Principles of Genetics (Zoo-352)

Lecture 7

Mendelian genetics

Department of Zoology, 1438-1439 H

Gregor Mendel

- He was born in 1822 in Austria.
- In 1854, Mendel began his classic experiments with the garden pea plant (*Pisum sativum*).
- He discovered the law of heredity in plants and animals.
- He died in 1884 by a kidney disorder.

Mendel's experimental design

- He did his experiments on the pea plants. This was achieved by two different methods:
  1) Self-fertilization: occurs when pollen falls from the anther onto the stigma of the same flower.
  2) Cross-fertilization: occurs when pollen of one plant is used to fertilize a different plant.
- He cross-fertilized the plants by opening the keel of a flower before the anthers matured and removed them to prevent self-fertilization (Figure 1)
- Mendel then collected pollen from the removed anther and placed it on the stigma of a second plant.

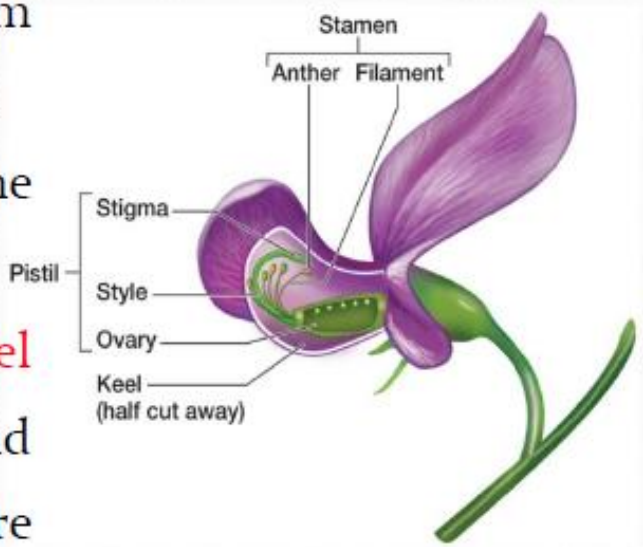
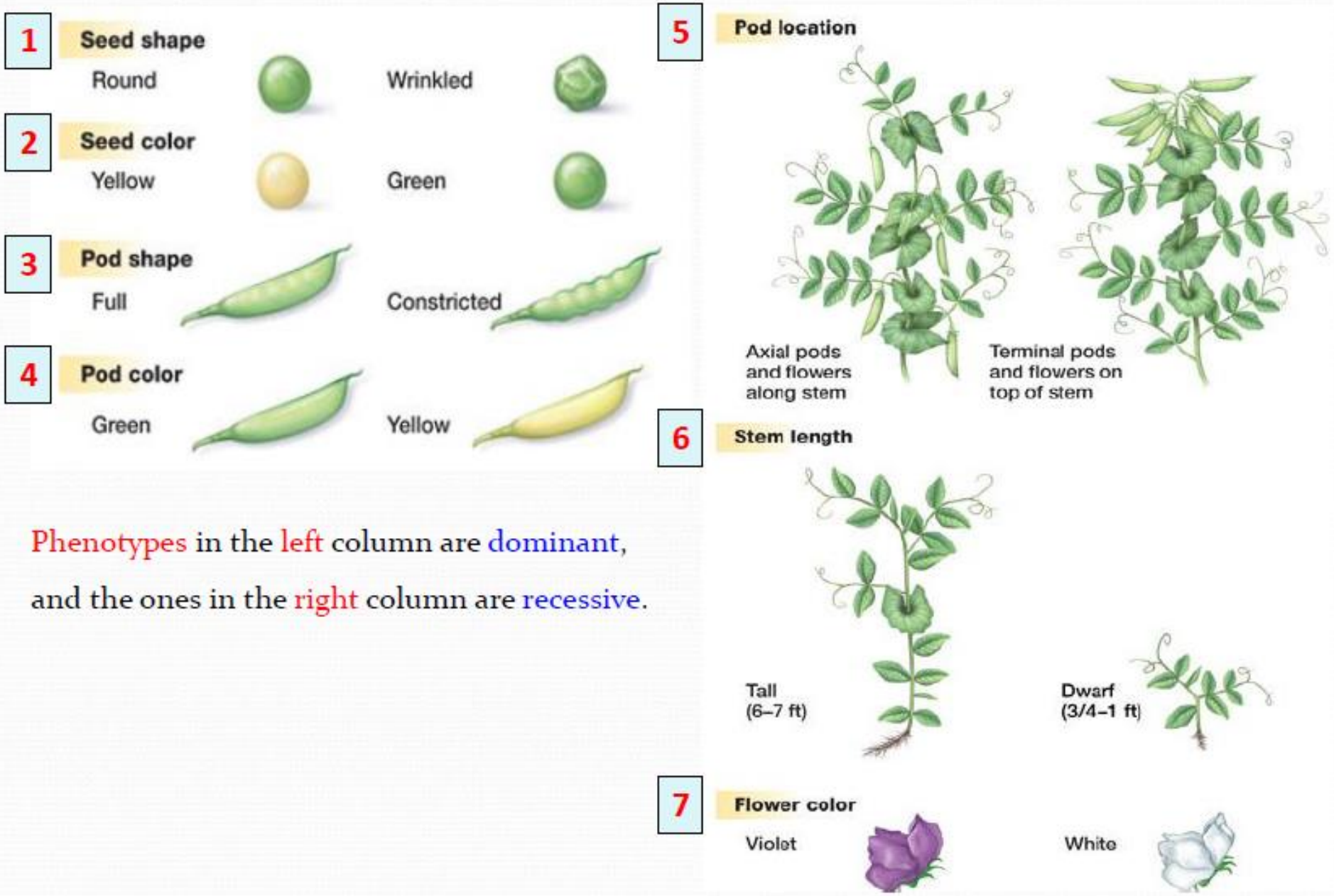


Figure 1: Anatomy of a garden pea plant flower

Why did Mendel use pea plants in his experiments?

1) Peas exhibit a variety of contrasting traits (seven traits; Figure 2).
2) The shape of the pea flower protected it from foreign pollen.
3) You can cross or self-pollination them by yourself.
4) Pea plants are inexpensive, easy to maintain and they grow quickly.
5) Short life cycle so you can make more generations.
6) Easy to see and recognize their different traits.

- Before Mendel started his actual experiments, he grew the plants for two years. During this time, he identified plants that were homogeneous or pure-breeding for each of the particular characteristics he wanted to study.
- Let us look at one of Mendel's crosses, where he crossed tall and dwarf (short) plants (Figure 3):



Phenotypes in the left column are dominant,

and the ones in the right column are recessive.

Figure 2: Seven characteristics that Mendel observed in peas

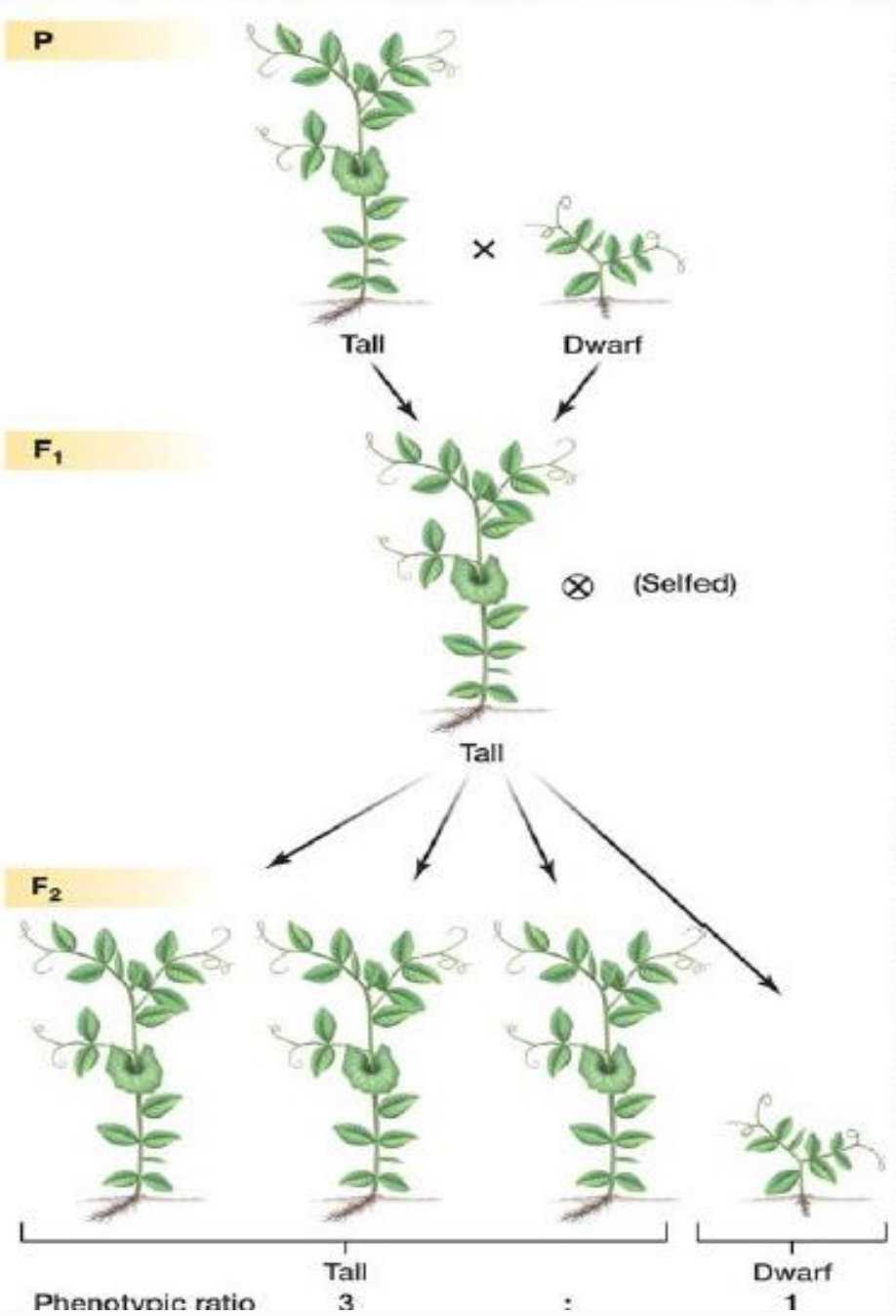


Figure 3: First two offspring generations (F1, and F2) from the cross between a tall and dwarf plant

Offspring generations from the cross between a tall and dwarf plant

- Offspring of this cross are referred to as the first generation or F1.
- Mendel also referred to these F1 individuals as hybrids because the offspring were a mixture from parents with different traits.
- We will refer to these offspring as monohybrids because they are hybrid for only one characteristic.
- Because all the F1 plants were tall, Mendel referred to tallness as the dominant trait and shortness as the recessive.
- Mendel wondered what happened to the short traits in the F1 generation. Therefore, self-fertilization was done to produce the second generation or F2.

- Among the F2 offspring, Mendel observed 787 tall and 277 short plants for a ratio of 2.84:1. Mendel recognized the dominant to recessive trait ratio in the F2 generation is 3:1 in a monohybrid cross.
- Mendel proposed that an organism carries two forms of a genetic unit, which we now call the alleles of a gene.
- The term gene would first be used in 1909 by Johannsen, 43 years after Mendel published his results.
- Each trait was controlled by a gene and alleles represent different forms of a gene.
- The allele for tall stem (D) is dominant compared to the allele for short stem (d) (Figure 4).

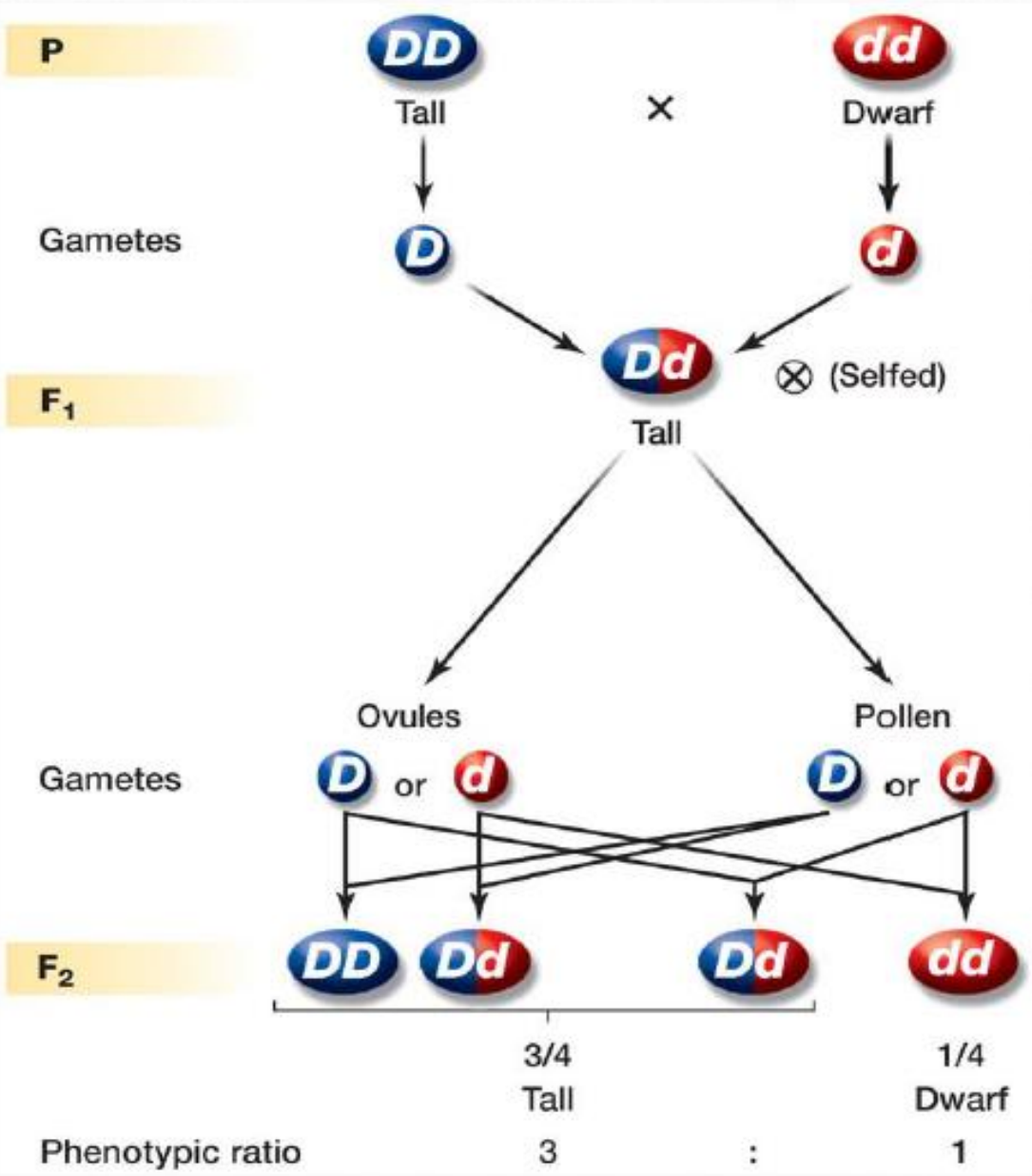


Figure 4: Assigning genotypes to the cross in Figure 3

Definitions of basic terms in Mendelian genetics

- A **dominant** trait is exhibited in the monohybrid individuals in the F1 generation. Indicated by a capital letter.
- A **recessive** traits is absent in the monohybrid F1 offspring, but reappears in the F2 generation. Indicated by a lowercase letter.
- **Genotype:** A description of the genetic makeup in an organism. Genotype may be either:
  1. **Homozygous:** An organism that carries two copies of identical alleles of a gene in homologous chromosomes for a character (for example, a DD, dd individual)
  2. **Heterozygous:** An organism that carries two different alleles for a character (for example, a Dd individual).

- **Phenotype:** A description of an organism's traits (feature).
- One or two copies of the dominant allele produce the dominant phenotype, whereas two copies of the recessive allele produce the recessive phenotype.
- **Locus:** The physical location of the alleles of a gene on it's chromosome.
- **Alleles:** All the different forms of the same gene.
- **Genotypic ratio:** The expected numbers of different genotypes produced by a particular cross.
- **Phenotypic ratio:** The expected numbers of different phenotypes produced by a particular cross.
- **Monohybrid Cross:** A cross between two individuals in the same species in which **one** genetic trait is documented.
- **Dihybrid Cross:** A cross between two individuals in the same species in which **two** genetic traits are documented.

Principles of Genetics (Zoo-352)

Lecture 8

The law of segregation

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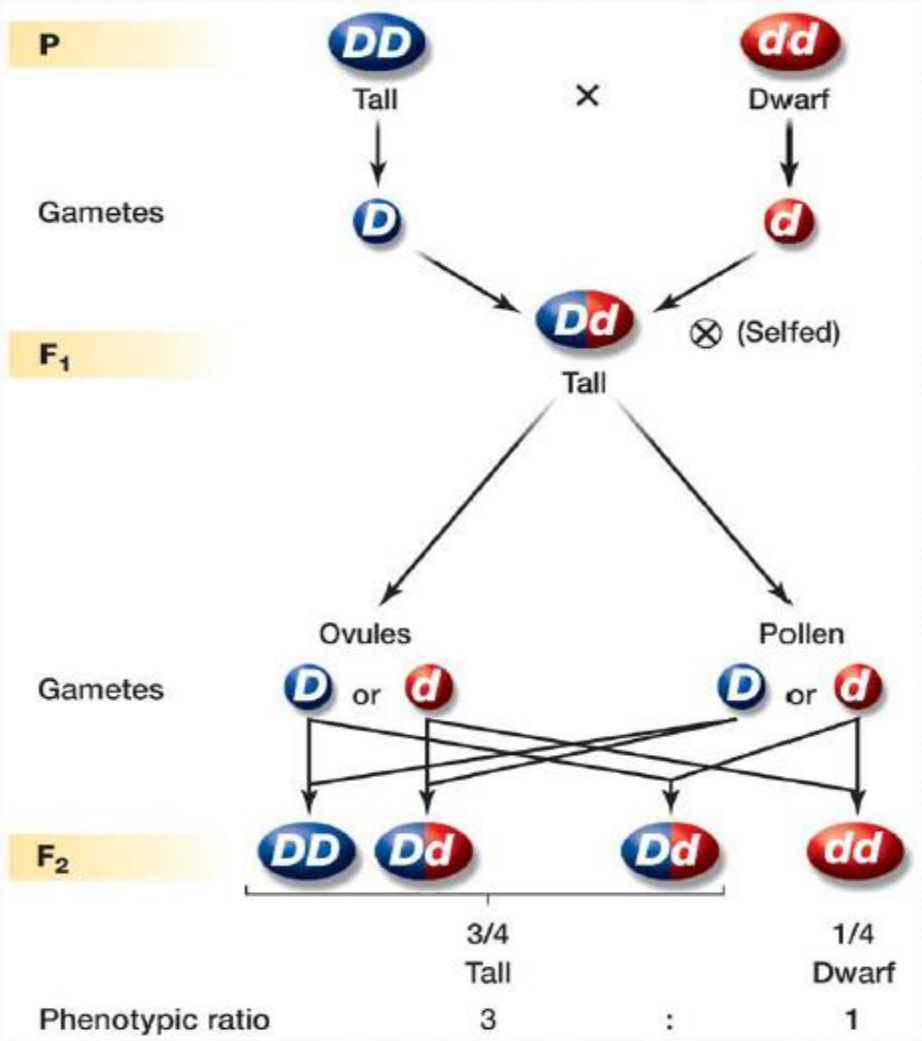
- Although the genotype of an individual involves two alleles, only one of these alleles is passed on to the gamete, which is either the pollen or ovule in plants.
- The fusion of two gametes, or fertilization, forms a zygote that restores two alleles in the cells.
- The explanation of how alleles are inherited from generation to generation constitutes Mendel's first principle, the law of segregation.

The laws of Mendel in genetics:

1. **First law:** segregation.
2. **Second law:** independent assortment.

Law of segregation



Law of segregation

- The law of segregation states that during gamete formation, the two alleles separate (segregate) randomly, with each gamete having an equal probability of receiving either allele.
- In the figure above, we can see that Mendel's law of segregation explains several things:
  - The heterozygous F_1 progeny (offspring), which all have the dominant tall characteristic, get one allele from each parent.
  - The DD homozygous can produce only one type of gametes, which contains the dominant D allele, and the dd homozygous can produce only gametes containing the recessive d allele.

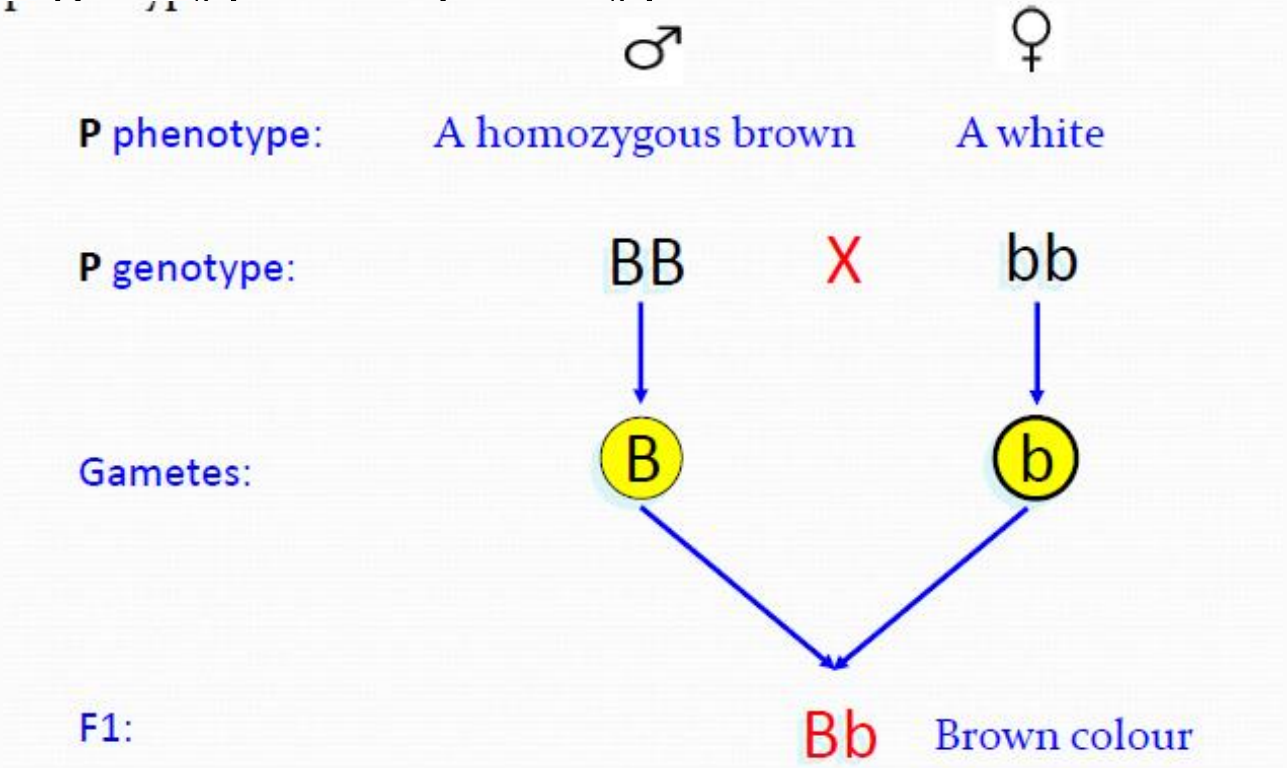
Law of segregation

- The F1 individuals are uniformly heterozygous Dd. Each F1 individual can produce two kinds of gametes. These two types of gametes randomly fuse during fertilization to produce the F2 generation.
- The F1 progeny are heterozygous because they have two different alleles.
- The F1 progeny have the recessive allele, which accounts for the reappearance of the short phenotype in the F2 generation.
- The hybrid nature of the F1 individuals accounts for the 3:1 ratio of tall-to-short phenotype in the F2 offspring.

Monohybrid Examples

- **Question 1:**

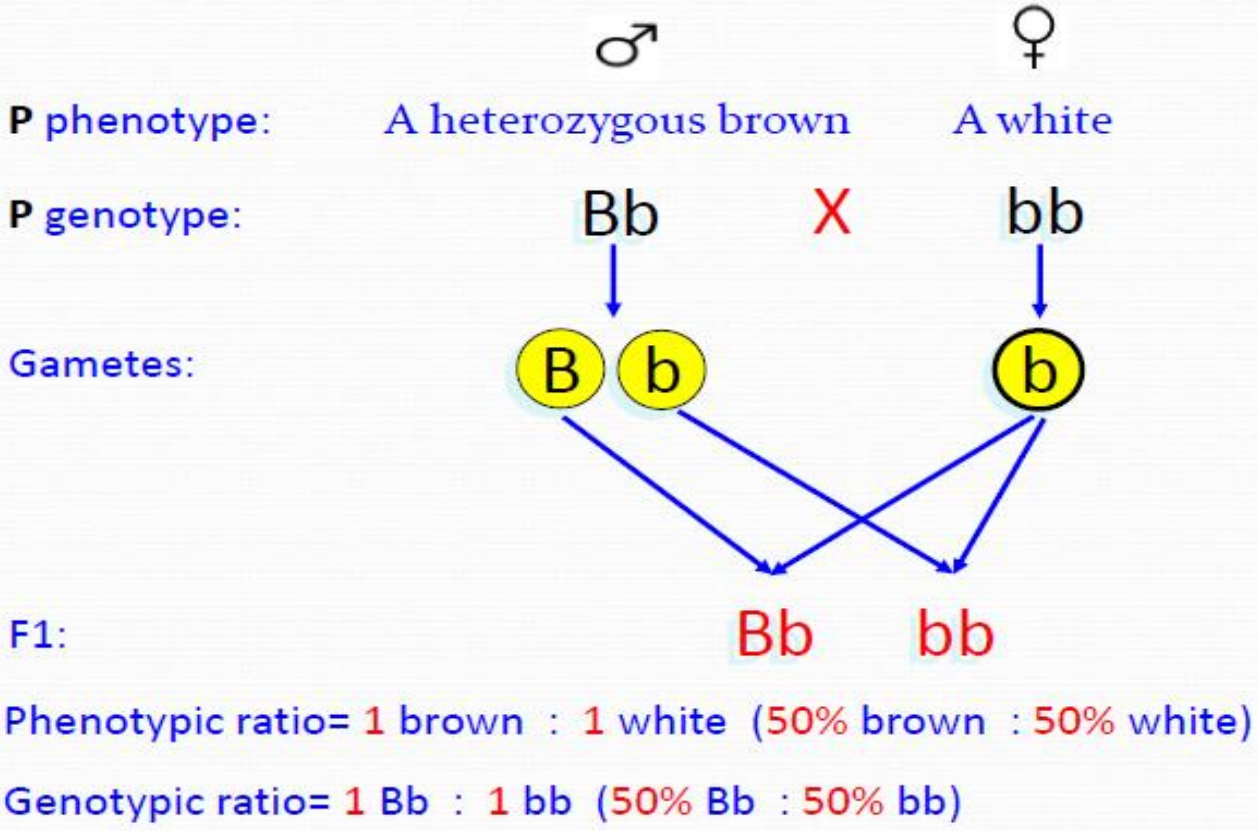
A rancher wants to cross a **brown (BB)** horse with a white mare. Colour is an unlinked gene and brown is dominant. What are the F1 generation genotypes and phenotypes?



Monohybrid Examples

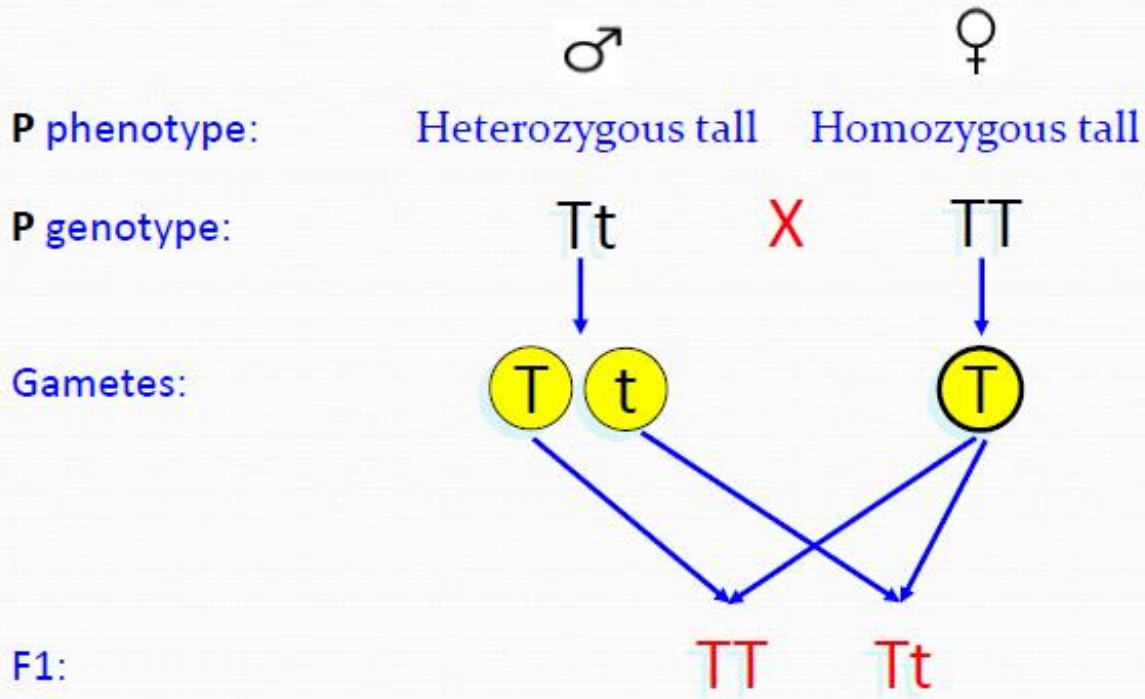
- **Question 2:**

A rancher wants to cross a brown (Bb) horse with a white mare.. What are the genotypic and phenotypic ratios for the F1 generation?



- **Question 3:**

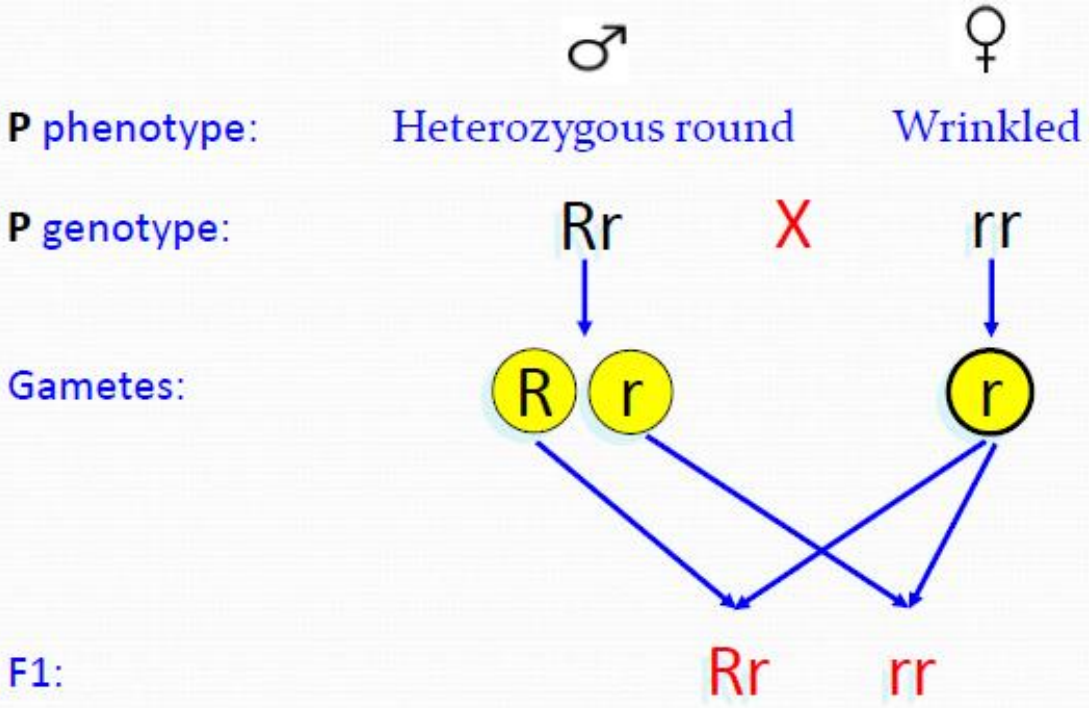
If an allele for tall plants (T) is dominant to short plants (t). What offspring would you expect from a Tt x TT cross?



Phenotypic ratio= 100% tall

Genotypic ratio= 1 TT : 1 Tt

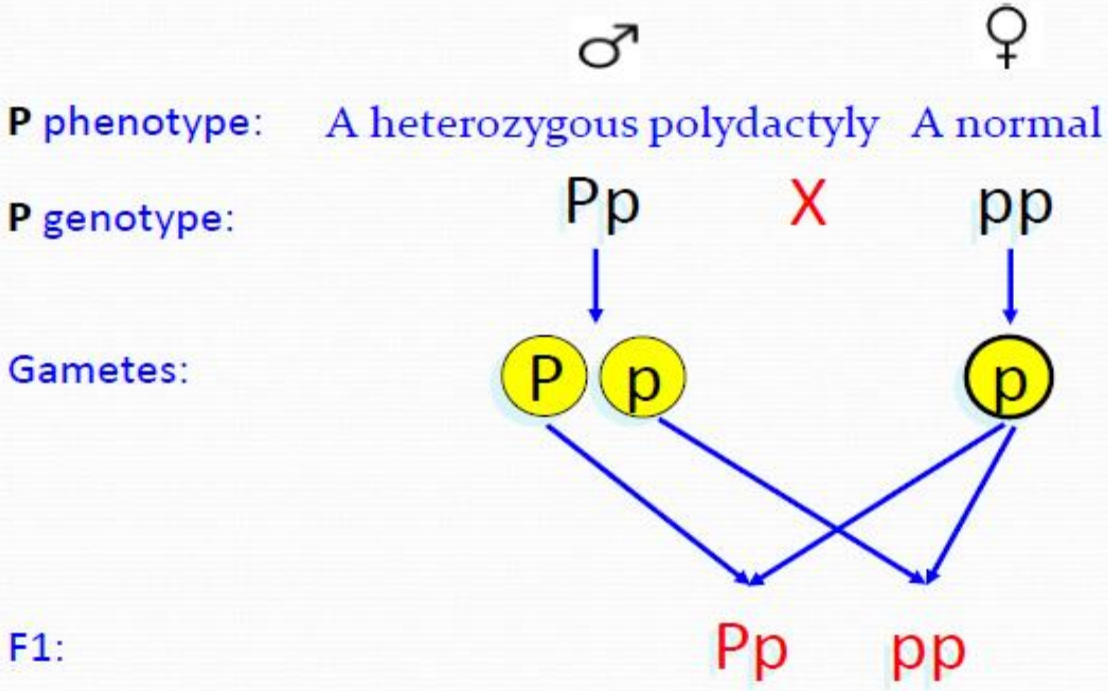
- **Question 4:** Cross a heterozygous round seeds of pea plant with a wrinkled seeds and determine the probability of producing wrinkled seeds.



The probability of producing wrinkled seeds = 50%

- **Question 5:**

A man heterozygous for polydactyly (extra fingers and toes), a dominant trait, is married to a normal woman. What is the probability of producing an offspring that has extra fingers or toes?



The probability of producing an offspring that has extra fingers or toes? = 50%