EXERCISE PAGE NO.66

1. Mention the advantages of selecting pea plant for experiment by Mendel.

Solution:

Gregor Mendel demonstrated characters of inheritance acquired by offspring from parents. He selected pea plants for this experiment for the following reasons:

- Peas exhibit several visible contrasting features such as dwarf/tall plants, wrinkled/round seeds, yellow/green pod, white/purple flowers and so on.
- As they possess bisexual flowers, they can easily undergo self-pollination. This is why pea plants are able to produce offspring with the same traits over generations
- Cross pollination can easily be achieved through emasculation wherein the stamen of the flower is plucked without any disturbance to the pistil
- These plants have a short life span wherein they produce plenty of seeds in one generation alone

2. Differentiate between the following –
(a) Dominance and Recessive
(b) Homozygous and Heterozygous
(c) Monohybrid and Dihybrid.

Solution:

The differences are as follows:

(a) Dominance and recessive

Dominance	Recessive
In the presence or absence of a recessive trait, dominant factor or allele expresses itself	A recessive trait expresses itself only in the absence of a dominant trait
Example: In a pea plant, round seed, violet flower are dominant characters	Example – In a pea plant, white flower, dwarf plant etc are recessive characters

(b) Homozygous and heterozygous

Homozygous	Heterozygous
For a particular trait, homozygous contains two similar alleles	For a particular trait, heterozygous contains two different alleles
Only one type of gamete is produced	It produces more than one type of gamete – two different types of gametes to be precise
For homozygous, the genotype contains either recessive or dominant never both the alleles. Example- TT or tt	For heterozygous, the genotype possesses both recessive and dominant alleles. Example – Tt

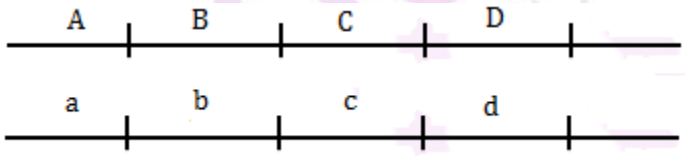
(c) Monohybrid and dihybrid

Monohybrid	Dihybrid
It is a cross between parents differing in only one pair of contrasting characters	It is a cross between parents differing in two pairs of contrasting characters
Example – a cross between a dwarf and a tall pea plant	Example – a cross between yellow wrinkled seed and a green rounded seed

3. A diploid organism is heterozygous for 4 loci, how many types of gametes can be produced?

Solution:

A locus is a fixed point on a chromosome that is occupied by one or more genes. For an allelic pair, heterozygous entities contain different alleles. Thus, a diploid entity which is heterozygous at four loci has four different contrasting characters at four different loci.
Example – if an entity is heterozygous at four loci with four different characters, such as Mm, Nn, Oo, Pp, then while meiotic division they split to form 8 different gametes.



Diploid Organism

AaBbCcDd

↓

16 different gametes

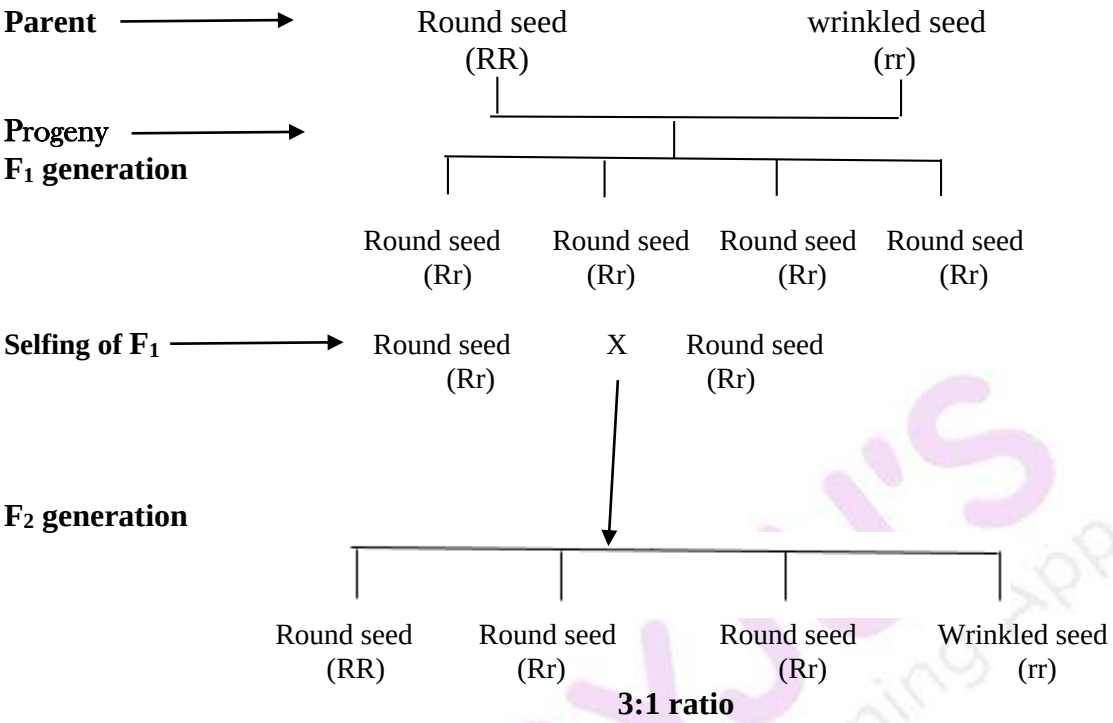
If genes are not linked to each other, then the diploid entities will produce 16 different gametes. But, if genes are linked, gametes will decrease their number as the genes may be linked which inturn will be inherited together during the meiotic cell division.

4. Explain the Law of Dominance using a monohybrid cross.

Solution:

The Law of Dominance was proposed by Mendel. It states that a dominant allele expresses itself in a monohybrid cross and suppresses the expression of recessive allele. But the recessive allele for a specific character is not vanished but remains masked or hidden in the progenies of F_1 generation which resurfaces in the subsequent generation.
Example- When a monohybrid cross between two pea plants having round seeds (RR) and wrinkled seeds(rr) was carried out, all the seeds in F_1 generation were observed to be round (Rr). If the round seeds were self-fertilized both the characters – round and wrinkled seeds appeared in F_2 generation in 3:1 ratio. Therefore, in F_1 generation, the character that is dominant i.e., the round seeds surfaced and

the recessive character i.e., the wrinkled seeds got suppressed that resurfaced in the F_2 generation.



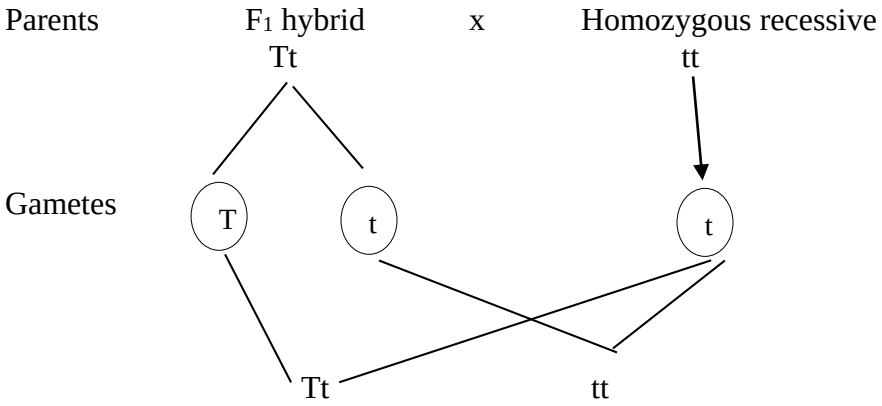
5. Define and design a test-cross.

Solution:

A test-cross can be defined as a cross of an F_1 individual that has a dominant phenotype with its homozygous recessive parent. This test cross can be used to determine if an individual displaying dominant character is homozygous or heterozygous.

Sample test cross:

- Take a tall plant (TT) and cross it with a dwarf plant(tt)
- The F_1 generation shows tall plant (Tt)
- This tall plant(Tt) is then test crossed with homozygous recessive plant(tt)

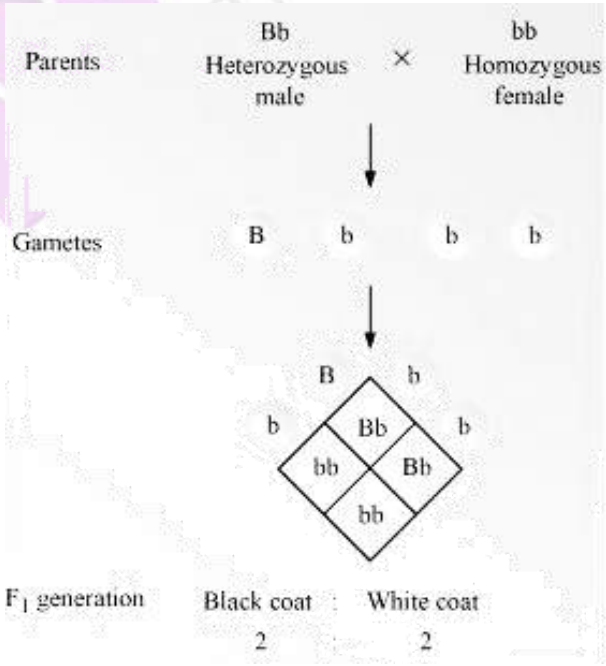


As seen above, the test cross between tall heterozygous F_1 hybrid with dwarf homozygous recessive parent producing tall and dwarf in the same equal proportion. This represents that the F_1 hybrid are heterogenous.

6. Using a Punnett Square, workout the distribution of phenotypic features in the first filial generation after a cross between a homozygous female and a heterozygous male for a single locus.

Solution:

In guinea pigs, there is a cross carried out between a heterozygous male with black coat colour (Bb) and a female having white coat colour (bb). The male yields two types of gametes B and b whereas the female yields one type of gamete only, b. Therefore, the ratio of the genotype and phenotype in the progenies of F_1 generation is in the same ratio, i.e., 1:1



7. When a cross in made between tall plant with yellow seeds (TtYy) and tall plant with green seed (Ttyy), what proportions of phenotype in the offspring could be expected to be
(a) tall and green.
(b) dwarf and green.

Solution:

When a cross between a tall plant with yellow seeds and a tall plant with green seeds is carried out, the following is produced:

- Three tall green plants
- One dwarf green plant

Parents — Tall yellow seed plant TtYy x Tall green seed plant Ttyy

Gametes — TY, Ty, ty, tY | Ty, ty

	Ty	**ty**
TY	**TT Yy Tall yellow**	**Tt Yy Tall yellow**
Ty	**TT yy Tall green**	**Tt yy Tall green**
ty	**Tt yy Tall green**	**tt yy Dwarf green**
tY	**Tt Yy Tall yellow**	**tt Yy Dwarf yellow**

Phenotype: Tall and green plant – 3
Dwarf and green plant - 1

8. Two heterozygous parents are crossed. If the two loci are linked what would be the distribution of phenotypic features in F1 generation for a dibybrid cross?

Solution:

The co-existence of two or more genes in the same chromosome is termed as linkage. If the genes are located close to each other and on the same chromosome, they are inherited together and are referred to as linked genes. If two heterozygous parents exhibit linkage, then the outcome is as follows:

Parents — BbLl x BbLl

Genotype — Blue long | Blue long

Phenotype in F_1 in all the possible may exhibit parental characters as the genes are linked completely. With all the possible genotypes in F_1 progeny can display blue long type of phenotype in the above-mentioned example. However, if there is an incomplete linkage, the parental combination will comparatively be more than the newer combinations which are less in number.

9. Briefly mention the contribution of T.H. Morgan in genetics.

Solution:

The contributions of T.H. Morgan in the field of genetics is as follows:

- He proposed and established that genes are positioned on the chromosomes
- He discovered the basis for variations as a result of sexual reproduction
- He discovered the concept of linkage and discriminated linked and unlinked genes
- He stated the chromosomal theory of linkage
- He carried out a study on sex-linked inheritance
- Morgan stated chiasma type hypothesis demonstrating that the chiasma causes crossing over
- He observed that the frequency of recombination between two linked genes is directly proportional to the distance between them both
- Proposed the theory of inheritance
- He put forward the methodology for chromosome mapping
- He carried out a study on mutation

10. What is pedigree analysis? Suggest how such an analysis, can be useful.

Solution:

A pedigree is a record of inheritance of a specific genetic trait for two or more generations which is presented in the form of a diagram or family tree. Pedigree analysis is an analysis of several generations of a family which is used on human beings and domesticated animals.

Usefulness of pedigree analysis:

- Serves as a powerful tool which can be used to trace the inheritance of a particular trait, disease or an abnormality
- It is helpful for genetic counsellors to suggest couples about the possibility of having children with genetic abnormalities such as colour blindness, haemophobia, thalassaemia, sickle cell anaemia etc
- The analysis is helpful in indicating the origination of a trait and its flow in ancestors
- It is helpful in suggesting that Mendel's principles can be applied to human genetics with some alteration such as quantitative inheritance, sex-related linkage and characters
- Helpful in reasoning why marriage between close relatives is harmful
- Helpful in extensive research in the field of medical science

11. How is sex determined in human beings?

Solution:

The chromosomal mechanism of determination of sex in human beings is of the genotype XX-XY. The nucleus of each cell consists of 23 pairs of chromosomes or 46 chromosomes out of which 22 pairs are autosomes and the last pair, the 23rd pair is the sex chromosome. Females are homomorphic, i.e., they possess two same sex chromosomes XX whereas males are heteromorphic, they possess two different sex chromosomes XY. Females are homogametic, producing only one type of egg (22+X) whereas males are heterogametic producing two types of sperms – (22+X) & (22+Y).

In the process of fertilization, if the sperm containing X chromosome fertilizes the egg, then the developing offspring would be a female (XX) and if the sperm containing Y chromosome fertilizes the egg, then the developing offspring would be a male (XY). Therefore, the sex ratio that is produced in the progeny is 1:1. Heterogamesis is the chromosomal mechanism of sex determination which can be male heterogamety or female heterogamety.

12. A child has blood group O. If the father has blood group A and mother blood group B, work out the genotypes of the parents and the possible genotypes of the other offsprings.

Solution:

A set of three alleles – IA, IB and i control the blood group characteristics in humans. Where alleles IA and IB are equally dominant and allele i is recessive to the other alleles. The table below depicts the genotypes and blood group.

Individuals with Genotype	**Blood group they would possess**
IA, IA, IA, i	A
IB,IB, IB, i	B
IA, IB	AB
ii	O

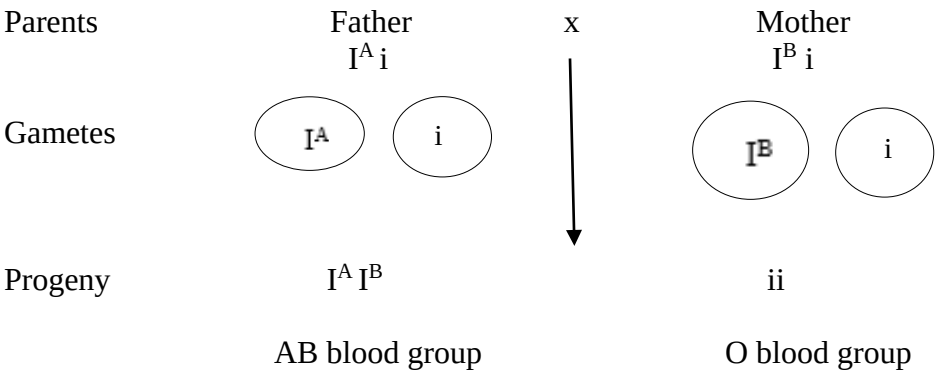
Thus, if father has blood group A and mother has blood group B, then the possible genotype of the parents will be as follows:

Parents — Father $I^A I^A$ x Mother $I^B I^B$

Gametes — I^A I^B

Progeny — $I^A I^B$ - AB blood group

A cross between heterozygous parents will produce progenies with AB blood group ($I^A I^B$) and O group (ii)



13. Explain the following terms with example
(a) Co-dominance
(b) Incomplete dominance

Solution:

(a) Co-dominance – These are the alleles that are able to express themselves independently when found together in a heterozygote. They are termed as co-dominant alleles.
(b) Incomplete dominance – it is the phenomenon of inheritance where none of the contrasting characters in a pair are dominant. In the F_1 hybrid, the expression of the trait is a fine mixture of the expression of the two factors. For instance, the *Mirabilis jalapa* produces pink flowers when a hybrid cross between a red and white flower is carried out.

14. What is point mutation? Give one example.

Solution:

The abrupt change in the gene structure due to a change in the single-base pair of DNA due to inversion and substitution without any alteration in the reading of succeeding bases. For example – sickle cell anemia.

A change in the shape of the RBCs from biconcave discs to elongated sickle-shaped structures is caused due to substitution of a single nitrogen base guanine to adenine at the sixth codon of the β-globin chain of the haemoglobin molecule. A typical RBC is biconcave, resembling flexible disc-like that facilitates the cells to pass through large and small blood vessels to convey oxygen. Whereas sickle-shaped RBCs are elongated, non-flexible and rigid in structure which causes the cells to stick to the walls of the blood vessels leading to a blockage slowing or stopping the blood flow, hence sickle cell anemia.

15. Who had proposed the chromosomal theory of the inheritance?

Solution:

In 1902, the chromosomal theory of inheritance was independently put forward by Theodore Boveri and Walter Sutton.

16. Mention any two autosomal genetic disorders with their symptoms.

Solution:

These disorders are caused as a result of a defect in the gene found on the autosomes. Some autosomal genetic disorders are – Down's syndrome, sickle cell anemia, Patau syndrome, Phenylketonuria.

Down's syndrome

Symptoms:

- Flat hands, short neck
- Broad forehead
- Partially open mouth, furrowed tongue
- Mongolian type eyelid fold and stubby fingers
- Stunted psychomotor, physical and mental development
- Heart deformities and deformity of other organs
- Underdeveloped genitalia and gonads

Sickle cell anemia

Symptoms:

- Shape of RBCs change from elongated to sickle-shaped(curved) under the influence of low oxygen tension
- These sickle-shaped RBCs are more rapidly destructed than the normal ones causing anaemia