Genetics: A study of heredity

The following terms are commonly used in genetics

Allelomorphs or alleles

Alleles, the abbreviated form of the term 'allelomorphs' (meaning one form or the other) indicates alternative forms of the same gene.

homozygous and heterozygous

An individual having only one allele or in other words two identical alleles, is known as homozygous.Similarly, an individual, having two different alleles will be called heterozygous or hybrid.

Monohybrid cross

A cross between two parents differing in one contrasting character isknown as monohybrid crosses. Single character is controlled by a single pair of genes or alleles

Dihybridcross

A cross between two parents differing in two contrasting characters isknown as dihybrid crosses.

Back Cross

It is a cross of F, hybrid with any one of its parents. The back cross is of two types; they are the dominant back cross and the recessive back cross.

When the F, hybrid is crossed with the dominant parent, the cross is called **dominant back cross**. All the resulting offspring will possess the dominant character; ie. 100% of dominant character.

If the F, hybrid is crossed with the recessive parent, the cross is called **recessive back cross**. In this cross, two types of offspring are obtained on equal numbers; ie., 50% dominant and 50% recessive, ie, in the ratio 1:1.

Test Cross

It is a back cross where F, plant is crossed with the recessive parent. This cross is used to test the heterozygosity of the F plant. Hence it is called test cross.

Mendelism

The contribution of Mendel to Genetics is called Mendelism. **Gregor Johann Mendel** is the Father of Genetics. He was born in a peasant family in 1822 in Austria. He worked as a teacher. He passed his later life as an abbot. He died in 1884.

Mendel was fond of gardening and fruit-culture from his boyhood. When he was working as teacher, he performed a series of experiments with pea plants in the garden. His work contains inheritance of characters in 22 varieties of garden peas. His papers were published in 1866 and 1867 in the proceedings of Natural History Society of Brunn.

The work of Mendel remained unnoticed to the world for 33 years. In 1900, the principles of Genetics worked by Mendel were rediscovered by three botanists, namely Correns, De Vries and Tshermark. The unrecognized papers of Mendel were taken out from the grave and made known to the scientific world. When Mendel's work was recognized and appreciated, he was no more.

Reasons for Mendel's Success

Mendel did his work by collecting several types of garden pea Pisum sativum from salesmen and studied the differences among them. Then he did hybridization experiments with different types of plants. The secret of Mendel's success lay in his wise selection. The following are the reasons for the success of Mendel:

1. The flowers of pea plants are normally self-fertilized.
2. The pea plant shows a number of clear-cut contrasting characters.

3. The hybrids of garden pea are perfectly fertile. 4.Cross pollination is not very difficult in pea plants. 5. Artificial fertilization is almost always successful.

6. The genes for the seven pairs of characters are located on seven separate homologous pairs of chromosomes.

7. Many pure breeding varieties are available for the experiments.

8. It is very easy to cultivate the pea plants in open ground. 9. They have a short growth period and a short life cycle.

10. He studied the inheritance of only one character at a time. This made the complex problem simple.

11. He maintained statistical records of the results. It helped Mendel to derive numerical ratios of significance.

Characters Selected by Mendel

The pea plant contains a number of contrasting characters. Out of these contrasting characters Mendel selected only seven characters. Each of these seven characters has two varieties or alternatives. The seven characters and their contrasting alternatives are shown on the table given below.

No.	Characters	Alternatives	
		Dominant	Recessive
1	The length of the stem	Tall	Dwarf
2	The position of the flower	Axial	Terminal
3	The colour of the pod	Green	Yellow
4	The shape of the pod	Inflated	Constricted
5	The shape of seed	Round	Wrinkled
6	The colour of the seed coat	Coloured	White
7	The colour of the cotyledon	Yellow	Green

Law of Segregation

Monohybrid Experiment

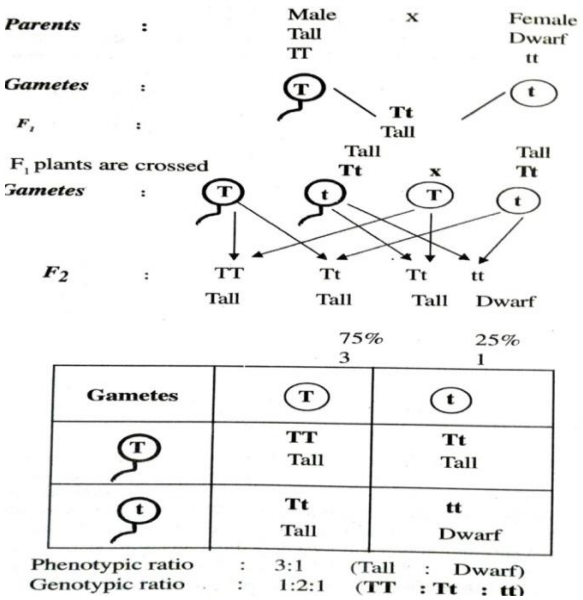
The law of segregation is a law of inheritance proposed by Mendel in 1866. According to this law, "each organism is formed of a bundle of characters whereeach character is controlled by a pair of factors (genes). During gamete formation, the two factors of a character separate and enter different gametes". This law is also called law of purity of gametes.

Monohybrid cross

The crossing of two plants differing in one character is called monohybrid experiment. Mendel carried out monohybrid experiments on pea plants and based on the results of monohybrid experiment, he formulated the law of segregation.

Mendel selected two pea plants, one with a tall stem and the other with a dwarf or short stem. These plants were considered as parental plants (P) and were pure breeding. A pure plant is one that breeds true in respect of a particular character for a number of generations. The pure-bred tall and dwarf Parental generation (P)plants were treated as parents and were crossed. Seeds were collected from these plants. These seeds were sown and a group of plants were raised.

These plants constituted the first filial generation or F generation. All the F1 plants were tall. The F1 plants were inbred. The seeds were collected and the next generation (F) was raised. In the F1 generation, two types of plants were found. They were tall and dwarf. Mendel counted the number of tall and dwarf plants. Of the 1064 plants of F1 generation, 787 plants were tall and 277 plants were
The pure tall parent has two dominant genes for height and are represented as **TT**. The pure dwarf parent has tworecessive genes and are represented as **tt**.



During gametes formation the two genes separate and enter different gametes. Hence each gamete will contain only one gene. The gametes produced by the tall parent contain **T** and the gametes produced by the dwarf parent contain **t**.

When these two plants are crossed the gamete carrying **T** gene fuses with the gamete carrying**t** gene. The resulting F plant thus contains **Tt**. In this plant, the dominant gene T masks the expression of the recessive gene**t**. Hence all the F plants are tall.

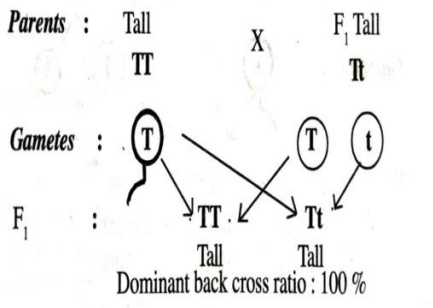
The F1 plants **Tt** produce two types of gametes; some gametes receive the dominant gene **T** and others receive the recessive gene **t**. These gametes are produced in equal numbers, ie., 50% of gametes contain **T** and the other 50% of gametes contain **t**.

The F1 male and female gametes unite at random and there are four possible combinations. These combinations are clearly understood when the gametes are placed in a Checker Board or Punnet square. The four possible combinations are **TT, Tt, Tt and tt**. The first three combinations **(TT, Tt, Tt)** contain dominant genes and hence they are tall plants. The fourth combination **(tt)** contains no dominant gene and hence the plant is dwarf. So, in the F1 generation three-fourth of the plants are tall. The external visible appearance of a plant or animal is called phenotype. It does not include the unexpressed characters caused by recessive genes. In Mendel's experiment, the F1 generation has phenotypically two types of plants. They are tall and dwarf. The tall and the dwarf occur in the ratio **3:1**. This ratio is called phenotypic ratio.

Back Cross

Back cross is a cross of F1 hybrid with any one of its parents. The back cross is of two types; they are the dominant back cross and the recessive back cross.

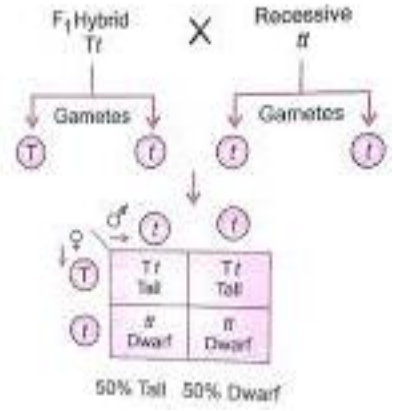
When the F, hybrid is crossed with the dominant parent, the cross is called dominant back cross. All the resulting offspring will possess the dominant character; ie. 100% of dominant character.



If the F, hybrid is crossed with the recessive parent, the cross is called recessive back cross (Fig.2.9). In this cross, two types of offspring are obtained on equal numbers; ie., 50% dominant and 50% recessive, ie, in the ratio 1:1. The recessive back cross helps to identify the heterozygosity of the hybrid. Hence this cross is also called test cross. In test cross, the resulting individuals will always be in the ratio 1:1.

The F tall plant of Mendel's monohybrid experiment includes both the homozygous and heterozygous plants. To find out the genotype of these plants, they are test crossed with the

recessive parents. If the resulting individuals appear in the ratio 1:1 then the experimental plant will be heterozygous in nature. If all the resulting individuals are of only one type (dominant), then the experimental plant will be homozygous.



Law of Independent Assortment

Dihybrid Experiment

The law of independent assortment is a law of inheritance proposed by Mendel in 1866. This law states that the genes for each character separate and enter the gametes independently of the genes of other characters. This law is the outcome of Mendel's dihybrid experiment.

Dihybrid cross

The crossing of two plants differing in two character is called dihybrid experiment. In dihybrid experiment, two characters (colour and shape) are considered at a time. For this experiment pea plant was selected. Mendel considered the cotyledon-colour (yellow and green) and seed-shape (round and wrinkled) as the two characters.

Mendel selected a pure breeding yellow, round seed producing plant and another pure breeding green, wrinkled seed producing plant. These two plants were treated as parents and were crossed.

The F1 generation plants produced only yellow round seeds. The F1 plants were self-fertilized.

In the F1 generation, four kinds of plants were produced. They were

a. plants producing yellow round seeds
b. plants producing yellow wrinkled seeds
c. plants producing green, round seeds and
d. plants producing green, wrinkled seeds.

They occurred in the ratio 9:3:3:1 respectively.

In cotyledon colour, yellow **(Y)** is dominant over green **(y)**; in seed shape round **(R)** is dominant over wrinkled **(r).** Hence the pure breeding yellow, round parent is represented by

the genotype **YYRR** and the pure breeding green wrinkled parent is represented by the genotype **yyrr.**

During gamete formation the paired genes of a character assort out independently of the other pair. Thus, the dominant parent produces only one type of gamete and each gamete is carrying one gene for seed colour (Y) and another gene for seed shape **(R).** Hence the gene content of the gametes produced by the dominant parent **(YYRR)** is **(YR).**

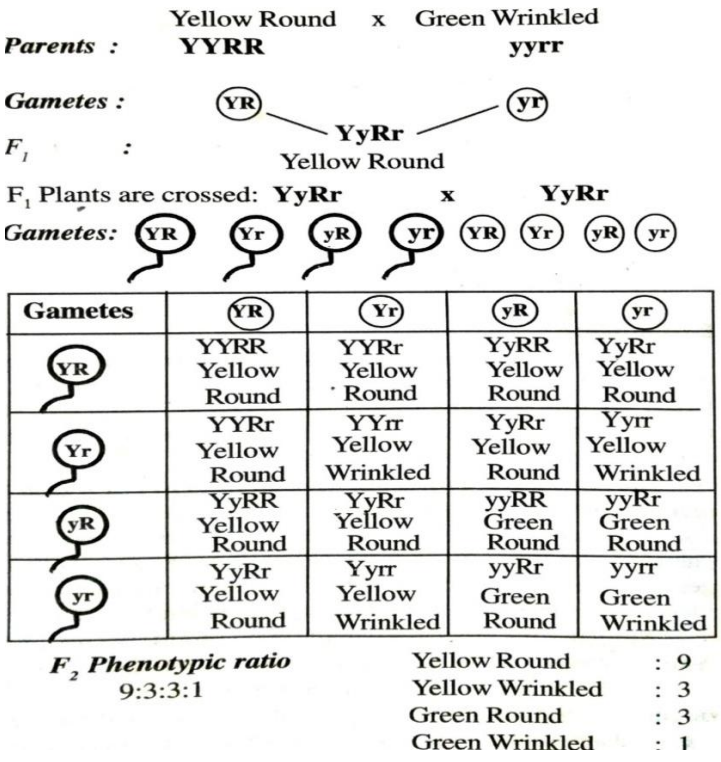
Similarly, the recessive parent **(yyrr)** produces only one type of gamete and the gene content of each gamete is **(yr).**

The F1 plants are formed by the union of these two types of gametes and hence the genotype of F1 plants is **YyRr**. As the F, plants contain dominant **Y** and dominant **R** the phenotype of F1 plant is yellow and round.

The F1 hybrid plants are self-fertilized or crossed among themselves. During gamete formation the two factors of a character assort out independently of the other pair. For example, the gene **Y** may combine with the dominant gene **R** or with the recessive gene**r** and enter a gamete.

In the same way, gene y may combine with the dominant gene R or with the recessive gene**r** and enter a gamete So F1 female dihybrid **(YyRr)** produces four types of gametes. They are **YR; Yr; yR**; and **yr**. The F1 male also produces four types of gametes.

The four types of female gametes fuse with the four types of the male gametes at random. Out of these sixteen, 9 combinations produce yellow round plants. 3 combinations produce yellow wrinkled plants. 3 combinations produce green round plants and the remaining one combination produces green wrinkled plants. Thus, in the F1 generation plants occur in the ratio **9:3:3:1.**



Gametes	YR	Yr	yR	yr
YR	YYRR Yellow Round	YYRr Yellow Round	YyRR Yellow Round	YyRr Yellow Round
Yr	YYRr Yellow Round	YYrr Yellow Wrinkled	YyRr Yellow Round	Yyrr Yellow Wrinkled
yR	YyRR Yellow Round	YyRr Yellow Round	yyRR Green Round	yyRr Green Round
yr	YyRr Yellow Round	Yyrr Yellow Wrinkled	yyRr Green Round	yyrr Green Wrinkled

F_2 Phenotypic ratio
9:3:3:1

Yellow Round : 9
Yellow Wrinkled : 3
Green Round : 3
Green Wrinkled : 1

Mendel's Laws Based on Mendel's experimental results certain principles are framed. These principles are called Mendel's laws. They are as follows:

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

1. Law of Dominance

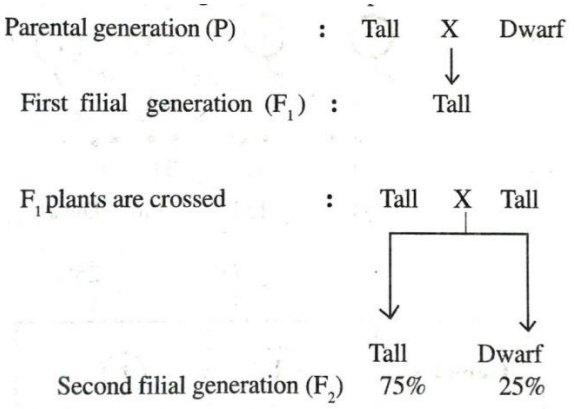
Each organism is formed of a bundle of characters and each character is controlled by a pair of factors or genes (T ort). Each factor of the paired factors (Tt) is responsible for the expression of a particular variety (tall or dwarf) of a character (height). Mendels law of dominance states that one factor in a pair may mask or prevent the expression of the other. He called the variety that appeared in the F1 generation of his monohybrid cross as dominant and those which did not appear in the F1 generation as recessive. A recessive factor freely expresses itself in the absence of its dominant allele. This law is formulated based on the monohybrid experiment.

2. Law of segregation or law of purity of gametes

The law of segregation is a law of inheritance proposed by Mendel in 1866.
According to this law, "each organism is formed of a bundle of characters. Each character is controlled by a pair of factors (genes).
During gamete formation, the two factors of a character separate and enter different gametes". This law is also called law of purity of gametes.

Each organism is formed of a bundle of characters. Each character is controlled by a pair of genes. The two genes of a particular character remain uncontaminated when they are inside the organism. During gamete formation the paired genes segregate and enter different gametes. Hence each gamete contains only one of the paired genes which are responsible for a particular character. During gamete formation the genes of a particular character separate and enter different gametes. This is the law of segregation. This law is also called law of purity of gametes. This law is also formulated based on monohybrid experiment.

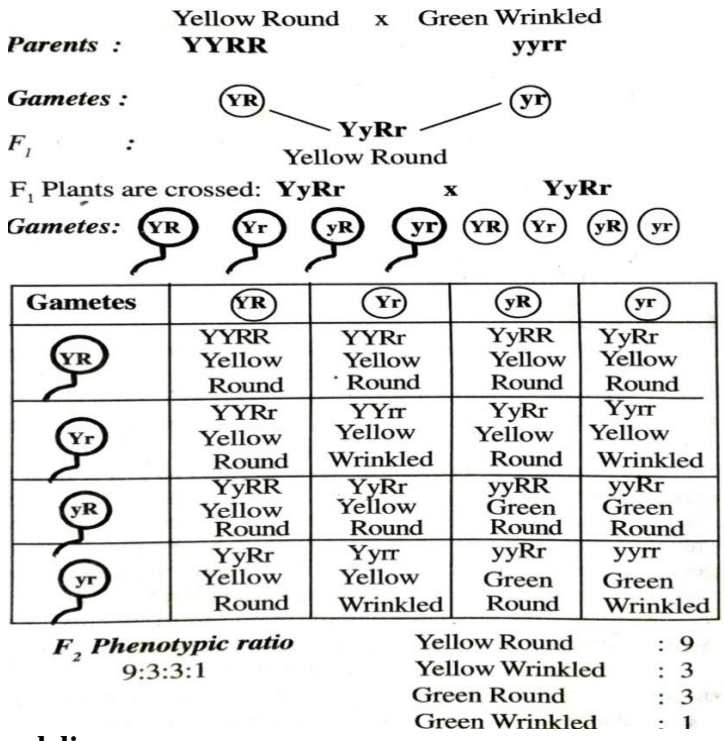
Example: During gamete formation the paired factors **(Tt)** present in the F1 plant segregate independently and enter different gametes. So, each gamete receives either Tort from the paired factors **Tt,** which are responsible for the expression of a single character.



3. Law of Independent Assortment

This law is based on dihybrid experiment. According to this law, the genes for each pair of characters separate independently from those of other characters during gamete formation.

During gamete formation of a dihybrid cross, the factors for yellow colour assort out independently of the factors for round shape. The gene Y may combine with the dominant gene R or the recessive gene r of the other character and enter a gamete. In the same way, the gene y may combine with the dominant gene R or the recessive gene r and enter a gamete. So, the F1 dihybrid plants produce four types of gametes and they are **YR, Yr, yR and yr.**



Gametes	YR	Yr	yR	yr
YR	YYRR Yellow Round	YYRr Yellow Round	YyRR Yellow Round	YyRr Yellow Round
Yr	YYRr Yellow Round	YYrr Yellow Wrinkled	YyRr Yellow Round	Yyrr Yellow Wrinkled
yR	YyRR Yellow Round	YyRr Yellow Round	yyRR Green Round	yyRr Green Round
yr	YyRr Yellow Round	Yyrr Yellow Wrinkled	yyRr Green Round	yyrr Green Wrinkled

F_2 Phenotypic ratio
9:3:3:1

Yellow Round : 9
Yellow Wrinkled : 3
Green Round : 3
Green Wrinkled : 1

Deviation to Mendelism

Genic interaction or interaction of genes.

The expression of a single character by the interaction of more than one pair of genes is called genic interaction or interaction of genes.

Bateson and Punnet proposed factor hypothesis to explain genic interaction. According to this hypothesis, some characters are produced by the interaction of two or more pairs of factors (genes).

The genic interaction is of two types, namely

1. Non-allelic gene interaction.

2. Allelic gene interaction.

The genic interaction occurring between genes located in different locus of the same chromosome or different chromosomes is known as non-allelic gene interactions.

The genic interaction between the two alleles of a single locus is knownas allelic gene interaction.

Some of the important forms of genic interactions are as follows:

Non-allelic gene interaction: 1. Complementary factors
2. Supplementary factors
3. Epistasis

Allelic gene interaction: 1. Complete dominance
2. Incomplete dominance
3. Co-dominance

Non-allelic gene interaction: 1. Complementary Gene interaction (9:7)

Complementary genes may be defined as, "two or more non-allelic dominant genes interact with one another to produce a character; but one gene cannot produce that character in the absence of the other". The action of these independent genes are complementary. It is a non-allelic gene interaction. Flower Colour in Sweet Pea

Bateson and Punnet studied the inheritance of flower colour in sweet pea, Lathyrus odoratus. There are two varieties of pea plants, one producing red flower and the other white flower.

The red colour of the flower is due to the presence of a pigment called anthocyanin. The anthocyanin is produced from a colourless substance called chromogen by the action of an enzyme or activator. The chromogen cannot be converted into anthocyanin in the absence of the enzyme. Thus, for the production of red colour both chromogen and enzyme should be present in the plant. In the absence of anyone the red colour cannot be produced.

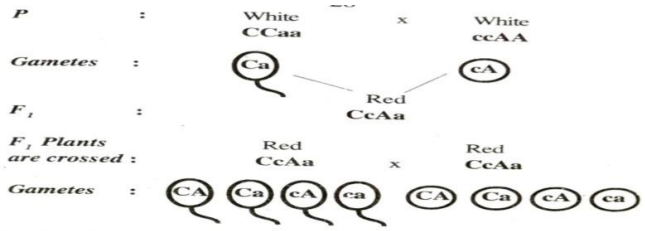
A dominant gene **C** is responsible for the production of chromogen. When this gene is recessive c the chromogen cannot be produced.

Similarly, another dominant gene A is responsible for the production of the enzyme which converts the chromogen into anthocyanin. When this gene is recessive the enzyme cannot be produced and thus chromogen cannot be converted into anthocyanin.

Gene C → Chromogen
Gene A → Enzyme
Chromogen + Enzyme → Anthocyanin (Red)

Red flower is produced by the interaction of both dominant genes **C** and **A. C** or **A** cannot give red colour independently.
A homozygous white flowered sweet pea plant **(CCaa)** is crossed with another white flowered sweet pea plant **(ccAA)**. The F, plants have red coloured flowers.
When the F1 red hybrid plants **(CcAa)** are crossed, in F1 red and white are produced in the ratio **9:7.**

Both the non-allelic genes **C** and **A** are complementary in nature. In the absence of either one or both of the complementary genes, white flowers are produced.



Gametes	CA	Ca	cA	ca
CA	CCAA Red	CCAa Red	CcAA Red	CcAa Red
Ca	CCAa Red	CCaa White	CcAa Red	Ccaa White
cA	CcAA Red	CcAa Red	ccAA White	ccAa White
ca	CcAa Red	Ccaa White	ccAa White	ccaa White

Fig.3.1: Inheritance of flower colour in sweet pea ratio 9:7.

Non-allelic gene interaction: 2. Supplementary Gene interaction

Supplementary genes may be defined as <u>two independent pairs of dominant genes, which interact in such a way that each dominant gene produces its effect whether the other is present or not, but when the second dominant gene is added to the first, a new character is expressed. It is a non-allelic genic interaction.</u>

Example: 1. **Inheritance of Combs in Fowls (9:3:3:1)**

The interaction of two dominant genes, to control the same character was discovered by Bateson and Punnet (1908) in fowls. In fowls, there are four varieties of combs. They are rose comb, pea comb, walnut comb and single comb.

Rose comb is controlled by a dominant gene **R** and pea is controlled by another dominant gene **P**. The recessive alleles of the above genes in the homozygous condition **(rrpp)** produce single comb. But when the two dominant genes **R** and **P** are brought together, they interact and produce a new comb called walnut.

Types of combs in fowls.

Walnut comb is due to the interaction of two non-allelic dominant genes **R** and **P** and the single comb is due to the interaction of two recessive genes **r** and **p.**
A pure rose combed **(RRpp)** chicken is crossed with that of pure pea combed **(rrPP)** chicken. The F1 progeny contains walnut.

Parents : Rose comb male **RRpp** x Pea comb female **rrPP**

Gametes : **Rp** **rP**

Walnut
F_1 Generation: **RrPp**

F_1 Fowls are crossed : Walnut male **RrPp** x Walnut female **RrPp**

Gametes: **RP** **Rp** **rP** **rp** **RP** **Rp** **rP** **rp**

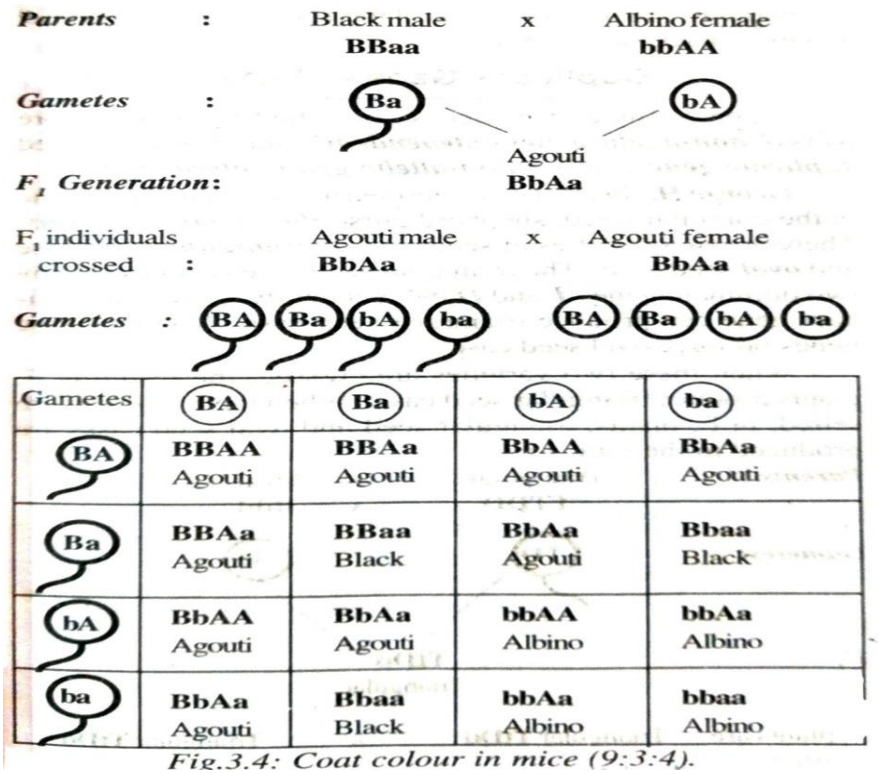
Gametes	RP	Rp	rP	rp
RP	**RRPP** Walnut	**RRPp** Walnut	**RrPP** Walnut	**RrPp** Walnut
Rp	**RRPp** Walnut	**RRpp** Rose	**RrPp** Walnut	**Rrpp** Rose
rP	**RrPP** Walnut	**RrPp** Walnut	**rrPP** Pea	**rrPp** Pea
rp	**RrPp** Walnut	**Rrpp** Rose	**rrPp** Pea	**rrpp** Single

F_2 generation: *Walnut : 9, Rose : 3, Pea : 3, Single : 1*

Then the F1 walnut individuals are selfed. In the F1 all the four types of combs appear in the following ratio. Walnut, rose, pea and single 9:3:3:1.

2. Coat Colour in Mice (9:3:4)

Inheritance of coat colour in mice was studied by Castle. There are three different varieties of mice. They are agouti (grey), black and albino (white). Agouti colour is dominant to both black and albino. Black is dominant to albino but recessive to agouti. Albino is recessive to both agouti and black.



Gametes	BA	Ba	bA	ba
BA	**BBAA** Agouti	**BBAa** Agouti	**BbAA** Agouti	**BbAa** Agouti
Ba	**BBAa** Agouti	**BBaa** Black	**BbAa** Agouti	**Bbaa** Black
bA	**BbAA** Agouti	**BbAa** Agouti	**bbAA** Albino	**bbAa** Albino
ba	**BbAa** Agouti	**Bbaa** Black	**bbAa** Albino	**bbaa** Albino

Fig.3.4: Coat colour in mice (9:3:4).

Agouti is produced by dominant genes **A** Dominant gene **B** alone produces black colour. Dominant gene **A** produces albino. The recessive condition of these genes causes albino

Castle crossed a homozygous black mice **(BBaa)** with a homozygous albino **(bbAA).** The F1 individuals are Agouti When the F1 Agouties are inbred their progeny consists of 9 agouti, 3 black and 4 albino.

Non-allelic gene interaction: 3. Epistasis

Epistasis is the prevention of the expression of one gene by another non-allelic gene. Epistasis means stopping or inhibiting

The inhibiting gene is called epistatic gene. The inhibited gene is called hypostatic gene.

Epistasis is of **two types:A)Dominant epistasis**
B)Recessive epistasis.

Dominant epistasis
The prevention of the expression of a gene by a dominant non-allelic gene is called dominant epistasis.

Epistasis is a non-allelic genic interaction. In epistasis, a single character is controlled by the interaction of two or more non-allelic genes.

Here gene located on one locus interacts with another gene located in another locus. So it is a non-allelic gene interaction.

Inheritance of colour pattern in poultry is a case of dominant epistasis. In white Leghorn, there are white birds and coloured birds. The coloured birds are due to a dominant gene C which produces coloured pigment. When this gene is recessive c the bird cannot produce colour pigment and the bird is white.

Further, the dominant gene C is inhibited by another dominant gene I located in another locus. When I is present along with the hind

In plymouth rock, the coloured bird is due to a dominant gene C and white bird is due to a recessive gene c. Here also the I gene inhibits the C.

When white leghorn and plymouth rock are crossed, the F, birds are white. When the F, birds are crossed, in the F, generation, white and colour birds appear in the ratio 13:3.

Example: Inheritance of White and colour feather in fowls.

CCII	- White	ccII	- White
CCIi	- White	ccIi	- White
CCii	- Colour	cCIi	- White
Ccii	- Colour	CCIi	- White
ccii	- White	CcIi	- White

White leghorns x Plymouth rock (white)
(Genetically coloured)

CCII **ccii**

CcIi
White

F_1 individuals are inbred
Gametes:

CcIi White x **CcIi** White

Gametes	CI	Ci	cI	ci
CI	**CCII** White	**CCIi** White	**CcII** White	**CcIi** White
Ci	**CCIi** White	**CCii** Colour	**CcIi** White	**Ccii** Colour
cI	**CcII** White	**CcIi** White	**ccII** White	**ccIi** White
ci	**CcIi** White	**Ccii** Colour	**ccIi** White	**ccii** White

F_2 generation: 13 white: 3 colour

Recessive epistasis:

The prevention of the expression of a gene by a recessive non-allelic gene is called recessive epistasis.

Example: Inheritance of coat colour in mice (9:3:4)

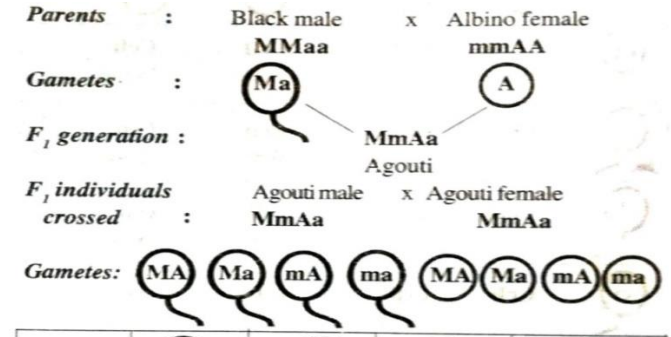
In mice, there are three colour patterns, namely agouti (grey), black and albino (white).

Agouti is produced by the interaction of two dominant genes **M** and **A.**

Black colour is produced by the dominant gene **M.**

The dominant gene **A** is inhibited by the recessive genes**mm**. So, when **A** is present along with mm, the coat colour is albino.

When a black mouse **MMaa** is crossed with an albino mouse **mmAA,** the F1 mice are agouti. When the F1 agouti are crossed, in the F1 generation, agouti, black and albino appear in the ratio **9:3:4.**



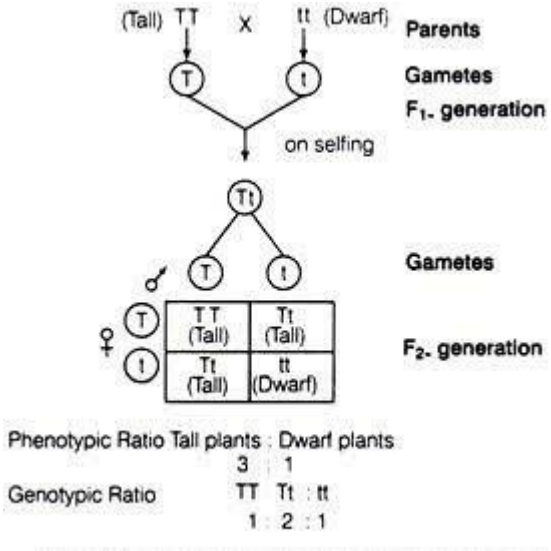
Gametes	MA	Ma	mA	ma
MA	**MMAA** Agouti	**MMAa** Agouti	**MmAA** Agouti	**MmAa** Agouti
Ma	**MMAa** Agouti	**MMaa** Black	**MmAa** Agouti	**Mmaa** Black
mA	**MmAA** Agouti	**MmAa** Agouti	**mmAA** Albino	**mmAa** Albino
ma	**MmAa** Agouti	**Mmaa** Black	**mmAa** Albino	**mmaa** Albino

F_2 Generation : Agouti 9: Black 3: Albino 4.

Allelic gene interaction: 1. Complete Dominance

The two genes controlling a character are called alleles. Of the two alleles, one allele expresses its character in the F1 generation. It is the dominant allele. When the dominant allele completely masks the expression of recessive allele, the dominance is called complete dominance.

Example: Inheritance of tallness in pea plants.

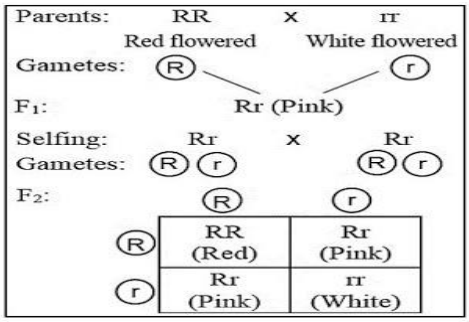


The pure tall parent has two dominant genes for height and are represented as **TT**. The pure dwarf parent has tworecessive genes and are represented as **tt**.
During gametes formation the two genes separate and enter different gametes. Hence each gamete will contain only one gene. The gametes produced by the tall parent contain **T** and the gametes produced by the dwarf parent contain **t**.

When these two plants are crossed the gamete carrying **T** gene fuses with the gamete carrying**t** gene. The resulting F plant thus contains **Tt**. In this plant, the dominant gene T masks the expression of the recessive gene**t**. Hence all the F plants are tall.

Allelic gene interaction: 2. Incomplete dominance

In incomplete dominance, <u>both alleles of a character express their character in the F1 generation. So, the F, individual has a mixture of characters of both the parents.</u>
Eg. Mirabilis jalapa (Four O'clock plants).

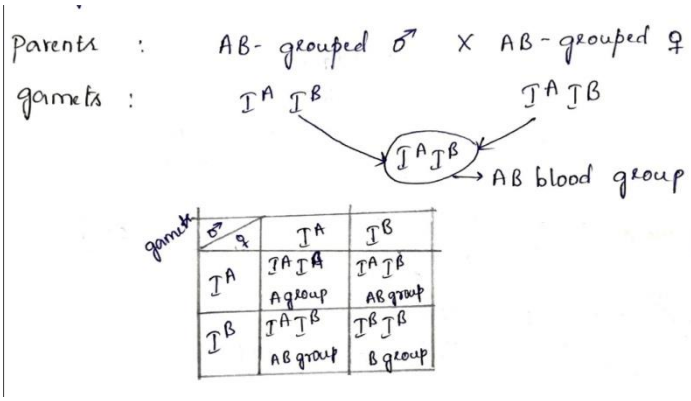


a homozygous red flowered **(RR)** 4 O'clock plant is crossed with a homozygous white flowered plant **(rr)** a pink coloured variety is produced **(Rr).** This is due to the incomplete dominance of the gene R over its allele r. The expression of the two genes (R and r) in the same individual leads to the production of an individual with mixed characters,

Allelic gene interaction: 3. Codominance

<u>In codominance, both alleles of a character are equally dominant and both of them express their character in the F1 generation. None is masked.</u>Codominance is an allelic interaction.

The AB blood group is due to co-dominance. AB group is controlled by the genes I^A and I^B. The I^A and I^B are equally dominant. I^Aproduces antigen A and I^Bproduces antigen B.



Sex Linked Inheritance

The transmission of body characters from parents to offspring along with sex is called sex linked inheritance. It is also called sex linkage.

The genes controlling body characters located on the sex chromosomes are called sex linked genes.

The body characters (other than sex characters) controlled by genes located on the sex chromosomes are called sexlinked characters.

Sex linked inheritance was discovered by T.H. Morgan in 1910.

The following are the common examples for sex-linked inheritance:

1. Colour blindness
2. Haemophilia
3. Eye colour in Drosophila

The sex-linked genes are located on **X** chromosome or **Y** chromosome or both **X** and **Y** chromosome.

The genes, controlling body characters, located on **X** chromosome are called **X**-linked genes. The inheritance of **X**-linked genes is called **X**-linked inheritance. The characters controlled by **X**-linked genes are called **X**-linked characters. Eg. Haemophilia, colour blindness, eye colour in Drosophila.

The genes controlling body characters located on **Y** chromosome are called **Y**-linked genes. The inheritance of **Y**linked genes is called **Y**-linked inheritance.

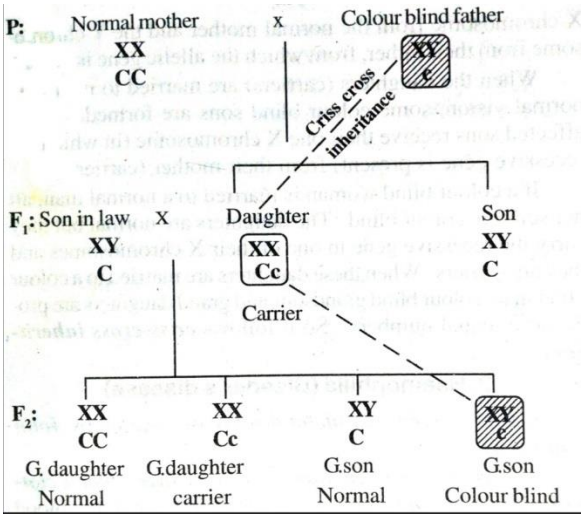
The characters Colour Blindness
1. Colour blindness is a sex-linked character discovered by Wilson in 1911.

2. It is a hereditary disease and the affected persons cannot distinguish red colour and green colour.
3. The red blindness is called protonopia. These persons cannot see red colour. The green blindness is called deuteronopia. Such persons cannot see green colour.
4. Colour blindness is a recessive character.
5. It is caused by recessive genes represented by cc. The normal persons contain the genes **CC or Cc or C** alone (in man). The recessive genes prevent the proper development of colour sensitive cells in the retina.
6. The genes for colour blindness are located on the **X** chromosomes. Their alleles are absent from **Y** chromosome.

So, man has only one gene. The presence of only one gene for a character is called hemizygous. So, man is a hemizygote for colour blindness.

7. This character is common in man Grand. Daughter,Grand. Daughter,Grand. Son are Normal carrier
8. Colour blindness follows criss-cross inheritance as this character is transmitted from the father to the grandson through the daughter. It appears only in alternate generations.
9. This character is never transmitted to the on from the father.
10. The daughter carrying one recessive gene for colour blindness is called carrier. The carriers are normal in their vision

When a normal woman possessing the dominant gene for normal vision **(CC)** happens to marry a colour-blind man **(cY),**all their daughters get one gene for colour blindness from their father. But they receive a dominant gene **C** from their mother. So, they are normal. But they carry the recessive gene in one of their **X** chromosomes. So, the daughters are called carriers because they carry the gene for colour blindness. The sons never get the disease because they receive theirchromosome from the normal mother and the **Y** chromosome) some from their father, from which the allelic gene is absent



When the daughters (carriers) are married to men with normal vision, some colour blind sons are formed. These affected sons receive their one **X** chromosome (in which the recessive gene is present) from their mother (carrier **Cc**).

If a colour-blind woman is married to a normal man, all her sons are colour blind. The daughters are normal but they carry the recessive gene in one of their **X** chromosomes and they are carriers. When these daughters are married to a colour-blind man, colour blind grandsons and grand daughters are produced in equal numbers. So it follows criss-cross inheritance.