

INHERITANCE

15.1 Introduction to Genetics

15.2 Chromosomes and Genes

15.3 Mendel's Laws of Inheritance

Q.1: Define inheritance and genetics. Explain the importance of instructions present in the molecules of DNA.

Ans. Inheritance

The process by which characteristics are transferred from parents to offspring is called inheritance.

Genetics:

The branch of biology for studying how characteristics are transmitted from parents to offspring is called genetics.

Importance of Instructions:

Inside the cells, instructions are present in the molecules of DNA. The cells use these instructions in their DNA to produce particular

proteins. The proteins made by a cell make its characteristics.

Q.2: Write a note on composition of chromosomes.

Ans. Composition of Chromosomes:

Chromosome is made of a chromatin material.

Eukaryotes: In eukaryotes, chromatin consists of DNA and special proteins called histones.

Chromatin: Chromatin is a thread-like material. In chromatin, a long molecule of DNA is wrapped around the bundles of histones.

Learning Outcomes

- Define genetics.
- Describe the composition of chromatin material.
- Define gene.
- Explain how genes control inheritance of characters.
- State clearly the difference between a gene and an allele.
- Explain that gene is a unit of inheritance and that it can be copied and passed on to the next generation.
- Describe the central dogma stating the role of gene in protein synthesis.

Recalling

- All the cells of the organisms of a species have a constant number of chromosomes.
- The body cells are diploid ($2n$). It means that the chromosomes are in pairs (homologous chromosomes).
- Before cell division, the DNA makes a copy of itself. In this way a chromatid is formed. When the cell divides, each daughter cell receives one chromatid from each chromosome.

When a cell is not dividing its chromatin is in the form of fine thread, scattered in

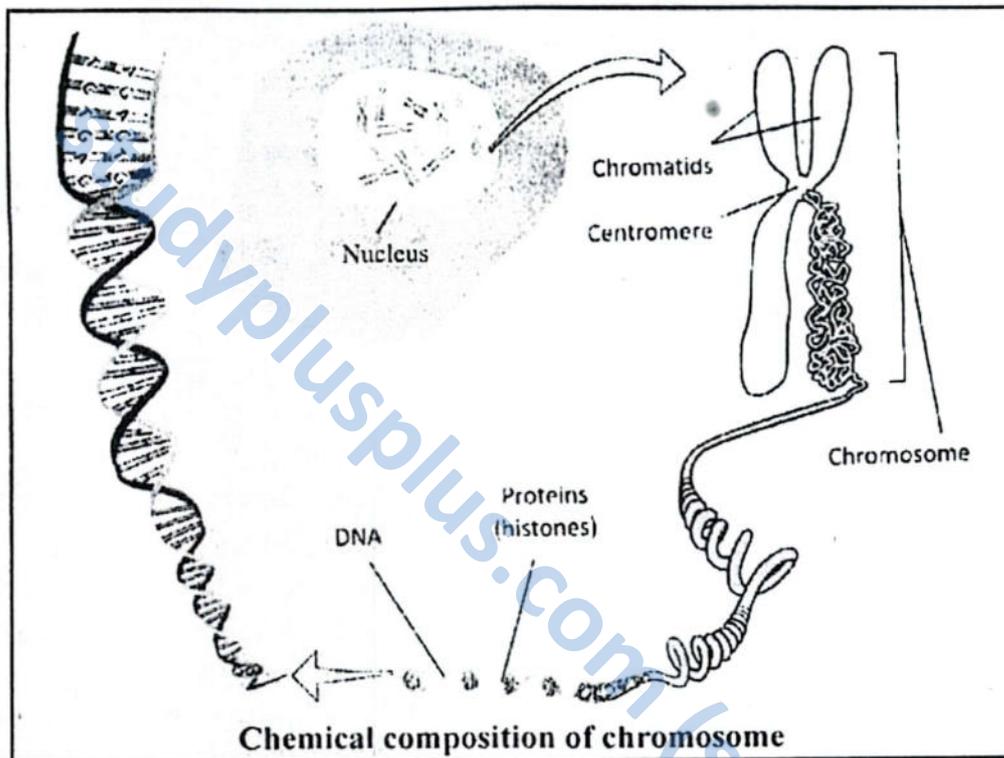
the nucleus. During cell division, chromatin coils and makes compact structures of chromosomes.

Shape of Chromosomes: Chromosomes are rod-shaped.

Chromatid: A chromosome consists of two identical halves. Each half of the chromosome is called a chromatid.

Centromere: The two chromatids of a chromosome are attached at a point called centromere. The centromere holds the two chromatids together until they separate during cell division.

Prokaryotes: The prokaryotes have only one chromosome which is made of a DNA molecule. It is not bound by a nuclear envelop and is present in cytoplasm.



Q.3: Write a note on gene and alleles.

Ans. Gene: A gene is a segment of DNA that contains the information for a hereditary character, such as the gene for eye colour, gene for earlobe shape, and gene for the hair texture.

Location of Genes: Genes are located on chromosomes.

Like chromosomes, genes are also in pairs. Before dividing, cell duplicates its chromosomes. Its genes are also copied. It is done for equal distribution of genes to the daughter cells. Genes are transferred to the next generation through gametes.

DNA of each chromosome contains thousands of genes. The locations or positions of genes on chromosomes are known as loci (singular locus).

Alleles: Each chromosome in pair may carry alternative forms of the same gene. These alternate (different) forms of a gene are called its alleles.

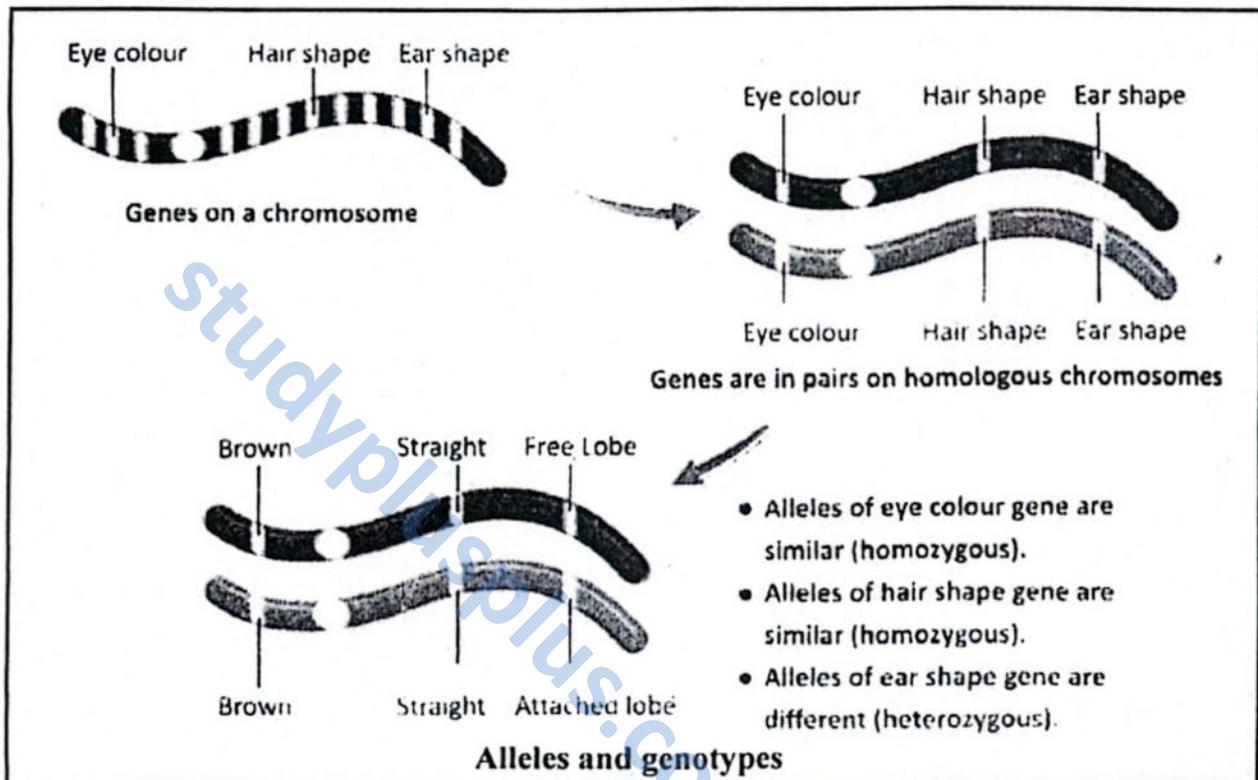
Example: For example, the gene of hair colour can have two alleles. One allele makes hair pigments while the other does not make pigments.

Genotype: The combination of the alleles of a gene pair is called genotype.

Homozygous: When a gene pair has both the same alleles, the genotype is known as homozygous.

Heterozygous: The genotype, in which the gene pair has different alleles, is called heterozygous.

Example: In the figure a cell has genes for eye colour, hair shape and ear shape. All genes are in pairs (on homologous chromosomes).



- Both alleles of the eye colour gene are similar. It means that the genotype for eye color is homozygous. Both alleles of the hair shape gene are also similar. It means that the genotype for hair shape is homozygous.
- The alleles of the ear shape gene have instructions for opposite characteristics. One allele makes free earlobes while the other allele makes attached earlobes. It means that the genotype for ear shape is heterozygous.

Dominant Allele: In the heterozygous genotype, one allele may mask the working of the other allele. Such an allele is called the dominant allele.

Recessive Allele: The allele which is masked (not expressed) is called recessive allele.

Phenotype: The observable outcome of genotype, in the form of characteristic, is called phenotype.

Representation of Alleles: Letters are used to represent alleles. Capital letters refer to dominant alleles, and lowercase letters refer to recessive alleles.

Q.4: Explain the working of a gene.

Ans. The working of a Gene:

A gene (segment of DNA) gives instructions to the protein-making machinery of cell i.e. ribosome.

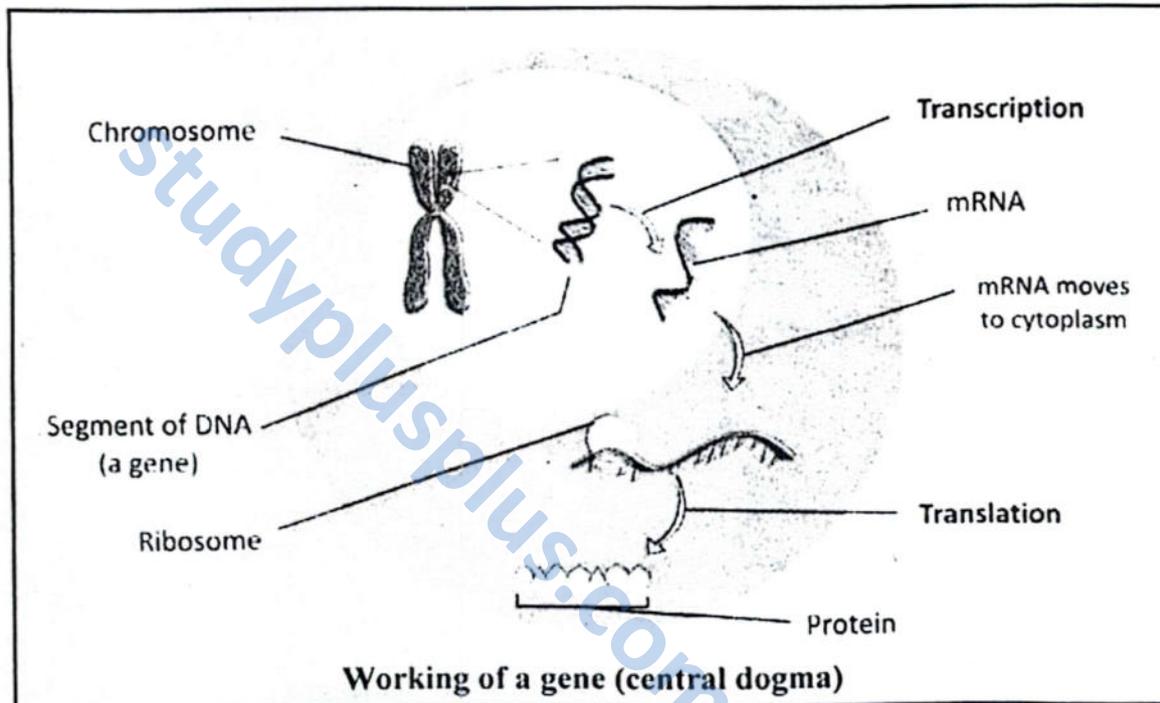
Transcription: The segment of DNA acts as a template for the synthesis of a type of ribonucleic acid, called messenger RNA (mRNA). In this way, DNA transfers the instructions to mRNA. This step is known as transcription.

Translation: The mRNA moves out into the cytoplasm. Here, ribosome attaches with mRNA and assembles amino acids according to the instructions. In this way, a protein is made. This step is called as translation.

Central Dogma: This concept of the working of a gene is called central dogma.

Representation: The central dogma is represented as:

DNA \longrightarrow mRNA \longrightarrow Protein



Q.5: Why did Mendel select peas as a model for studying genetics? Explain your answer.

Ans. Selection of Garden pea:

For his experiments, Mendel chose the garden pea. His choice was a good one for several reasons.

1. Pea plants are small and easy to grow. They have a short life cycle. Several generations can be grown in a single year.
2. Pea plant has seven easily distinguishable characteristics, such as round and wrinkled seeds and purple and white flowers. It helped Mendel to easily observe and calculate the results of crosses among plants.

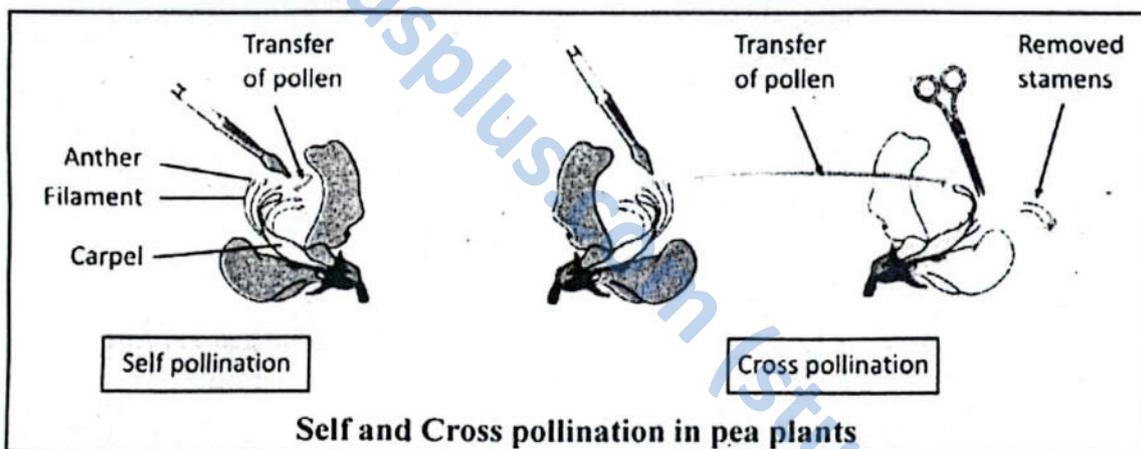
Learning Outcomes

- Describe complete dominance.
- Demonstrate that the 3:1 monohybrid F₂ phenotypic ratio is an evidence of segregation of alleles.
- State Mendel's law of Segregation.
- Demonstrate that 9:3:3:1 dihybrid F₂ phenotypic ratio is an evidence of independent assortment.
- State Mendel's law of Independent Assortment.
- Selecting the example of ABO blood group system, explain co-dominance.
- Explain incomplete dominance in Japanese 4 O' Clock plant.

	Flower colour	Seed colour	Seed shape	Pod colour	Pod shape	Flower position	Plant height
Character 1	 Purple	 Yellow	 Round	 Green	 Flat	 Axial	 Tall
Character 2	 White	 Green	 Wrinkled	 Yellow	 Constricted	 Terminal	 Short (dwarf)

Distinguishing characters in pea plant, studied by Mendel

3. The flowers of pea contain both male and female reproductive parts i.e. stamen and carpel. Normally, self pollination occurs in pea flowers. Cross pollination can also be performed in pea flowers. It is done by removing a flower's stamens and transferring its pollen grains on the flower of another plant.



Self and Cross pollination in pea plants

Q.6: Explain Mendel's experiment in which he studied the inheritance of two characteristics. State the law which he concluded at the end.

Ans. Dihybrid Cross:

In a dihybrid cross, the inheritance of two characteristics is studied at a time. In such experiments, Mendel wanted to know whether different pairs of alleles also segregate independently. He chose to study the characteristics of seed shape (round or wrinkled) and seed colour (yellow or green).

Experiment: He first grew true-breeding varieties of plants, which differed in these two characteristics. One plant had round yellow seeds and the other had wrinkled green seeds.

Mendel crossed these true-breeding plants. All the plants of the F₁ generation had round yellow seeds. It proved that the allele for round seeds (R) is dominant while the

allele for wrinkled seeds (r) is recessive. Similarly, the allele for yellow seeds (Y) is dominant while the allele for green seeds (y) is recessive. All the F_1 plants were heterozygous ($RrYy$) for both characteristics.

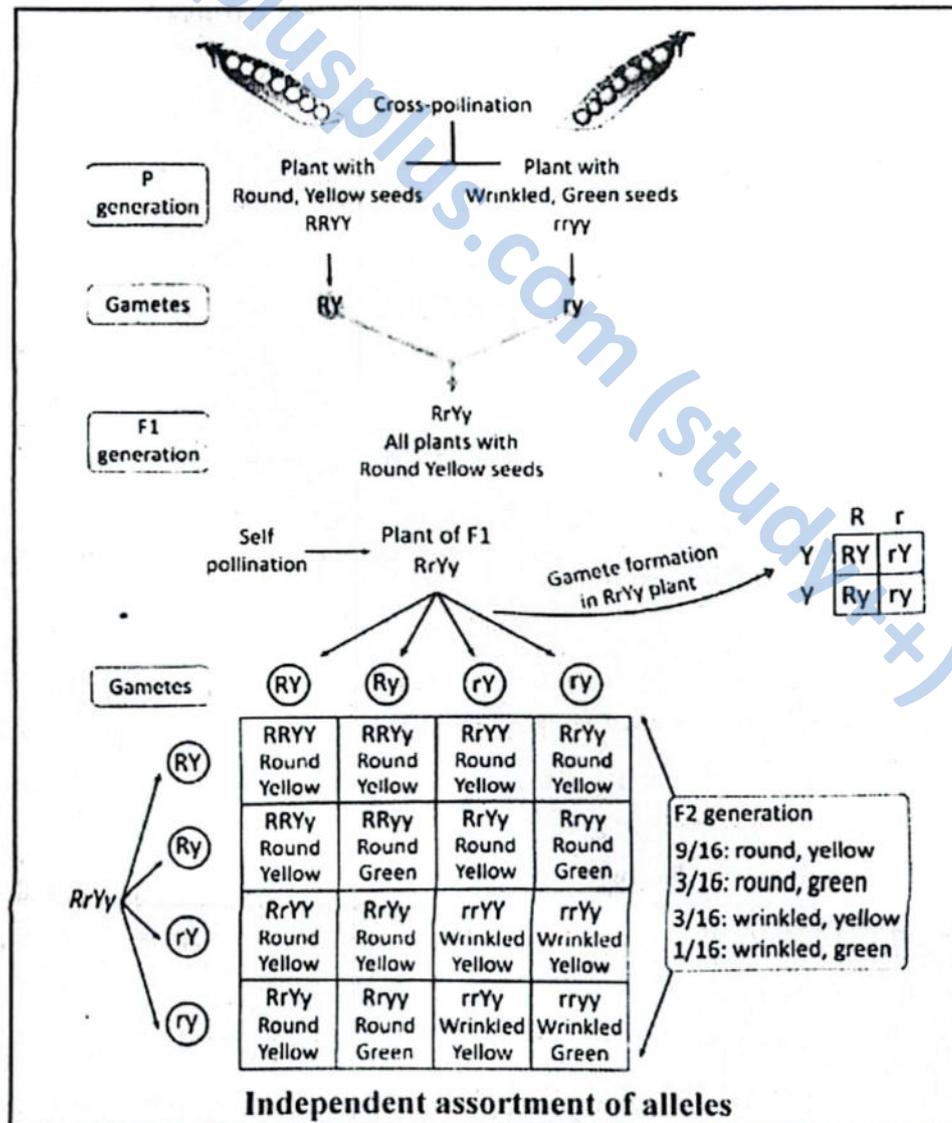
Mendel allowed self-pollination in the F_1 plants and got the F_2 generation. The F_2 generation had the following four phenotypes:

- 9/16 that have round, yellow seeds (genotypes: $RRYY$, $RRYy$, $RrYY$, and $RrYy$)
- 3/16 that have round, green seeds (genotypes: $RRyy$ and $Rryy$)
- 3/16 that have wrinkled, yellow seeds (genotypes: $rrYY$ and $rrYy$)
- 1/16 that have wrinkled, green seeds (genotype: $rryy$)

Conclusions:

Law of Independent Assortment: The F_1 plants ($RrYy$), produced four types of gametes i.e. RY , Ry , rY , and ry . When these plants were allowed to self-pollinate, there were 16 combinations of alleles in F_2 generation. It means that the segregation of alleles R and r is independent of the segregation of alleles Y and y .

Mendel's discovery is called as the law of independent assortment. It states that "alleles separate independently of one another during the formation of gametes".



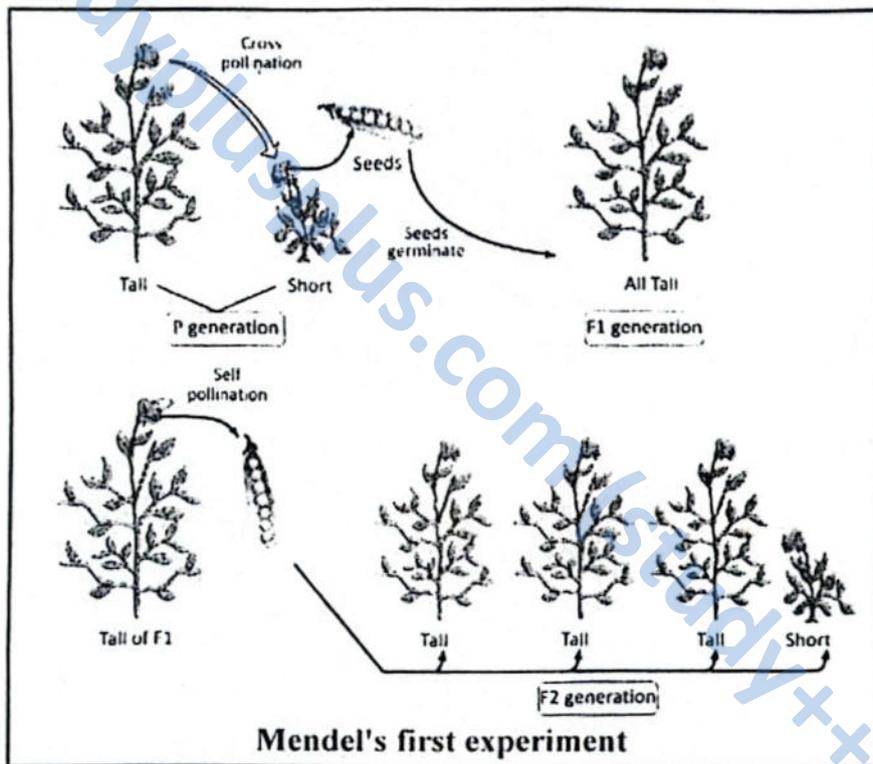
Q.7: Describe Mendel's experiment in which he studied the inheritance of one characteristics. State the law which he concluded at the end.

Ans. Monohybrid Crosses:

Mendel performed monohybrid crosses. It is a cross in which only one characteristics is studied.

Experiment: During Mendel's time, most people believed that characteristics were contributed from both parents. They believed that characteristics of parents are mixed together and are passed to offspring. For example, if a short plant is crossed with a tall plant, we would expect the offspring to be medium sized plants. Mendel crossed a true-breeding tall plant with a true-breeding short plant. He called these true-breeding parents as P generation and the offspring of this cross as F1 generation. All offspring in F1 were tall plants. This result was unexpected.

Next, Mendel allowed the tall plants of F1 generation to self-pollinate. He noted that 75% of the offspring (called the F2 generation), were tall, while 25% were short.



Conclusions:

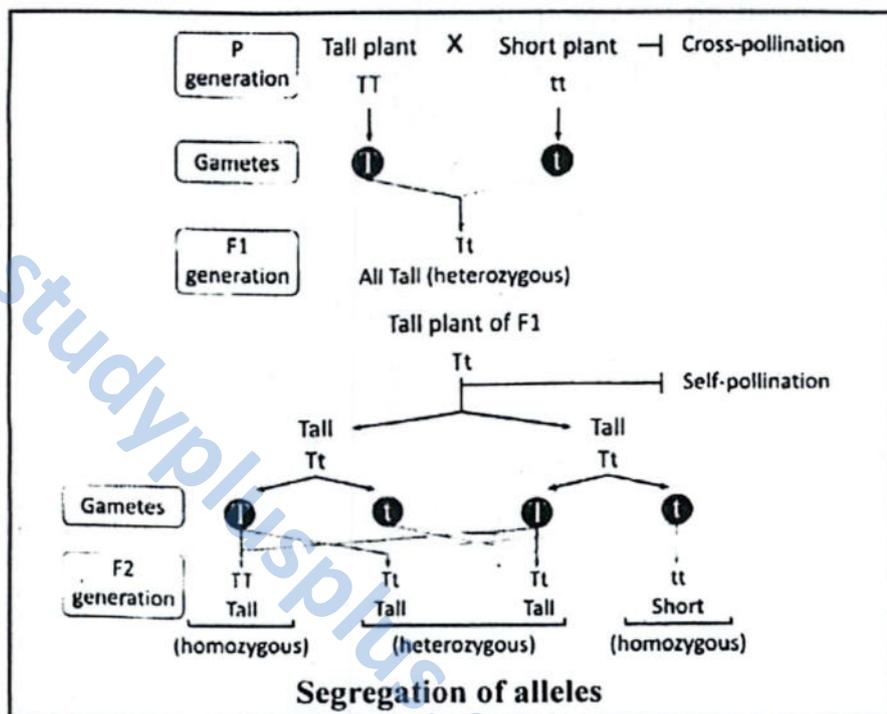
Concept of Dominance and Law of Segregation

Mendel found the same results with all the characteristics. For example, purple flowers and white flowers were crossed. In F1 generation, all plants made purple flowers. After self-pollination in F1 purple flowers, the F2 generation had 75% plants with purple flowers and 25% plants with white flowers.

Mendel explained his results and proposed that pea plant had two hereditary factors (genes) for each characteristic. There were two forms (alleles) of each gene i.e. dominant allele and recessive allele. The dominant allele masked the effects of the other.

This is called as concept of **dominance**.

Moreover, Mendel explained that each parent has two alleles of a gene. But a parent can only pass one allele to the offspring. Therefore, during the formation of gametes, the alleles must separate so there is only one allele per gamete. When fertilization occurs, the offspring then has the two alleles again. It is called the law of segregation. It states that "the paired genes (alleles) are separated during gamete formation and each gamete receives one of the two alleles, but not both".



Q.8: Explain complete dominance and incomplete dominance with the help of an example.

Ans. Complete Dominance:

Such a relationship in which one allele is completely dominant over another is called complete dominance.

Explanation: In complete dominance, homozygous dominant and heterozygous genotypes make the same phenotype.

Example: Both TT and Tt pea plants were tall.

But it does not always happen in all organisms. There are two deviations in the rule of dominance. These are incomplete dominance and co-dominance.

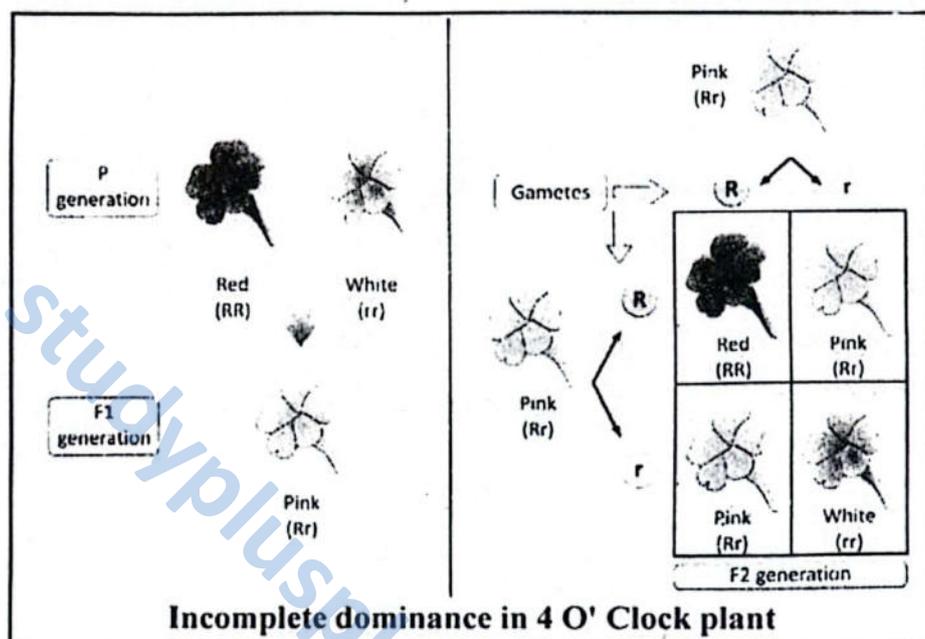
Incomplete Dominance:

It is a relationship between two alleles, when one allele is not completely dominant over the other. In incomplete dominance, the heterozygous offspring has a phenotype in between the phenotypes of both parents. In other words, the phenotype of a heterozygous is intermediate between the phenotypes made by the dominant and recessive alleles.

In the plant Japanese **four o'clock**, two alleles control the characteristic of flower colour i.e. red (R) and white (r). When red-flowered plant (RR) self-pollinates, it produces only red-flowered offspring. Similarly, when a white-flowered plant (rr) self-

pollinates, it produces only white-flowered offspring. However, when a true-breeding red flower (RR) is crossed with a white flower (rr), all of the F1 offspring have pink flowers. All these F1 offspring are heterozygous (Rr). Here, alleles R and r show incomplete dominance and the phenotype is intermediate.

When two pink flowers (Rr) are crossed, the genotype ratio of F2 is 1 RR : 2 Rr : 1 rr. It results in 1 red flowered, 2 pink flowered and 1 white flowered plants.



Q.9: Write a comprehensive note on co-dominance.

Ans. Co-dominance:

Co-dominance occurs when both the alleles of a gene are completely expressed in a heterozygous offspring. In co-dominance, neither allele is dominant or recessive. In co-dominance, the phenotype of heterozygous offspring represents the phenotypes of both parents. Here, both alleles make their characteristics independently.

An example of co-dominance is **ABO blood group system**. In humans, there are three alleles to control this characteristic. Two alleles are dominant and completely expressed (alleles I^A and I^B), while one allele is recessive (i). The allele I^A is responsible for making antigen A on red blood cells, while the allele I^B is responsible for making antigen B. The recessive allele (i) does not make any antigen. There are four phenotypes (blood groups) produced by the expression of alleles.

1. If the genotype is homozygous recessive (ii), no antigen is made and the phenotype is blood group O.
2. If the genotype is homozygous ($I^A I^A$) or heterozygous ($I^A i$), antigen A is made and the phenotype is blood group A.
3. If the genotype is homozygous ($I^B I^B$) or heterozygous ($I^B i$), antigen B is made and the phenotype is blood group B.
4. If the genotype is heterozygous ($I^A I^B$), both the alleles i.e. I^A and I^B express and antigens A and B are produced. In this case, the phenotype is blood group AB. It

means that alleles I^A and I^B show co-dominance.

Genotype	Relationship between alleles	Antigen produced	Phenotype
$I^A I^A$ or $I^A i$	Allele I^A is dominant Allele i is recessive	A	Blood Group A
$I^B I^B$ or $I^B i$	Allele I^B is dominant Allele i is recessive	B	Blood Group B
ii	Allele i is recessive	No Antigen	Blood Group O
$I^A I^B$	Allele I^A and I^B are co-dominant	A and B	Blood Group AB

15.4 Variations and Evolution

Q.10: Define variations. Describe the types of variations.

Ans. Variations:

The differences in the characteristics of the members of the same species are called variations.

Reason of Variations:

- Some variations may be due to environmental factors.
- Most variations are due to differences in the genetic make-up of organisms.

Types of Variations:

Variations are of two types:

- Continuous variations
- Discontinuous variations

Continuous variations: In continuous variations, the phenotypes show complete range of measurement from one extreme to another. These variations are minor differences. These may be due to differences in genes or due to the influence of environment.

Examples: Human height is an example of continuous variation. Height ranges from dwarf to tall. Any height is possible between these values. So it is continuous variation. Similarly, human skin colour, size of feet, body weight etc. are also continuous variations.

Discontinuous variations: Discontinuous variations show distinct phenotypes. Such variations are large and prominent. They are due to genetic differences.

Examples: Human blood group is an example of discontinuous variation. There are only four types of blood group (A, B, AB, and O). Similarly, ear shape (free earlobe or attached earlobe) and tongue rolling (some people can roll their tongue and other cannot) are examples of discontinuous variations.

Learning Outcomes

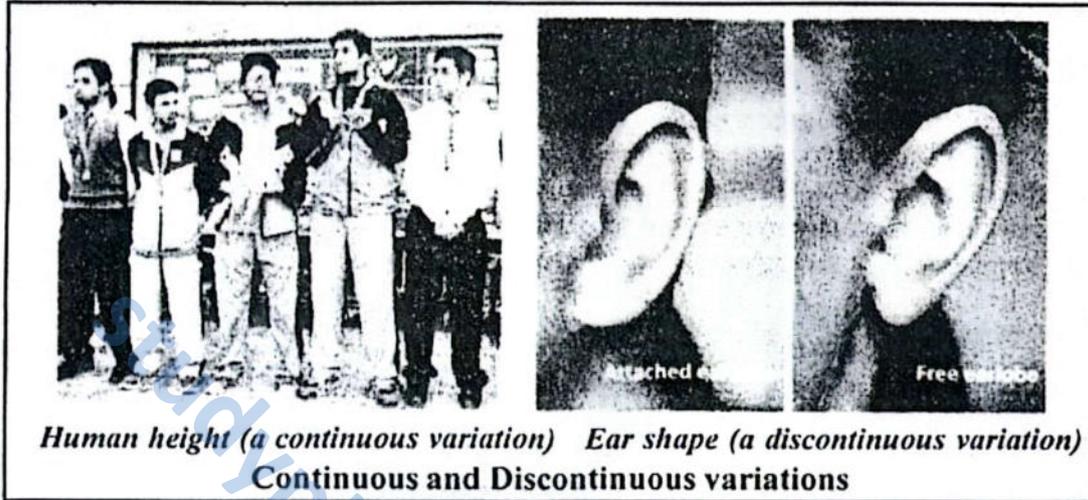
- Describe the sources of variations.
- Relate meiosis with variations.
- Describe variations and explain difference between continuous and discontinuous variations.
- Define organic evolution and explain how variations can lead to evolution.
- Describe how variations lead to competition in a population and differential survival by best fitting the environment.
- Assess selection as a possible means of Evolution.
- Develop an understanding of artificial selection as a means of improvement of yield in economically important plants.

Q.11: Describe the sources of variations.

Ans. Sources of Variations

Variations arise more in sexually reproducing organisms. The following are the sources of variations.

1. **Mutation** is a change in the gene that is passed on to offspring. Mutations are the biggest source of variations.



2. **Recombination** is the reshuffling of genes. It happens during gamete formation. It results in the formation of a variety of gametes in an individual. When gametes of parents fuse, the next generation gets the genetic composition which is different from both parents.
3. The **random pairing of gametes** occurs because each organism produces large numbers of gametes. The union of a particular pair of gametes is a matter of chance.

You look similar to your parents and siblings. However, you don't look exactly the same, and this is due to **variations**.
4. **Environmental factors** such as climate, diet, culture and lifestyle also produce variations.

Q.12: Explain the theory of natural selection. How the existence of variations is a necessary condition for evolution?

Ans. Evolution:

The development of advanced types of organisms from pre-existing types of organisms overtime is called evolution (organic evolution).

Modern scientists define evolution as a change in the characteristics within a population, which is inherited from one generation to the next.

The Theory of Natural Selection The English naturalist, Charles Darwin (1809-1882) presented the evidence that the evolution of new organisms occurs. He formed a theory to explain how evolution occurs. His theory is known as the

Before the 18th century, most scientists thought that all species were permanent and unchanging. Furthermore, they thought that the Earth was only thousands (and not billions) of years old. This anti-evolution idea is known as the "theory of special creation".

Theory of Natural Selection. This theory was published in a book "On the Origin of Species by means of Natural Selection" in 1859.

According to this theory, the inherited characteristics of a population change over time through natural selection. In other words, natural selection is the mechanism of evolution.

Natural Selection:

Natural selection is the process through which, the individuals with better characteristics (variations) produce more surviving offspring than the individuals lacking these variations. As a result, the population gradually includes more individuals with the better variations.

The French biologist Jean Lamarck (1744-1829) proposed an idea to explain how evolution happens. He proposed that individuals acquire characteristics during their lifetimes as a result of experience. Then they pass on those characteristics to offspring. Lamarck's idea is called the inheritance of acquired characteristics. Lamarck's idea was rejected by scientists because it is not supported by the mechanisms of inheritance.

Steps of Natural Selection:

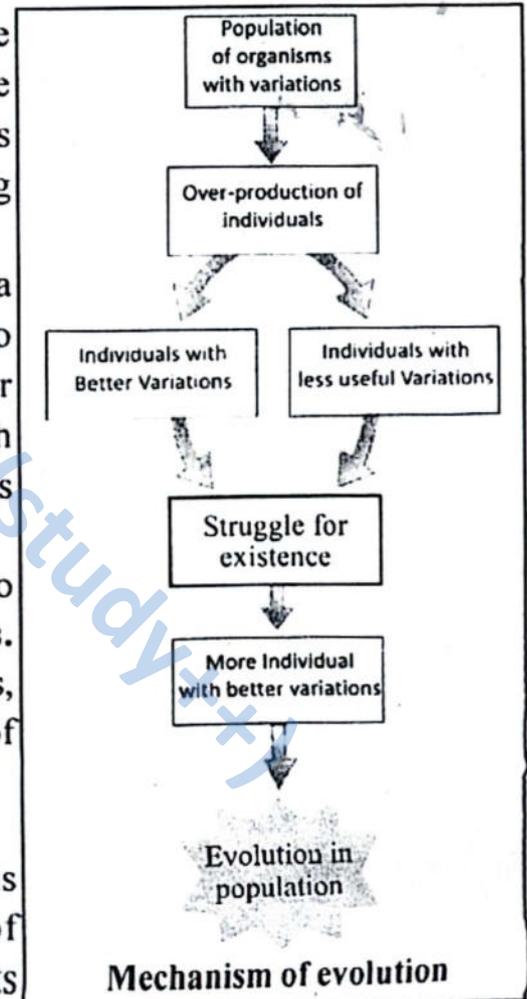
Natural selection works in three steps.

1. All species have capacity to produce excessive numbers of offspring. But in nature, resources are limited. The production of more individuals leads to a **struggle for existence (competition)** among the individuals of population.
2. **Variations** exist among individuals in a population. Some variations are more adapted to the environment. In the competition for environmental resources, the individuals with better variations are more successful. It means that better variations are selected.
3. The selected variations have genetic basis and so these are **passed on to the next generations**. When this process repeats over many generations, each new generation has a higher proportion of individuals with the better variations.

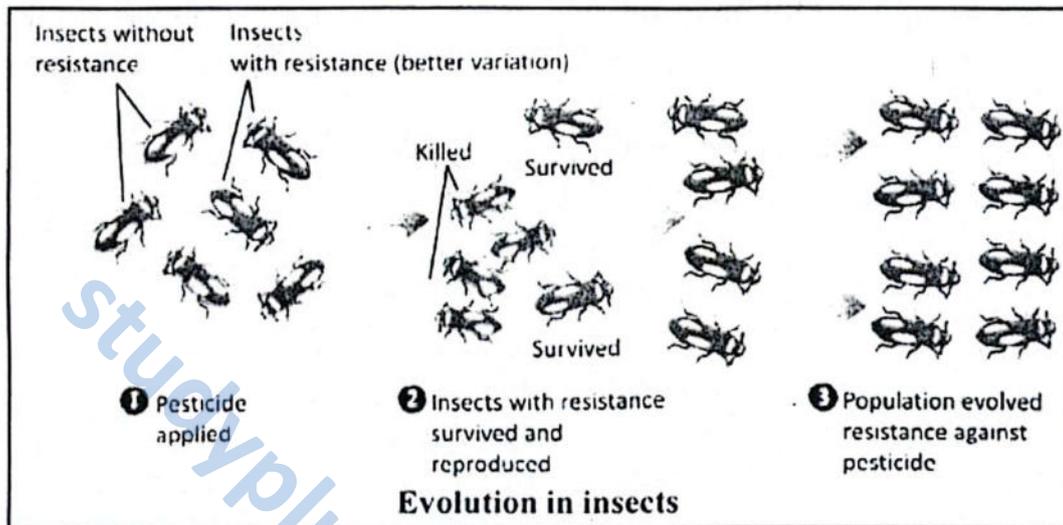
Example of Natural Selection:

An example of Natural selection and evolution is the evolution of pesticide resistance in hundreds of insect species. Pesticides are poisons used to kill pests (harmful insects). When a new type of pesticide is used, its small amount may kill 99 percent of the pests. But later sprayings are less and less effective.

For example, the flour beetle is a pest that damages stored grain. In the early 1950s, a pesticide was introduced to control these insects. Only a small concentration of



pesticide was enough to control them. After the first pesticide spray, the survivors were the insects who had variations against the pesticide chemical. They passed on such variations to their next generation. In each generation, the percentage of pesticide-resistant individuals increased in population. Thus, the population underwent evolution that resulted in resistance in these insects against pesticide. Today, the flour beetles are not killed even by very high concentrations of the same pesticide.



Q.13: Write a note on artificial selection.

Ans. Artificial Selection:

Artificial selection or selective breeding means the process in which humans breed selective varieties of plants and animals to produce plants and animals with the characteristics of choice.

Darwin started his famous book with a chapter on artificial selection.

Plant breeders can improve characteristics such as grain production, disease resistance, or protein content. Animal breeders improve growth rate or milk production. Artificial selection helps to produce many changes in species in a short time.

In artificial selection, humans favour specific traits while in natural selection the environment selects or rejects variations.

Breeds: The varieties of animals which are artificially bred are called breeds.

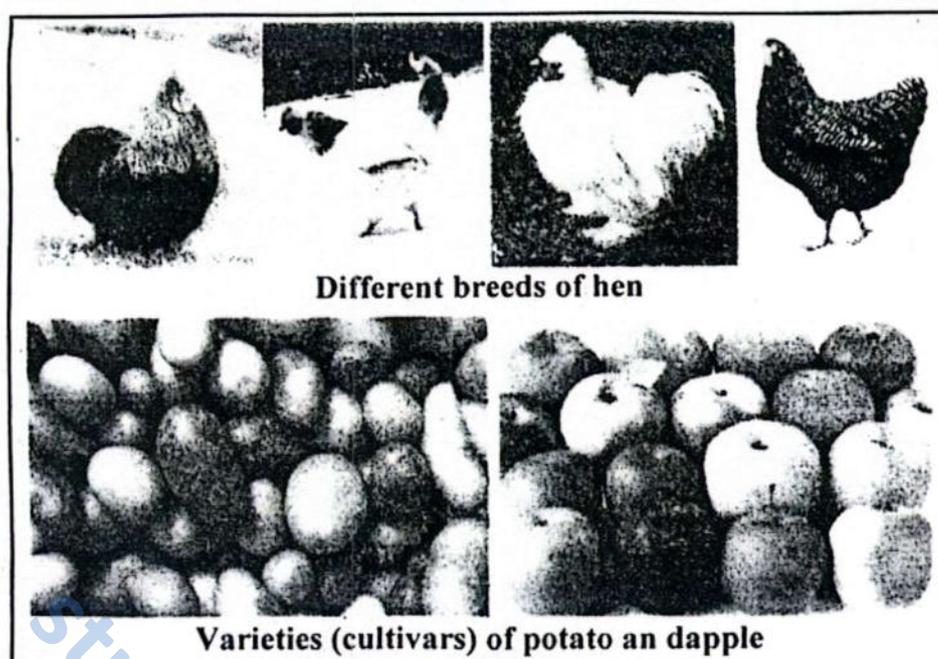
Varieties or Cultivars: The varieties of plants which are bred are known as varieties or cultivars.

Many breeds of sheep, goat, cow, hen etc. have been produced by artificial selection to increase the production of meat, milk, eggs, wool etc.

Similarly many plant varieties (cultivars) have been produced for better quantity and quality of food. This process has proved very successful for the improvement of yields in economically important plants like wheat, rice, potato, and apple etc.

Importance of Artificial Selection:

This process has proved very successful for the improvement of yields in economically important plants like wheat, rice, potato and apple etc.



KEY POINTS

- The process by which characteristics from parents are transferred to offspring is called inheritance.
- Chromosome is made of a single DNA molecule and histone proteins.
- A gene is a segment of DNA that contains the information for a hereditary character.
- The different forms (variants) of a gene are called its alleles.
- The combination of the alleles of a gene pair is called genotype. The observable outcome of genotype, in the form of characteristic, is called phenotype.
- The allele which masks the working of the other allele, is called the dominant allele, while the allele which is not expressed, is called recessive allele.
- A segment of DNA acts as a template for the synthesis of mRNA. This step is known as transcription.
- Ribosome assembles amino acids according to the instructions on mRNA. This step is called as translation.
- A plant which is true-breeding for a characteristic always produces offspring with that characteristic on self-pollination.
- Mendel's law of segregation states that "the paired genes (alleles) are separated during gamete formation and each gamete receives one or the other allele, but not both".
- Mendel's law of independent assortment states that alleles separate independently of one another during the formation of gametes.
- The relationship between two alleles, when the heterozygous offspring has a phenotype in between that of the parents, is known as incomplete dominance.

- Co-dominance occurs when both alleles for a gene are expressed in a heterozygous offspring.
- In ABO blood groups system, alleles I^A and I^B are dominant over allele i . Alleles I^A and I^B are codominant with each other.
- The differences among the members of the same species is called variations.
- The development of new types of organisms from pre-existing types of organisms overtime is called evolution (organic evolution).
- Evolution is also defined as a change in the characteristics within a population, which is inherited from one generation to the next.
- According to the theory of natural selection, the inherited characteristics of a population change overtime through natural selection.
- Natural selection is the process through which, the individuals with better variations produce more surviving offspring than the individuals lacking these variations.
- All species tend to produce excessive numbers of offspring and there is a struggle for existence (competition) among the individuals of population.
- In competition, the individuals with better variations are more successful.
- The selected variations are passed on to the next generations.
- Artificial selection (selective breeding) is the process in which humans breed plants and animals to produce offspring with the desired characteristics.
- The varieties of animals which are artificially bred are called breeds. The varieties of plants which are bred are known as varieties or cultivars.

Activities

1. Draw the chromosomes of a plant cell after observing in prepared slides / unlabelled charts.
2. Record the heights of class fellows to predict which kind of variation is it.
3. Present the data of class fellow's heights in graphical form.

Ans. Practical work

Science, Technology and Society

1. Describe various possibilities if humans could be able to control the functioning of genes.

Ans. Humans can be able to control the functions of genes through the following ways.

- (i) Genetic engineering, i.e. the artificial synthesis, modification, removal, addition and repair of the genetic material (DNA), is considered as modern biotechnology. It is done to alter the characteristics of organisms. So changes in characteristics of organisms are controlled by humans.
- (ii) Artificial selection (or selective breeding) means intentional breeding between individuals for certain traits, or combination of traits. Animals or plants having

desirable characteristics are selected for breeding. In this way, many new generations with desirable characteristics are produced. In this process, humans control the function of genes.

2. **Prepare a report using newspaper clippings on the recent advances and future possibilities in genetics.**

Ans. Practical work

3. **Rationalize life as a product of the diversity brought about by chromosomes, genes and DNA.**

Ans. DNA, genes and chromosomes are the building blocks of inheritance.

DNA (deoxyribonucleic acid) is a biomolecule that holds the blueprint for how living organisms are built. DNA is made out of two long twisted strands that contain complementary genetic information. A gene is a segment of DNA that is passed down from parents to children and confers a trait to offspring. Genes are organized and packaged in units called chromosomes. Human have 23 pairs of chromosomes. One set of chromosomes for each pair comes from a person's mother, and the other set of chromosomes comes from father.

From the above discussion, it is clear that DNA, genes and chromosomes are necessary for life existence. These are the main factors which cause variation among individuals. Without DNA, genes and chromosomes all living organisms can not build up even their body structure and life is not possible.

So we can say that life as a product of the diversity brought by chromosomes genes and DNA.

4. **Outline the scientific findings and some of the technological advances that led to the modern concept of gene.**

Ans. Modern concept of gene:

- (i) The chromosomes carry the units of inheritance called the genes.
- (ii) Genes consist of DNA. They contain specific instructions for protein synthesis. DNA molecule consists of two polynucleotide strands.
- (iii) Mutations (changes in DNA) are important source of variations. Mutations also happen during gametes formation through meiosis now can be observed without any error.
- (iv) Due to latest discoveries, genetic disorders can be cured now.
- (v) Interferon, Insulin and other latest medicines are also made from genes which leads to modern concept about genes.

5. **Analyze the concept of gene to produce various proteins of the body.**

Ans. A gene (segment of DNA) gives instructions to the protein-making machinery of cell i.e. ribosome. The segment of DNA acts as a template for the synthesis of a type of ribonucleic acid, called messenger RNA (mRNA). In this way, DNA

transfers the instructions to mRNA. This step is known as transcription. The mRNA moves out into the cytoplasm. Here, ribosome attaches with mRNA and assembles amino acids according to the instructions. In this way, a protein is made. This step is called as translation. This concept of the working of a gene is called central dogma. The central dogma is represented as;



6. **Describe the importance of scientific investigation and mathematical know how in genetics.**

Ans. In genetics, due to scientific investigation we can predict the progeny of two individuals which are crossed.

Due to scientific investigation, humans introduced the concept of natural selection. Due to natural selection, we can select generations of a population with better genetic variations. Due to knowledge of discontinuous variations, we can say that in a human population, an individual has one of the four distinct blood groups (A, B, O and AB) and can not have in between.

Similarly due to scientific research in genetics we can predict that in every human population, the individuals have a range of heights (from very small to tall). No population can show only two or three distinct heights.

Due to scientific research in genetics, selective breeding has revolutionized and livestock throughout the world. Numerous breeds of sheep, goat, cow, her etc. have been produced by artificial selection to increase the production of wool, meat, milk, eggs etc. similarly many plant varieties (cultivars) have been produced for better quantity and quality of cereals, fruits and vegetables.

Mathematics has also a lot of applications in genetics. Mendel succeeded in his work not only because he selected the right organisms for his experiments but also he analyzed the results by using the principles of statistics (ratios, percentage etc.). Similarly an English mathematician introduced a concept of the Punnett square diagram that is used in genetics to predict an outcome of a particular cross or breeding experiment. Pedigree charts and different graphs are used in genetics to represent the data of different variations of a population.

7. **Explain how genetics can predict the progeny of two individuals which are crossed.**

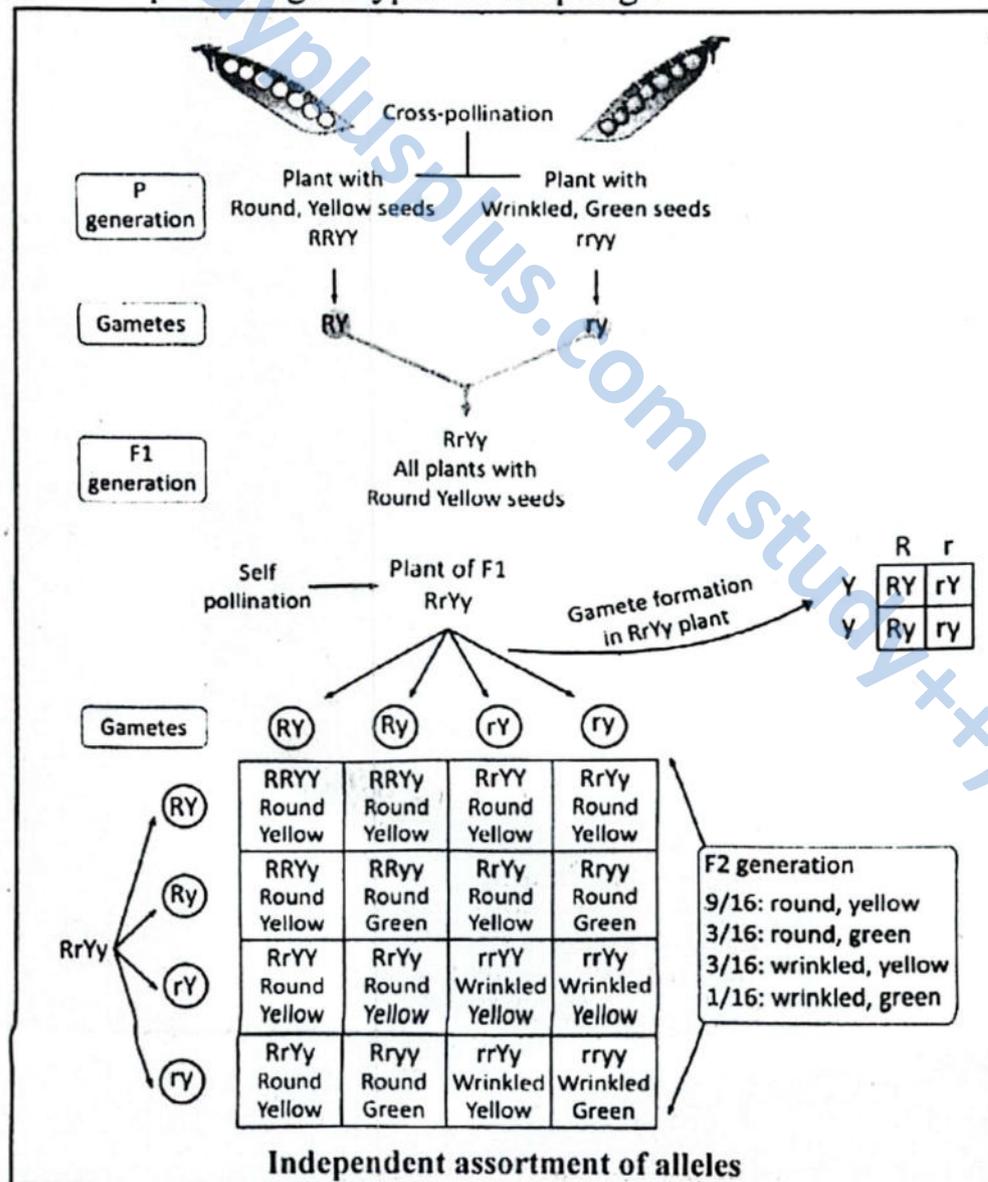
Ans. The laws of Gregor Mendel can help to predict progeny of two individuals when there is a situation where there is a dominant and a recessive relationship or blending inheritance, incomplete dominance or sex linkage. However, when a trait is due to multifactorial inheritance and is a polygenic trait, prediction becomes less precise due to additive effects of multiple genes as well as environmental components.

However, when two individuals are crossed in a dominant/ recessive situation,

only one dominant gene is needed in the offspring to produce a phenotype that displays the trait. Two recessive alleles would be needed for the recessive trait to appear.

For example, purple flowers and white flowers were crossed. In F_1 generation, all plants made purple flowers. After self-pollination in F_1 purple flowers, the F_2 generation had 75% plants with purple flowers and 25% plants with white flowers. Similarly in blending inheritance, as in Japanese four O clock plant, when red flowered plant is crossed with white flowered plant. In F_1 generation, all plants made pink flowers. After self-pollination in F_1 pink flowers, the F_2 generation shows phenotypes of red, pink and white flowers in the ratio 1:2:1.

The Punnett square is a diagram that is used to predict an outcome of a particular cross or breeding experiment. The gametes of both parents having all possible genetic set-ups are determined. A checker board is used to cross all the possible gametes of one parent with all the gametes of other parent. In this way, a biologist can find all the possible genotypes of offsprings.



8. Describe the effects of environment that lead to the selection of a variant which is more adapted to it.

Ans. Almost every population contains several variations for the characteristics of its members. In other words, there are morphological and physiological variations in all populations.

Different populations face different environments and they have to adopt to different conditions. Natural selection is the process by which the better genetic variations become more common in successive generations of a population. Environmental factors such as climate, diet, culture and lifestyle also produce variations. In natural selection the environment selects or rejects variations.

In England, the moths had two variations i.e. dark and white coloured moths. The moths used to rest on the light coloured tree trunks (on which white lichens had grown). In the 19th century when industries were established in England, the lichens on tree trunks died (due to polluted air) and the naked tree trunks turned dark. Now the white moth variation became harmful because a white moth resting on a dark tree trunk was easily visible to the predatory birds. The natural selection selected dark moths to reproduce. In this way dark coloured moth became more common and at last the white moths disappeared from population.

In this case, the dark colour variation in moth may be considered an adaptation to environment.

SOLVED EXERCISE

A. Select the correct answers for the following questions.

1. Chromosomes are made of;

- a) DNA only b) proteins c) RNA and proteins d) DNA and proteins

2. The central dogma of molecular biology is best represented by

- a) DNA + RNA = Protein b) DNA \rightarrow RNA + Protein
c) DNA \rightarrow RNA \rightarrow Protein d) Protein \rightarrow RNA \rightarrow DNA

3. What happens during transcription?

- a) a new protein is made b) mRNA attaches to a ribosome,
c) a new copy of DNA is produced d) mRNA is made

4. In peas, allele for purple flower (P) is dominant over the allele for white flower (p). If a white flower is crossed with a heterozygous purple flower (Pp), what will be the ratio of offspring?

- a) 100% purple b) 75% purple & 25% white
c) 50% purple & 50% white d) 100% white



5. What is the relationship between the I^A and I^B alleles of human blood group system?
- a) complete dominance b) co-dominance
c) incomplete dominance d) none of the above
6. What is the term for the inheritance where an individual has an intermediate phenotype between the two parents?
- a) complete dominance b) co-dominance
c) incomplete dominance d) none of the above
7. The allele that is expressed, when two different alleles are present;
- a) dominant b) recessive c) homozygous d) heterozygous
8. What are the possible genotypes of the parents of homozygous recessive individual?
- a) homozygous dominant b) homozygous recessive
c) heterozygous d) both 'b' and 'c'
9. A population of worms has two variations, i.e. black worms and pink worms. A predator moves into the area that eats only pink worms. What will happen to the worm population overtime?
- a) the population will consist of more black worms than pink worms
b) the population will consist of more pink worms than black worms
c) the whole population will go extinct
d) the population will not change
10. Artificial selection is similar to natural selection because;
- a) environmental conditions play role in both
b) both occur over millions of years
c) both are carried out by humans
d) both depend upon variations among individuals

ANSWERS

1. DNA and proteins 2. DNA → mRNA → Protein 3. mRNA is made
4. 75% purple & 25% white 5. co-dominance 6. incomplete dominance
7. dominant 8. both 'b' and 'c'
9. the population will consist of more black worms than pink worms
10. both depend upon variations among individuals

B. Give short answers.

1. Differentiate genes from alleles.

Ans. Gene: A gene is a segment of DNA that contains the information for a hereditary character.

Example: Gene for eye colour, gene for earlobe shape and a gene for the hair texture.



Alleles: The different forms (variants) of a gene called its alleles.

Examples: The gene of hair colour can have two alleles. One allele makes hair pigments while the other does not make pigments.

2. **What do you mean by a true-breeding plant?**

Ans. True-breeding Plant: If a plant with a characteristic produces offspring with the same characteristic on self-pollination; it means that the plant is true-breeding for that characteristic.

Example: When a true-breeding tall plant self-pollinates, it will always produce tall plants.

3. **What do you mean by P, F1 and F2 generations?**

Ans. 'P' means P generation (True-breeding parents)

'F1' means F1 generation (First filial generation)

'F2' means F2 generation (second filial generation)

4. **Define the terms dominant and recessive.**

Ans. Dominant Allele: In the heterozygous condition, one allele masks or prevents the expression of the other, it is called dominant allele.

The dominant alleles are represented by capital letters.

Recessive Allele: The allele which is not expressed is called recessive allele.

The recessive allele is represented by small letters.

5. **Differentiate between homozygous and heterozygous.**

Ans. Homozygous: When a gene pair has both the same alleles, the genotype is homozygous.

Heterozygous: The genotype, in which the gene pair has different alleles, is called heterozygous.

6. **Write down the alleles in the gametes of a plant, which has genotype RrYy.**

Ans. The alleles in the gametes of a plant, which has genotype RrYy are as follows:

The allele for round seeds is R. It is dominant allele.

The allele for wrinkled seeds is r. It is recessive allele.

The allele for yellow seed is Y. It is dominant allele.

The allele for green seed is y. It is recessive allele.

7. **State Mendel's law of segregation.**

Ans. Mendel's Law of Segregation: Mendel's law of segregation states that "the paired genes (alleles) are separated during gamete formation and each gamete receives one or the other allele, but not both."

8. **State Mendel's law of independent assortment.**

Ans. Mendel's Law of Independent Assortment: Mendel's law of independent assortment states that:



"Alleles separate independently of one another during the formation of gametes."

9. **Write the difference between a monohybrid cross and a dihybrid cross and give an example of each.**

Ans. Monohybrid Cross: The cross in which only one characteristic is studied is called monohybrid cross.

Example: Mendel crossed a true-breeding tall plant with a true-breeding short plant. He called these true-breeding parents as P generation and the offspring of the cross as first filial generation or F1 generation. All offspring in F1 were tall plants.

Next, Mendel allowed the tall plants of F1 generation to self-pollinate. He noted that 75% of the offspring (called the F2 generation), were tall, while 25% were short.

Dihybrid Cross:

The cross in which the inheritance of two characteristics is studied at a time is called dihybrid cross.

Mendel chose to study the characteristics of seed shape (round or wrinkled) and seed colour (yellow or green). He first grew true-breeding varieties of plants, which differed in these two characteristics. One plant had round yellow seeds and the other had wrinkled green seeds.

Mendel crossed these true-breeding plants. All the plants of the F1 generation had round yellow seeds. It proved that the allele for round seeds (R) is dominant while the allele for wrinkled seeds (r) is recessive. Similarly, the allele for yellow seeds (Y) is dominant while the allele for green seeds (y) is recessive. All the F1 plants were heterozygous (RrYy) for both characteristics.

Mendel allowed self-pollination in the F1 plants and got the F2 generation. The F2 generation had the following four phenotypes:

- 9/16 that have round, yellow seeds (genotypes: RRYy, RRyy, RrYY, and RrYy)
- 3/16 that have round, green seeds (genotypes: RRyy and Rryy)
- 3/16 that have wrinkled, yellow seeds (genotypes: rrYY and rrYy)
- 1/16 that have wrinkled, green seeds (genotype: rryy)

10. **What is the inheritance pattern where both alleles are expressed?**

Ans. In co-dominance, both the alleles of a gene are completely expressed in a heterozygous offspring.

In co-dominance, neither allele is dominant or recessive. In co-dominance, the phenotype of heterozygous offspring represents the phenotypes of both parents. Here, both alleles make their characteristics independently.

11. Use the information about the ABO blood group system and complete the following table:

Ans.

Genotype	Phenotype
I ^A I ^A	Blood Group A
I ^A I ^A or I ^A i	Blood Group A
I ^B I ^B or I ^B i	Blood Group B
I ^B i	Blood Group B
I ^A I ^B	Blood Group AB
ii	Blood Group O

12. Differentiate between continuous and discontinuous variations.

Ans. **Continuous Variation:** In continuous variations, the phenotypes show complete range of measurement from one extreme to another.

These variations are minor differences. They may be due to differences in genes or due to the influence of environment.

Examples: Human height, human skin colour, size of feet, body weight etc. are examples of continuous variations.

Discontinuous Variations: Discontinuous variations show distinct phenotypes. Such variations are large and prominent. They are due to genetic differences.

Examples: Human blood group (A, B, AB and O) ear shape (free earlobe or attached earlobe) and tongue rolling (some people can roll their tongue and other cannot) are examples of discontinuous variations.

13. What are the key differences between natural selection and artificial selection?

Ans. **Difference between Natural Selection and Artificial Selection:**

The key *difference* between natural selection and artificial selection is this that in artificial selection, humans favour specific traits while in natural selection the environment selects or rejects variations.

14. List the steps in the process of natural selection.

Ans. **Steps in the process of natural selection:** Natural selection works in three steps:

- (i) All species have capacity to produce excessive numbers of offspring. But in nature, resources are limited. The production of more individuals leads to a **struggle for existence (competition)** among the individuals of population.
- (ii) **Variations** exist among individuals in a population. Some variations are more adapted to the environment. In the competition for environmental resources, the individuals with better variations are more successful. It means that better variations are selected.

(iii) The selected variations have genetic basis and so these are passed on to the next generations. When this process repeats over many generations, each new generation has a higher proportion of individuals with the better variations.

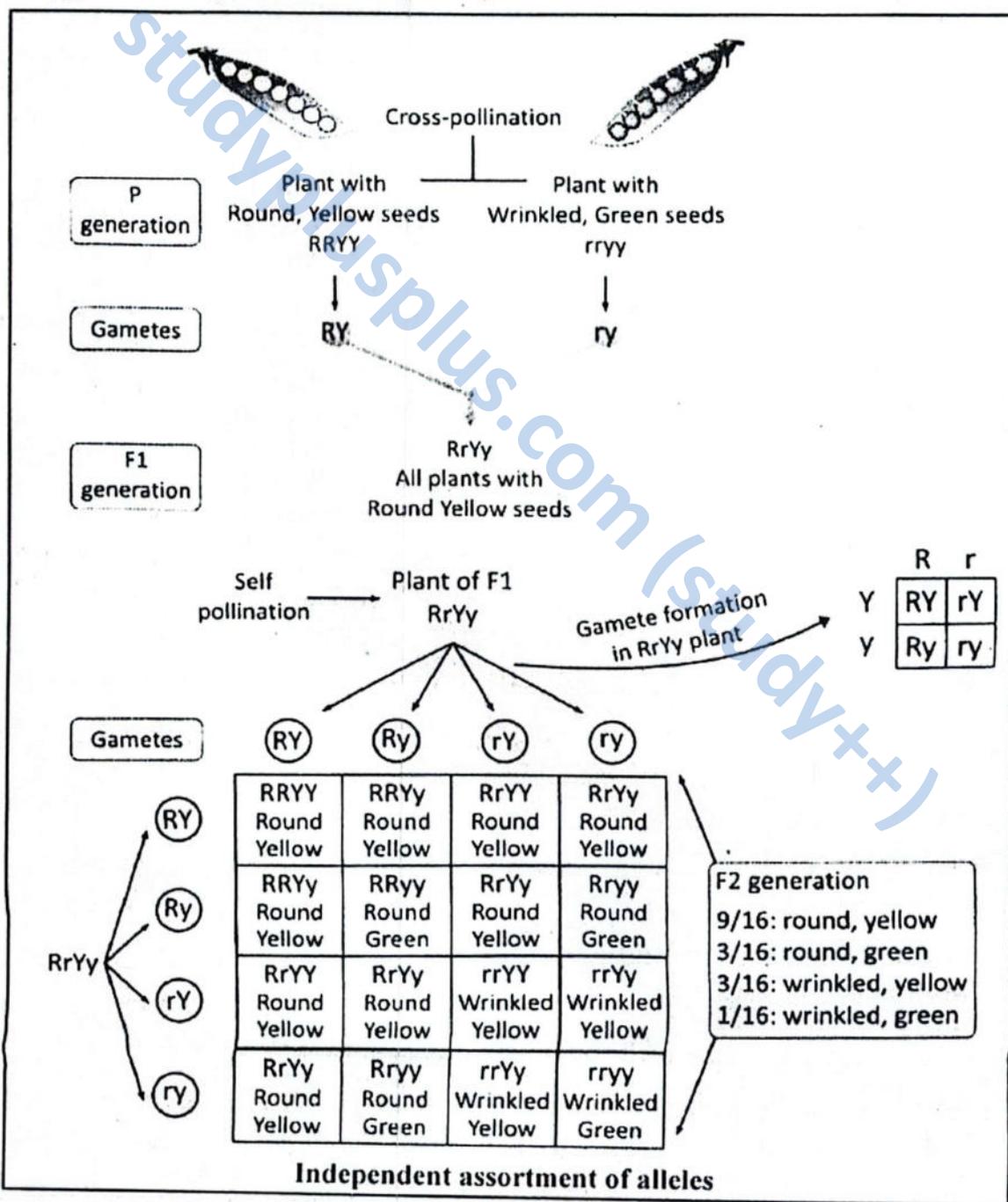
15. What is the goal of artificial selection?

Ans. The goal of artificial selection is:

- (i) Increase the production of meat, milk, egg, wool etc.
- (ii) Get plant varieties (cultivars) for better quantity and quality of food.

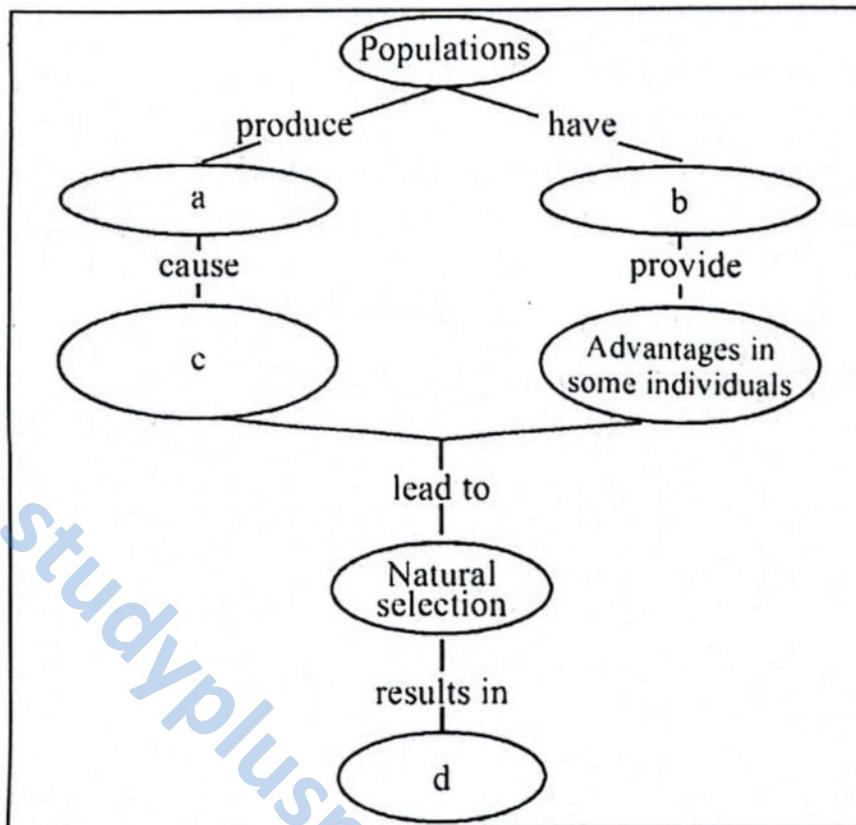
16. Draw a cross between two pea plants. One of them has round green seeds (RRyy) while the other has wrinkled yellow seeds (rrYY).

Ans. A cross between two pea plants one having round green seeds (RRyy) and other having wrinkled yellow seeds (rrYY) is as follows:



17. Complete the following concept map.

Ans.



- (a) More offspring/ large number of individuals (b) Better variation
(c) Offspring/ individuals with less useful variation (d) Evolution

C. Give answers in detail.

1. Relate the structure of chromosome with DNA and gene. Also draw a concept chart to explain your answer.

Ans. For answer see Question No. 2, 3

2. Why did Mendel select peas as a model for studying genetics? Explain your answer.

Ans. For answer see Question No. 5

3. Explain Mendel's experiment in which he studied the inheritance of two characteristics. State the law which he concluded at the end.

Ans. For answer see Question No. 6

4. Explain incomplete dominance with the help of an example.

Ans. For answer see Question No. 8

5. If father's blood group is B and mother's blood group is A, is it possible that their child can have blood group O? Explain your response.

Ans. If father's blood group is B and the mother's blood group is A, it is possible the child will have any of A, B, AB or O blood group.

It is because the blood antigen phenotype is determined by more than one gene. If mother has $I^A i$ genotype and father has $I^B i$ genotype, their I^A and I^B alleles are

codominant while i allele is recessive. The I^A allele produces antigen A and I^B allele produces antigen B and i allele is actually non-functional which does not work.

So both parents will contribute their recessive allele to their child and he or she will have O type blood group.

6. Explain the theory of natural selection. How the existence of variations is a necessary condition for evolution?

Ans. For answer see Question No. 12

Objective Type Questions

15.1 Introduction to Genetics

15.2 Chromosomes and Genes

15.3 Mendel's Laws of Inheritance

○ Choose the correct option.

- The process by which characteristics are transferred from parents to offspring is called:
(a) transcription (b) inheritance (c) genetics (d) translation
- The branch of biology for studying how characteristics are transmitted from parents to offspring is called:
(a) biotechnology (b) genetics (c) biochemistry (d) embryology
- When a cell is not dividing its chromatin is in the form of fine thread, scattered in the:
(a) vacuole (b) cytoplasm (c) nucleus (d) cell membrane
- A point where the two chromatids of a chromosome are attached is called the:
(a) centromere (b) allele (c) loci (d) nucleus
- In prokaryotes, only one chromosome made of DNA molecule not bounded by a nuclear envelop is present in:
(a) nucleus (b) cytoplasm (c) vacuole (d) ribosome
- It is a segment of DNA that contains the information for a hereditary character:
(a) allele (b) chromatid (c) gene (d) histone
- Genes are located on:
(a) alleles (b) chromosomes (c) chromatid (d) centromere
- Genes are transferred to the next generation through:
(a) gametes (b) zygote (c) embryo (d) all of these

9. The alternate (different) forms of a gene are called its:
 (a) chromatid (b) chromosome (c) allele (d) a and b
10. The combination of the alleles of a gene pair is called:
 (a) phenotype (b) genotype (c) homozygous (d) heterozygous
11. When a gene pair has both the same allele, the genotype is:
 (a) homozygous (b) heterozygous (c) a and b (d) none of these
12. The genotype, in which the gene pair has different alleles, is called:
 (a) homozygous (b) heterozygous (c) a and b (d) none of these
13. The allele which masks the working of the other allele, is called the:
 (a) dominant allele (b) recessive allele (c) homozygous (d) heterozygous
14. The allele which is not expressed, is called the:
 (a) recessive allele (b) heterozygous (c) homozygous (d) dominant allele
15. A segment of DNA acts as a template for the synthesis of mRNA. This step is known as:
 (a) true-breeding (b) translation (c) transcription (d) monohybrid cross
16. Ribosome assembles amino acids according to the instructions.
 (a) translation (b) transcription (c) true-breeding (d) monohybrid cross
17. It is a cross in which only one characteristic is studied is called:
 (a) monohybrid cross (b) dominance
 (c) dihybrid cross (d) translation
18. It is a cross in which two characteristics are studied is called:
 (a) translation (b) dihybrid cross (c) monohybrid cross (d) transcription
19. Alleles separate independently of one another during the formation of gametes.
 (a) co-dominance (b) incomplete dominance
 (c) complete dominance (d) law of independent assortment
20. The relationship between two alleles, when the heterozygous offspring has a phenotype in between that of the parents, is known as:
 (a) incomplete dominance (b) law of independent assortment
 (c) translation (d) co-dominance

ANSWERS

- | | | | |
|--------------------------|----------------------|-----------------------------------|------------------|
| 1. inheritance | 2. genetics | 3. nucleus | 4. centromere |
| 5. cytoplasm | 6. gene | 7. chromosomes | 8. gametes |
| 9. allele | 10. genotype | 11. homozygous | 12. heterozygous |
| 13. dominant allele | 14. recessive allele | 15. transcription | 16. translation |
| 17. monohybrid cross | 18. dihybrid cross | 19. law of independent assortment | |
| 20. incomplete dominance | | | |

○ Write short answers of the following questions.

1. Define inheritance.

Ans. **Inheritance:** The process by which characteristics are transferred from parents to

offspring is called inheritance.

2. What is genetics?

Ans. The branch of biology for studying how characteristics are transmitted from parents to offsprings is called genetics.

3. What is chromosome?

Ans. Chromosome: Chromosome is a structure made of thread like chromatin material. Chromatin consists of DNA and special proteins called histones.

4. What is chromatid?

Ans. Chromatid: A chromosome consists of two identical halves. Each half of the chromosome is called a chromatid.

5. What is the difference between eukaryotic and prokaryotic chromosome.

Ans. Eukaryotic chromosome: In eukaryotes, in chromatin, a long molecule of DNA is wrapped around the bundles of histones.

Prokaryotic chromosome: In prokaryotes, there is only one chromosome which is made of a DNA molecule. It is not bounded by a nuclear envelope and is present in cytoplasm.

6. Define Loci.

Ans. Loci: The locations or positions of genes on chromosomes are known as loci.

7. What is gene?

Ans. Gene: A gene is a segment of DNA that contains the information for a hereditary character.

For example: Gene for eye colour, gene for earlobe shape, gene for the hair texture.

8. Define alleles.

Ans. Alleles: The alternate (different) forms of a gene are called alleles.

For example: The gene of hair colour can have two alleles. One allele makes hair pigments while the other does not make pigments.

9. Differentiate between genotype and phenotype.

Ans. Genotype: The combination of the alleles of a gene pair is called genotype.

Phenotype: The observable outcome of genotype, in the form of characteristic, is called phenotype.

10. Differentiate between homozygous and heterozygous.

Ans. Homozygous: When a gene pair has both the same alleles, the genotype is called homozygous.

Example: Both alleles of the eye colour gene are similar. It means that the genotype for eye colour is homozygous.

Heterozygous: The genotype, in which the gene pair has different alleles, is called heterozygous.

Example: The alleles of the ear shape gene have instructions for opposite characteristics. One allele makes free earlobes while the other allele makes attached earlobes. It means that the genotype for ear shape is heterozygous.

11. Differentiate between dominant allele and recessive allele.

Ans. Dominant Allele: The allele which masks the working of the other allele, is called the dominant allele.

Capital letters refer to dominant alleles.

Recessive Allele: The allele which is not expressed, is called recessive allele.

Lowercase letters refer to recessive alleles.

12. Define transcription.

Ans. Transcription: A segment of DNA acts as a template for the synthesis of mRNA. This step is known as transcription.

13. What is translation?

Ans. Translation: Ribosome assembles amino acids according to the instructions on mRNA. This step is called as translation.

14. What do you mean by central dogma?

Ans. Central Dogma: This concept of the working of a gene is called central dogma.

Representation: The Central dogma is represented as:



15. Who carried out the first quantitative studies of inheritance?

Ans. Gregor Mendel carried out the first quantitative studies of inheritance.

16. What do you mean by true-breeding?

Ans. True-breeding: If a plant with a characteristic produces offspring with the same characteristic on self-pollination, it means that the plant is true-breeding for that characteristic.

Example: When a true breeding tall plant self-pollinates, it will always produce tall plants.

17. Differentiate between monohybrid cross and dihybrid cross.

Ans. Monohybrid Cross: It is a cross in which only one characteristic is studied.

Dihybrid Cross: It is a cross in which inheritance of two characteristics is studied at a time.

18. State Mendel's law of segregation.

Ans. Mendel's Law of Segregation: This law is stated as:

"The paired genes (alleles) are separated during gamete formation and each gamete receives one or the other allele, but not both."

19. Write down Mendel's law of independent assortment.

Ans. Mendel's Law of Independent Assortment: This law states as:

"The alleles separate independently of one another during the formation of gametes."



20. What is complete dominance?

Ans. **Complete Dominance:** In complete dominance, homozygous dominant and heterozygous genotypes make the same phenotype.

For example: Both TT and Tt pea plants were tall.

21. Which are two deviations in the rule of dominance?

Ans. The two-deviations in the rule of dominance are as follows:

- Incomplete Dominance
- Co-dominance

22. Define incomplete dominance.

Ans. **Incomplete Dominance:** The relationship between two alleles, then the heterozygous offspring has a phenotype in between that of the parents, is known as incomplete dominance.

23. When does co-dominance occur? Give example of co-dominance.

Ans. **Co-dominance:** Co-dominance occurs when both alleles of a gene are completely expressed in a heterozygous offspring.

In co-dominance, neither allele is dominant or recessive.

Example: An example of co-dominance is ABO blood group system.

15.4 Variations and Evolution

○ Choose the correct option.

1. The differences among the members of the same species are called:

- (a) mutation (b) recombination
(c) variations (d) random pairing of gametes

2. Characteristics are made by:

- (a) chromosomes (b) genes
(c) alleles (d) environmental factors

3. Different _____ determine different characteristics.

- (a) alleles (b) chromosomes (c) variations (d) genes

4. Human height is an example of:

- (a) discontinuous variations (b) mutation
(c) continuous variations (d) recombination

5. These variations have minor differences:

- (a) discontinuous variations (b) continuous variations
(c) natural selection (d) artificial selection

6. These variations are large and prominent:

- (a) discontinuous variations (b) continuous variations
(c) natural selection (d) artificial selection

7. These variations are due to an influence of environment.

- (a) discontinuous variations (b) natural selection



- (c) artificial selection (d) continuous variations
8. **Which of the following is an example of discontinuous variations?**
(a) human blood (b) ear shape (c) tongue rolling (d) all of these
9. **It is a change in the gene that is passed on to offspring.**
(a) recombination (b) mutation
(c) continuous variation (d) natural selection
10. **It is the biggest source of variations.**
(a) random pairing of gametes (b) environmental factors
(c) mutation (d) recombination
11. **It is the reshuffling of genes.**
(a) recombination (b) mutation
(c) discontinuous variations (d) continuous variations
12. **It occur because each organism produces large numbers of gametes.**
(a) environmental factors (b) random pairing of gametes
(c) recombination (d) mutation
13. **The development of advance types of organisms from pre-existing types of organisms over time.**
(a) mutation (b) evolution (c) variation (d) recombination
14. **It is a change in the characteristics within a population, which is inherited from one generation to the next.**
(a) natural selection (b) evolution (c) variation (d) artificial selection
15. **He proposed an idea to explain how evolution happens.**
(a) Charles Darwin (b) Jean Lamarck (c) Mendel (d) none of them
16. **He gave the theory of Natural selection.**
(a) Jean Lamarck (b) Mendel (c) Charles Darwin (d) all of them
17. **A process through which the individuals with better characteristics (variations) produce more surviving offspring than the individuals lacking these variations.**
(a) recombination (b) artificial selection
(c) natural selection (d) mutation
18. **It is the process in which humans breed selective varieties of plants and animals to produce plants and animals with the characteristics of choice.**
(a) cultivars (b) mutation (c) artificial selection (d) natural selection
19. **The varieties of animals which are artificially bred are called:**
(a) cultivars (b) breeds (c) recombination
(d) random pairing of gametes
20. **The varieties of plants which are bred are known as:**
(a) mutation (b) variations (c) cultivars (d) breeds

ANSWERS

- | | | | |
|-------------------------------|-----------------------------|--------------------------|--------------------------|
| 1. variations | 2. genes | 3. alleles | 4. continuous variations |
| 5. continuous variations | 6. discontinuous variations | 7. continuous variations | |
| 8. all of these | 9. mutation | 10. mutation | 11. recombination |
| 12. random pairing of gametes | 13. evolution | 14. evolution | |
| 15. Jean Lamarck | 16. Charles Darwin | 17. natural selection | |
| 18. artificial selection | 19. breeds | 20. cultivars | |

○ Write short answers of the following questions.

1. Define Variations.

Ans. The differences among the members of the same species are called variations.

2. Explain the reasons of variations.

Ans. 1. Some variations may be due to environmental factors.

2. Most variations are due to differences in the genetic make-up of organisms.

3. What are the types of variations?

Ans. The variations are of two types:

- Continuous variations
- Discontinuous variations

4. Define continuous variations. Give example.

Ans. **Continuous Variations:** In continuous variations, the phenotypes show complete range of measurement from one extreme to another. These variations are minor differences. These may be due to differences in genes or due to the influence of environment.

Examples: Human height, human skin colour, size of feet, body weight etc. are examples of continuous variations.

5. What are discontinuous variations? Give example.

Ans. **Discontinuous Variations:** Discontinuous variations show distinct-phenotypes. Such variations are large and prominent. They are due to genetic differences.

Examples: Human blood group, ear shape and tongue rolling.

6. State the sources of variations.

Ans. The following are the sources of variations:

- Mutation
- Recombination
- Random pairing of gametes
- Environmental factors

7. Define mutation.

Ans. **Mutation:** It is a change in the gene that is passed on the offspring. Mutations are the biggest source of variations.

8. What is recombination?

Ans. **Recombination:** It is the reshuffling of genes. It happens during gamete formation.

9. Why does random pairing of gametes occur?

Ans. The random pairing of gametes occurs because each organism produces large

numbers of gametes.

10. Which environmental factors do produce variation?

Ans. Environmental factors such as climate, diet, culture and lifestyle also produce variations.

11. Define evolution:

Ans. Evolution: The development of new types of organisms from pre-existing types of organisms overtime is called evolution (organic evolution)

OR A change in the characteristics within a population, which is inherited from one generation to the next is called evolution.

12. Who gave the theory of natural selection?

Ans. Charles Darwin (1809-1882) gave the theory of natural selection.

13. In which book the theory of Natural selection was published?

Ans. The theory of Natural selection by Charles Darwin was published in a book "On the origin of species by means of Natural selection" in 1859.

14. Explain the theory of Natural selection.

Ans. According to the theory of Natural selection, the inherited characteristics of a population change over time through natural selection. In other words, natural selection is the mechanism of evolution.

15. What is natural selection?

Ans. Natural Selection: Natural selection is the process through which the individuals with better characteristics (variations) produce more surviving offspring than the individuals lacking these variations.

16. Give an example of natural selection.

Ans. An example of Natural selection and evolution is the evolution of pesticide resistance in hundreds of insect species.

17. What are pesticides?

Ans. Pesticides are poisonous used to kill pests (harmful insects).

18. Define artificial selection.

Ans. Artificial selection: Artificial selection or selective breeding means the process in which humans breed selective varieties of plants and animals to produce plants and animals with the characteristics of choice.

19. Define breeds.

Ans. Breeds: The varieties of animals which are artificially bred are called breeds.

20. Define varieties or cultivars.

Ans. Varieties or cultivars: The varieties of plants which are bred are known as varieties or cultivars.

