Monohybrid, Dihybrid Cross Ratio & Mendelian laws

Aim:- Experiments on monohybrid, dihybrid cross ratio and deducing the applicability of Mendelian laws (three examples of each ratio).

Introduction:-

Gregor Johan Mendel is considered the father of genetics who first introduced both monohybrid and dihybrid cross. He formulated his two laws, the law of segregation and the law of independent assortment based on monohybrid cross and dihybrid cross respectively

Monohybrid cross:- In a monohybrid cross, the fertilization takes place between two homozygous parents that differ only in one contrasting character which is being studied. The offspring produced by monohybrid cross are called monohybrids.

The Mendel's first law i.e. Law of segregation or purity of gametes can be explained by considering the monohybrid ratio i.e. by studying inheritance of only one character.

Example of monohybrid cross:-In pea, tall height of plant is dominant over dwarf height of plant. Both the plants were homozygous. The genotype of a tall plant was TT and that of short plant was tt. Mendel crossed the two plants which produced offspring or progeny known as F1 generation. The progenies produced in F1 generation were hybrid or heterozygous plants (monohybrids) having genotype Tt. However, the monohybrids were of tall phenotype (external appearance).

Phenotype of parents → Pure Tall × Pure Dwarf

Genotype → TT × tt

Gametes → T, t

F_1 generation → Tt

Hybrid tall

Selfing of F_1 hybrid → Tt × Tt

Gametes → T, t × T, t

F_2 generation →

♀ \ ♂	T	t
T	TT Tall	Tt Tall
t	Tt Tall	tt Dwarf

Phenotypic ratio → 3 : 1 (3 tall : 1 dwarf)

Genotypic ratio → 1 : 2 : 1 (1 pure tall : 2 hybrid tall : 1 pure dwarf)

Two different alleles of the same gene i.e. 'T'and't' were brought together in the hybrid (F_1). Even though the hybrid was tall in the next generation (F_2) it produced both tall and dwarf height plant. Thus both the alleles for tall height (T) and dwarf height (t) remained together in the hybrid without contaminating each other. In F2 generation (selfing of (F1) hybrid), the different phenotypes could be recovered because the two alleles in F1 remained pure and did not contaminate each other thus producing two types of gametes from F i.e. (T) and (t).

Problem:-

1) Cross between homozygous white mice with homozygous black mouse. We will assume that fur color is determined by one pair of genes. Therefore, we will designate a letter of the alphabet to represent this trait. Homozygous black will be represented by "AA," and homozygous white "aa". Calculate the monohybrid cross ratio with the help of Punnett's square.

2) In dogs, there is the hereditary type of deafness cause by recessive gene. Two dogs who carry gene for deafness but have normal hearing are mate. What are the possible genotypes & phenotypes of their offspring & percentage chance for each?

Punnett square:-

Result:- _____

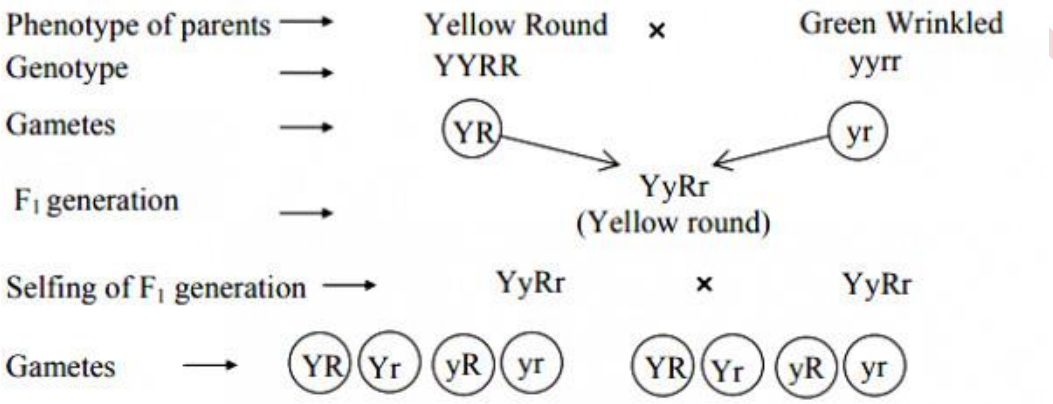
Conclusion:-

The conclusions that Mendel developed about inheritance from his monohybrid crosses have been further developed and formalized into the principle of segregation and the concept of dominance.

The principle of segregation states that each individual organism possesses two alleles that can encode a characteristic. These alleles segregate when gametes are formed, and one allele goes into each gamete. The concept of dominance states that, when the two alleles of a genotype are different, only the trait encoded by one of them the "dominant" allele is observed.

Di-hybrid cross:- Dihybrid cross is the cross between two different genes that differ in two observed traits. Mendel's second law i.e. Law of independent assortment can be explained by studying the inheritance of two characters at a time, simultaneously.

Example of dihybrid cross:- when plants of garden pea with yellow round seeds (Y Y RR) were crossed with plants having green wrinkled seeds (yyrr), yellow round seed plants (YyRr) were obtained in F1. Thus yellow colour of seed exhibited dominance over green and round seed shape over wrinkled seed shape independently. The F1 produces four types of gametes YR, Yr, yR and yr. Selfing of F1 gives rise to yellow round, yellow wrinkled, green round and green wrinkled individuals in 9:3:3:1 ratio. This is possible only when the alleles of two genes controlling the two characters assort independently to one another.



F_2 generation →

♀ \ ♂	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

Phenotypic Ratio: 9 Yellow round:3 Yellow wrinkled:3 green round:1 green wrinkled

Genotypic Ratio: 1 YYRR: 2 YYRr:1 YYrr:2 YyRR:4YyRr: 2Yyrr:1 yyRR:2 yyRr:1yyrr

Problem:-

1) In rabbits, gray hair is dominant to white hair. Also in rabbits, black eyes are dominant to red eyes. These letters represent the genotypes of the rabbits:

GG = gray hair Gg = gray hair gg = white hair	BB = black eyes Bb = black eyes bb = red eyes

Calculate the dihybrid cross ratio with the help of Punnet's square & also describe the expected phenotypic & genotypic ratio.

2) An aquatic arthropod called a Cyclops has antennae that are either smooth or barbed. The allele for barbs (B) is dominant over smooth (bb). In the same organism Non-resistance to pesticides (N) is dominant over resistance to pesticides (nn). Make a "key" to show all the possible genotypes (and phenotypes) of this organism.

Punnett square:-

Result:- _____

Conclusion:- Independent segregation for two genes can be explained by assuming that the two genes are located in two different chromosomes. The two alleles of a gene will be located in the two homologues of the concerned chromosome. Independent separation of these two pairs of chromosomes at anaphase I of meiosis will lead to the independent segregation of the genes located in them. Thus any allele of one gene is equally likely to combine with any allele of the other gene and pass into the same gamete. Independent segregation of two genes produces four different types of gametes in equal proportion. A random union among these gametes gives rise to sixteen possible zygotes. These zygotes yield 9:3:3:1 phenotypic ratio, which is known as the typical dihybrid ratio. When two pairs of independent alleles enter into F1 combination, both of them have their independent dominant effect. These alleles segregate when gametes are formed but the assortment occurs independently at random and quite freely.