Zoo-352 Principles of genetics
Lecture 6

Mendelian genetics

Outlines:

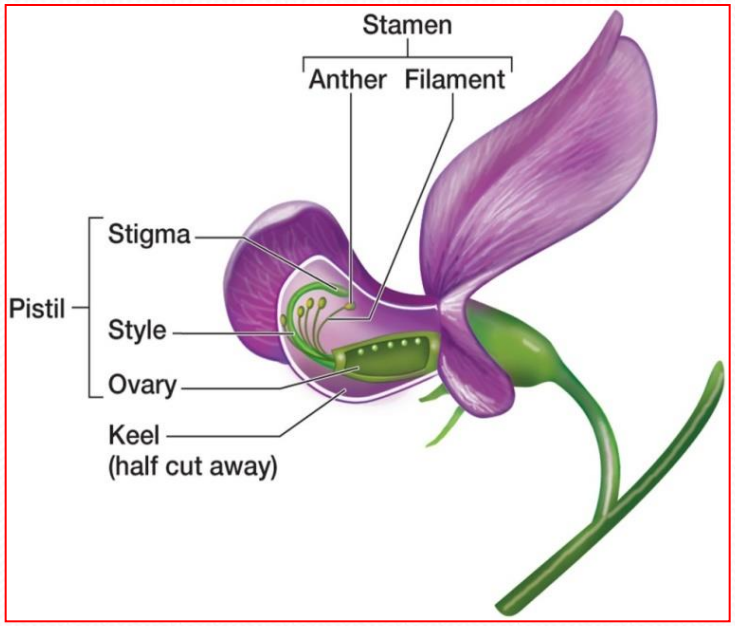
- The father of genetics.
- Mendel's experimental design.
- Hybrid crossing (monohybrid- vs dihybrid).
- Definitions related to Mendelian genetics.
- The laws of Mendel.
- The 1st principle: The law of segregation.

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

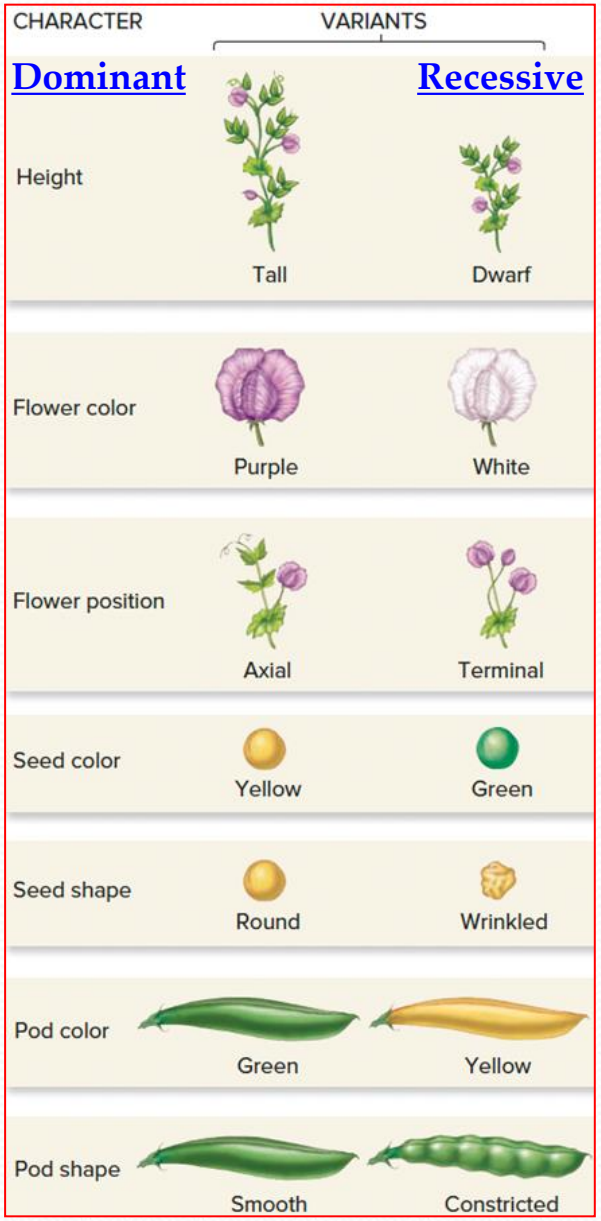
- Mendel did his experiments on the pea plants.
- This was achieved by two different methods:
  1. **Self-fertilization:** occurs when pollen falls from an anther onto the stigma of the same flower.
  2. **Cross-fertilization:** occurs when pollen of a plant is used to fertilize a different plant.
-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



Anatomy of a garden pea plant flower

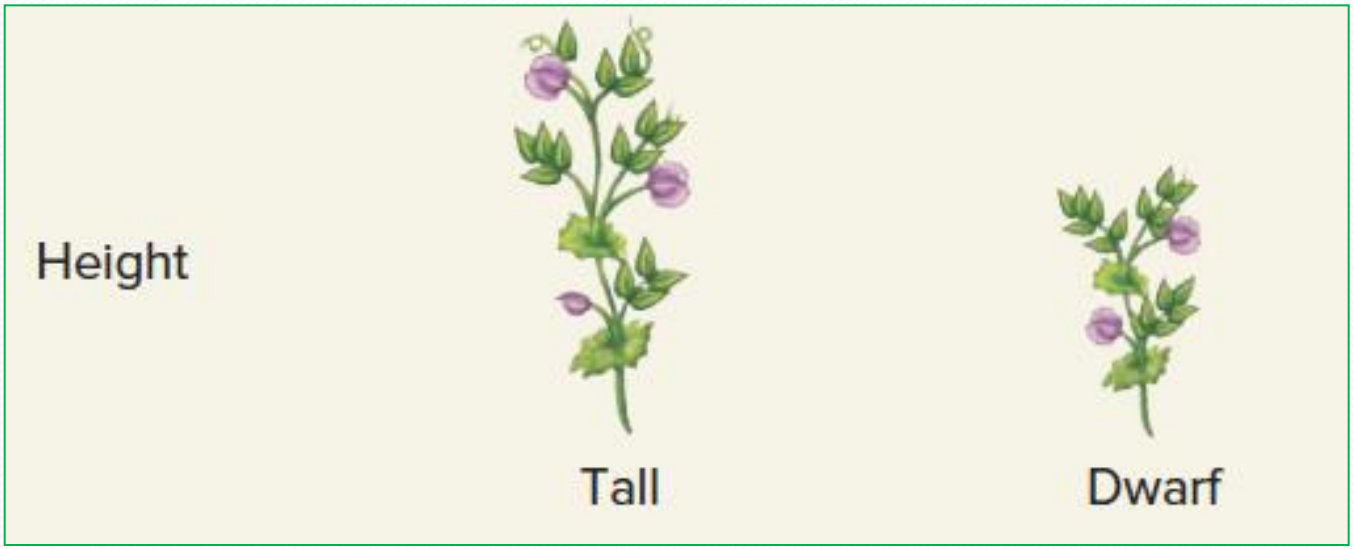
Why did Mendel use pea plants in his experiments?

1. Peas exhibit a variety of contrasting traits (seven traits; see Figure).
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.



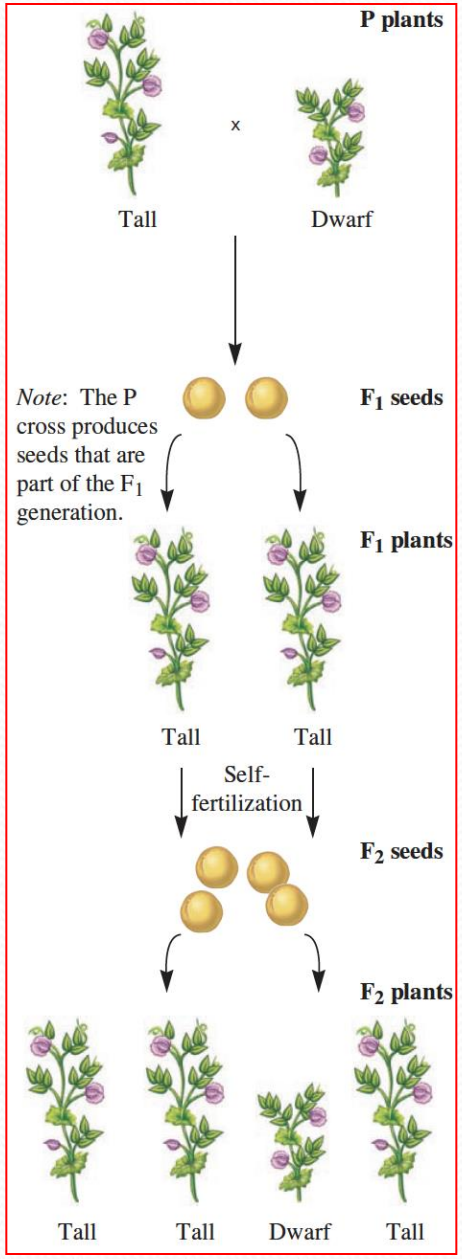
Mendel's experimental design

- 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.



Offspring generations from the cross between a tall and dwarf plants

- 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 (T) is dominant compared to the allele for short stem (t).
- Predict the outcome of a single-factor cross or a self-fertilization using a Punnett square.

P gametes (T, T x t, t)

	T	T
t		
t		

F1 generation (all tall)

	T	T
t	Tt	Tt
t	Tt	Tt

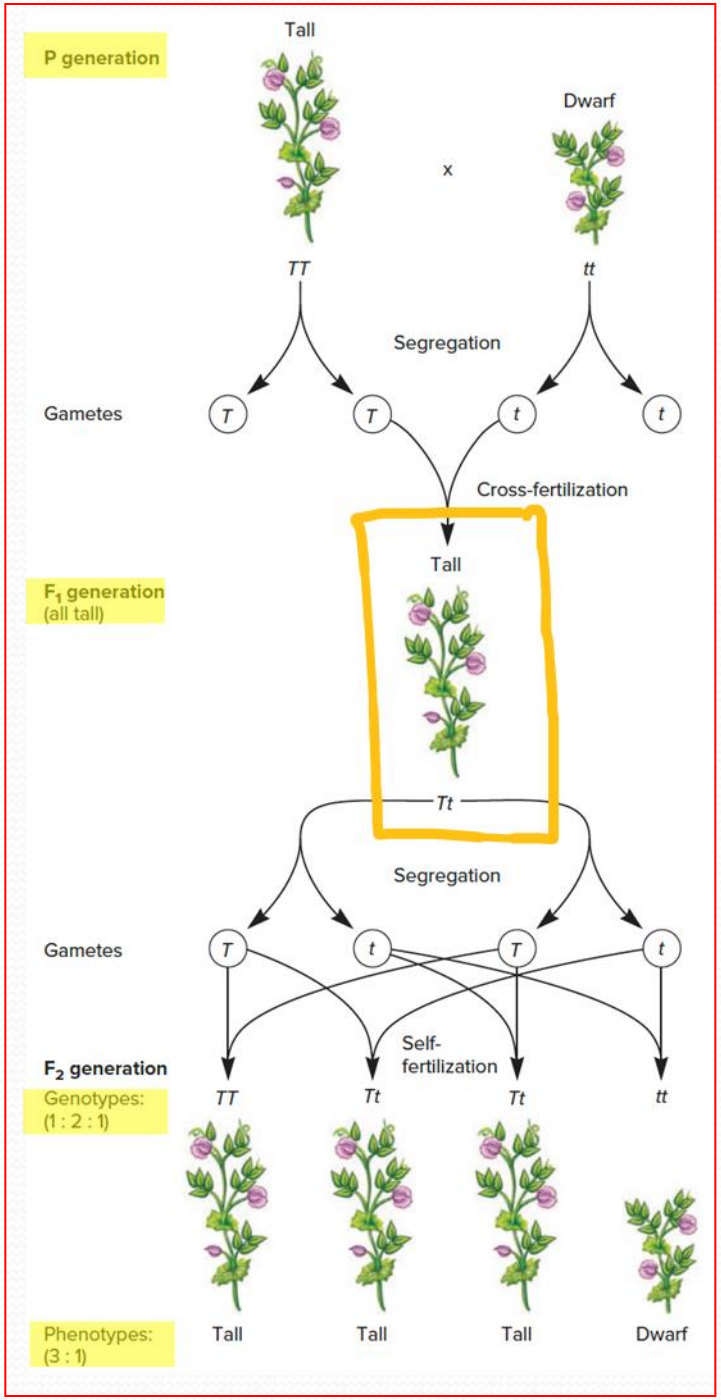
F1 gametes (T, t x T, t)

	T	t
T		
t		

F2 generation (3:1)

	T	t
T	TT	Tt
t	Tt	tt

- Phenotypic ratio = 3:1
- Genotypic ratio = 1:2:1



Definitions of basic terms in Mendelian genetics - Part 1

- A **dominant** trait is exhibited in the monohybrid individuals in the F1 generation and indicated by an uppercase (capital) letter.
- A **recessive** traits is absent in the monohybrid F1 offspring, but reappears in the F2 generation and indicated by a lowercase (small) letter.
- **Genotype:** refers to the genetic composition in an organism. Genotype may be either:
  1. **Homozygous** is for an organism that carries two copies of identical alleles of a gene in homologous chromosomes for a character (for example, a TT, tt individual)
  2. **Heterozygous** is for an organism that carries two different alleles for a character (for example, a Tt individual).

Definitions of basic terms in Mendelian genetics - Part 2

- **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.

The laws of Mendel

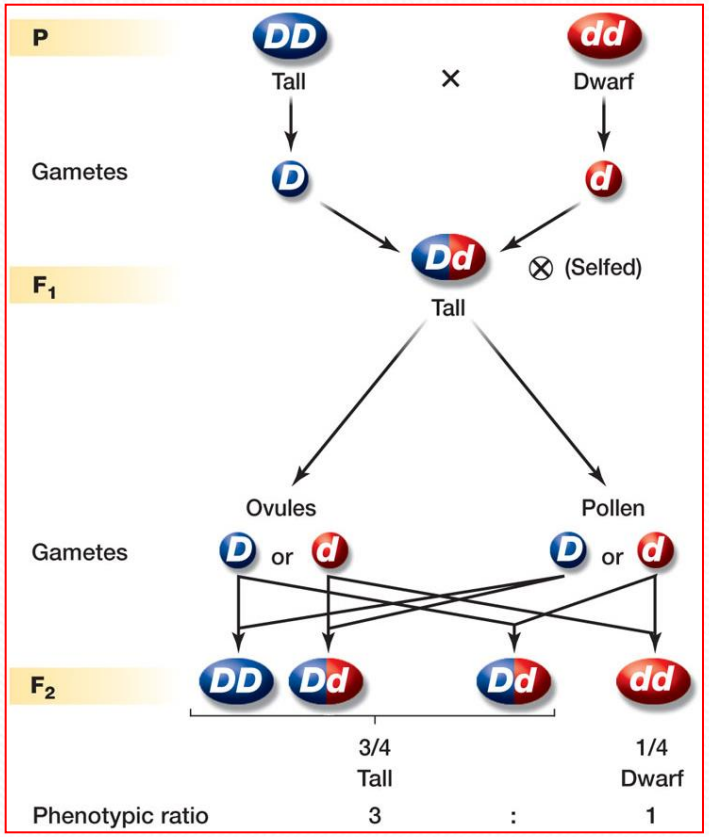
- Although the genotype of an individual involves two alleles, only one of these alleles is passed on to the gamete, which is either the pollen or ovule in plants.
- The fusion of two gametes, or fertilization, forms a zygote that restores two alleles in the cells.
- The explanation of how alleles are 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.

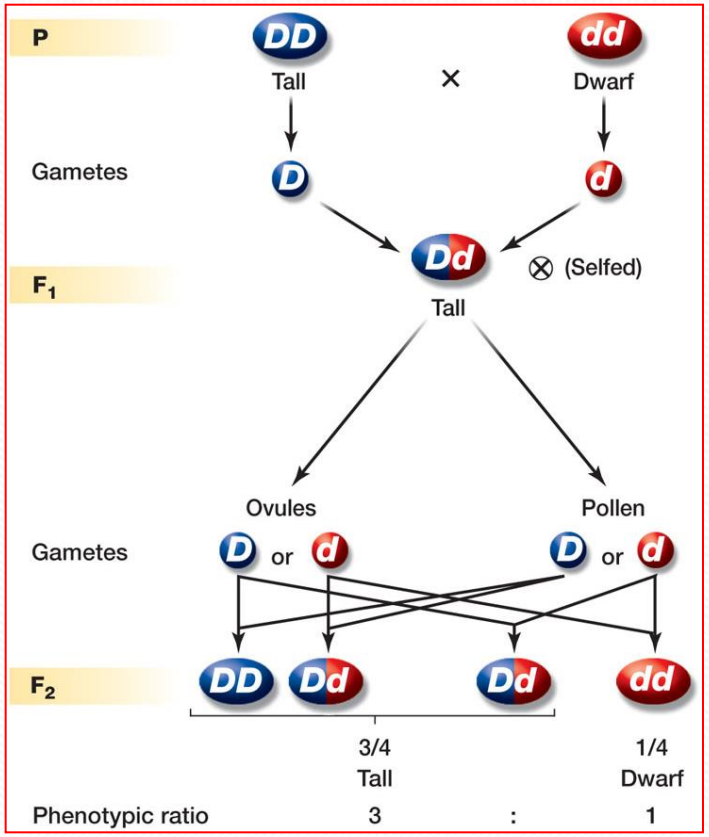
The law of segregation (Mendel's first law)

- 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 here, we can see that Mendel's law of segregation explains several things:
  - The heterozygous F1 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.



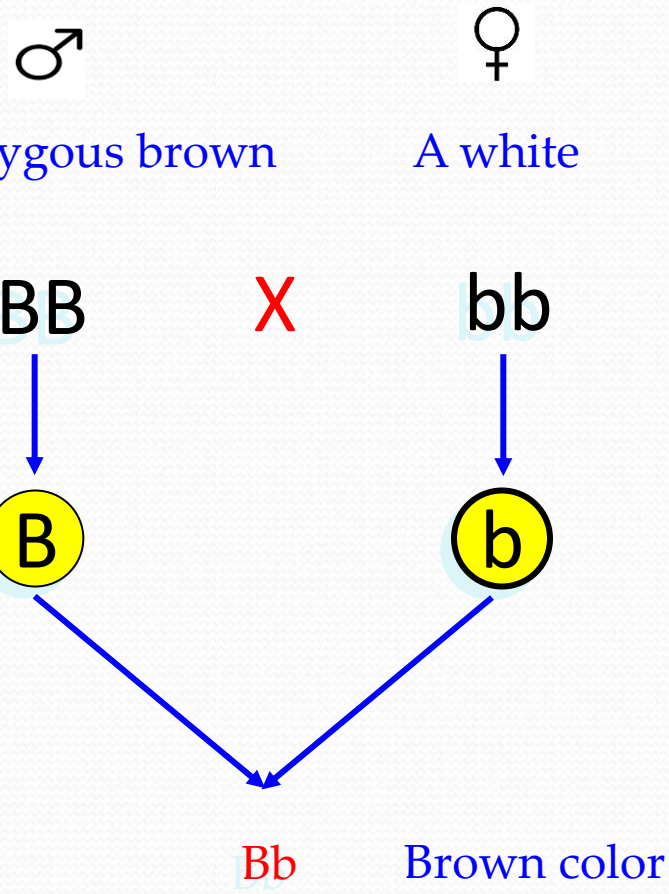
The law of segregation (Mendel's first law)

- 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.

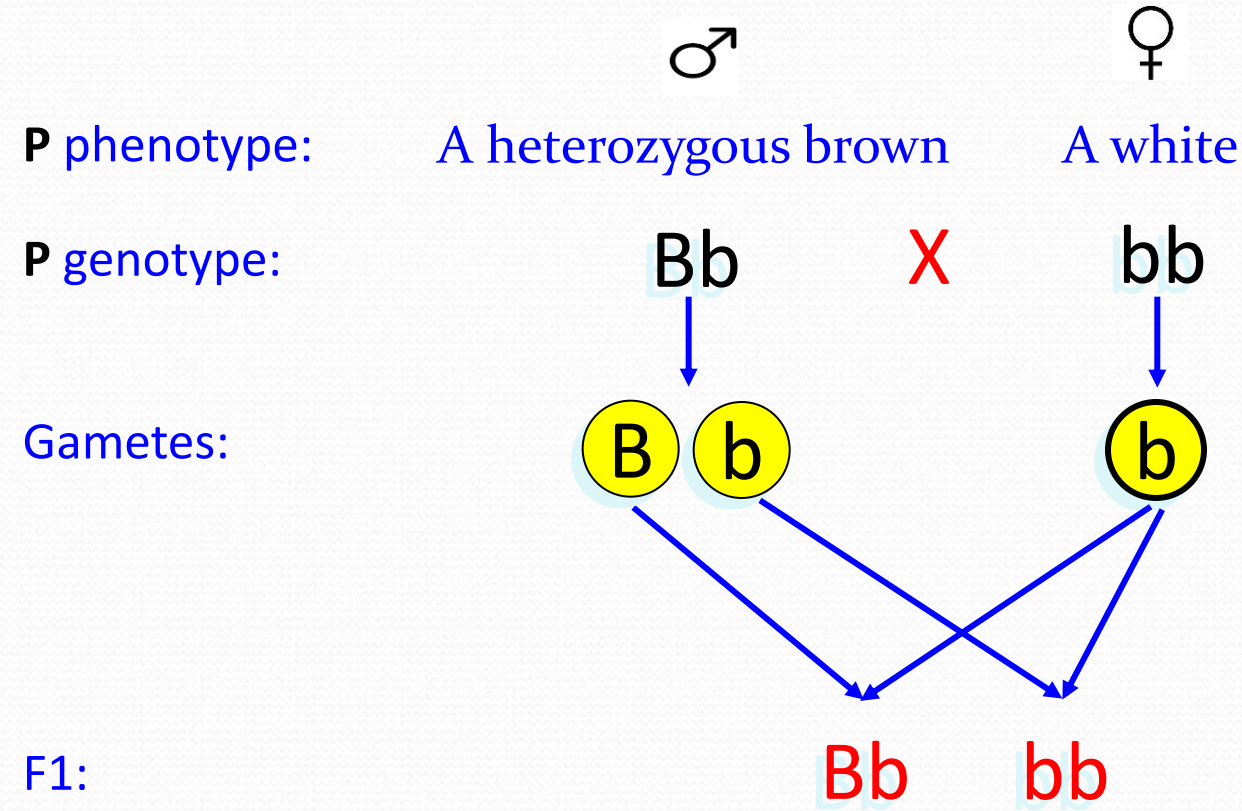


Monohybrid Examples

Question 1: A rancher wants to cross a homozygous brown horse with a white mare (female). Brown is dominant. What are the F1 generation genotypes and phenotypes?



Question 2: A rancher wants to cross a heterozygous brown horse with a white mare. What are the genotypic and phenotypic ratios for the F1 generation?



- Phenotypic ratio= 1 brown : 1 white (50% brown : 50% white).
- Genotypic ratio= 1 Bb : 1 bb (50% Bb : 50% bb).

First Assignment (Due: 9/3/2025)

Question 1:

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

Question 2:

Cross a heterozygous round seeds of pea plant with a wrinkled seeds and determine the probability of producing wrinkled seeds.

Question 3:

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?

Quiz: Mendelian genetics

1. To avoid self-fertilization in pea plants, what actions did Mendel take?

- Spray the plants with a chemical that damages the pollen.
- Remove the anthers from immature flowers.
- Grow the plants in a greenhouse free of pollinators.
- Perform all of the above.

2. If a pea plant has the genotype **Tt**, which of the following statements is correct?

- Its genotype is Tt, and its phenotype is dwarf.
- Its phenotype is Tt, and its genotype is dwarf
- Its genotype is Tt, and its phenotype is tall.
- Its phenotype is Tt, and its genotype is tall.

3. When a **Tt** pea plant is crossed with a **tt** plant, what is the expected ratio of phenotypes for the offspring?

- 3 tall: 1 dwarf
- 1 tall: 1 dwarf
- 1 tall: 3 dwarf
- 2 tall: 1 dwarf