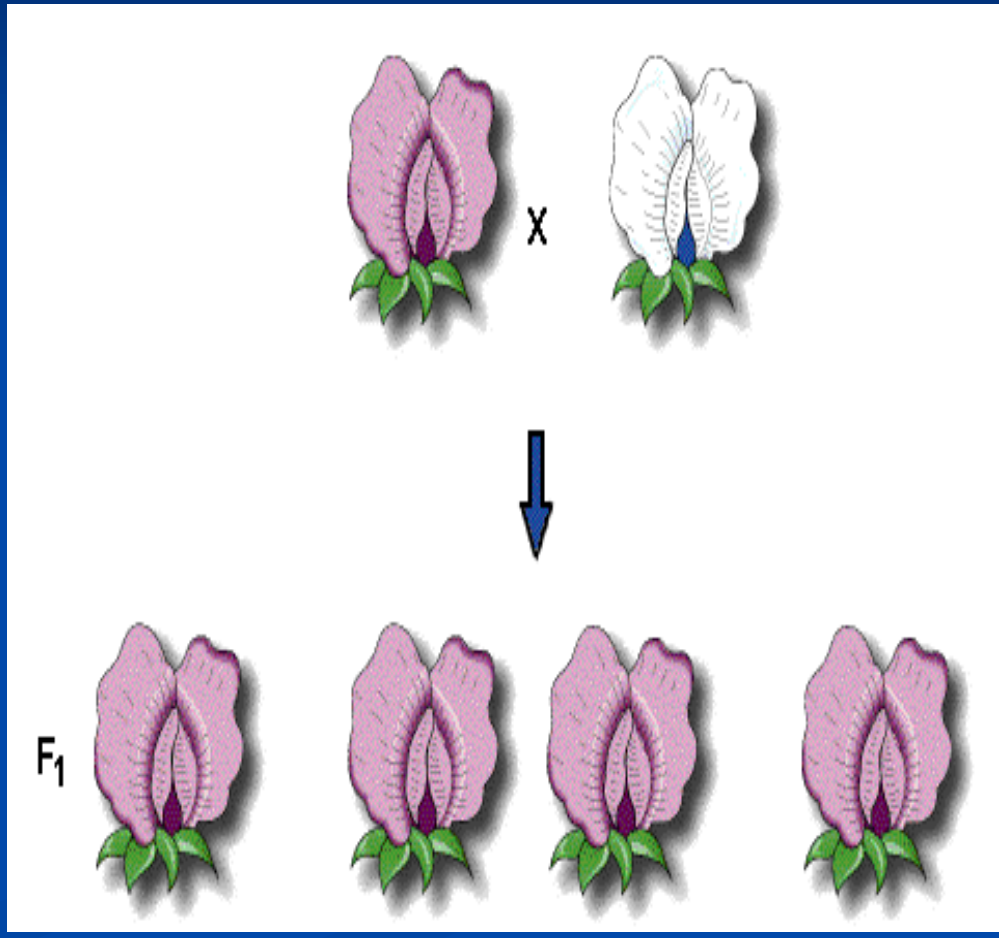
75% purple to 25% white

F_1 generation yielded 100% purple flowers, heterozygous for the purple trait.

white (pp) x purple(PP)

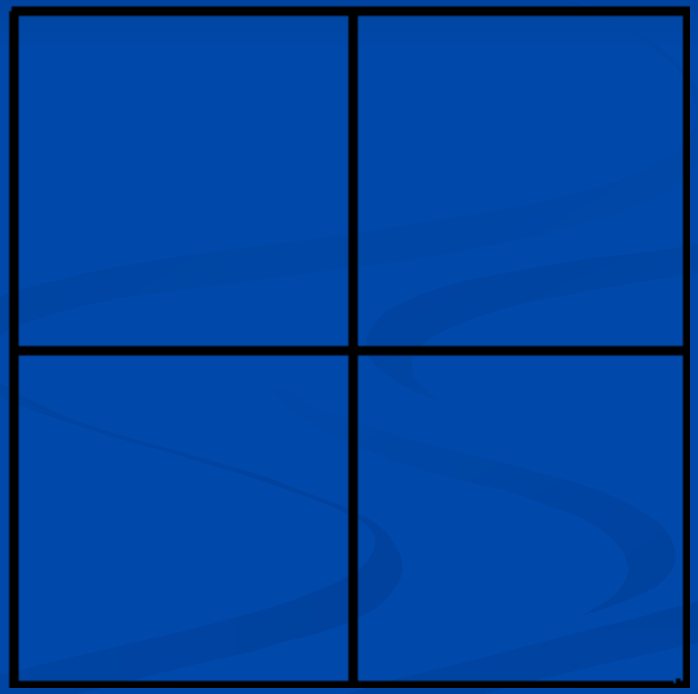
yields

100% purple flowers that are heterozygous for the purple flower trait (Pp).



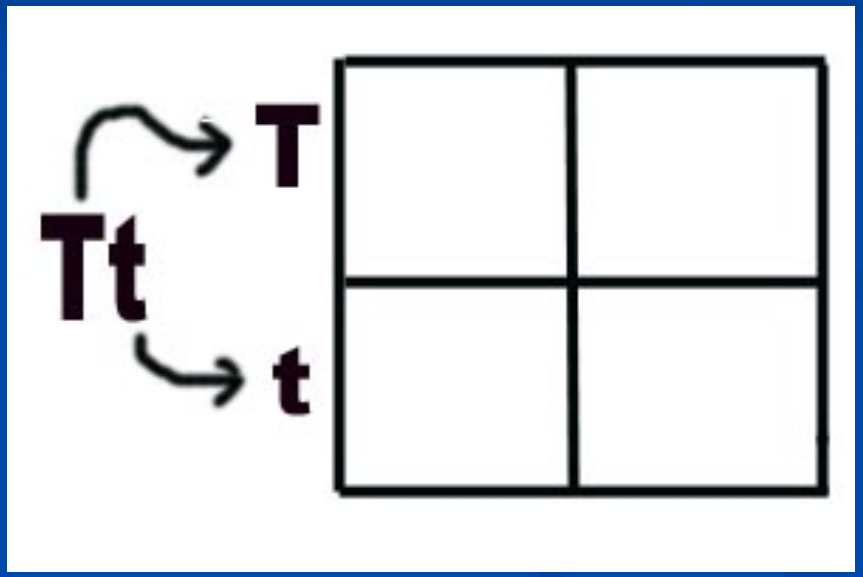
Punnett Square

- A diagram used to predict the probability of certain traits by offspring.
- The following examples will illustrate the outcome of different types of crosses.



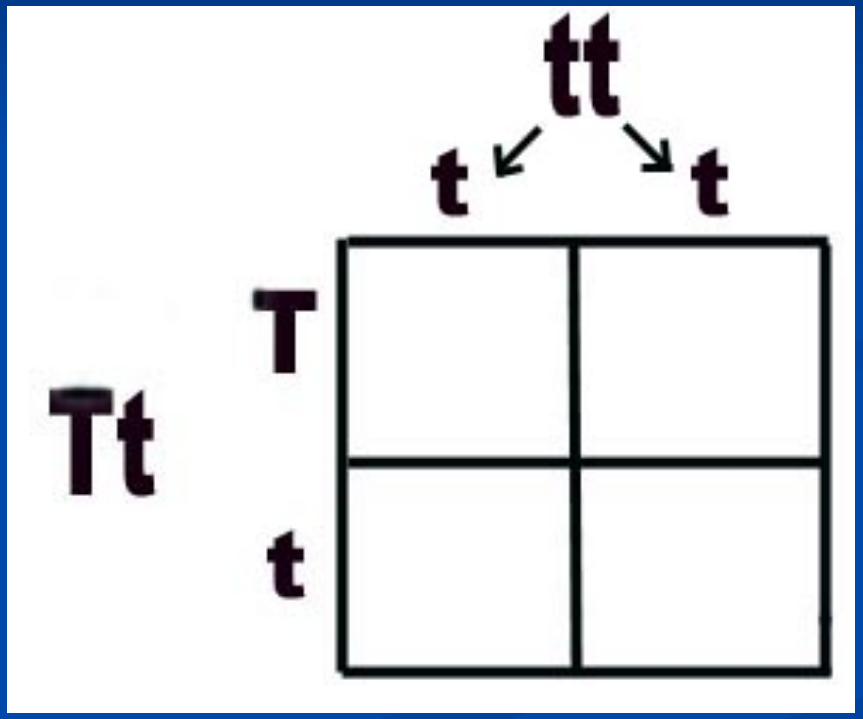
How to set up and work a Punnett square

- Draw a four-square box.
- Place one set of alleles on the side of the box as shown at right.



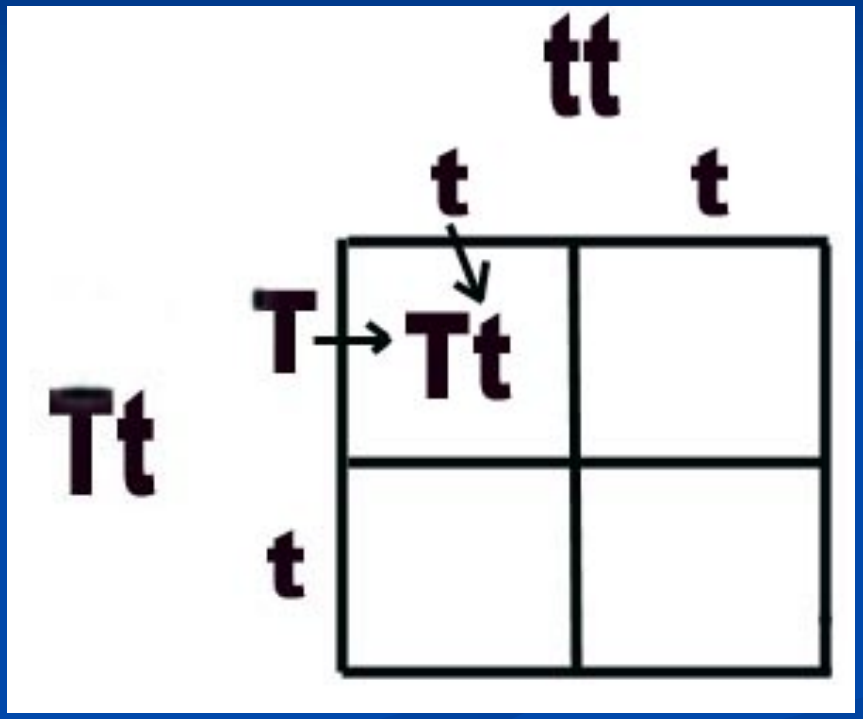
How to set up and work a Punnett square

- One set of alleles for a trait go on top of the box (usually male) and the other set of alleles go on the side of the box.
- Each letter from the set of alleles is placed on top of the square.



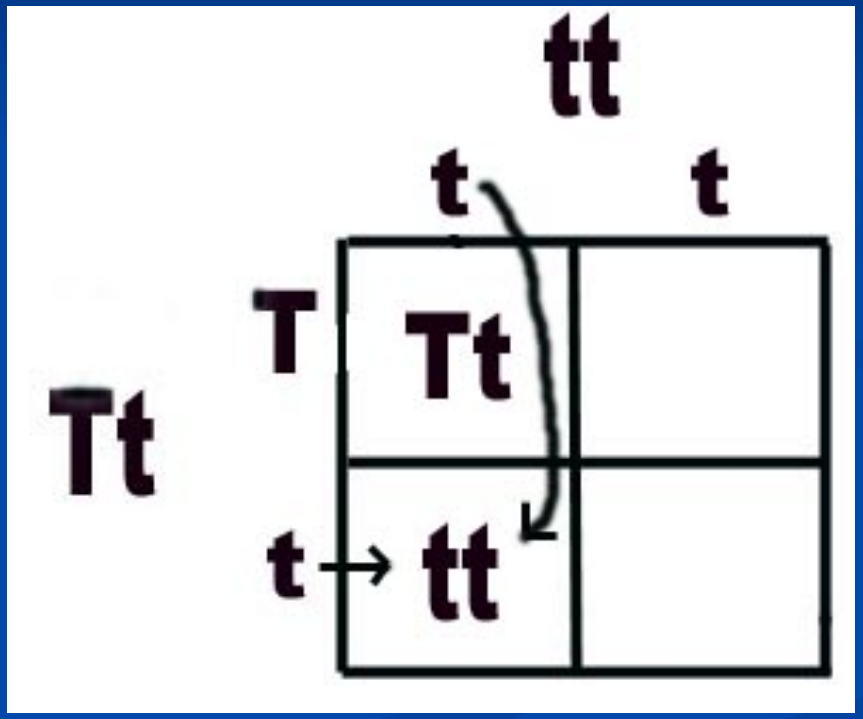
Filling in the boxes…

- Fill in the top left box with the alleles from top left and upper left.
- The dominant letter is placed first.



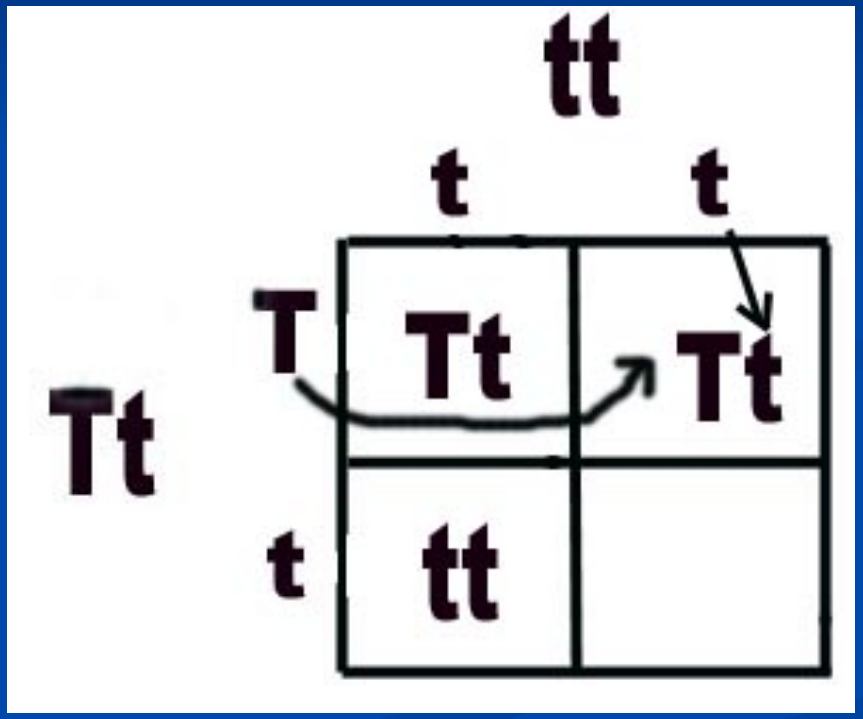
Filling in the boxes…

- The second box gets the top left and bottom left allele



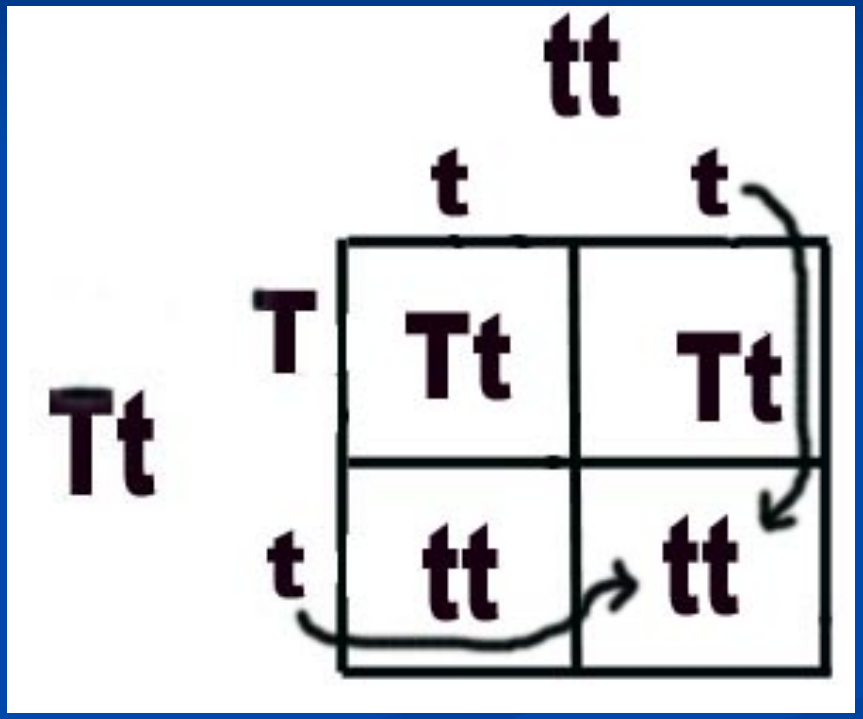
Filling in the boxes…

- The third box gets the top right and the top left letters
- Remember that the capital letter goes first.



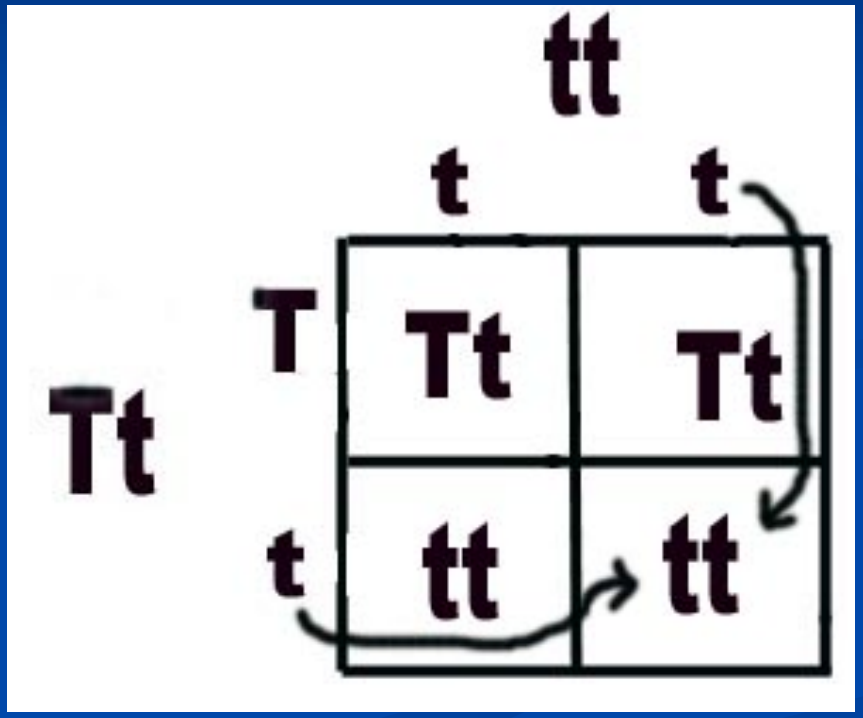
Filling in the boxes…

- The fourth box gets the top right and the lower left letter.



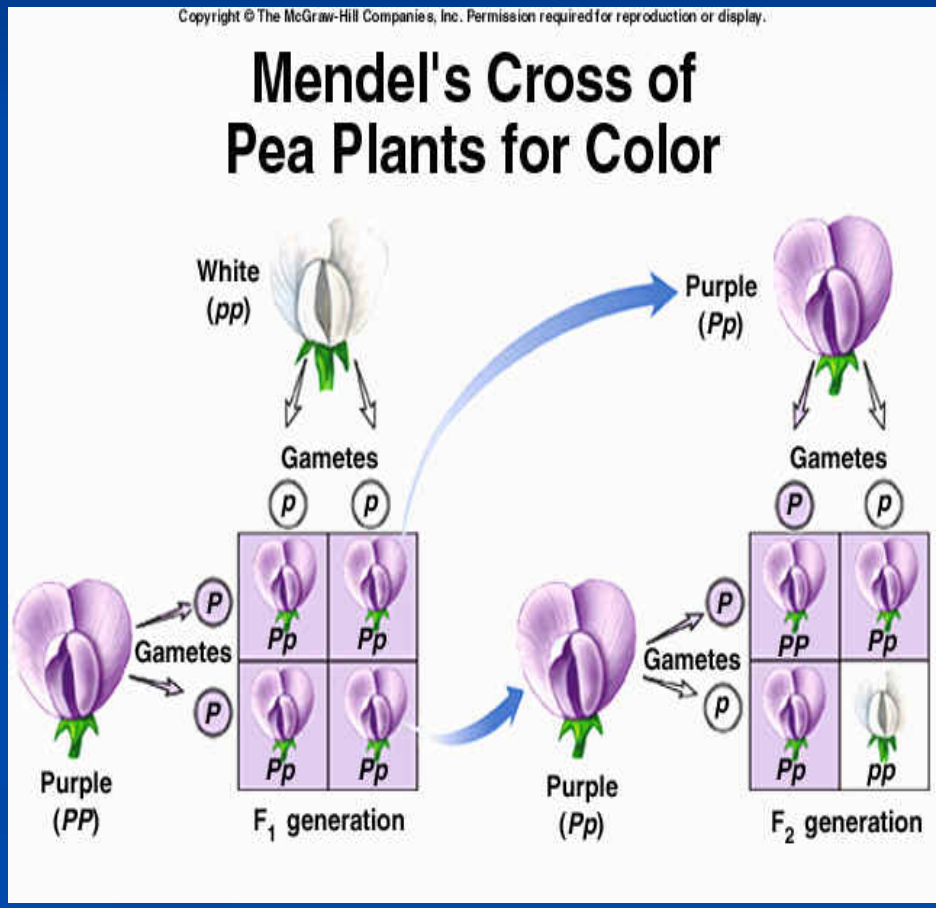
Ok. So what does this mean?

- Each box represents a possible zygote.
- The alleles are for a single trait, in this case T is tall and t is short.
  - **Tt is the genotype for a heterozygous tall.**
  - **tt is the genotype for homozygous recessive short.**
  - **From this cross, 50% of the offspring will be tall and 50% will be short. This is the phenotype.**



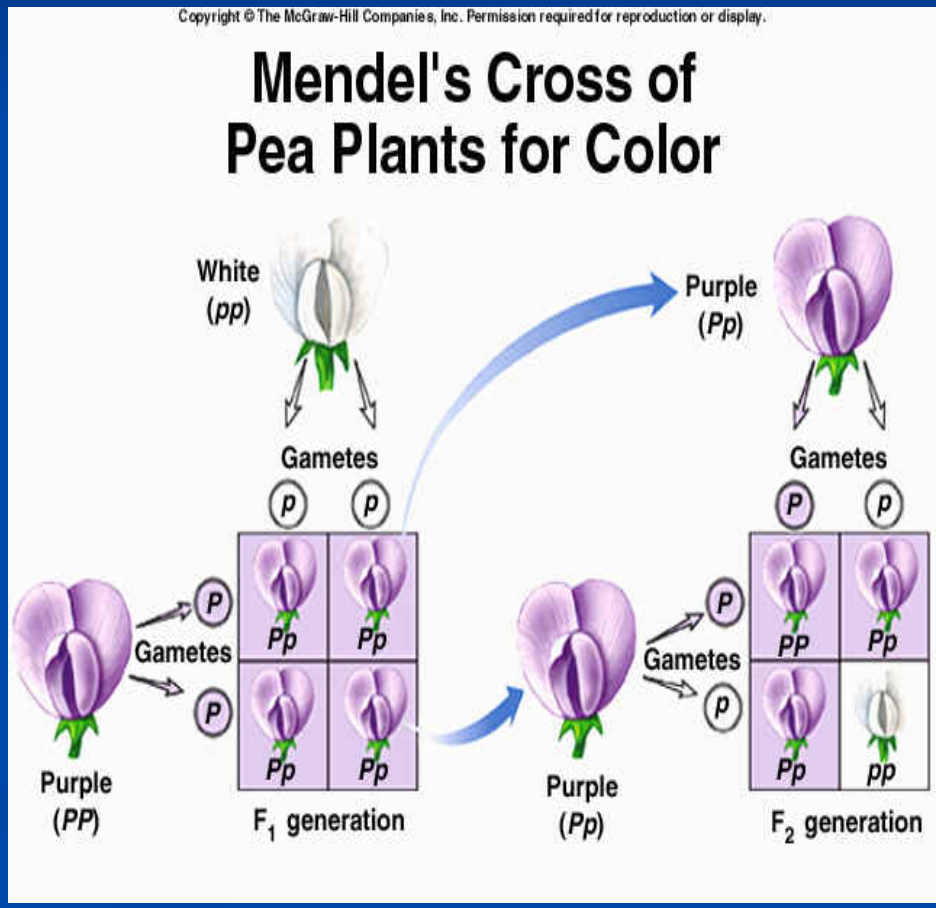
Let's apply this to Mendel's experiment.

- Two homogeneous parental generations were crossed to yield the F_1 generation.
  - The results were 100% purple flowers, heterozygous for the trait (Pp).



Let's apply this to Mendel's experiment.

- Two heterozygous F_1 generations were self-pollinated.
  - The results were 25% heterozygous purple flowers; 50% homozygous purple flowers, and 25% white flowers (homozygous recessive)
- This 3:1 ratio hold true for all heterozygous monohybrid crosses!



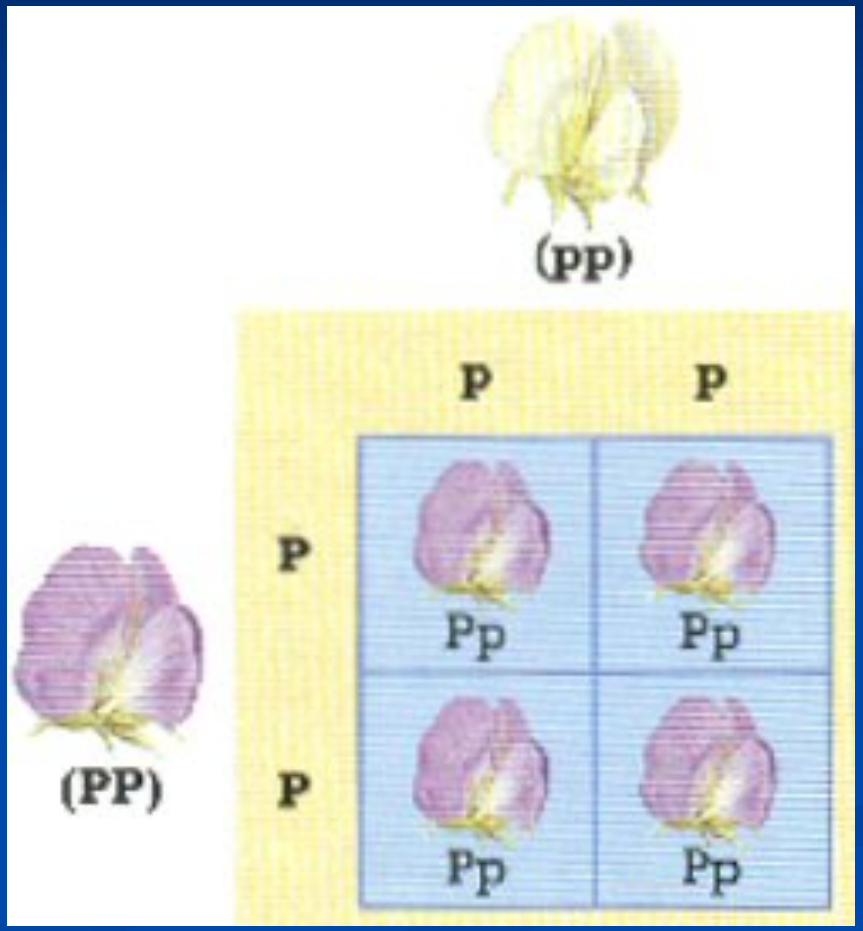
Genetic Crosses

- Genetic crosses are used to predict the probability of offspring resulting from the union of sperm and egg.
- Types of crosses:
  - Monohybrid cross - cross between one pair of contrasting traits.
  - Dihybrid cross - cross between two pairs of contrasting traits.
  - Test cross - an unknown genotype is crossed with a homozygous recessive individual.

Homozygous x Homozygous

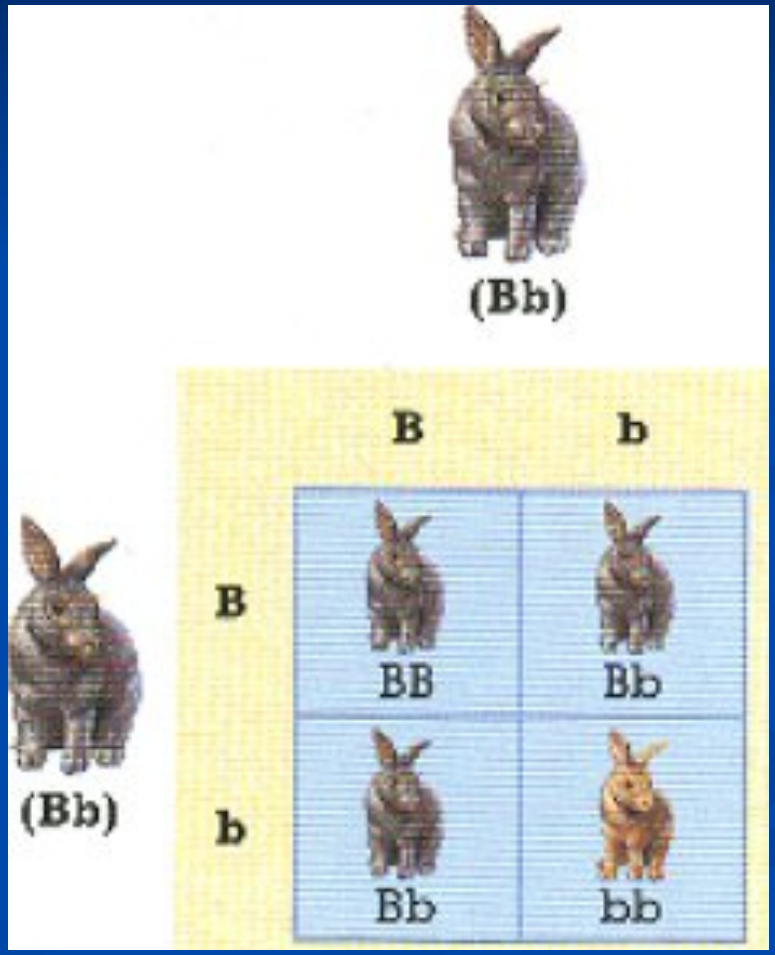
pp x PP

- This Punnett represents Mendel's P_1 generation
  - The recessive alleles for white flowers (pp) are crossed with the homozygous dominant purple flower (PP)
  - All of the offspring are heterozygous (Pp) and show the dominant trait of purple.
  - Genotype: 100% Pp
  - Phenotype: 100%purple flower color



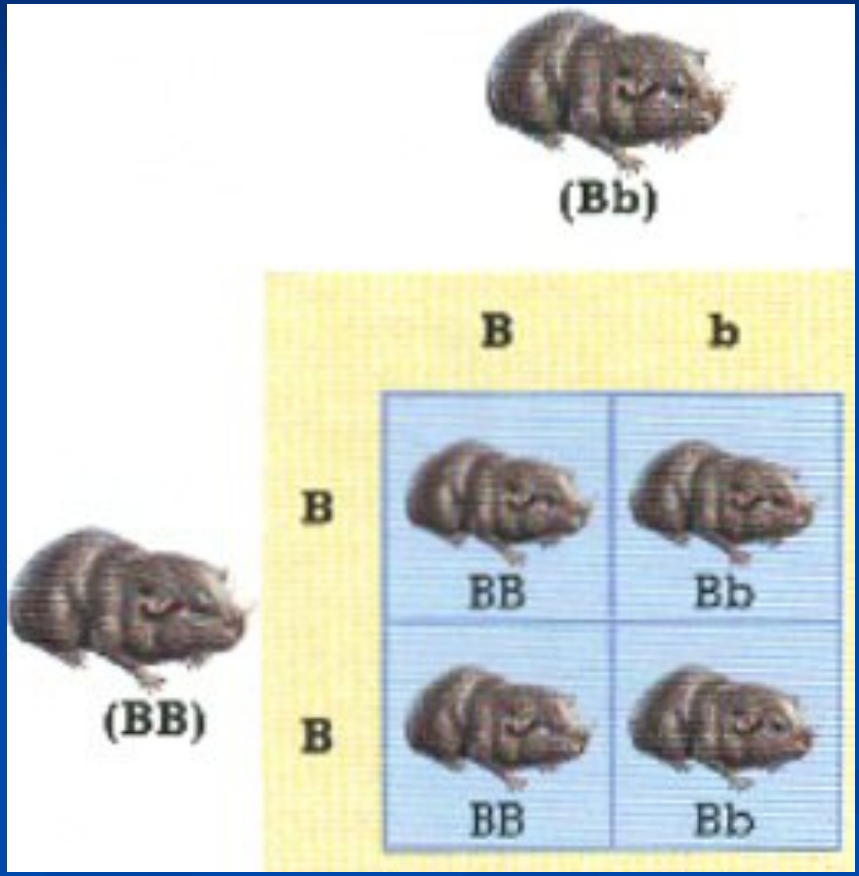
Heterozygous x Heterozygous
Bb x Bb

- This is an example of Mendel's F_2 generation that shows 75% dominant and 25% recessive trait (3:1 ratio).
- This cross represents a cross between two heterozygous black haired rabbits (brown hair is the recessive trait).
  - Genotype: 25% BB; 50% Bb; 25% bb or 1:2:1 ratio.
  - Phenotype: 75% black hair and 25% brown hair (3:1 ratio).



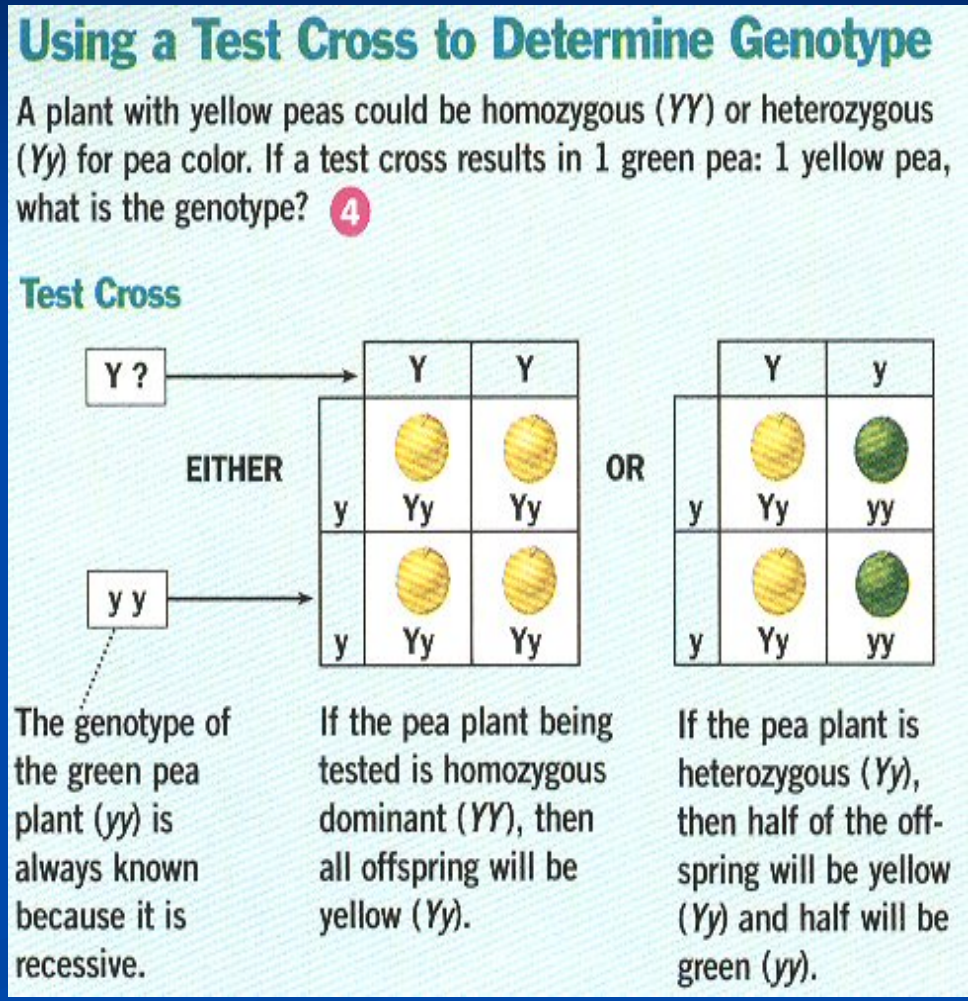
Homozygous x Heterozygous
BB x Bb

- This cross represents a homozygous dominant allele for black coat (BB) crossed with a heterozygous allele for black coat (Bb)
  - Genotype: 50% of the offspring are homozygous dominant (BB) and 50% are heterozygous (Bb)
  - Phenotype: 100% black coat.



Test Cross

- Useful when you want to determine whether a trait is homozygous or heterozygous for the trait.
- An unknown genotype is crossed with a homozygous recessive individual.
  - Left; If no recessive traits appear, then the unknown genotype if most likely homozygous for the trait.
  - Right: If any of the offspring show the recessive trait, then the unknown genotype is likely heterozygous for the trait.

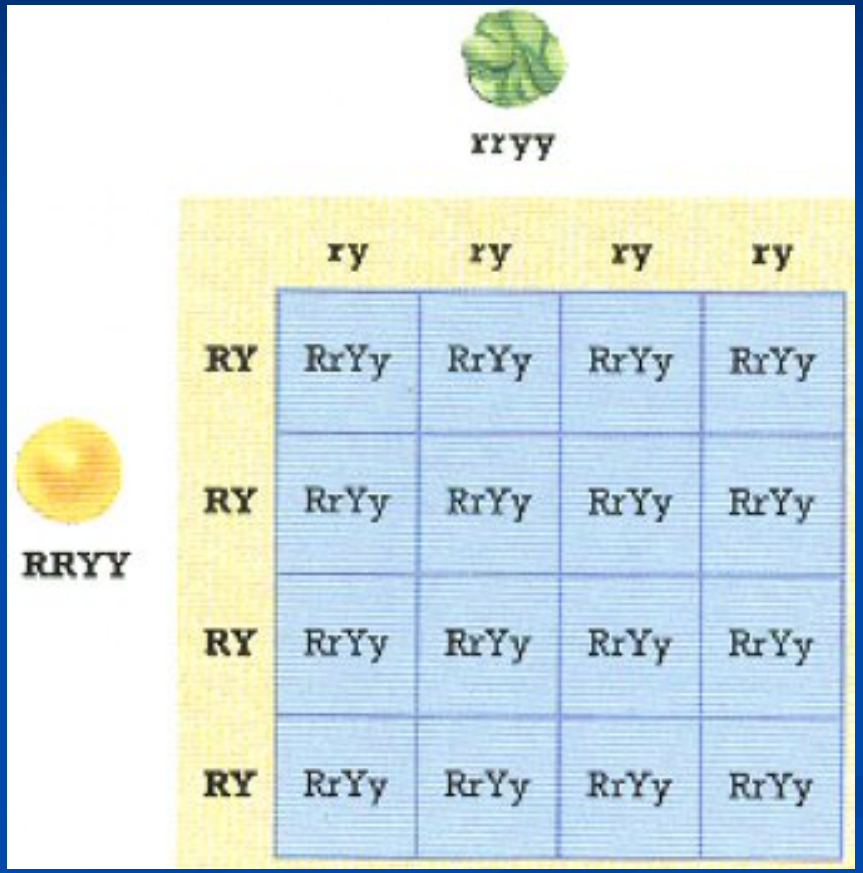


Dihybrid Crosses

- Cross between individuals that involves two pairs of contrasting traits
- Four alleles allows for 16 possible combinations of alleles. (16 box Punnett square)
- Four combinations of alleles can be determined by using the "foil" method of distribution. YyTt
  - First pair of alleles = YT (dominant)
  - Outer pair of alleles = Yt (heterozygous)
  - Inner pair of alleles = yT (heterozygous)
  - Last pair of alleles = yt (recessive)

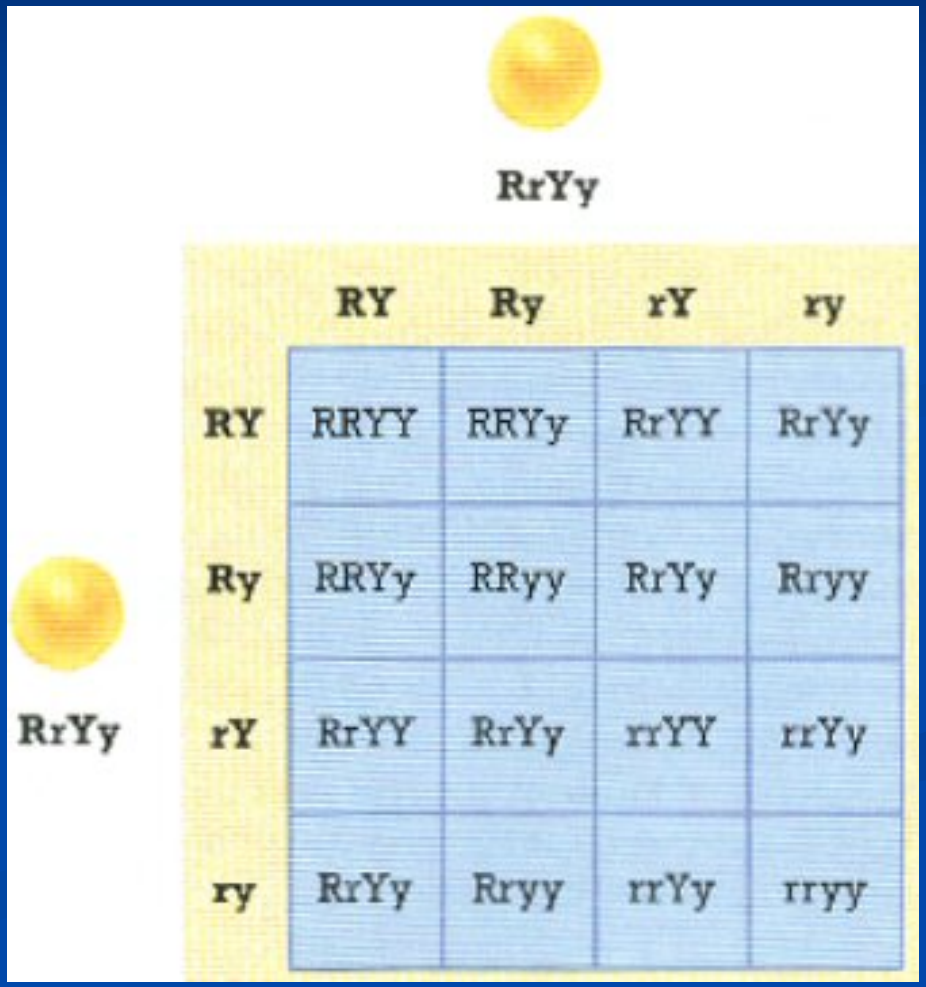
Dihybrid Crosses homozygous x homozygous

- The example at right crosses two homozygous monohybrid traits
- This is representative of a dihybrid cross of Mendel's P generation
- Notice that all of the offspring are heterozygous (RrYy) for the dominant trait-- yellow (R) and smooth (Y)



Dihybrid Cross heterozygous x heterozygous

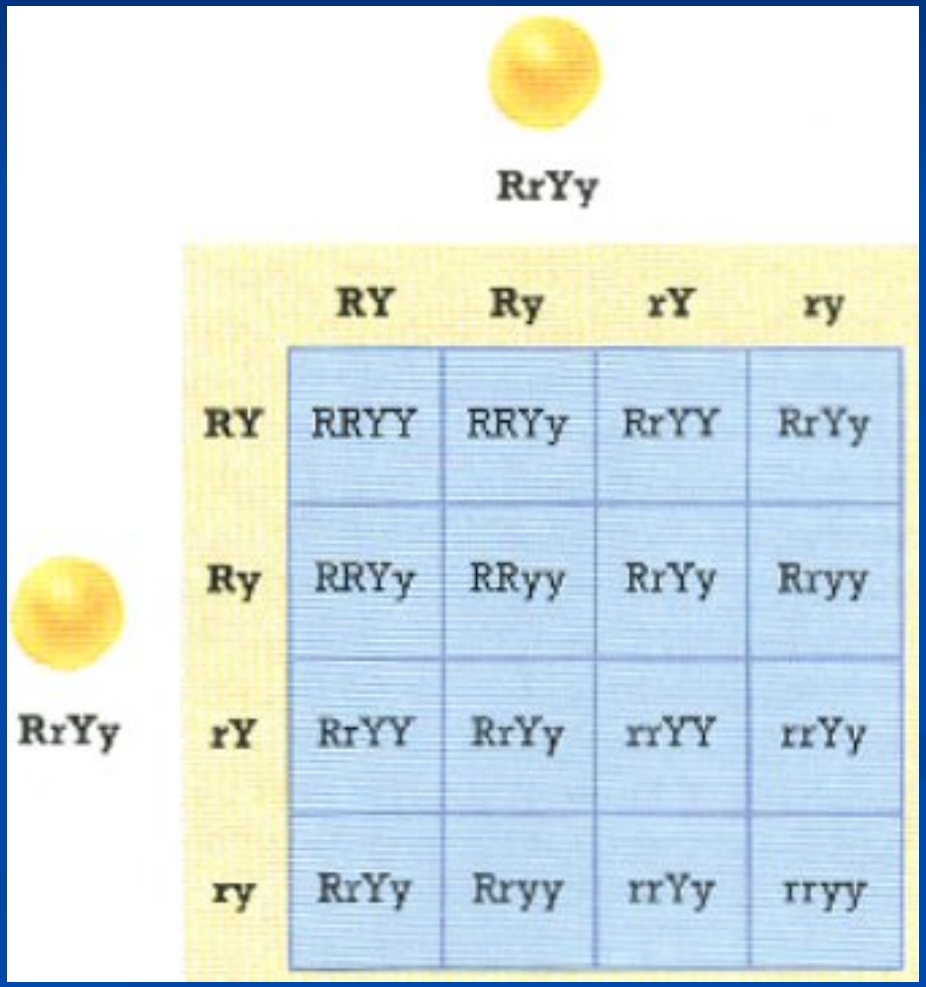
- RrYy is a heterozygous trait for yellow, smooth peas
- This represents Mendel's cross of the F_1 generation, with two traits.
- Using the foil method to determine possible gametes, the choices are RY, Ry, rY, and ry
- After placing the allele combinations along the top and side, you follow the basic rule for combining alleles, remembering to place capital letters first, and like combinations of alleles together.



	RY	Ry	rY	ry
RY	RRYY	RRYy	RrYY	RrYy
Ry	RRYy	RRyy	RrYy	Rryy
rY	RrYY	RrYy	rrYY	rrYy
ry	RrYy	Rryy	rrYy	rryy

Dihybrid Cross
heterozygous x heterozygous

- Yellow color (R) is dominant to green (r) : = yellow; = green
- Round (Y) is dominant to wrinkled (y):
- The possible combinations are:
  - 9/16 - round and yellow seeds (genotype: RRYY, RRYy, RrYY, RrYy)
  - 3/16 - round, green seeds (genotype: Rryy, Rryy)
  - 3/16 wrinkled,yellow seeds (genotype: rrYY, rrYy)
  - 1/16 wrinkled, green seeds (genotype: rryy)
- **The ratio of 9:3:3:1 holds true for every dihybrid heterozygous cross!**
- Nine different genotypes and four different phenotypes.



Genetic Problem

- Assume that black hair is dominant to brown hair. Cross a heterozygous black haired trait with a homozygous recessive brown hair trait.
  - Draw a Punnett square and predict the offspring.
  - Give the percentages and ratio's of the phenotype and genotypes of the offspring.