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Topic: Laws of Heredity

Laws of Heredity

- The first scientific study leading to formulations of Laws of inheritance was carried out by **Gregor Johann Mendel (1822-1884),** known as **'father of genetics'.**
- Mendel had conducted hybridization experiments in garden pea ***Pisum sativum.***
- On the basis of his experiments, Mendel was able to explain fundamentals of inheritance.
- Mendel derived **two laws or principles related to segregation (**purity of gametes) and independent assortment.

Reasons for the success of Mendel in his experiments:

- Mendel selected peas for many reasons. Pea plant is **self-fertilizing** in nature.
- Pea reproduces well and grows to maturity in a season. Many varieties are available with observable alternate forms for traits or characteristics.
- The number of **characters studied by Mendel in pea plant was seven.**
- The number of **chromosomes** in *Pisum sativum* is **14 (2n).**

- Mendel restricted his experiments to one or few pairs of contrasting traits in each experiment.
- Mendel also kept accurate quantitative records, a necessity in genetic experiments.
- Self-fertilization in pea can be prevented by removing anthers (emasculation) before pollen grains mature.

Traits of Pea studied by Mendel

Characters	Contrasting Traits	
	Dominant	**Recessive**
1. Stem height	Tall	Dwarf
2. Flower colour	Purple (red)	White
3. Flower position	Axial	Terminal
4. Pod colour	Green	Yellow
5. Pod shape	Inflated	Constricted
6. Seed colour	Yellow	Green
7. Seed shape	Round	Wrinkled

Monohybrid cross

- **Monohybrid cross** is the simplest cross performed by Mendel. It is the cross made to **study inheritance of a single character (trait).**
- Mendel crossed **two varieties** of *Pisum sativum***, tall and dwarf**. In the first filial generation (F1), all plants were tall. Now he allowed F1 plants to self-pollinate. The next generation (F2) resulted in the production of tall and dwarf in the ratio of 3:1. So their phenotypic ratio was 3:1. But they had a genotypic ratio 1:2:1 (1TT, 2Tt and 1tt). The reciprocal crosses gave a similar result.

- Two crosses between the same pair of genotypes or phenotypes in which the sources of the gametes are reversed in one cross, is known as reciprocal cross.
- Tall plants produced in the F2 generation may either be TT or Tt genotype.

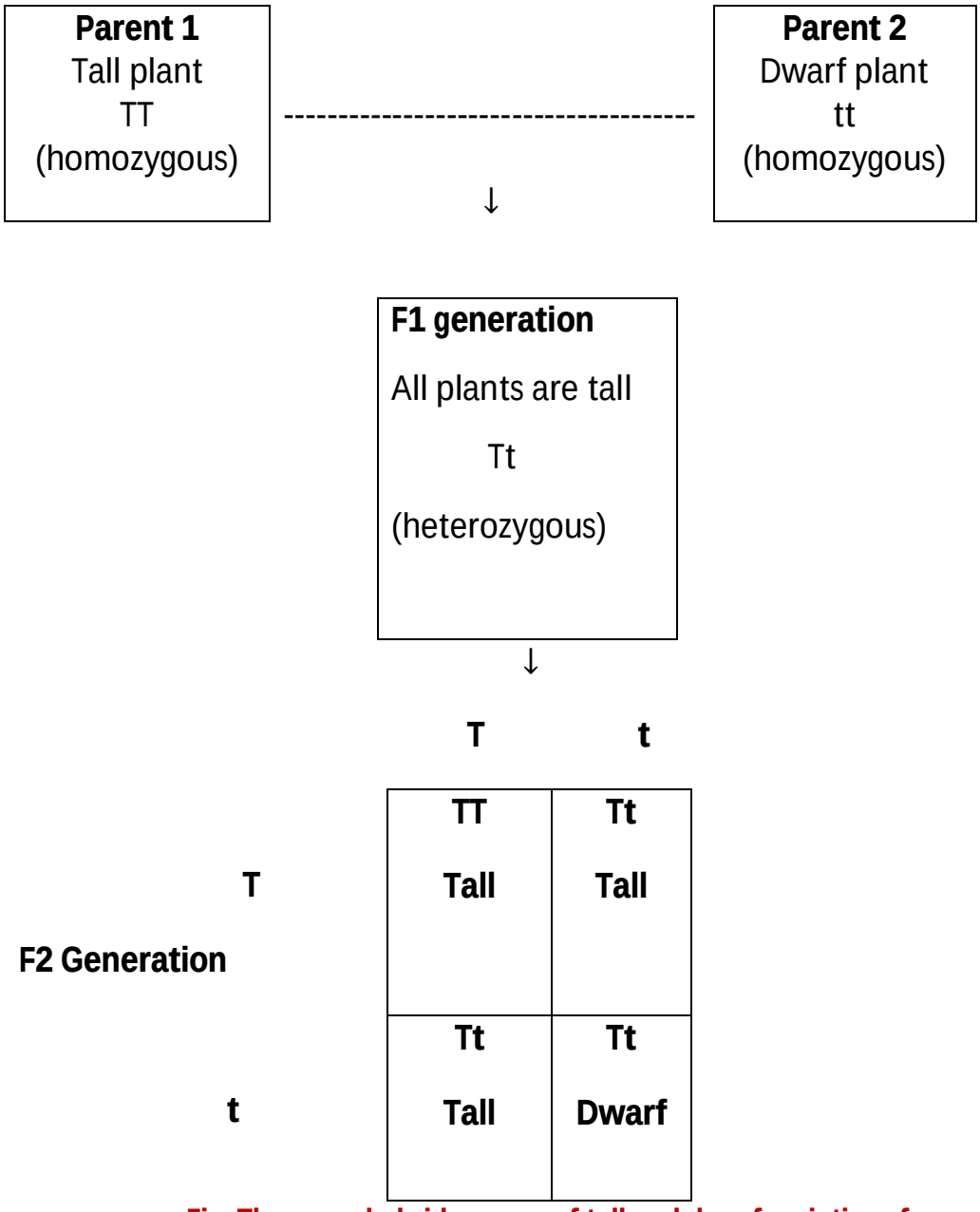


Fig. The monohybrid crosses of tall and dwarf varieties of pea plant.

Dominance -Recessiveness

- When two unlike unit factors are present in individual, one unit factor is dominant to the other which is said to be recessive.
- For example, tallness (T) dominates over the dwarf (t). In homozygous condition, the tall and dwarf both gain expression. In heterozygous condition (Tt) only tallness gains expression.
- When an allele fails to express itself in the presence of the other , the former is said to recessive.
- Mendel observed red flower in F1 when he crossed red and white because of dominance.
- Mendel formulated his first law, the law of segregation, with the help of monohybrid cross.

Law of segregation

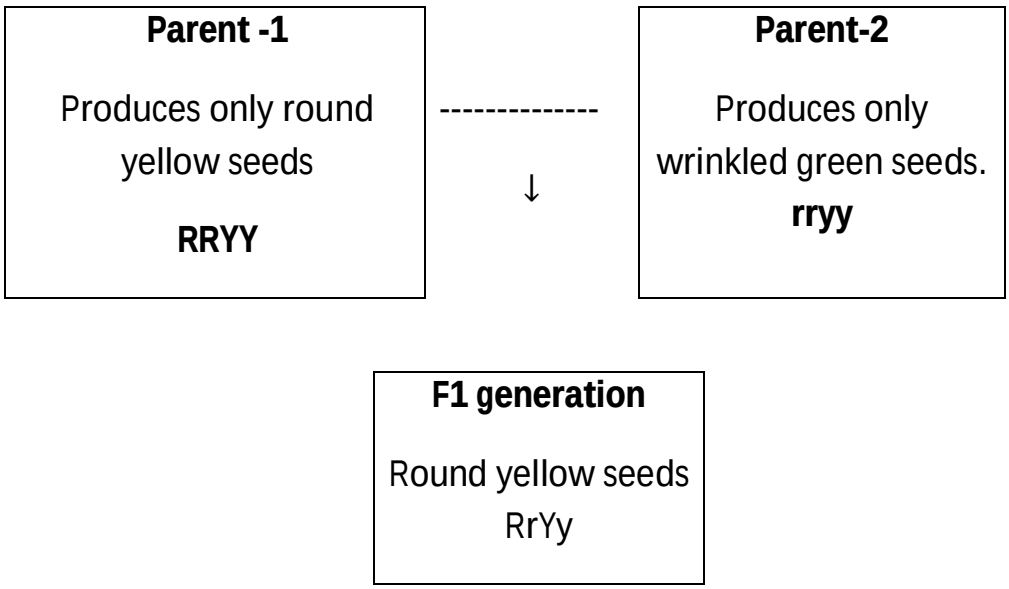
- Mendel's first law is known as law of segregation.
- The hereditary characters in the form of alleles segregate (separate)from each other in the formation of gametes;half gametes carry one allele and the other half carry the other allele. In other words, each gamete carries only one allele of each gene. This law is also called law of purity of gametes.

Dihybrid cross

- Dihybrid cross is a cross involving two pairs of contrasting characters.
- A cross between two individuals for studying inheritance of two characters is known as Dihybrid cross.

- Mendel crossed a pea plant with round yellow seeds with plant having wrinkled green seeds (rryy). In F1 generation, all plants produced only round yellow seeds (RrYy). This means, round is dominant over wrinkled and yellow is dominant over green. The selfing of these plants produced four types of combinations in F2. They are:

- **Round yellow -9**
- **Round green-3**
- **Wrinkled yellow-3**
- **Wrinkled green-1**



F2 generation

Gametes	RY	Ry	rY	ry
RY	RRYY Round yellow	RRYy Round yellow	RrYY Round yellow	RrYy Round yellow
Ry	RRYy Round yellow	RRyy Round green	RrYy Round green	Rryy Round green
rY	RrYY Round yellow	RrYy Round yellow	rrYY wrinkled yellow	rrYy wrinkled yellow
Ry	RrYy Round yellow	Rryy Round green	rrYy wrinkled yellow	rryy wrinkled green

Fig. The dihybrid cross of pea plant with round yellow seeds with green wrinkled seeds. Punnett square below show all possible genotypes and phenotypes.

- Thus the phenotypic ratio of F2 in a Dihybrid cross is 9:3:3:1.

- The genotypic ratio of Dihybrid cross is 1:2:2:4:1:2:1:2:1.
  Mendel's **second law, the law of independent assortment** is based on F2 ratio of Dihybrid cross.

Seed shape **seed colour** **Final ratio**

Yellow 3 ---------- -9

Round **3**— — ——→

Green 1----------3

Yellow 3----------3

Wrinkled 1 ---------- →

Green 1----------1

Fig. Derivation of the Dihybrid ratio 9:3:3:1

Law of independent assortment

- Mendel's second law, the principle of independent assortment, states that the members of one pair of factors segregate independently of the member of other gene pairs at the time of gamete formation.
- In Dihybrid cross, it has been found that colour of seeds is independent of the shape of the seed. Factor for round (R) or wrinkled (r) assort independently of yellow(Y) or green (y). It produces four types of gametes with two parental and two recombinants i.e., RY,Ry,rY and ry.
- Their fusion with opposite gamete results in the production of phenotypes in the ratio 9:3:3:1 in F2 generation.
- Independent assortment is not applicable for the genes located on the same chromosome,i.e.,linked genes.
- Linkage is an exception to Mendelian principles.

Test cross: Two characters

- Test cross is also applicable to Dihybrid cross.
- A cross between Dihybrid and double recessive parent is an example of test cross.
- When a tall red plantis crossed with dwarf white plant,all the plants in F1 generation are found to be tall red.
- A Dihybrid test cross give a 1:1:1:1 ratio, indicating that two pairs of factors are segregating and assorting independently.

Common crosses involving simple Dominance

Examples	Phenotypic ratios
Rr x Rr	3:1 (dominant to recessive)
Rr x rr	1:1 (dominant to recessive)
RrYy x RrYy	9:3:3:1(9 dominant: 3 mixed: 3mixed: 1 recessive)
RrYy x rryy	1:1:1:1(all possible combinations in equal number)

Trihybrid cross

- To confirm the law of independent assortment, Mendel examined the inheritance of traits in a cross between plants that differed for three characters which is called a **Trihybrid cross.**
- Mendel crossed plants from a true-breeding strain with **round, yellow** seeds and a **gray** seed coat(RR YY GG) with plants from a strain with **wrinkled, green** seeds and a **white** seed coat (rr yy gg). The F1 seeds (Rr Yy Gg) were all round, yellow and gray.
- According to Mendel's rules of segregation and independent assortment, each F1 plants should produce gametes with eight different genotypes.
- Selfing of the F1 plants give 8x8=64 possible combinations of gametes producing 27 different F2 genotypes.
- Because of dominance, these 27 genotypes should give eight different F2 phenotypes in a 27:9:9:9:3:3:3:1 ratio.

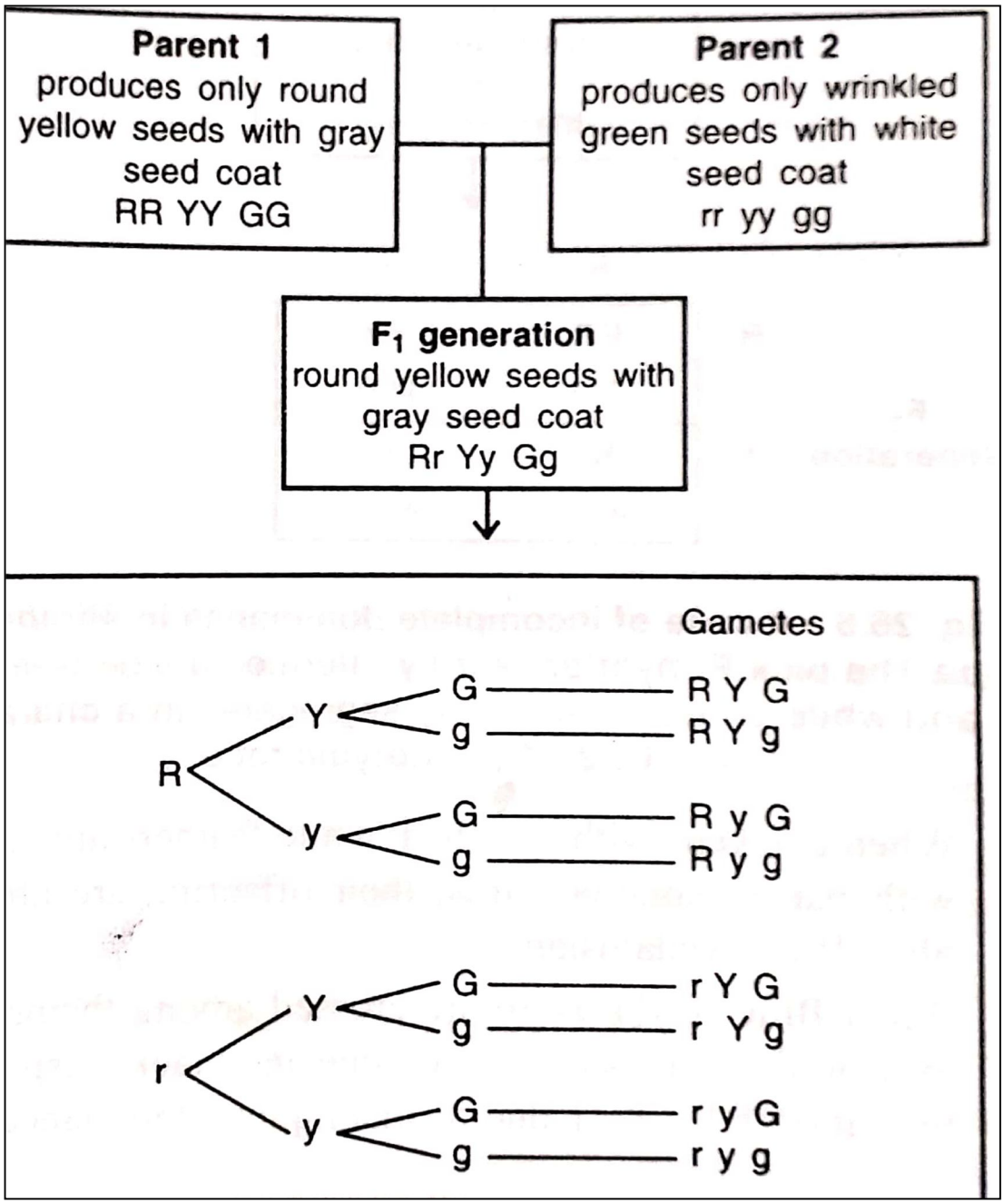


Fig. Eight different types of gametes produced by a Trihybrid using a dichotomous branching system.