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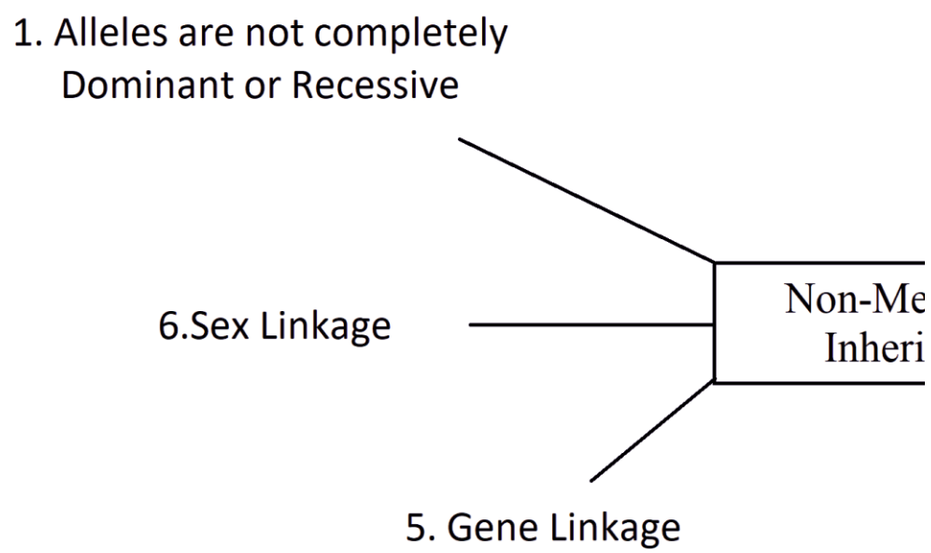


1. (i) Name three characters in human which show polygenic inheritance.
   (ii) If particular character is controlled by four pairs of alleles all of which shows dominance, how many height classes are expected in the population.
   (iii) What proportion of plants in the population are expected to be in the shortest class.

Parents Purple Flower AABB × White Flower Flower aabb

F_1 AaBb (Purple Flower)

$F_1 \times F_1$

F_2

	AB	Ab	aB	ab
AB	AABB [P]	AABb [P]	AaBB [P]	AaBb [P]
Ab	AABb [P]	AAbb [W]	AaBb [P]	Aabb [W]
aB	AaBB [P]	AaBb [P]	aaBB [W]	aaBb [W]
ab	AaBb [P]	Aabb [W]	aaBb [W]	aabb [W]

P = Purple Flower, W = White Flower

Polygenic inheritance

Inheritance of a phenotype such as quantitative characters; height, skin colour, intelligence quotient etc. which results from a cumulative expression of two or more genes is called polygenic inheritance.

Eg: Skin colour in humans is determined by many genes. For simplicity only three genes are considered. Each gene (A, B, or C) has a dark-skin allele contributing one "unit" of darkness to the phenotype and being incompletely dominant to the other allele (a, b, or c). Therefore, AABBCC person: very dark skin aabbcc person: very light skin AaBbCc person: intermediate between skin colour

Because the dominant alleles from various loci have a cumulative effect, on the skin colour.

Based on the number of genes involved in determining a polygenic character, the phenotypic and genotypic combinations in the progenies may vary. Data for a polygenic character representing a population may result in a normal distribution curve. The majority of off spring would be expected to have intermediate phenotypes (skin colour in the middle range).

2. Polyallelism

Mendelian heritance

3. Pleiotrphy

4. Epistasis

Non-Mendelian inheritance

Non-Mendelian inheritance refers to inheritance patterns in which traits do not segregate in accordance with *Mendel's* laws of inheritance. Phenotypes that do not appear in ratios predicted by Mendelian genetics are the indicators of Non-Mendelian inheritance.

Examples for non-mendelian patterns

- When alleles are not completely dominant or recessive (incomplete dominance and co-dominance),
- When a particular gene has more than two alleles (polyallelism)
- When a single gene produces multiple phenotypes (pleiotropy)
- Sometimes two or more genes are involved in determining a particular phenotype (epistasis and polygenic inheritance)
- Gene linkage
- Genes which are located in sex chromosomes exhibit a different pattern of inheritance in males and females due to the unequal distribution of genes in their sex chromosomes.

Incomplete Dominance

The phenomenon of dominant allele completely masking the recessive phenotype, resulting similar phenotypes for both homozygous dominant zygote as well as heterozygous zygote is called **complete dominance**.

On the other hand, at the heterozygous state, the phenomenon of expressing blend phenotypes from both alleles is called **incomplete dominance**. Degree of expression of each allele in the blend phenotypes may vary based on the nature of the alleles.

In *Mirabilis jalapa* (Four o'clock plant), there are several types of flower colours.

When red flowered plants are crossed with white flowered plants, all the F1 hybrids (heterozygotes) have pink flowers. This third, intermediate phenotype results from flowers of the heterozygotes having less red pigment than the red homozygotes.

When these F1 pink flowers are self-pollinated or crossed among themselves to raise F2 generation, they produce red (C^RC^R), pink (C^RC^W) and white (C^WC^W) flowers giving 1:2:1 ratio.

This phenotypic ratio is identical with genotypic ratio because heterozygotes are phenotypically intermediate between two homozygous types.

Note: Since, neither allele is dominant, instead of upper- and lowercase letters, a superscript is used to indicate the trait; Eg: C^R for red colour and C^W for white colour.

Recessive epistasis

When a homozygous recessive genotype of a particular chromosomal locus alters/masks the expression of a separate gene at a different locus, it is referred to as **recessive epistasis.**

A good example for recessive epistasis is found for flower colour in sweet pea (*Lathyrus*) plant. There are purple flowered and white flowered varieties.

A cross between homozygous dominant purple flower (AABB) and homozygous recessive white flower (aabb) strains produced 100% purple colour flowers in F1 generation. Inter breeding of F1 plants produced F2 generation with purple and white flower plants in a ratio of 9: 7. The purple colour in sweet pea flower is governed by two dominant genes, A and B. Both A and B alleles are coding for compounds that are necessary for the expression of purple colour. Hence, purple colour will be there only when both the dominant alleles (A and B) are present

Double recessive genotype at any locus (AAbb, aaBB, Aabb or aabb) results white flowers by masking the expression of purple colour. Thus, double recessive genotype at any of the above locus is epistatic to either homozygous dominant (AA and BB) or heterozygous condition (Aa and Bb) of the other. (AAbb, Aabb, aaBB, aaBb, aabb - White and AaBb, AaBB, AABb, AABB Purple).

All of the F1 generation plants were found to express purple flowers due to the presence of heterozygous condition at both loci (AaBb).

In F2 generation, plants having genotypes with both A and B alleles (9/16) express purple flowers, and plants having genotypes with 'aa' and a 'B' allele (3/16) or 'A' allele and 'bb' alleles (3/16) and 'aabb' genotype (1/16) produce white flowers, thus only two phenotypic classes are expressed; purple and white. Thus, the normal dihybrid phenotype ratio as per Mendelian principles 9 : 3 : 3 : 1 is changed to 9 : 7 ratios in F2 generation.

P: CCII × ccii

(White house fowl with double dominant alleles) × (White house fowl with double recessive alleles)

F_1 CcIi

(white)

$F_1 \times F_1$

	CI	Ci	cI	ci
CI	CCII (white)	CCIi (white)	CcII (white)	CcIi (white)
Ci	CCIi (white)	CCii (coloured)	CcIi (white)	Ccii (coloured)
cI	CCII (white)	CcIi (white)	ccII (white)	ccIi (white)
ci	CcIi (white)	Ccii (coloured)	ccIi (white)	ccii (white)

Phenotype ratio white : colour

13 : 3

As per the Mendelian principles, genotype ratios in both F1 and F2 generation are expected to be similar to the genotype ratios seen in a normal dihybrid cross. However, due to the effect of epistasis, phenotype ratio would deviate from Mendel's principles for normal dihybrid cross. F2 phenotypic ratio may get altered from 9:3:3:1 to 13:3.

1. Expression of colour of lemon is prevented by the allele "W". The second dominant allele "G" gives yellow colour "g" gives green colour.
   If WWgg (White) x wwGG (Yellow) plant were crossed then find the phenotype of the F1 generation.
   If two F1 plants were crossed find the phenotypic ratio of F2 generation.

P generation Red flower .× White flower

Genotype C^RC^R C^WC^W

Gametes C^R (100%) C^W (100%)

F_1 Generation C^RC^W Pink

C^RC^W * C^RC^W

F_2 gneration

Sperm / egg	C^R 50%	C^W 50%
C^R 50%	C^RC^R	C^RC^W
C^W 50%	C^RC^W	C^RC^W

Genotypic ratio : $C^{RR} : C^{RW} : C^{WW}$

1 : 2 : 1

Phenotypic ratio: Red : Pink : White

1 : 2 : 1

Question

1. Pink colour of some flowers is due to incomplete dominance. Double dominants are red and recessives once are white in colour. Which of the following combination result maximum number of pink coloured flowers?
   (1) Red x Red (2) Red x White (3) Pink x Pink (4) Pink x White (5) Pink x Red

Co-dominance

In certain traits, at heterozygote state, expression of both alleles contributes equally to the phenotype. Such phenomenon is called co-dominance.

For example, a person with AB blood group type has both A and B carbohydrates on the surface of red blood cells at the same time. The two carbohydrates are added to the surface of RBC by enzymes encoded by the I^A and I^B alleles of a single gene.

A heterozygous individual would express both carbohydrates (I^AI^B) in an equal manner.

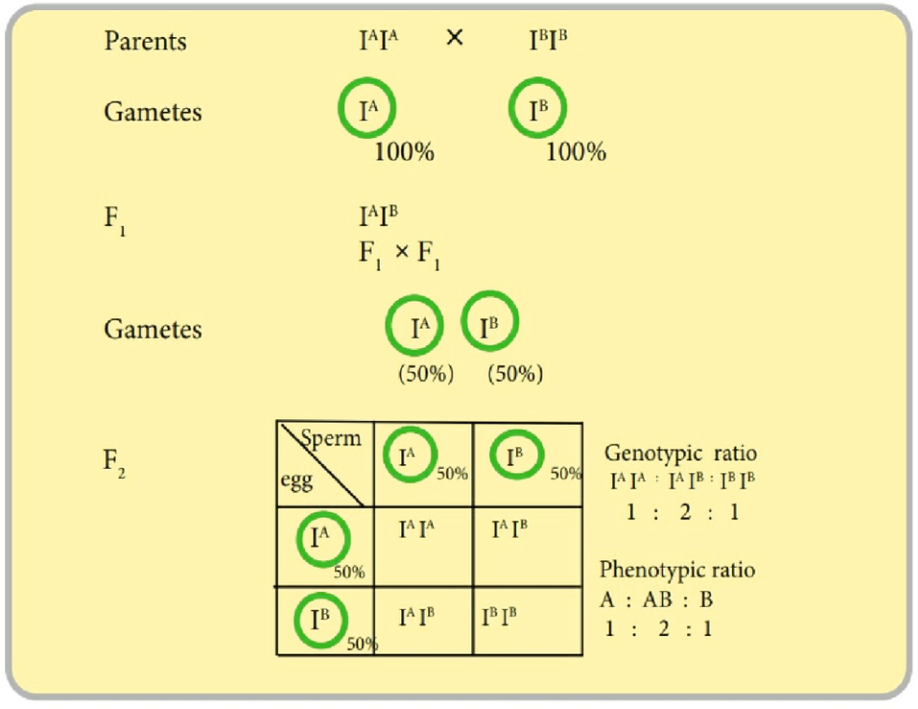
Likewise,

Homozygotes for I^A allele (I^AI^A) will carry only A carbohydrate on RBC.

Homozygotes for I^B allele (I^BI^B) will carry only B carbohydrates on RBC.

As shown below, the F1 progeny resulting from the mating of two homozygous individuals for each allele would consist of individuals only of AB blood group.

F2 generation produced by the possible mating with in F1 progeny or heterozygous individuals for the AB alleles, would produce the three phenotypes, blood type A: AB: B at a ratio of 1:2:1.



As shown, the F2 phenotype ratios in both incomplete dominance and co-dominance are 1:2:1. Hence the two phenomena cannot be differentiated using F2 phenotypic ratios.

The key to differentiate between incomplete dominance and co-dominance is that in incomplete dominance F1 generation shows a different phenotype than both the parents whereas in co-dominance F1 generation shows both the parental traits together.

stasis — Recessive

Dominant — Epista

Poly-allelism (Multiple alleles)

Poly-allelism refers to the presence of multiple alleles for a single genetic locus, a phenomenon where certain traits are determined by the combination of more than two types of alleles.

Eg: There are three alleles called I^A, I^B, and i for a single genetic locus which at different combinations determine ABO blood groups in humans.

In any diploid individual there are only two of the several alleles are present.

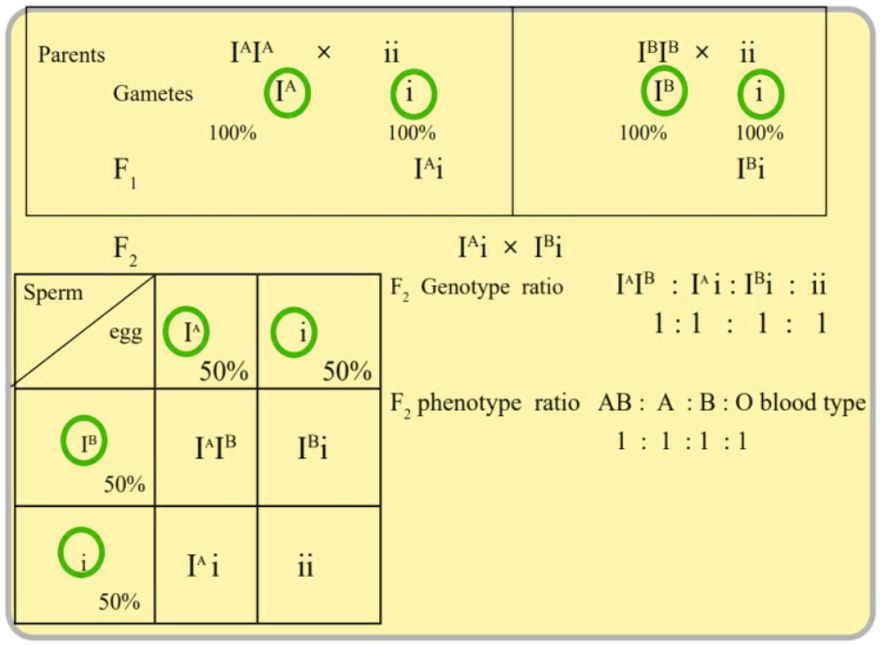
As mentioned earlier, the alleles I^A and I^B code for enzymes that add A and B carbohydrates to the surface of red blood cells.

The two alleles are in a co-dominant relationship. However, the allele 'i' results in lack of these carbohydrates on the red cell surface and it is recessive to both I^A and I^B alleles.

Therefore, both I^Ai and I^Bi genotypes will result in dominant phenotypes; having either the A or B carbohydrates. The ii genotype will result in the recessive trait of not having either of the carbohydrates.

Thus, based on the presence of the two carbohydrates, a person's blood group may be one of four types as follows: type A (carbohydrate A present), type B (carbohydrate B present), type AB (both carbohydrates A & B present), or type O (neither of the two carbohydrates present).

F1 and F2 generations resulting from a mating between individuals with different blood groups are shown below



1. A couple with a newborn baby is troubled that the child does not resemble either of them. Suspecting that a mix-up occurred at the hospital, they check the blood type of the infant. It is type O. As the father is type A and the mother type B, they conclude a mix -up must have occurred. Are they correct?

2. What would the expected phenotypic ratio be in a cross between a man of blood type O and a woman of blood type AB? Remember, type A and B blood types are codominant and type O is recessive.

Epitasis

Epistasis is the phenomenon resulting from interactions between genes of different loci. The alteration in the phenotypic expression of a gene at one locus is due to the interference of another gene at a different locus.

Epistasis could be categorized into two types; dominant epistasis and recessive epistasis, based on the nature of the gene interaction. This causes deviation from the phenotype ratios of Mendelian principles.

Dominant epistasis

When a dominant allele at a specific lous alters the expression of a separate gene at a different locus, it is referred to as dominant epistasis. Dominant epistasis is seen in the plumage colour of house fowls. Consider the following experiment.

A cross between a known homozygous, double dominant, white housefowl and a homozygous double recessive white house fowl results a 100% white F1 progeny. F2 generation produced from a cross between these F1 individuals consists of white and coloured fowls in the ratio of 13:3.

The colour of these two fowl varieties are determined by two separate genes;

- The gene ‘C’/ ‘c’ is responsible for producing colour in the feathers.
- The dominant ‘C’ allele produces colour while the recessive ‘c’ allele result in the absence of pigmentation.
- The gene ‘I’ is epistatic to gene ‘C’ and suppresses the expression of the colour. The dominant ‘I’ allele prevents production of pigments while recessive ‘i’ allele is unable to prevent colouration.

As a result, the double dominant homozygous (CCII) house fowl is white (dominant I allele prevents colouration). The double homozygous recessive house fowl (ccii) is white (recessive c allele couldn’t produce colour).

The F1 generation all consist of heterozygous (CcIi) fowls. Due to the inhibitory effect of the dominant ‘I’ allele, all F1 individuals are white. When these fowls are allowed to interbreed, the F2 generation genotypes carrying inhibitory ‘I’ allele will give rise to white colour plumage, despite the presence of the dominant ‘C’ allele. The presence of dominant ‘C’ allele in the absence of inhibitory ‘I’ allele gives rise to coloured fowls.