Chapter -3

Genetics

The branch of biology which deals with the study of heredity and variation is called **genetics**. The term genetics was first coined by **Bateson** (1905). This term is derived from the Greek language word ***gene.***

During the process of sexual reproduction various characters are transmitted from generation to generation by gametes. These characters are known as **hereditary characters**. The transmission of hereditary characters from parental generation to offspring is called as **heredity**. The term heredity was coined by **Spencer** (1863). During sexual reproduction variations occur among individuals of the same species due to crossing over during meiosis.

3.1 Mendelism

Gregor Johann Mendel (1822-1884) is called father of genetics because Mendel proposed the laws of inheritance in plants for the first time. Mendel was born on 22th July, 1822 in **Silision** village of **Heinzendarf** state of Austria. In 1842, after receiving a degree in philosophy he became a priest in the church of Brunn town of Austria in 1843. Mendel performed hybridization experiments on garden pea *(Pisum sativum)* for seven years (1856-1863). In 1865, the findings of these experiments were presented in the form of a research paper to the Brunn Society of Natural History. In 1866, these experiments were published in the society's annual proceedings entitled-**"Experiments on plant hybridization**." On the basis of results of these experiments on garden pea, Mendel proposed the laws of inheritance which are also known as **Mendelism**. Mendel died on January 6, 1884.

Gregor Johann Mendel

3.1.1 Reasons for Mendel's success

(i) Mendel studied the inheritance of one character at a time.

(ii) Mendel maintained the statistical record of the experiments and analysed them carefully.

(iii) Mendel selected the plant material for his experiments carefully.

3.1.2 Selection of pea plant

Mendel selected garden pea plant for his experiments because–

(i) Pea plant is annual, therefore, it was possible to study many generations in a short duration.

(ii) It was easy to get pure line or homozygous plants by self pollination because of bisexual flowers.

(iii) Artificial cross pollination can be easily done by emasculation technique.

(iv) Various contrasting characters are present in pea plant.

Mendel selected seven contrasting characters for his experiments which are as follows–

S.N.	Characters of plant	Dominant	Recessive
1.	Shape of seed	Rounded	Wrinkled
2.	Colour of seed	Yellow	Green
3.	Colour of flower	Violet	White
4.	Shape of mature pod	Inflated	Constricted
5.	Colour of immature pod	Green	Yellow
6.	Position of flower	Axial	Terminal
7.	Height of plant	Tall	Dwarf

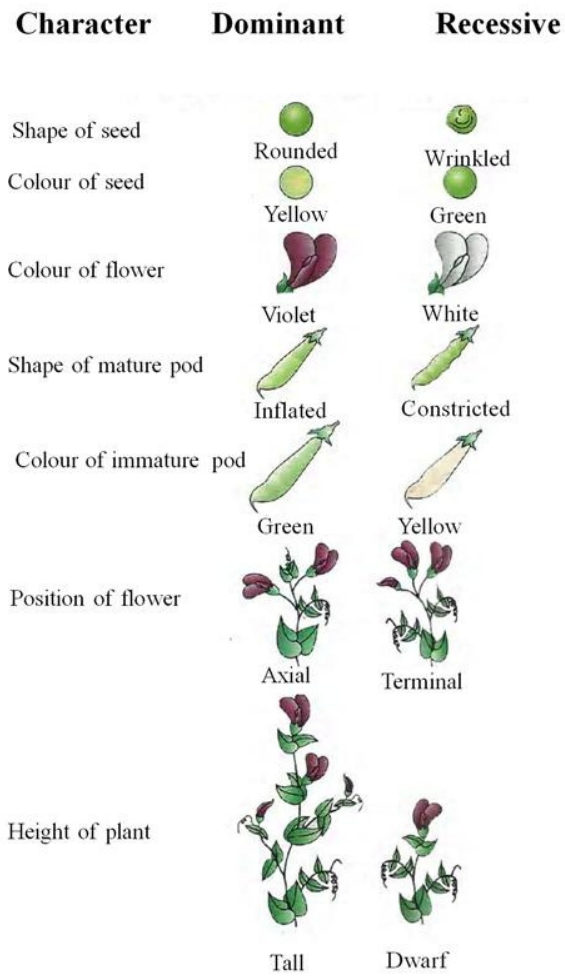


Fig 3.1 Seven pairs of contrasting traits studied by Mendel

3.2 Rediscovery of Mendelism

The laws of inheritance given by Mendel were neglected for about 35 years. The Hugo De Vries of Holand, Carl Correns of Germany and Erich von Tschermak of Austria rediscovered Mendel's laws in 1900 while working separately.

3.3 Genetics terminology

It is very important to understand the following technical terms to understand the laws of inheritance–

1. **Gene -** The factor that controls a character is called gene. Johannsen gave the name gene for factor used by Mendel.

2. **Allelomorph or allele-** Alternative form of a gene which controls any one character is called allelomorph or allele. eg- Height of the plant is controlled by a gene which has two alleles T (Tallness) and t (Dwarfism).

3. **Homozygous -** When both alleles of a gene are similar, the condition is known as homozygous eg- TT or tt.

4. **Heterozygous -** When both alleles of a gene are dissimilar, the condition is known as heterozygous eg-Tt.

5. **Phenotype -** External appearance of an individual is called phenotype. eg - Tall plant which genotypically may be homozygous (TT) or heterozygous (Tt).

6. **Genotype -** Genetic constitution of an individual is called genotype. eg-pure or homozygous tall (TT) and impure or heterozygous tall (Tt).

7. **Dominant characters-** The character which express itself in F_1 generation is called dominant character.

8. **Recessive characters-** The character which does not express itself in F_1 generation is called recessive character.

9. **Monohybrid cross -** Such type of cross in which single contrasting character (Trait) is considered is called monohybrid cross.

10. **Dihybrid cross -** Such type of cross in which two contrasting characters (Traits) are considered is called dihybrid cross.

11. **Trihybrid cross-** Such type of cross in which three contrasting characters (Traits) are considered is called trihybrid cross.

12. Polyhybrid cross - Such type of cross in which many contrasting characters (Traits) are considered is called Polyhybrid cross.

13. Test cross - Such type of cross in which F_1 - generation is crossed with recessive parent, called as test cross.

14. Back cross - Such type of cross in which F_1 generation is crossed with any one of two parents, called as back cross.

15. Reciprocal cross - Such type of cross in which 'A' plant (TT) is considered as male and ' B ' plant (t t) is considered as female and in another cross if 'A' plant (TT) is considered as female and 'B' plant (tt) is considered as male, called as reciprocal cross.

16. Parental generation - The plants which are crossed to obtain the offspring called as parental generation

17. Frist filial generation (F_1 generation) The affspring obtained from parents is called F_1 generation.

18. Second filial generation(F_2 generation) - The offspring obtained from F_1 generation is called F_2 generation.

19. Monohybrid ratio - The ratio obtained from monohybrid cross is called monohybrid ratio.

20. Dihybrid ratio - The ratio obtained from dihybrid cross is called dihybrid ratio.

3.4 Mendel's laws of inheritance

Mendel proposed some important laws through hybridization experiments on garden pea (*Pisum sativum*), Which are called **Mendel's laws of inheritance**. These laws are as follows-

1. Law of dominance
2. Law of segregation or Law of purity of gametes
3. Law of independent assortment

3.4.1 Law of dominance

This law is based on the results of Mendel's Monohybrid cross. According to this law, when a cross takes place in between homozygous contrasting plants, the character which express itself in F_1 generation is called **dominant** and the character which does not express itself in F_1 generation is called **recessive**.

Example – When a pure or homozygous tall (TT) plant is crossed with pure or homozygous dwarf (tt) plant then in F_1 generation all plants (100%) were tall (Tt).

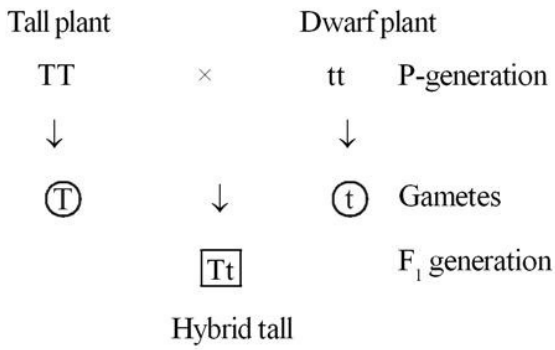


Fig. 3.2 Law of dominance

3.4.2 Law of segregation or Law of purity of gametes

This law is also based on results of Mendel's monohybrid cross. According to this law– During gamete formation from hybrid or heterzygous of F_1 generation, both alleles separte or segregate to each other, therefore, it is called as **law of segregation** and each gamete carries one allele for each character, therefore, it is also called as **law of purity of gametes**.
Example- If homozygous tall (TT) plant is crossed with homozygous dwarf (t t) plant then in F_1 generation all plants were hybrid or heterozygous tall (T t). In heterozygous condition, both alleles are not contaminated with one another, at the time of gamete formation both alleles segregate from each other and

enters in different gametes. Due to this segregation dwarfism (t t) character reappear again in F_2 generation phenotypic ratio obtained from F_2 generation is 3 : 1 and the genotypic ratio is 1 : 2 : 1.

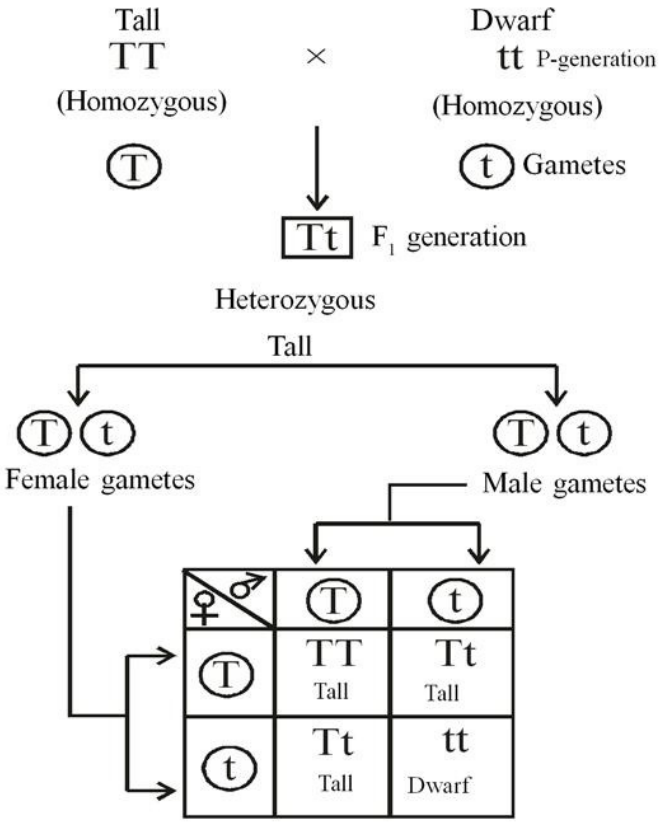


Fig. 3.3 Law of segregation

Phenotypic ratio – 3 Tall : 1 Dwarf

Genotypic ratio –

1 Homozygous Tall : 2 Heterozygous Tall : 1 Homozygous dwarf

1 (T T) : 2 (T t) : 1 (t t)

3.4.2.1 Back cross

If F_1 generation (T t) is crossed with any one parent T T or t t , then it is called as Back cross.

It is of two types -

1. **Out cross -** If F_1 generation (T t) is crossed with dominant parent (TT), called as **out cross**. The offspring obtained from this cross were all tall plants, out of these 50% were homozygons tall (TT) and 50% were heterozygons tall (Tt) plants.

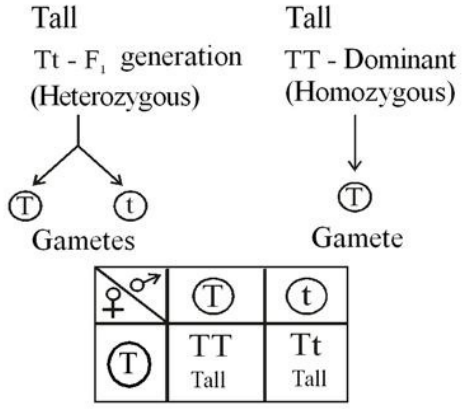


Fig. 3.4 Out cross

Phenotypic ratio – 100% Tall plants

Genotypic ratio – 1 : 1

50%TT : 50 % Tt

(Homozygous) (Heterozygous)

2. **Test Cross -** If F_1 generation (Tt) is crossed with recessive parent (tt), then it is called as **test cross**. The phenotypic and genotypic ratio of offspring obtained from this cross was same i.e. 1:1. 50% heterozygous tall (Tt) and 50% homozygous dwarf (tt) plants are obtained.

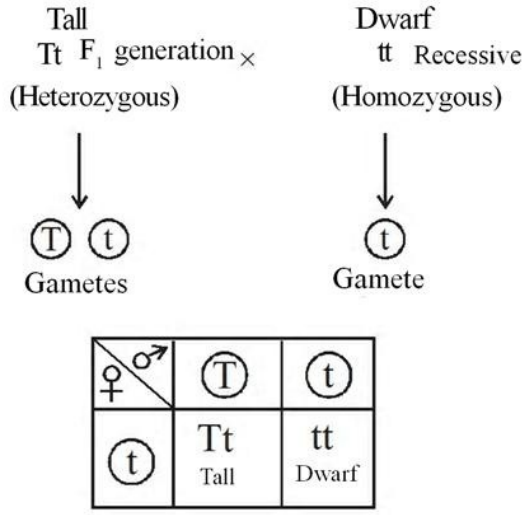


Fig 3.5 Test cross

Phenotypic ratio – 50% Tall : 50% Dwarf

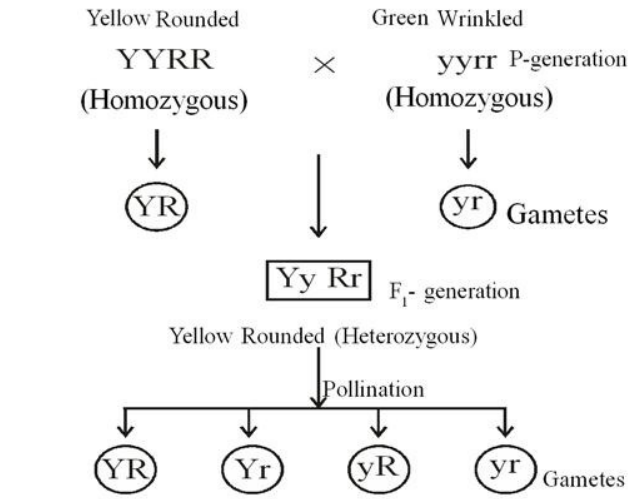
Genotypic ratio –

50% Heterozygous tall (Tt) : 50% Homogzygous dwarf (tt)

3.4.3 Law of independent assortment

This law is based on results of Mendel's dihybrid cross. According to this law-If two or more than two contrasting characters are considered then there is not any effect of inheritance of one character on the inheritance of another character or alleles of each character are not only separate but alleles of different characters behave independently or they assort independently, therefore, it is called as **Law of independent assortment**.

Example–If homozygous yellow round seeded (YYRR) plant is crossed with green wrinkled (yyrr) seeded plant then in F_1 generation all plants were yellow round seeded (YyRr).



♀ / ♂	YR	Yr	yR	yr
YR	YYRR Yellow Rounded	YYRr Yellow Rounded	YyRR Yellow Rounded	YyRr Yellow Rounded
Yr	YYRr Yellow Rounded	YYrr Yellow Wrinkled	YyRr Yellow Rounded	Yyrr Yellow Wrinkled
yR	YyRR Yellow Rounded	YyRr Yellow Rounded	yyRR Green Rounded	yyRr Green Rounded
yr	YyRr Yellow Rounded	Yyrr Yellow Wrinkled	yyRr Green Rounded	yyrr Green Wrinkled

Fig : 3.6 Law of independent assortment

Phonotypic and genotypic ratio of F_2 -generation obtained by self pollination in F_1 generation is 9 : 3 : 3 : 1 and 1 : 2 : 2 : 4 : 1 : 2 : 1 : 2 : 1 respectively.

Phenotypic ratio :

9 : Yellow rounded

3 : Green rounded

3 : Yellow wrinkled

1 : Green wrinkled

Genotypic ratio

1	:	2	:	2	:	4	:	1	:
YYRR		YyRR		YYRr		YyRr		yyRR	

2	:	1	:	2	:	1
yyRr		YYrr		Yyrr		yyrr

3.5 Importance of Mendel's laws of inheritance

1. It is important to find dominant character in living organisms because many harmful and lethal recessive genes are not able to express themselves in the presence of dominant gene.

2. Gene concept was proved by mendel's law of segregation.

3. According to law of segregation one gene has two alleles and they control two contrasting characters.

4. With the help of Mendel's laws, we know about the new characters develop in hybrid off spring.

5. Useful characters can be brought into same species and harmful characters can be removed by the method of hybridisation.

6. With the help of Mendel's laws disease resistant and high yielding varieties of crop plants can be developed.

7. A branch of science **Eugenics** related with the improvement of human race is based on Mendel's laws.

Important Points

1. The term genetics was coined by Bateson.
2. Transmission of herditary characters from parents to offspring is called heredity.
3. The study of heredity and variation is called genetics.
4. Gregor Johann Mendel is called father of genetics.
5. Mendel performed hybridization experiments on garden pea (*Pisum sativum*), on the basis of results of these experiments, Mendel formulated the laws of inheritance, called as Mendelism.
6. Hugo de Vries, Carl Correns and Erich Von Tschermak rediscovered the Mendel's laws of segregation.
7. Mendel studied the inheritance of one character at a time.
8. When two alleles of a gene are similiar, they are called as homozygous and if they are dissimilar, then they are called as heterozygous.
9. Offspring obtained from parents is F_1 generation and obtained from F_2 generation is called generation.
10. A character which expresses itself in generation is called dominant and which does not express itself in generation is called recessive.
11. When generation is crossed with recessive then it is called as test cross.
12. When generation is crossed with any one of both the parents called as back cross.
13. According to Mendel's law of segregation or law of purity of gametes, at the time of gamete formation alleles segregate and each gamete carries one alleles for each character.
14. According to Mendel's law of independent assortment, two or more than two gene pairs behave independently of each other while living together.
15. According to Mendel, phenotypic ratio and genotypic ratio obtained from monohybrid cross is 3 : 1 and 1 : 2 : 1 respectively.
16. Phenotypic ratio obtained from generation of dihybrid cross is 9 : 3 : 3 : 1 and genotypic ratio is 1 : 2 : 2 : 4 : 1 : 2 : 1 : 2 : 1
17. Good characters of different genera can be brought in a single genus by **hybridization**.
18. With the help of mendel's laws disease resistant and high yielding varieties of crops can be developed.
19. Mendel's laws confirm the concept of gene.
20. A branch of science Eugenics related with the improvement of human race is based on Mendel's laws.

Practice questions

Objective type questions

1. Who coined the term genetics–
   (a) Mendel (b) Bateson
   (c) Morgan (d) Punnet
2. Experiments of Mendel were on–
   (a) Sweet pea (b) Wild pea
   (c) Garden pea (d) All of the above
3. Study of heredity and variation is called–
   (a) Genetics (b) Geology
   (c) Forestry (d)None of the above
4. Green colour of pea pod is which type of character–
   (a) Dominant (b) Recessive

(c) Incomplete dominance

(d) Codominance

5. Usually number of alleles of a gene are–

(a) Four (b) Three

(c) Two (d) One

6. Mendel selected how many pairs of contrasting characters for his experiments–

(a) 34 (b) 2

(b) 12 (d) 7

7. When F_1 generation is crossed with any one parent, then it is called as –

(a) Reciprocal cross (b) Test cross

(c) Back cross (d) All of the above

8. Ratio of offspring from $Tt \times tt$ cross is –

(a) 3 : 1 (b) 1 : 1

(c) 1 : 2 : 1 (d) 2 : 1

9. Which contrasting character was not selected by mondel for his experiments–

(a) Colour of root (b) Colour of flower

(c) Colour of seed (d) Colour of pod

10. How many types of genotypes formed in F_2 generation of monohybrid cross–

(a) 2 (b) 3

(c) 4 (d) 9

Very short type questions

11. Who is called father of genetics ?

12. Which plant was selected by Mendel for his experiments?

13. What is dominant character?

14. What is knows as the transmission of genetic characters from one generation to another generation?

15. Who rediscovered Mendel's laws?

16. What is the full name of Mendel?

17. Write the name of laws proposed by Mendel.

18. What is test cross?

19. What do you understand by out cross.

20. Which law of Mendel can not be explained by monohybrid cross?

Short type questions

21. Write the difference between phenotype and genotype.

22. Explain the dihybrid cross.

23. Write the reasons of successfulness of Mendel.

24. Why did Mendel select pea plant for his experiments?

25. Write a brief life introduction of the Mendel.

26. Explain the Mendel's law of dominance.

27. Write the importance of Mendel's laws of inheritance

Essay type questions

28. Explain the Mendel's law of segregation with example.

29. What is Mendelism? Explain law of independent assortment in detail.

30. Explain the Mendel's laws of inheritance.

Answer key

1. (b) 2. (c) 3. (a) 4. (a) 5. (c)
6. (d) 7. (c) 8. (b) 9. (a) 10. (b)