MENDEL AND HEREDITY

Gregor Mendel

- **Gregor Mendel** - "father of modern genetics"
- Born 1822 - Austria; monk
- One of the first to use a **quantitative approach** with biology
- Performed genetic experiments and accurately predicted patterns of heredity
- **Later** scientists found that traits were determined by genes encoded in DNA

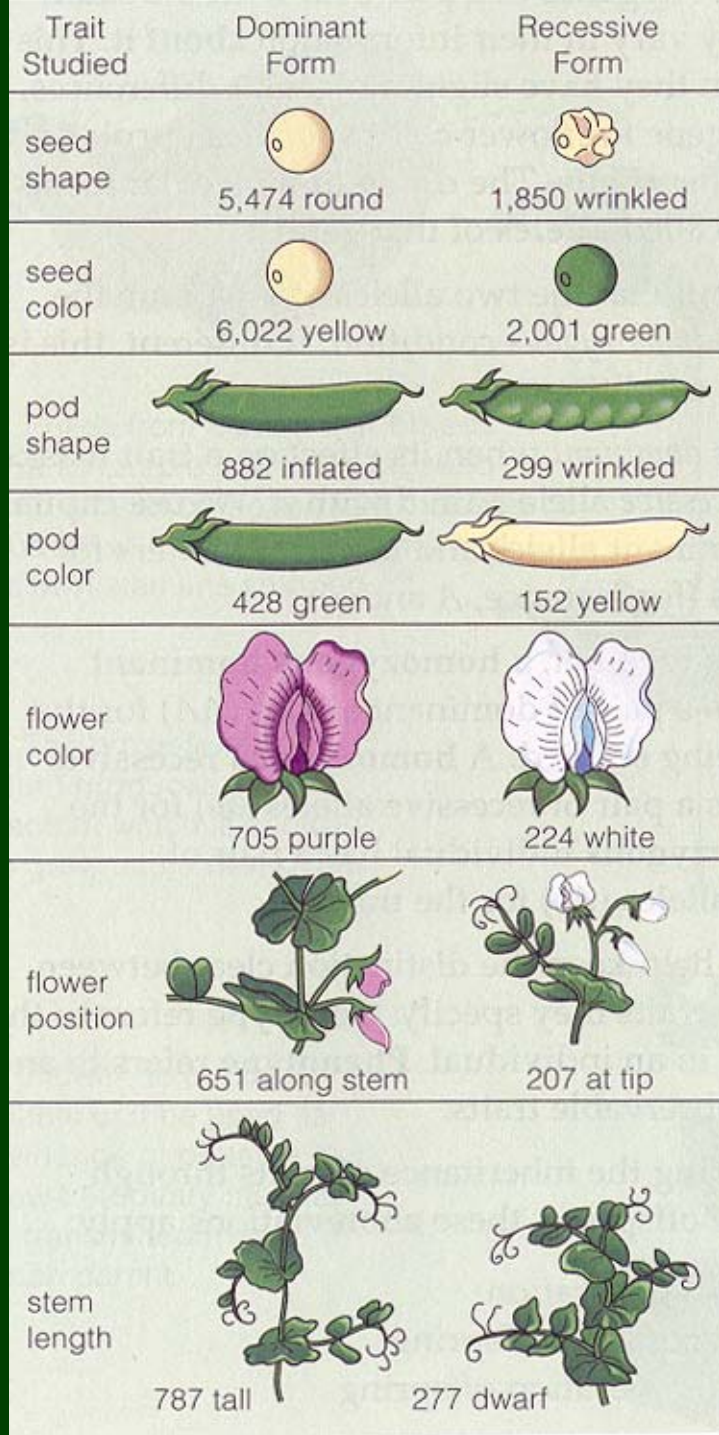
Important Terms

- Genetics - branch of biology that studies how characteristics are transmitted from parents to offspring.

- Heredity - transmission of these characteristics (**traits**) from parent to offspring.

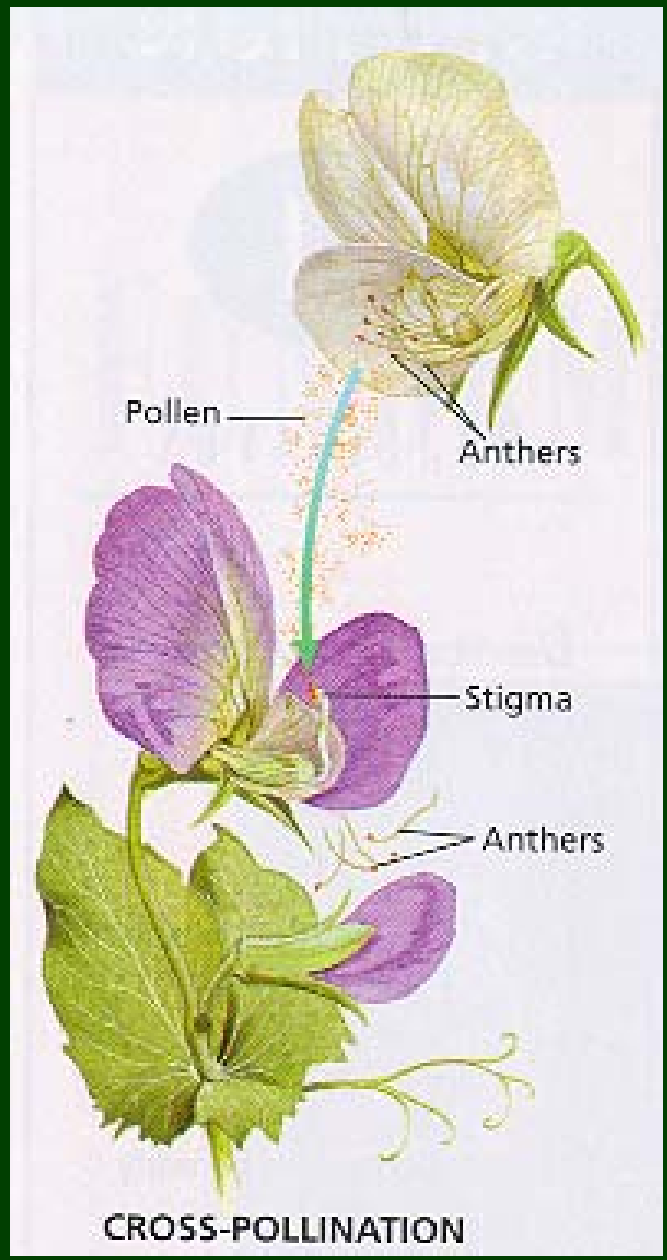
Mendel's Garden Peas

- Mendel chose the **garden pea** for his experiments :
  - many varieties that grow quickly
  - able to self-pollinate
  - many traits with alternate forms (e.g. tall/short; purple/white flowers)
  - small, easy to grow
  - provide many offspring



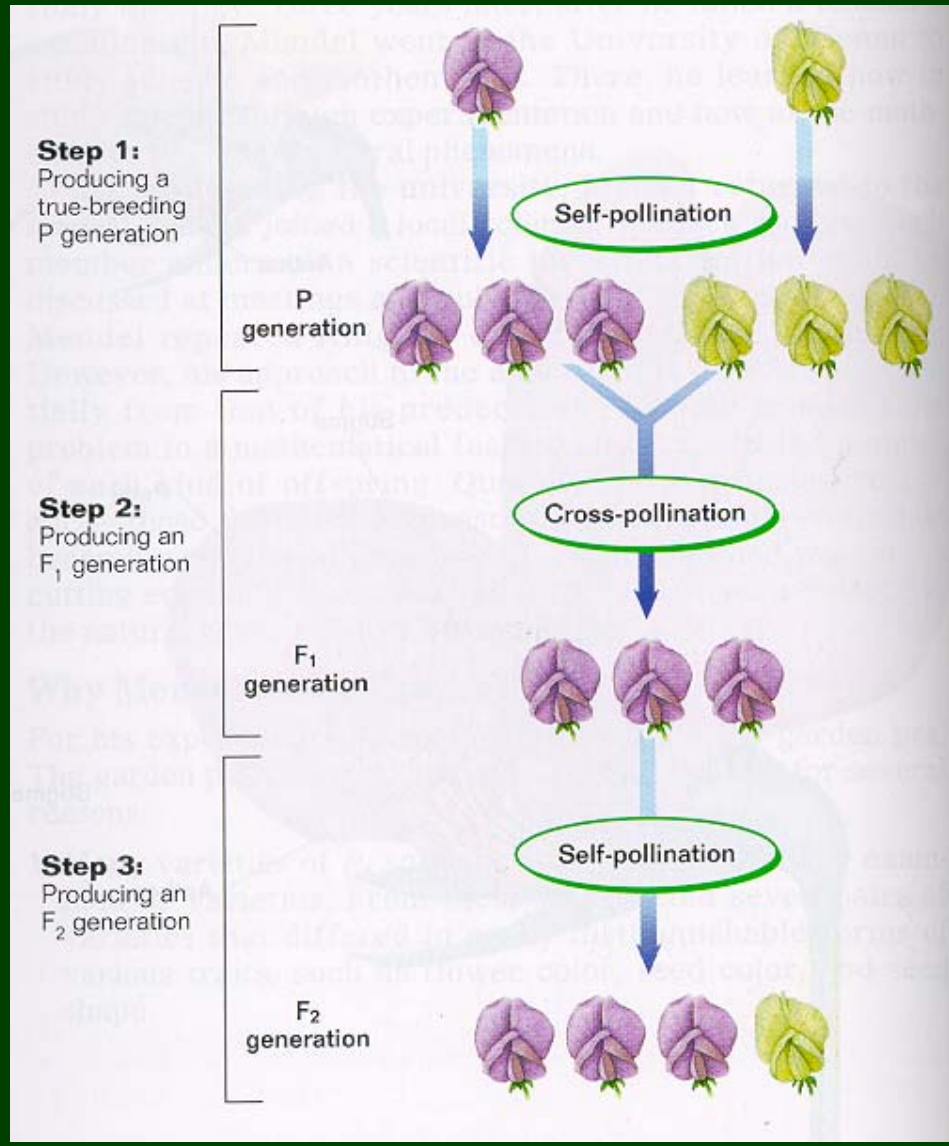
Mendel's Methods

- Mendel controlled how the pea plants were pollinated.
- **Pollination** occurs when pollen grains produced in the ♂ parts are transferred to the ♀ reproductive part.
- **Self-pollination** occurs when pollen is transferred from two parts of the same plant; while **cross-pollination** involves two different plant.



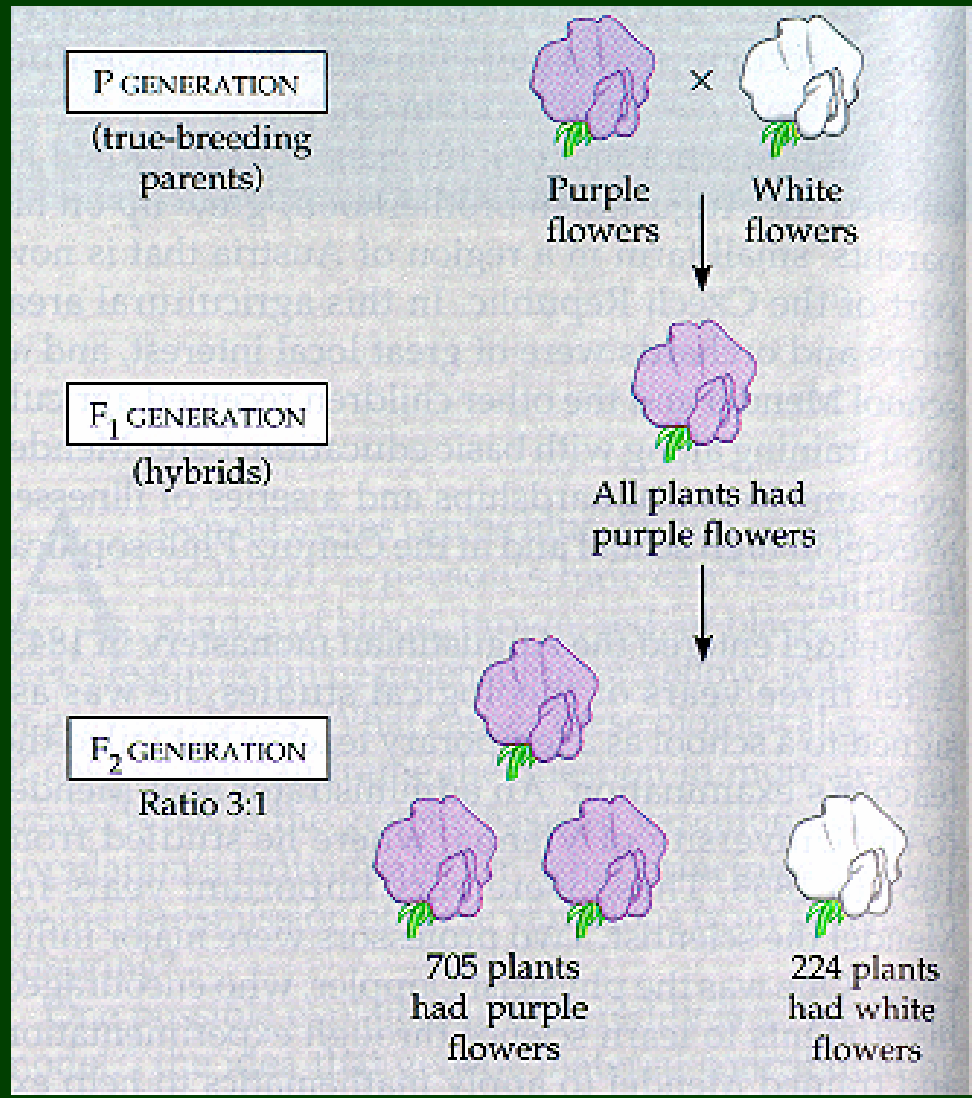
Mendel's Experiments

Mendel began by growing plants that were: **true-breeding/pure** for **each trait.** Plants that are pure always produce offspring with the same trait (ex. tall plants → tall plants).



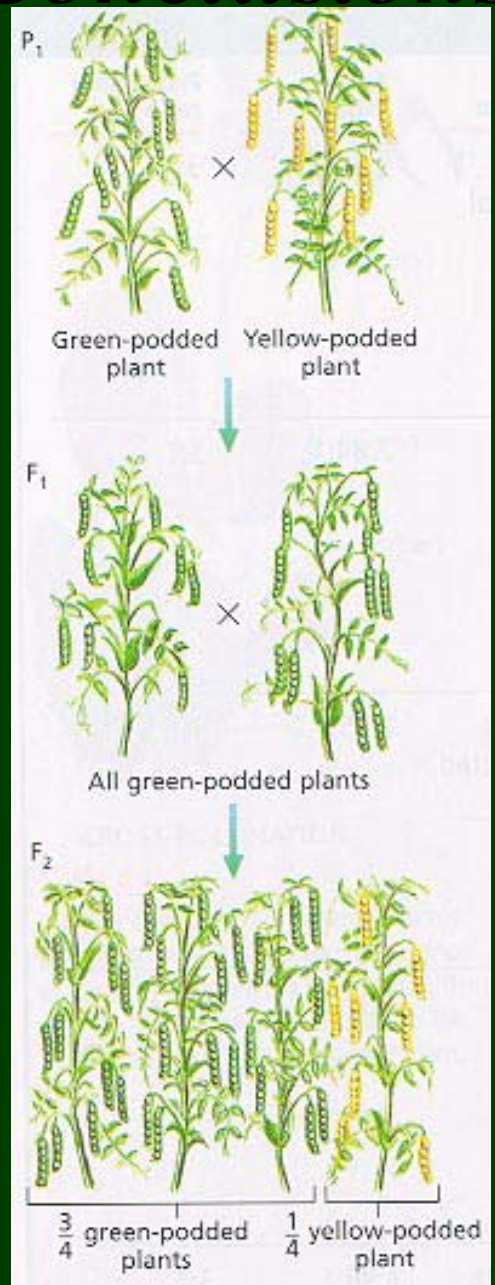
Mendel's Experiments

- Mendel then cross-pollinated pure plants with contrasting traits. These parents represented the **P_1 generation.**
- The offspring of this cross would be the **F_1 generation** and they would be **hybrid.**
- If the **F_1 generation** self pollinates, the **F_2** is produced.



Mendel's Results and Conclusions

- For each cross, Mendel obtained F_1 plants that expressed only one form of the original crossed trait.
- Mendel described the expressed trait as **dominant**; the trait that was not expressed as **recessive.**

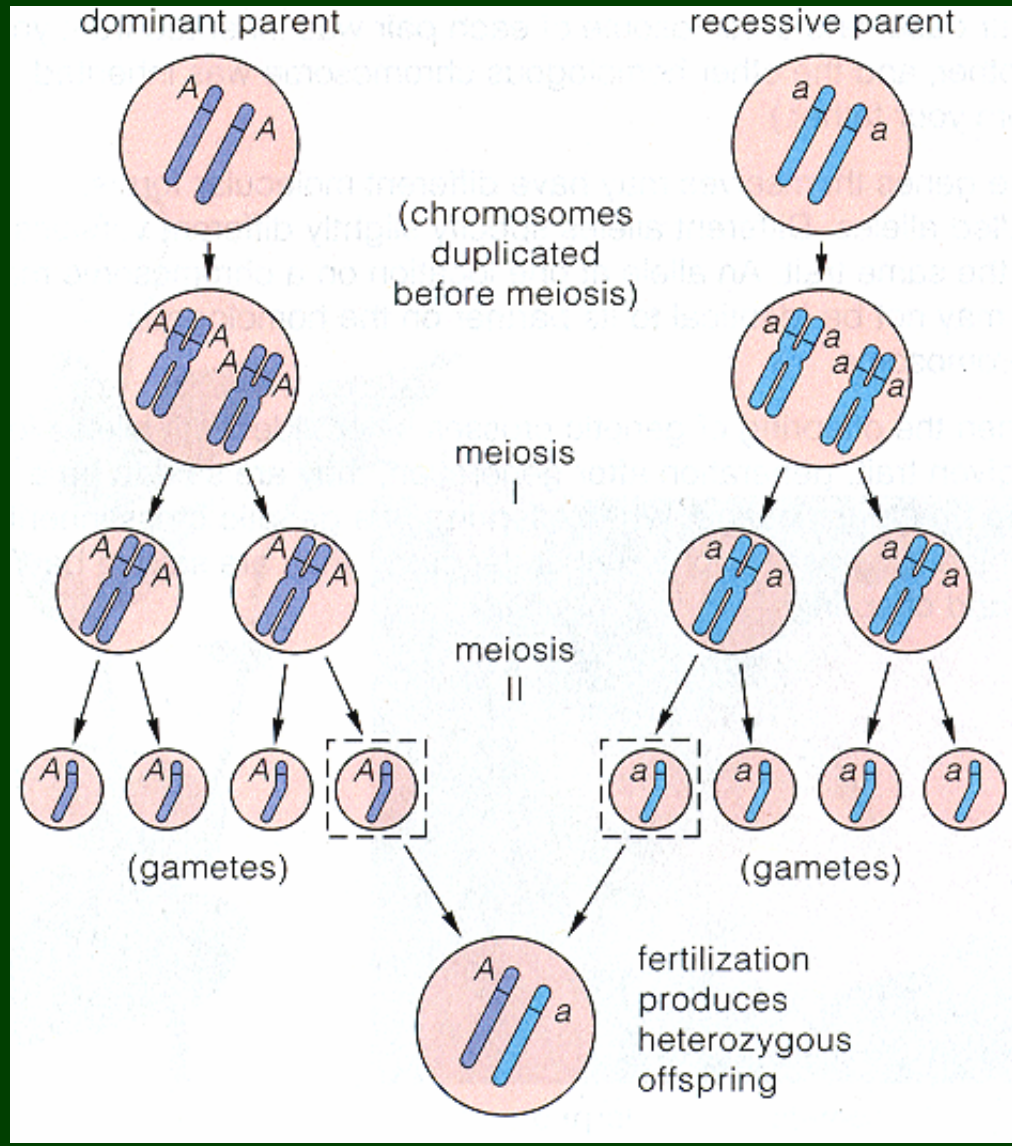


Mendel's Laws

- To explain his results, Mendel hypothesized the following:
  - parents do not transmit traits directly to offspring but pass on "units of information" (now called "**genes**")
  - for each trait, an individual has two factors - one from each parent.

The Law of Segregation

- Mendel's theory became laws of heredity:
  - **Law of Segregation** - the members of each pair of alleles will separate at meiosis



The Law of Independent Assortment

- Mendel also crossed plants that differed in two characteristics, such as height and seed color.
- The data from these crosses indicate that factors for separate traits do not necessarily appear together.

- Mendel's second law:
  - **Law of Independent Assortment -** pairs of alleles separate independently of each other during meiosis if located on different chromosomes (**or far apart on same chromosome**)

Chromosomes and Genes

- (Mendel's paper published in 1866 was ignored until 16 years after his death in 1900)
- Most of Mendel's findings agree with what biologists now know about **molecular genetics**, the study and function of chromosomes and genes.
- Each copy of a factor is now called an allele (**alleles** = alternate forms of the gene e.g. green/yellow seeds)
- Biologists use letters to represent the alleles -
  - capital letters for dominant alleles - T=tall
  - lowercase letters for recessive - t = short

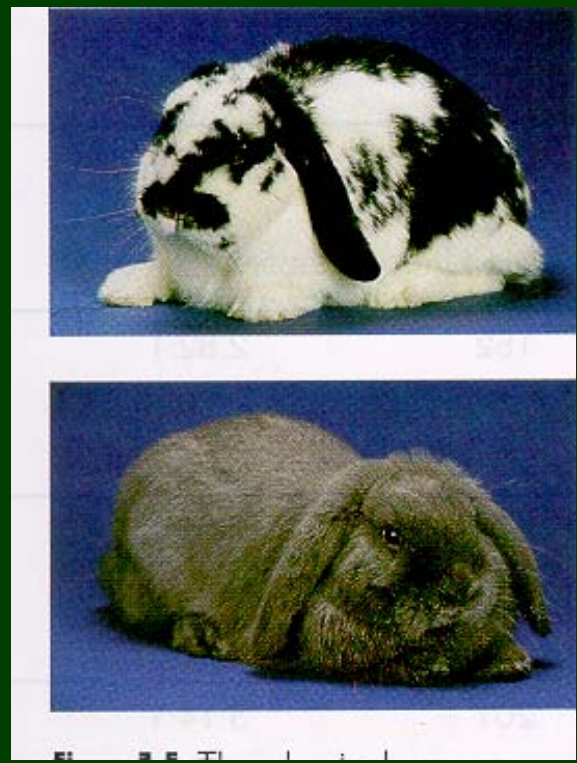
GENETIC CROSSES

- Genotype and Phenotype
  - **Genotype**: the genetic makeup of an organism determined by its alleles (ex. homozygous dominant)
  - **Phenotype**: the physical appearance of an organism determined by its genotype (ex. tall, short)
- If two traits are identical, individual is **homozygous**
- If two traits are different, individual is **heterozygous.**
  - homozygous dominant = TT
  - homozygous recessive = tt
  - heterozygous = Tt

Genotype and Phenotype

- An individual receives one allele from one parent, the other from the other parent.

- The presence of the allele does not guarantee that the trait will be expressed; usually only dominant traits are expressed



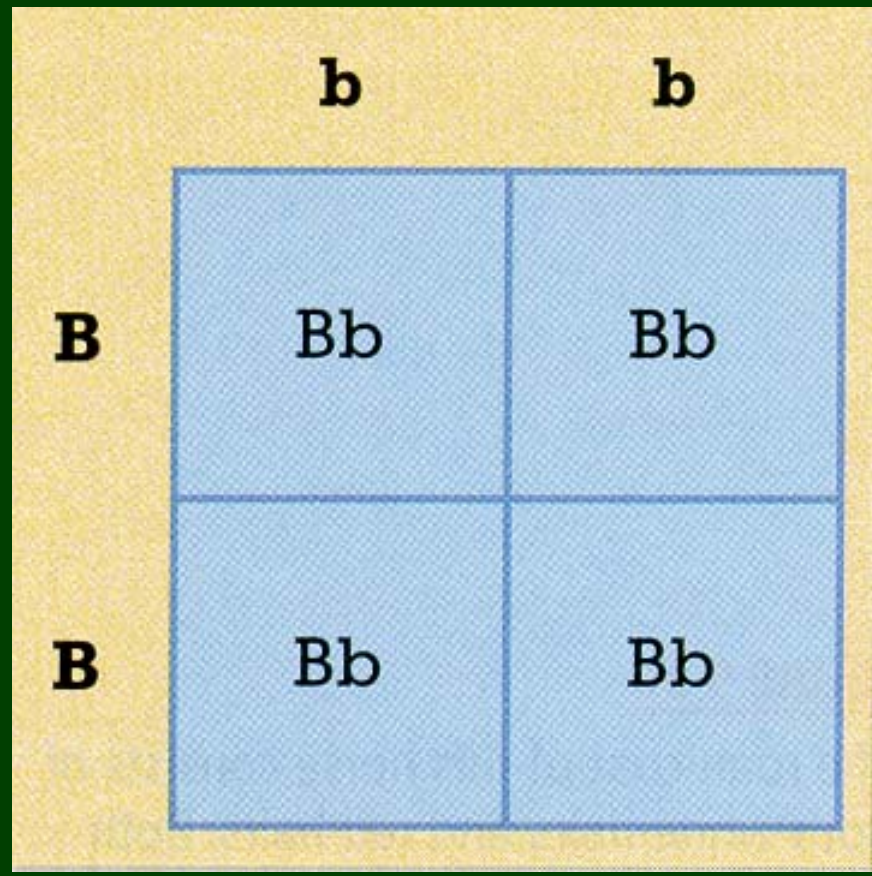
Probability

- Mendel's crosses follow the rules of probability.
- **Probability** is the likelihood that a specific event will occur:
  - Probability = $\frac{\text{\# of times event is expected to happen}}{\text{\# of opportunities for event to happen}}$
  - Example – What is the probability that a coin will land heads up?
- **Multiplication Law** – If two coins are tossed simultaneously, the outcome for each coin is independent of what happens with the other.
  - Example: What is the probability of getting two heads in a row?

Predicting Results of Monohybrid Crosses

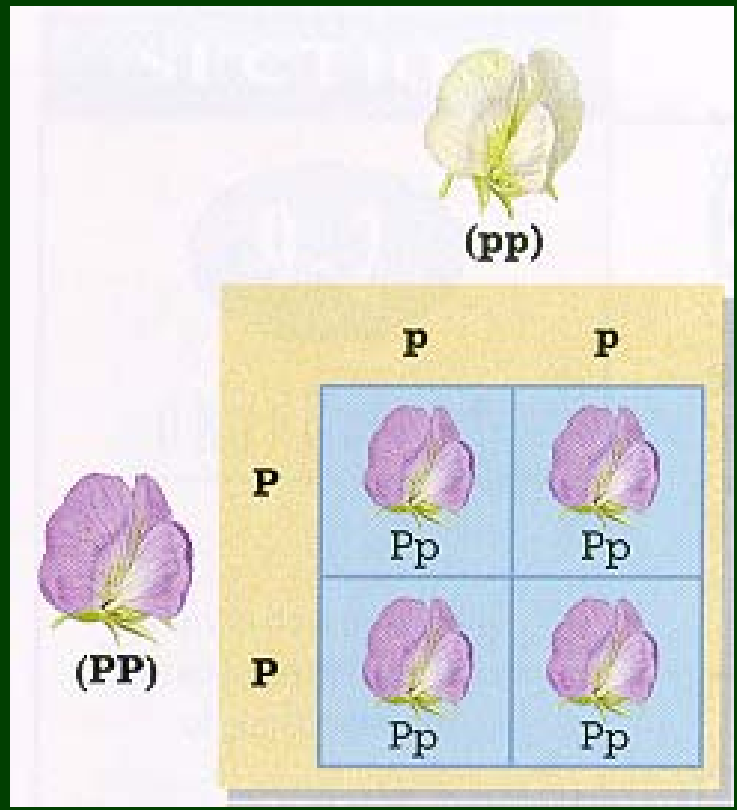
MONOHYBRID CROSSES

- A **monohybrid cross** involves one pair of contrasting traits.
- Biologists can predict the the probable outcome of a cross by using a diagram called a **Punnett Square.**



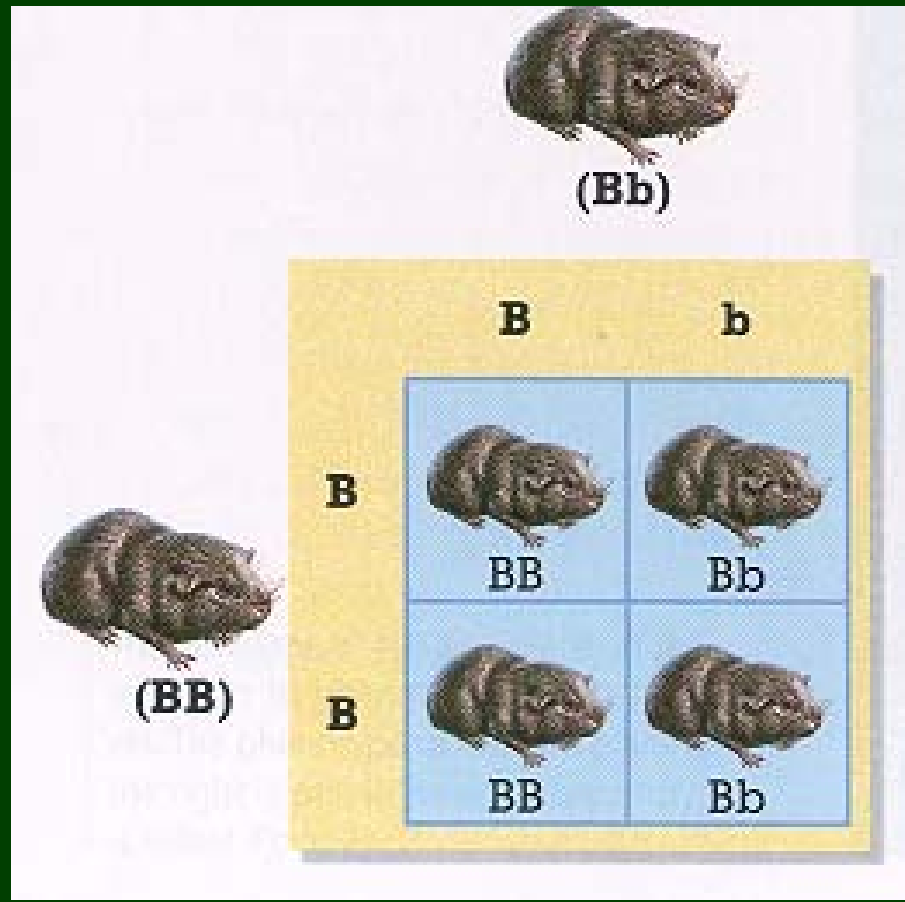
Homozygous x Homozygous

- A monohybrid cross between a homozygous dominant and a homozygous recessive individual results in all heterozygous (hybrid) individuals.



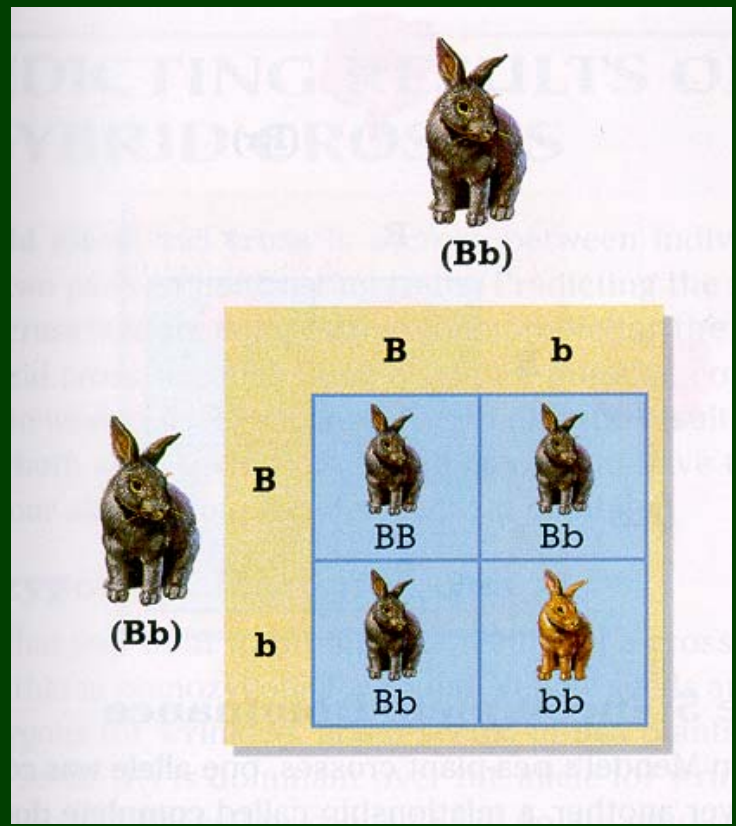
Homozygous x Heterozygous

- A monohybrid cross between a homozygous and heterozygous individual yields homozygous dominant and heterozygous offspring with a 1:1 genotypic ratio and a 1:1 phenotypic ratio.



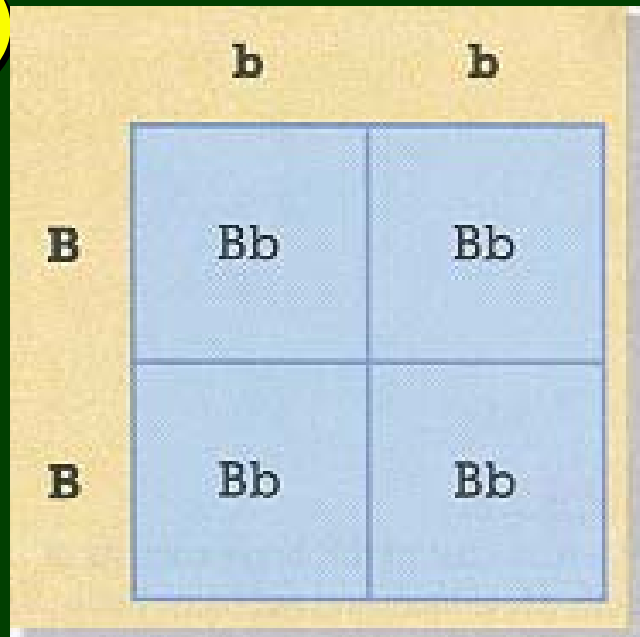
Heterozygous x Heterozygous

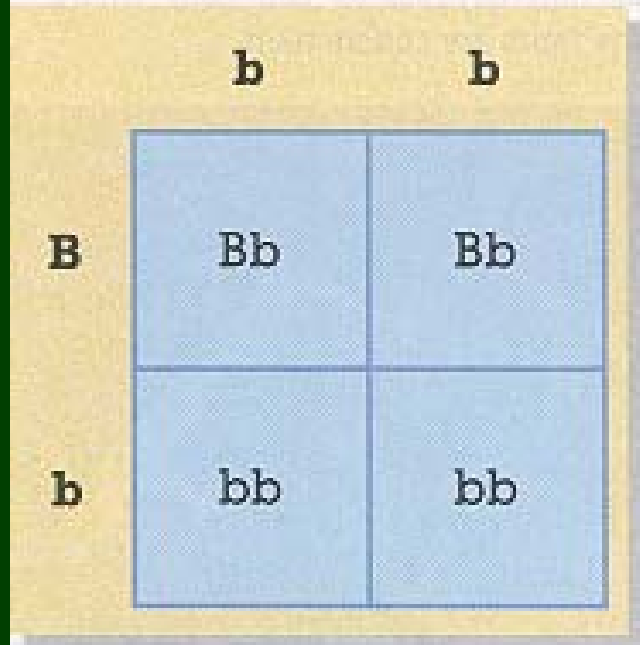
- A monohybrid cross between two heterozygous individuals yields homozygous dominant, heterozygous and homozygous recessive offspring with a 1:2:1 genotypic ratio and a 3:1 phenotypic ratio.



Test Cross (Back Cross)

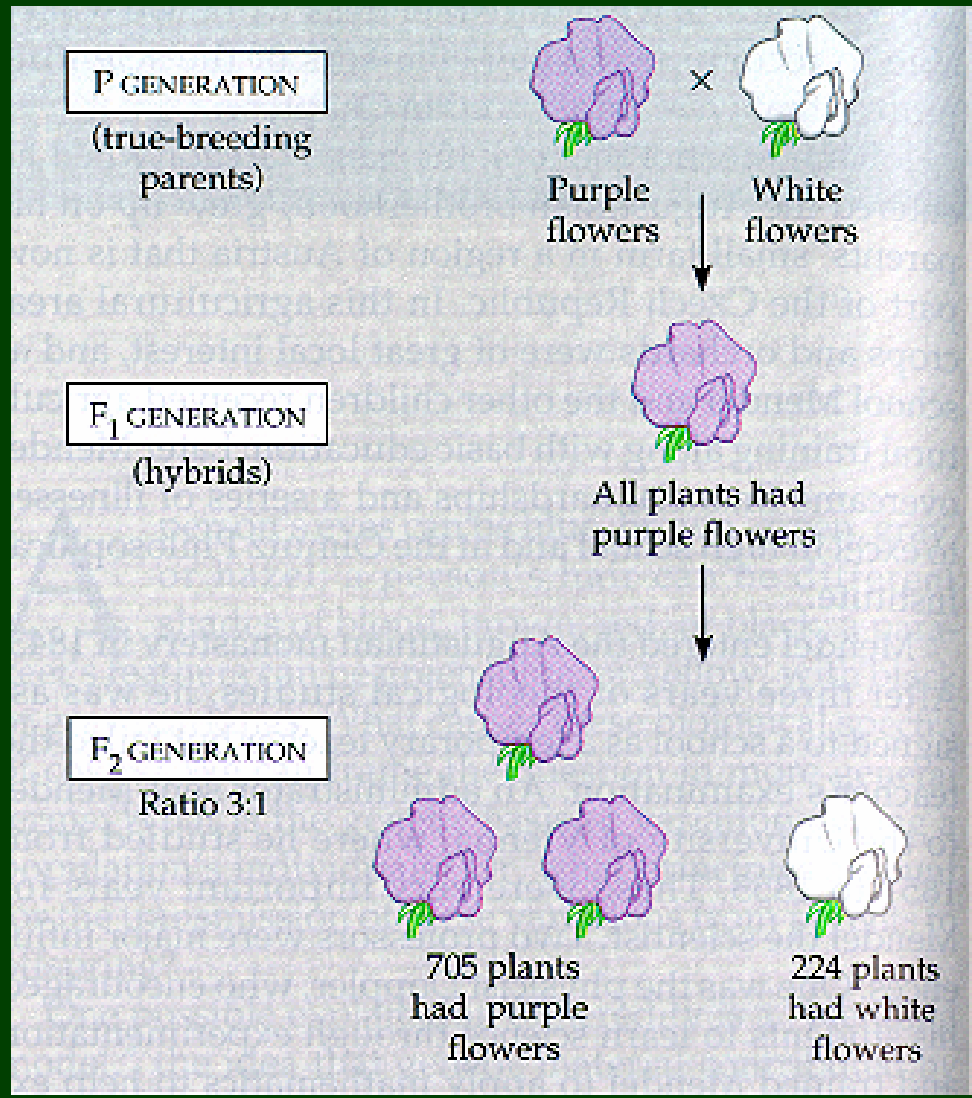
- A test cross occurs when an individual of unknown genotype is crossed with a homozygous recessive individual.
- The results should indicate whether the unknown individual is homozygous or heterozygous.





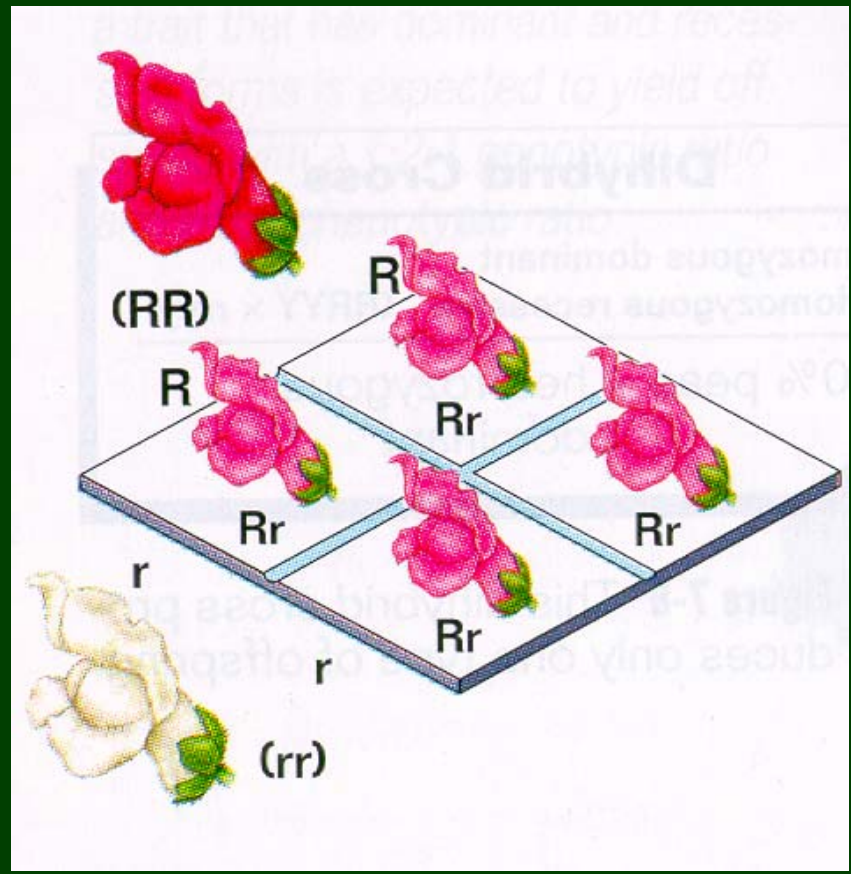
Mendel's Experiments & Probability

- In Mendel's experiments, only the dominant traits were expressed in the F_1 generation. Recessive traits appeared in the F_2 generation in a ratio of 3:1 dominant to recessive.



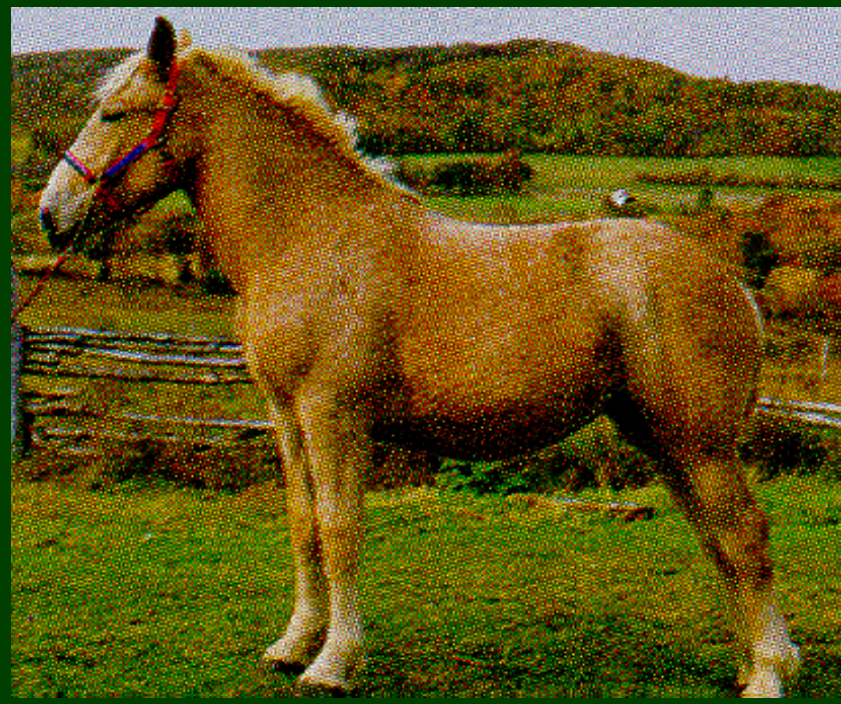
Incomplete Dominance

- When one allele is completely dominant over the other, it is called complete dominance.
- Incomplete dominance occurs if two or more alleles influence the phenotype, resulting in an intermediate appearance. Ex. red + white = pink.



Codominance

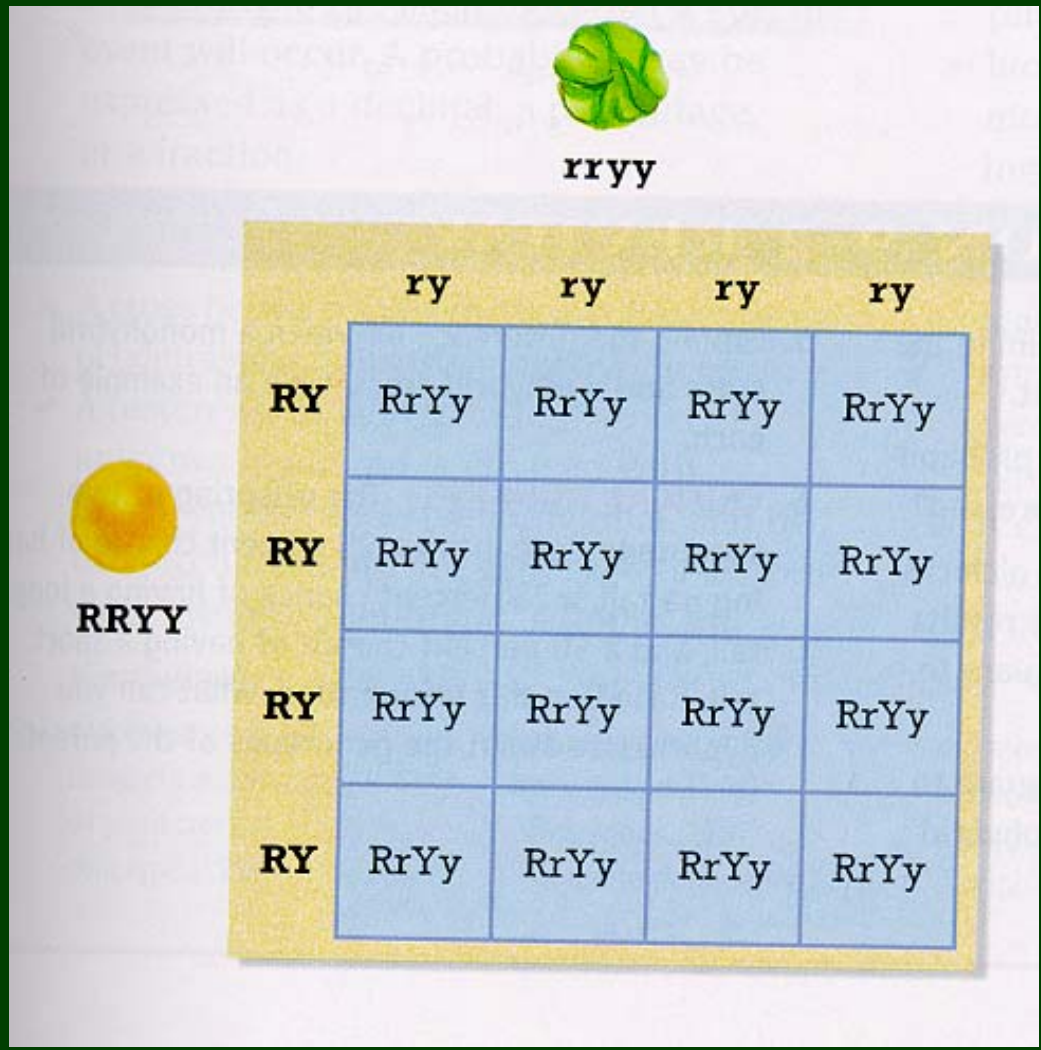
- Codominance occurs when **both alleles for a gene are expressed** in a heterozygous offspring.
- In codominance, neither allele is dominant, nor recessive, nor do the alleles blend in the phenotype.



Predicting the Results of Dihybrid Crosses

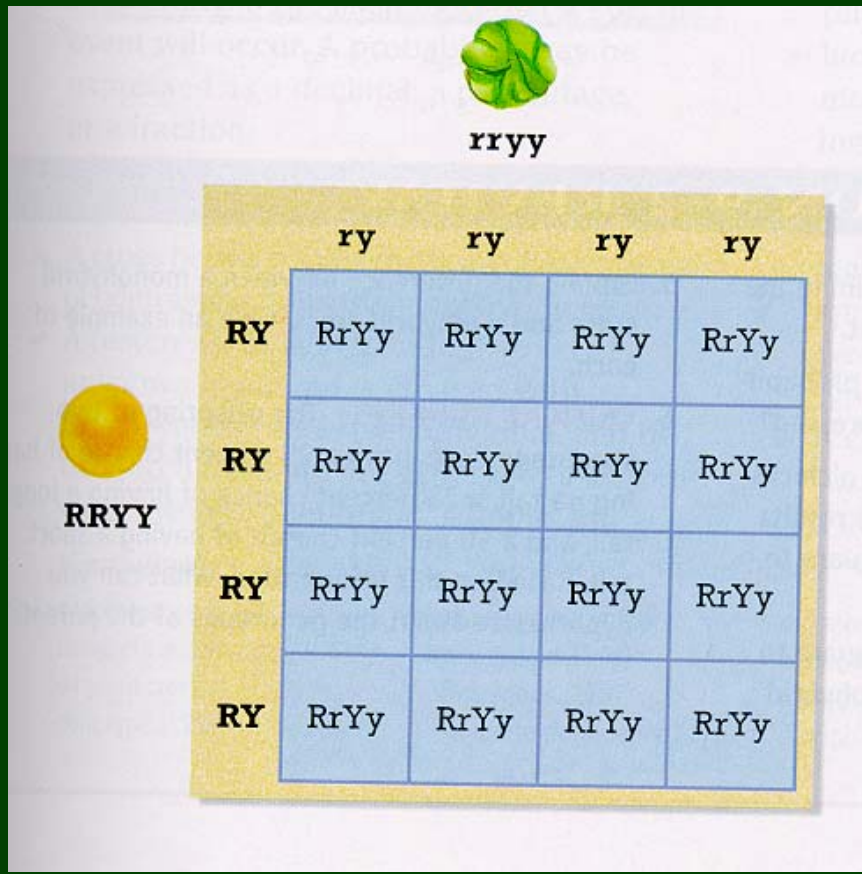
DIHYBRID CROSSES

- A cross involving two pairs of contrasting traits.



Homozygous x Homozygous

- A **dihybrid cross** between two homozygous individuals with contrasting traits yields heterozygous offspring expressing the dominant trait.



Heterozygous x Heterozygous

A **dihybrid cross**

between two heterozygotes yields offspring in a phenotypic ratio of 9:3:3:1

9 dom both traits (R_Y_)

3 dom one trait (R_yy)

3 dom other trait (rrY_)

1 rec both traits (rryy)