MENDELIAN GENETICS

Gregor Johan Mendel (1822 – 1884)

- Known as the **Father of Modern Genetics**
- He was an Austrian Monk (in Brunn)
- The modern Concepts of Genetics took birth from his pioneering
- He works were on ***Pisum satium (Garden Pea)***
- The period of study: 1856 – 1864
- Published in: The annual ***Proceedings of the natural History Society*** of Brunn in **1866**
- Title of his publication: **Experiments in Plant Hybridization** (German)
- Mendel died as an unrecognized man, His studies remain in dark for 34 years

The Experiments of Gregor Mendel

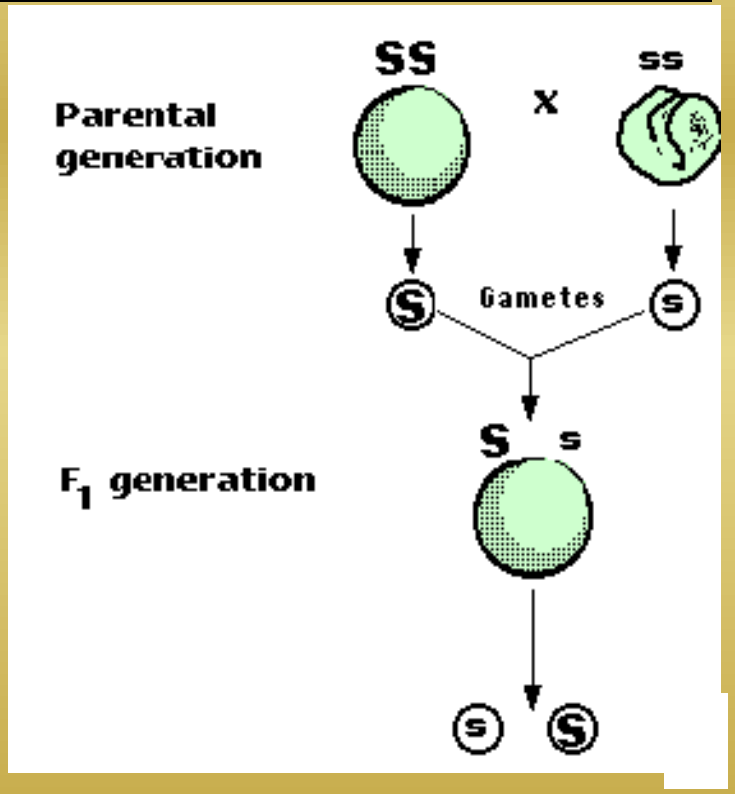
- Gregor Mendel did an experimented in which he crossbred pea plants and discovered that the traits could be passed onto another.
- Mendel's discovery with the peas is now used as a "model system."
- A model system is convenient because it may tell us how other organisms (including humans) actually function.

Mendel's Experiments

- Gregor Mendel conducted heredity experiments using common garden pea plants.
- Mendel crossed (mated) large numbers of plants.
- Mendel concluded that there were traits that always appeared (were expressed) when they were present in an organism.

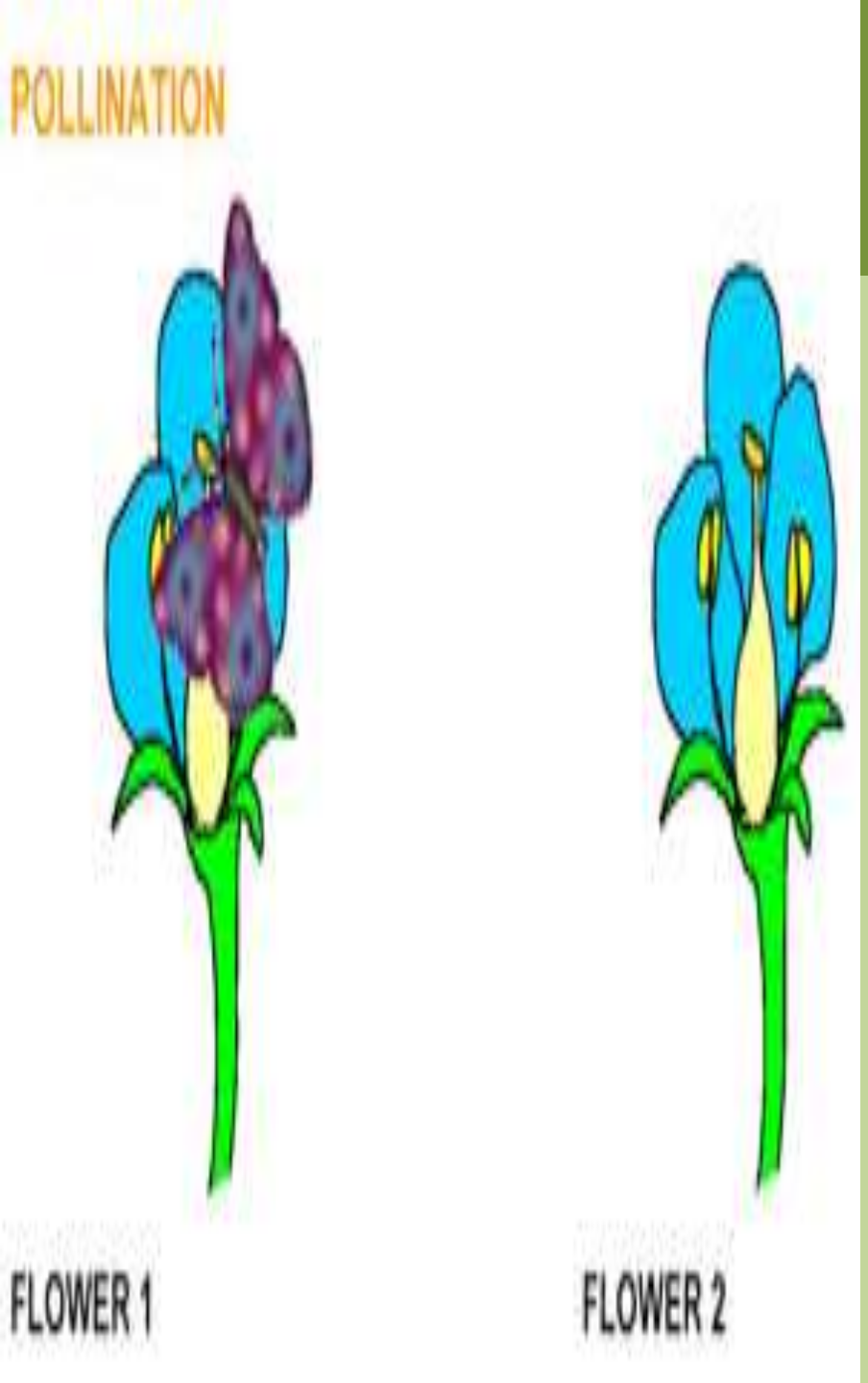
Mendel's Experiments

- The purebred plants are called the **parent (P) generation**.
- The offspring of a cross between two parent (P) generation plants are called the **first filial (F_1) generation**.
- The trait that always appears when it is present is called the **dominant** trait.
- The trait that is hidden by the dominant trait is called the **recessive** trait.



Mendel's Genetics

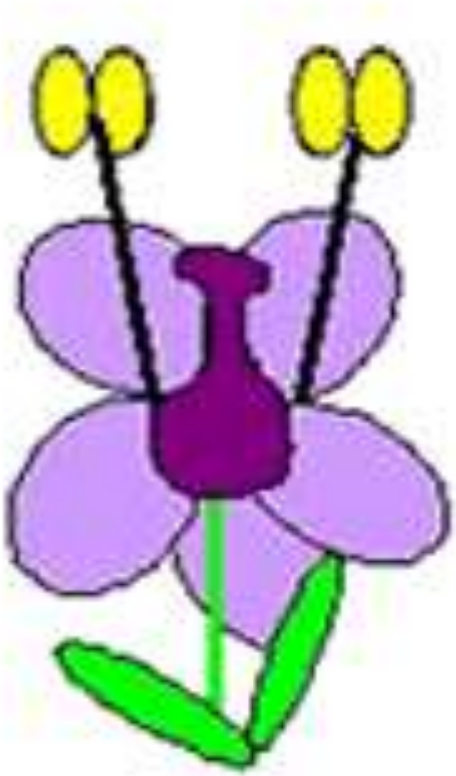
- Mendel's pea plants were **true-breeding**, meaning that if they were allowed to self pollinate, they would produce offspring identical to themselves.
- Mendel wanted to form different pea plants other than his true-breeding plants so he **cross pollinated** his pea plants by joining male and female reproductive cells from different plants.

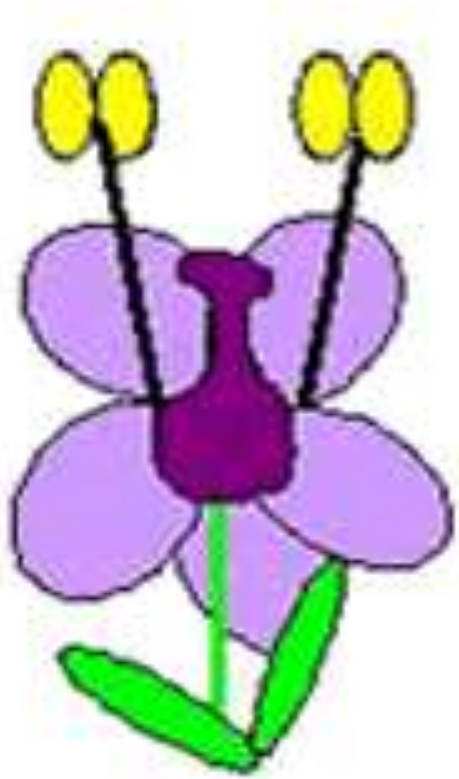


The Role of Fertilization

- **Fertilization:** During this process it is when the male and female reproductive join.
- **Trait:** a specific characteristic. For example: flower color!
- **Hybrid:** The offspring of parents with different traits.
- When Mendel began his experiment, he used the pollen to cross breed them. He knew a male reproductive cell was sperm and a female reproductive cell was an egg.

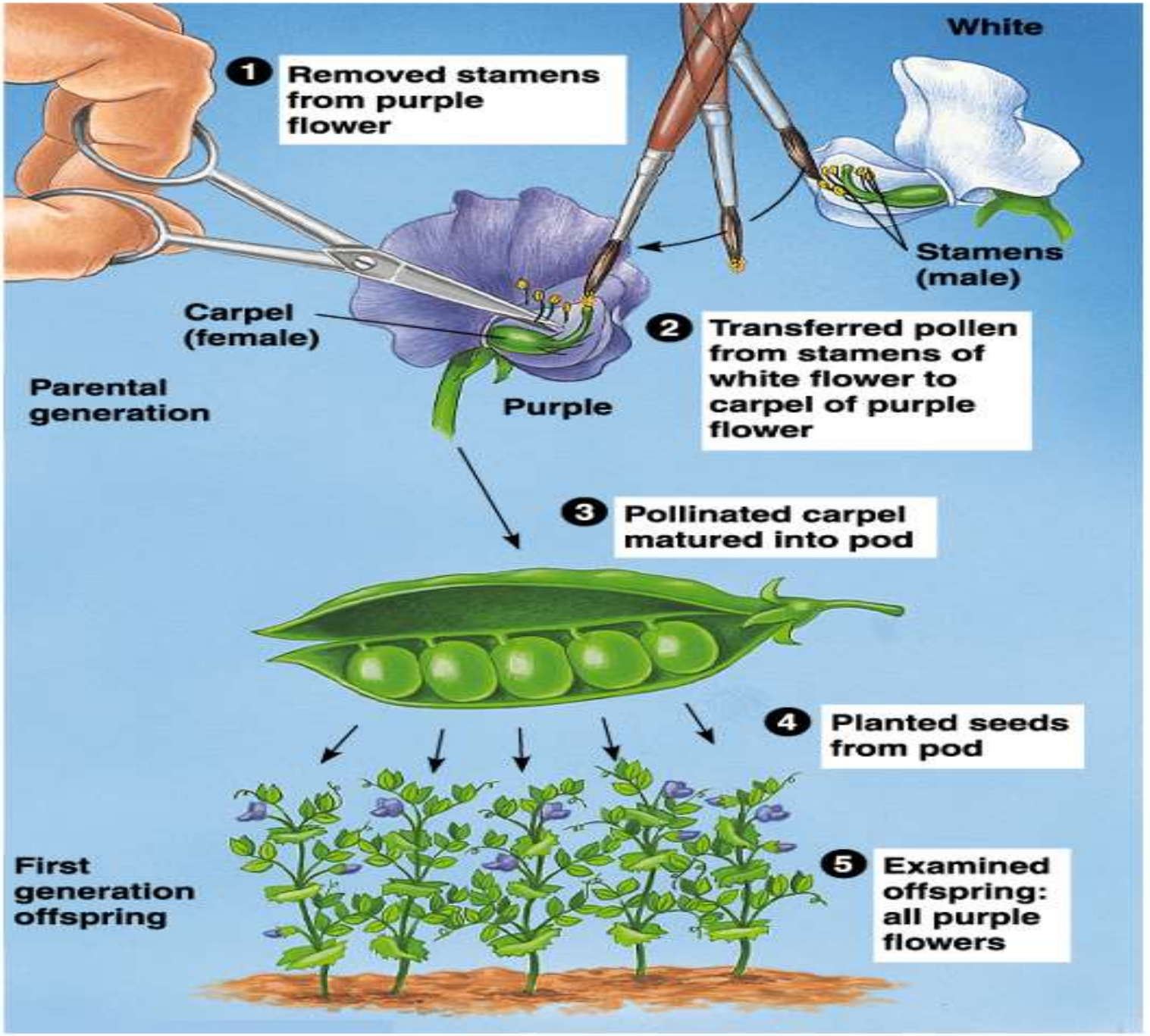
Cross Pollination



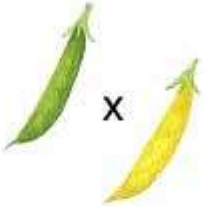


Mendel's Genetics

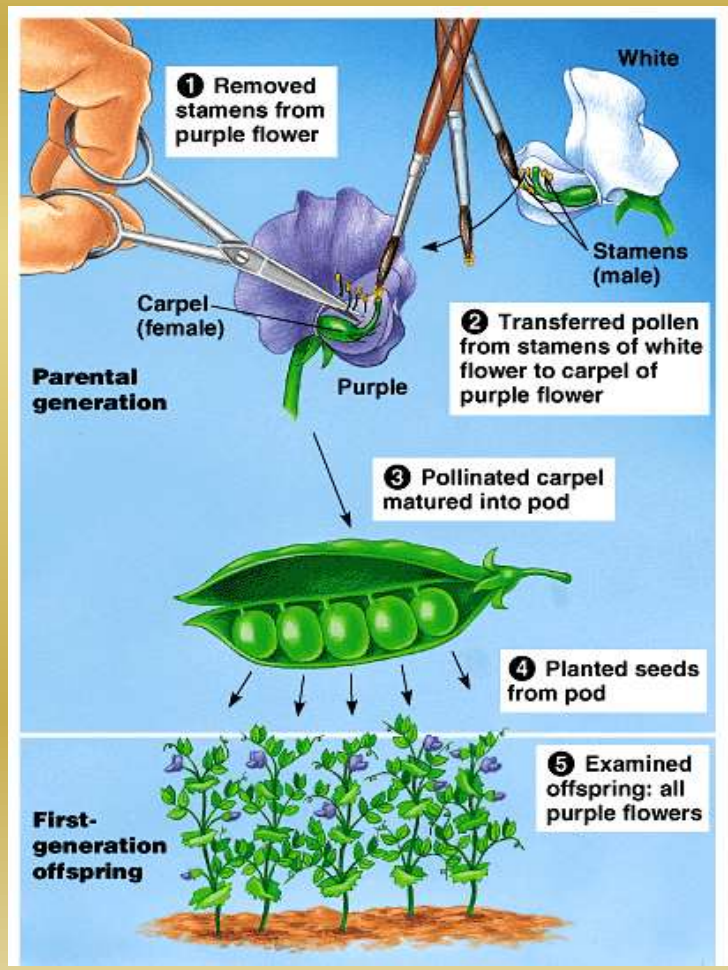
- Mendel studied 7 different pea plant traits
- **Trait:** a specific characteristic, such as seed color or plant height, that varies from one individual to another.
- **Hybrids:** are the offspring of crosses between parents with different traits
- P= parental generation
- F1= 1st son or daughter generation (1st offspring)



Mendel's Seven F_1 Crosses on Pea Plants

	Seed Shape	Seed Color	Seed Coat Color	Pod Shape	Pod Color	Flower Position	Plant Height
P	Round  Wrinkled	Yellow  Green	Gray  White	Smooth  Constricted	Green  Yellow	Axial  Terminal	Tall  Short
F_1	 Round	 Yellow	 Gray	 Smooth	 Green	 Axial	 Tall

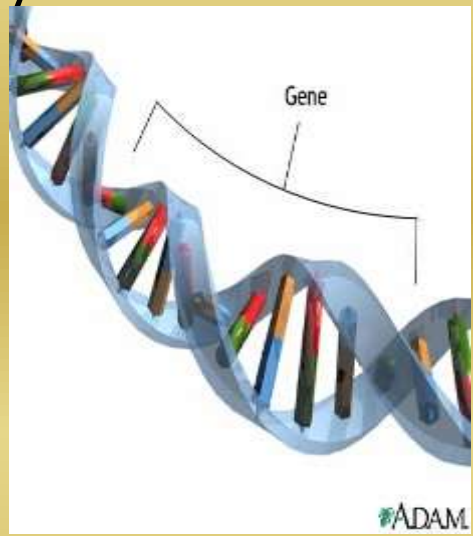
- Pea plants have several advantages for genetics.
  - Pea plants are available in many varieties with distinct heritable features (**characters**) with different variants (**traits**).
  - Another advantage of peas is that Mendel had strict control over which plants mated with which.
  - Each pea plant has male (stamens) and female (carpal) sexual organs.
  - In nature, pea plants typically self-fertilize, fertilizing ova with their own sperm.
  - However, Mendel could also move pollen from one plant to another to cross-pollinate plants.



- In a typical breeding experiment, Mendel would cross-pollinate (**hybridize**) two contrasting, true-breeding pea varieties.
  - The true-breeding parents are the **P generation** and their hybrid offspring are the **F_1 generation**.
- Mendel would then allow the F_1 hybrids to self-pollinate to produce an F_2 generation.
- It was mainly Mendel's quantitative analysis of F_2 plants that revealed the two fundamental principles of heredity: the law of segregation and the law of independent assortment.

Mendel's Conclusions From His Experiments

1st: was that **biological inheritance** is determined by factors that are passed from one generation to the next. (Scientist, call the chemical factors that determine traits **genes**.)

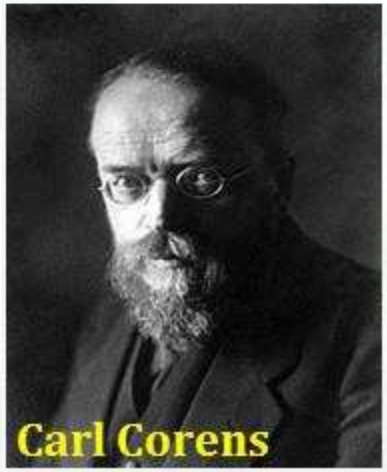


2nd: **Principal of dominance**: states that some alleles are dominant and others are recessive. (**Alleles:** different forms of a gene)

3rd: During **gamete formation**, alleles segregate from each other so that each gamete (sex cells) carries only a single copy of each gene. Each F1 plant produces two types of gametes- those with the allele for tallness and those with the allele for shortness

Rediscovery of Mendel's original work

- In **1900**, three scientists independently **rediscovered** the Mendel's work:
  - ***Carl Corens*** (Germany)
  - ***Hugo deVries*** (Holland)
  - ***Erich von Tschermak*** (Austia)
- Mendel's findings were now know as **Mendelism** or **Mendelian Lows of Inheritance**


Carl Corens


Hugo deVries


Tschermak

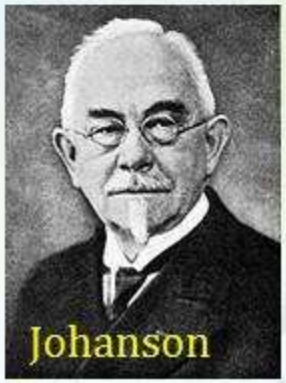
Terminologies in Genetics

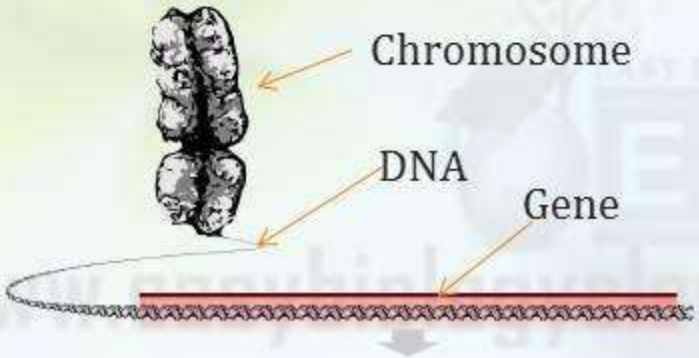

William Bateson

- The term '**Genetics**' was coined by **William Bateson** in 1905

(1). Gene

- The term '**Gene**' was coined by **Johanson** in 1909
- **Definition**: *Gene is the hereditary determining factor*
- Gene consists of a **continuous segment of DNA**
- In eukaryotes, the gene occupies in specific position on the chromosome called ***locus (loci)***

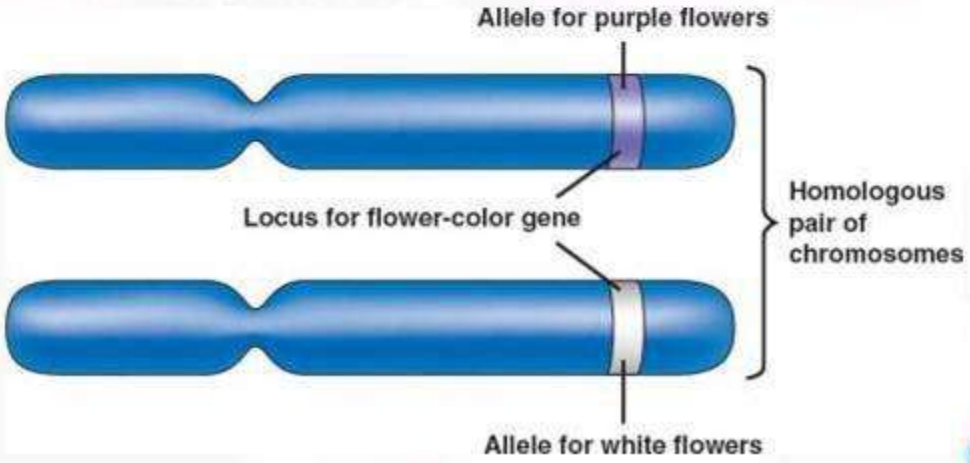

Johanson



(2). Allele

- Also called **allelomorphs**
- **Definition**: *Alleles are **alternate forms of a gene** which occupy **identical loci** on **homologous chromosome***
- Allele control the **contrasting** characters of **same trait**
- Usually alleles exists in **TWO** different forms:

1. **Dominant allele**
2. **Recessive allele**



(3). Dominant and Recessive Alleles

- Dominant allele will always express
- Recessive alleles will express only in the **absence** of dominant allele
- Dominant allele **mask** or **suppress** the expression of recessive allele
- **Dominant** alleles are classically symbolized with **capital letters**
- **Recessive** alleles are symbolized with **small letters**

  - **Trait**: Height
  - **Characters**: Tall and Dwarf
  - **Dominant**: Tall (**T**)
  - **Recessive**: Dwarf (**t**)

Multiple Alleles

- Many genes exist in several different forms and are therefore said to have multiple alleles.
- **Multiple Alleles:** A gene with two or more alleles.
- Rabbit's coat color is an example.
- The color of a rabbit's coat is determined by one gene with at least FOUR different alleles.

Multiple Alleles

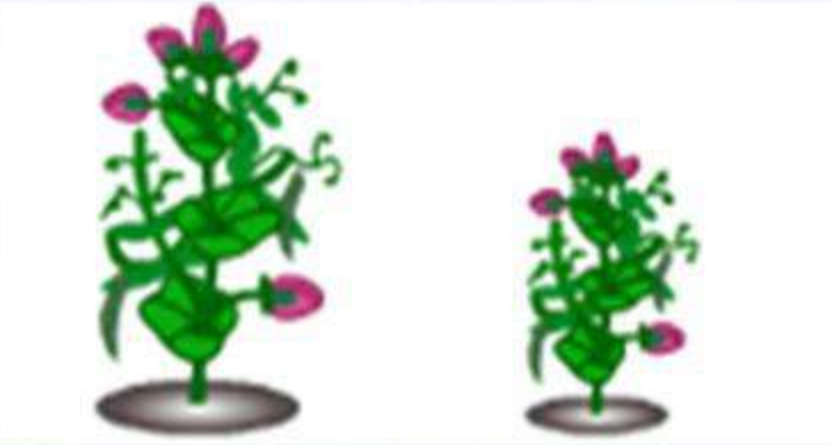
(4). Genotype and Phenotype

- **Genotype**: *The **genetic makeup** (constitution) of an organism*
- **Phenotype**: *The **physical features**/appearance of an organism*
- Phenotype is the **expression** of **genotype**
- Phenotype is produced not only by the **genotype** but also by the **interaction** between **genotypes** and **environmental factors**

Trait: Height

Phenotype : **Tall** and **Dwarf**

Genotype: **TT** or **Tt** and **tt**



TT tt

Genetic Terms

- **Genotype** - The genetic makeup of an organism.
- **Phenotype** - The external appearance of an organism.
  - For example, an organism that looks tall can have a genotype that is pure tall or hybrid tall. This is because whenever the dominant trait is present, the organism expresses (shows) the dominant trait.

Genotype and Phenotype

- **Genotype:** genetic make-up.
- **Phenotype:** physical traits.
- Just because something has the same phenotype DOES NOT mean it can have the same genotype.
- The genotype of an organism is inherited, while the phenotype just solely relies on the genotype.

(5). Homozygous

- A condition in which both the members of **an allelic pair** in the homologous chromosome are **identical** (either dominant or recessive alleles)

Tall : **TT**

Dwarf : **tt**

(6). Heterozygous:

- A condition in which the members of an allelic pair in the homologous chromosome are **NOT** identical (one dominant and one recessive allele)

Tall : **Tt**

Genetic Terms

- **Homozygous Trait** - Both genes for that trait are the same.
  - A pea plant with two genes for tallness.
- **Heterozygous Trait** - Both genes for that trait are not the same.
  - A pea plant with one gene for tallness and one for shortness.

(7). Hemizygous

- A condition when gene are present only in **one copy**
  - Genes on X chromosome in male (have one X and one Y Chromosome)
  - Genes on Y chromosome (only one Y chromosome in males)

(8). Dominance

- *The **ability** of an allele to **express** itself phenotypically both in homozygous (**TT**) and in heterozygous (**Tt**) conditions*

(9). Recessiveness:

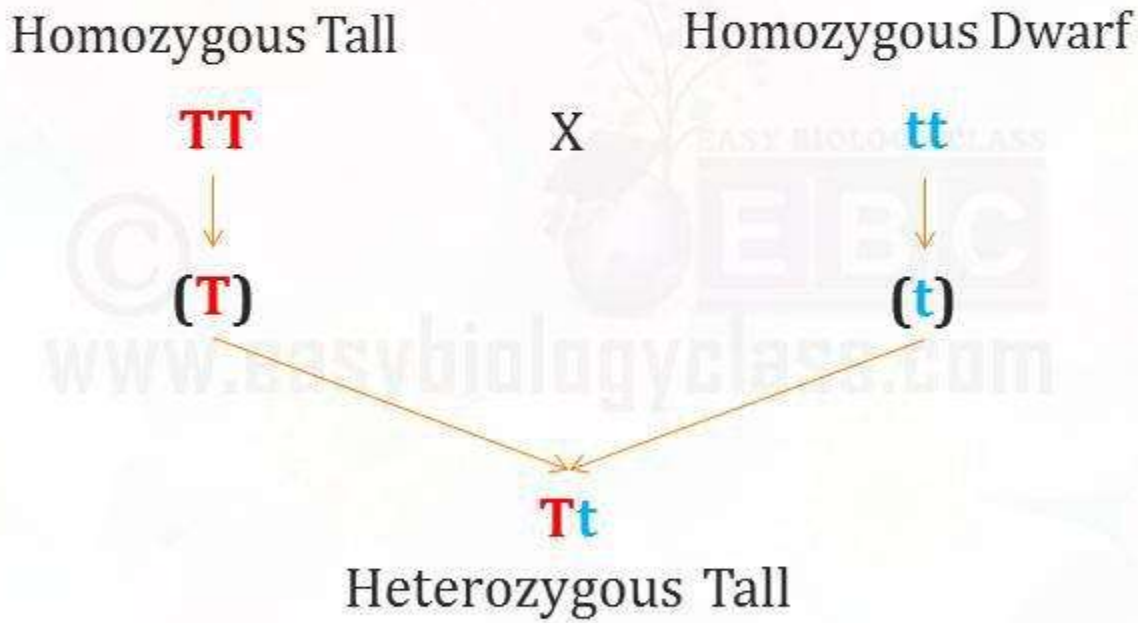
- The **inability** of an allele to manifest its phenotype in heterozygous (***Tt***) condition

Dominant and Recessive Alleles

- Mendel's second conclusion is called the **principle of dominance**.
- The principle of dominance states that some alleles are dominant and others are recessive.
- An organism with a recessive allele will express that trait when a dominant form isn't present.
- In Mendel's experiment, the trait for tall plants was dominant and short plants was recessive.

(10). Hybridization and Hybrid

- **Hybridization**: *The process of **crossing** two **genetically different** individuals*



- **Hybrid:** The progeny of hybridization is called hybrid

(11). Monohybrid

- An organism which is heterozygous with respect to only **ONE** pair of allele at **a** locus under study

Tall **X** Dwarf

(12). Dihybrid

- An organism which is heterozygous with respect to **TWO** pairs of alleles at **two** loci under study

Yellow Round Seed **X** Green Wrinkled Seed

(13). Monohybrid Cross

- A cross between two individual organism which differ from each other with respect to **<u>ONE</u> pair** of allele under study

Tall		Dwarf
TT	X	tt

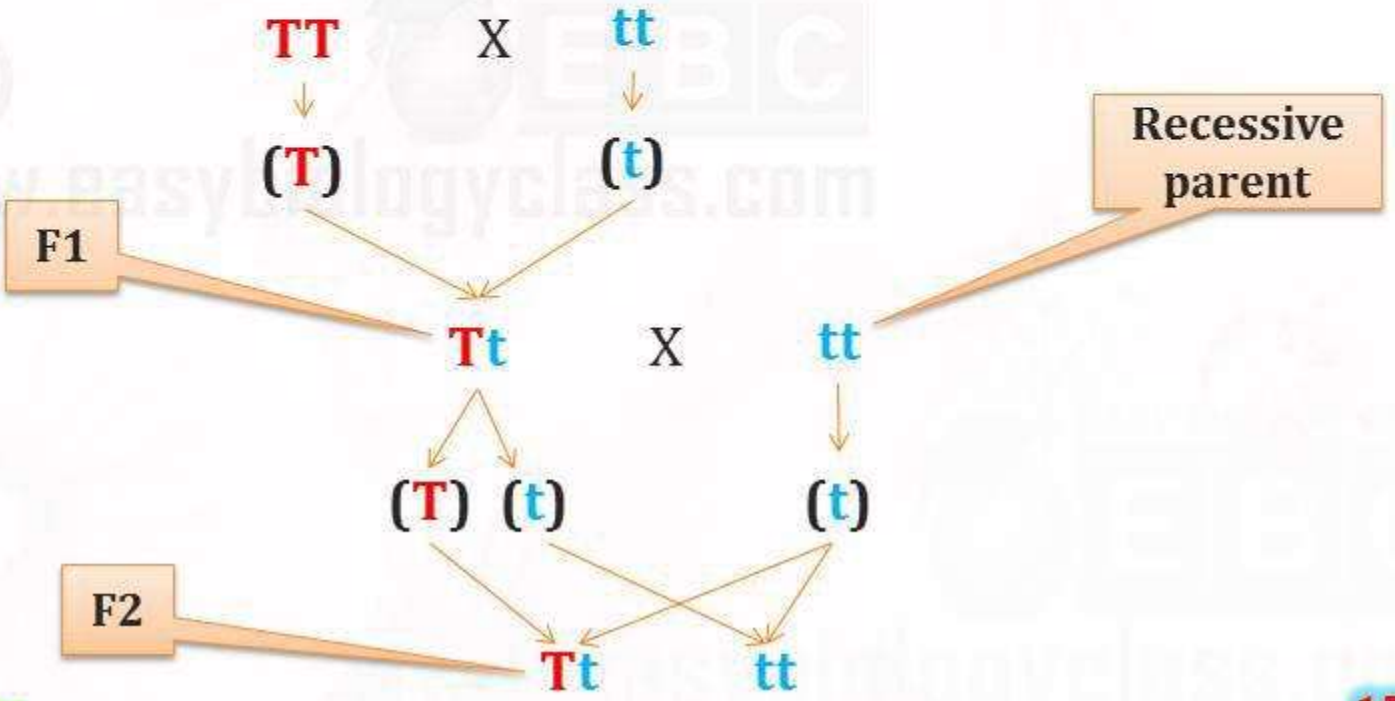
(14). Dihybrid

- A cross between two individual organism which differ from each other with respect to **<u>TWO</u> pairs** of allele under study

Yellow Round Seed		Green Wrinkled Seed
YYRR	X	yyrr

(15). F1 and F2 Generation

- **F** – filial meaning son
- F1: *First generation progeny of a hybridization*
- F2: *Progeny of hybrid (F1) when it is hybridized with any of its parents*



(16). Reciprocal Cross

- Two reverse crosses in which the **sexes** of the parents are **interchanged**

Tall ♂ X Dwarf ♀

Dwarf ♂ X Tall ♀

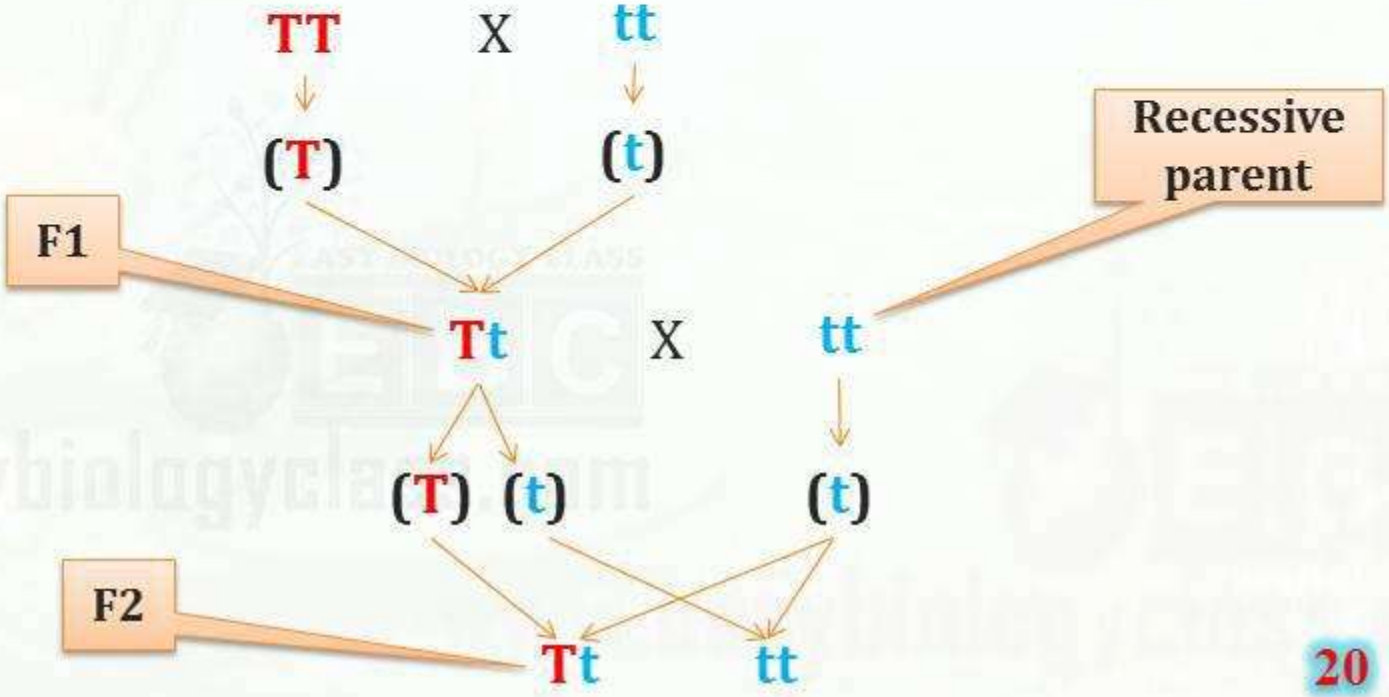
- If the traits are **autosomal** the reciprocal cross always yield **same result**
- If the traits are on **sex chromosomes**, the reciprocal cross gives different results

(17). Backcross

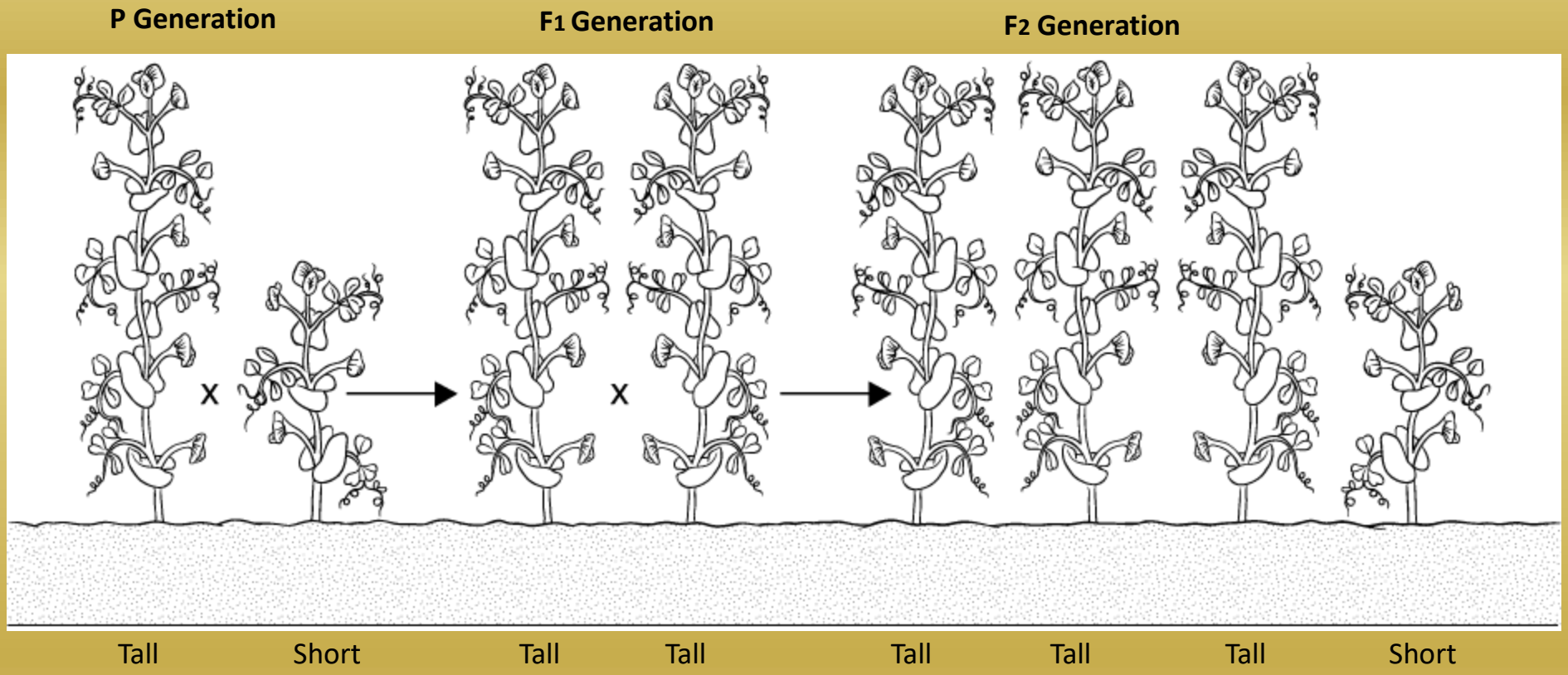
- The cross of F1 offspring with one of its parents
- If F1 is crossed with dominant parent, all progenies (F2) will be dominant
- If F1 is crossed with recessive parent, individuals with both phenotype will appear in equal proportion
- The ratio of progenies produced during back cross is called back cross ratio

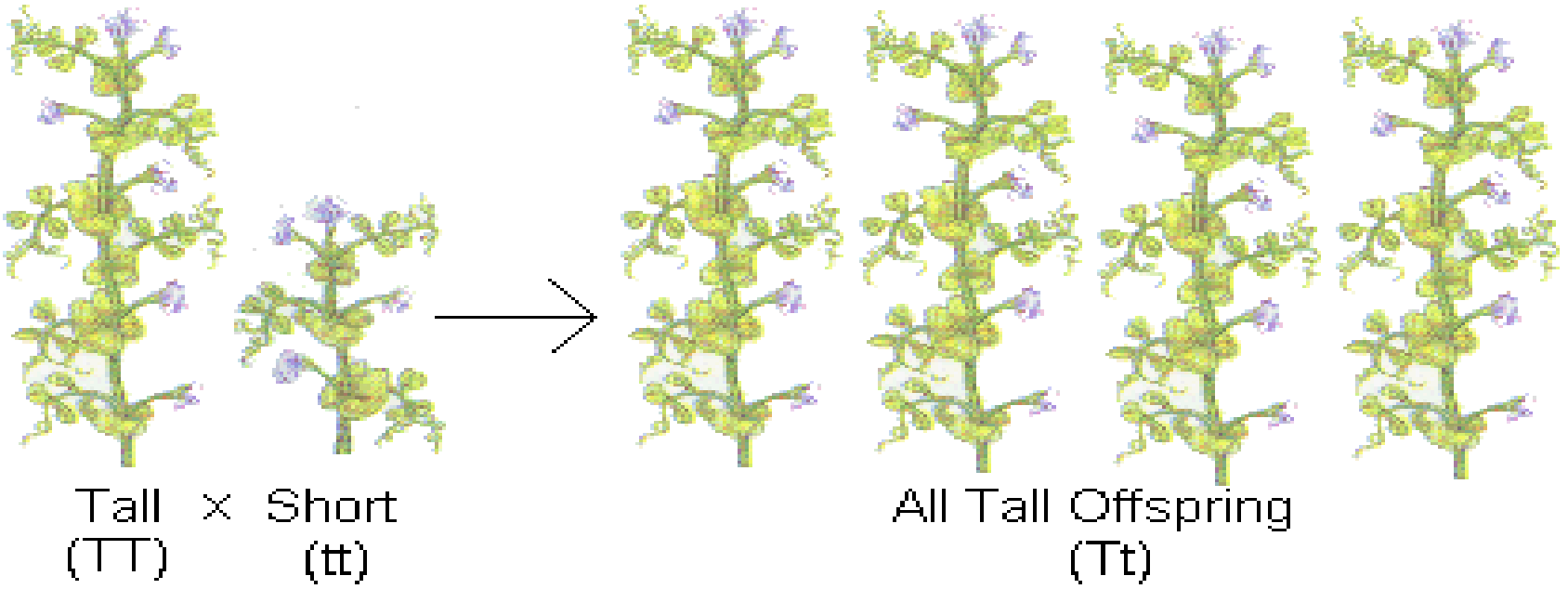
(18). Test Cross

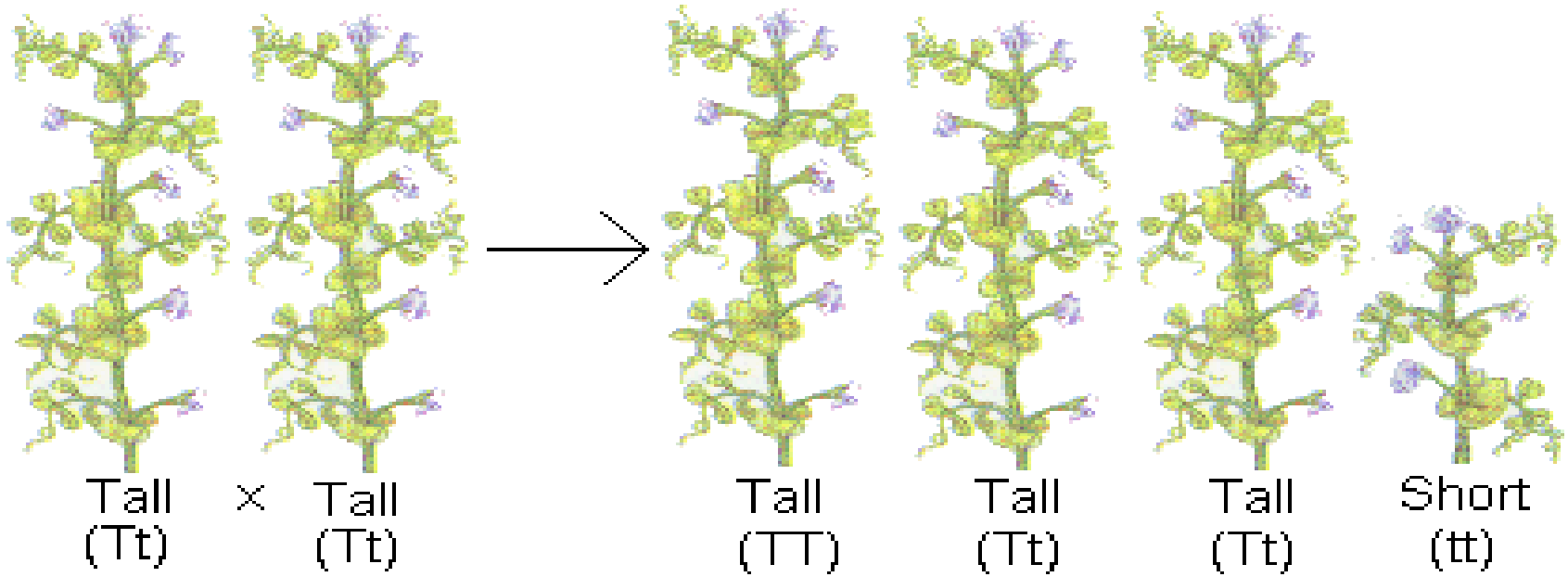
- *Test cross is a type of back cross in which the F1 progeny is crossed with its double recessive parent*
- *Test cross is used to determine whether the individuals exhibiting dominant character are homozygous or heterozygous* (to detect the genotype of F1)



Principles of Dominance




Tall
(TT)
×
Short
(tt)
All Tall Offspring
(Tt)


Tall
(Tt)
×
Tall
(Tt)
Tall
(TT)
Tall
(Tt)
Tall
(Tt)
Short
(tt)

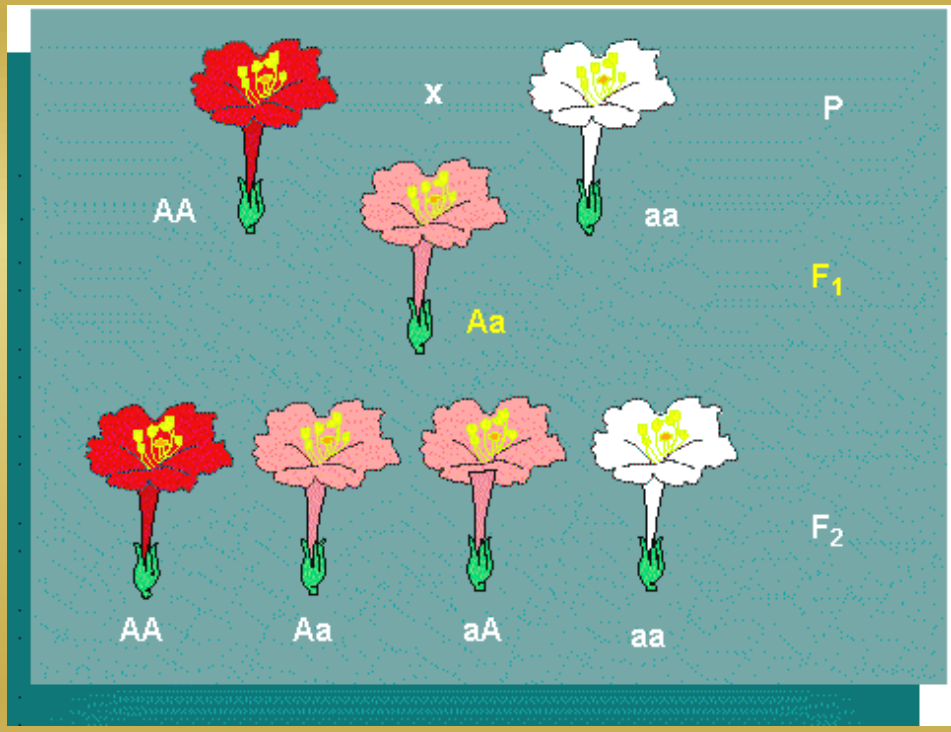
Codominance

- **<u>Codominance:</u>** the phenotypes produced by both alleles are clearly expressed.
- For example, chickens will have the black and white colors that their parents had.
- In humans, a gene for protein that controls cholesterol levels in the blood, show codominance.

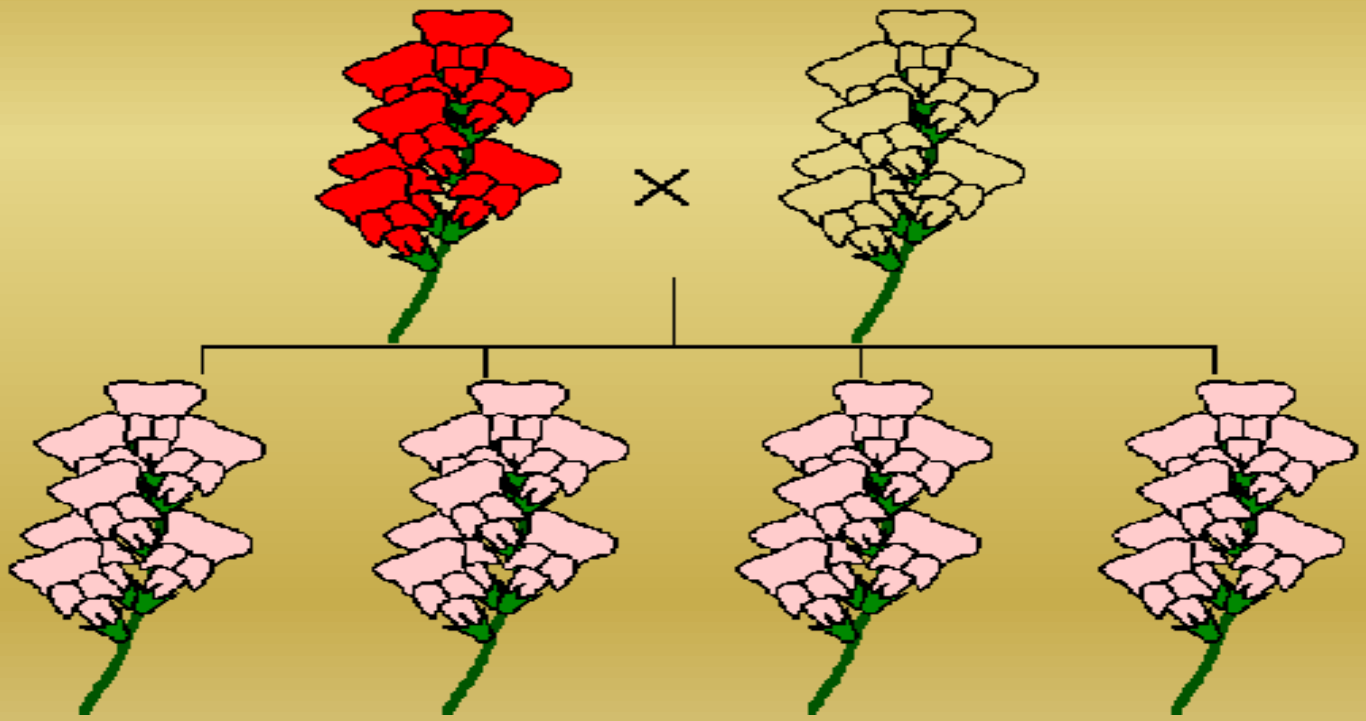
Co-dominance

Incomplete Dominance

- **Incomplete dominance** or **blending inheritance** occurs when the offspring shows traits that are a blend or mix of the two parents.



Incomplete Dominance



Shared Traits

- Some alleles are neither dominant nor recessive, and many traits are controlled by multiple alleles or multiple genes.
  - **Incomplete Dominance:** Cases in which one allele is not completely dominant over another (Ex. crosses between red flowers and white flowers are pink flowers)
  - **Co-dominance:** Cases in which both alleles contribute to the phenotype. (Ex. Feathers that are speckled with black and white)
  - **Multiple Alleles:** Many genes have more than two alleles. (Ex. A rabbit's coat color is determined by a single gene that has at least 4 different alleles.)
  - **Polygenic Traits:** Traits controlled by 2 or more genes. (Ex. At least 3 genes are involved in making the reddish-brown pigment in eyes of fruit flies.)

QUESTIONS