BIOLOGY

PAPER & SOLUTION

Code : SS-42-BIO

Time : $3\frac{1}{4}$ Hours **M.M. 56**

General Instruction :

(1) Candidate must write first his/her Roll No. on the question paper compulsorily.

(2) All the questions are compulsory.

(3) Write the answer to each question in the given answer-book only.

(4) For questions having more than one part the answers to those parts are to be written together in continuity.

(5) If there is any error/ difference/ contradiction in Hindi and English versions of the question paper, the question of Hindi version should be treated valid.

(6)

Section	Q. Nos.	Marks per question
A	1-13	1
B	14-24	2
C	25-27	3
D	28-30	4

(7) Question Nos. 24, 27, 28, 29 and 30 have internal choices.

SECTION-A

Q.1 What are the morphologically and genetically alike individuals called ? **[1]**

Sol. Clones.

Q.2 Define embryogenesis. **[1]**

Sol. Embryogenesis refers to the process of development of embryo from the zygote. During embryogenesis, zygote undergoes cell division and cell differentiation.

Q.3 Write the importance of colostrum. **[1]**

Sol. The milk produced during the initial few days of lactation is called colostrum which contains several antibodies absolutely essential to develop resistance for the new born babies.

Q.4 Write the full form of IVF. **[1]**

Sol. IVF - In Vitro Fertilisation.

Q.5 Name any one Intra uterine device. **[1]**

Sol. Copper - T (Cu-T, Cu 7, Multiload 375)

Q.6 What is the genotype of person having klinefelter syndrome. **[1]**

Sol. XXY with 47 chromosomes.

Q.7 'Genetic code is unambiguous and specific.' Explain. **[1]**

Sol. Unambiguous and specific : - One codon codes for only one amino acid.

Q.8 Who propounded the biological evolution theory of use and disuse of organs. **[1]**

Sol. Jean Baptist de Lamarck.

Q.9 Mention the importance of blue - revolution . **[1]**

Sol. It results in the increase in the production of fish.

Q.10 How do ultraviolet rays coming from sun affect the living organisms. **[1]**

Sol. It may cause skin cancer, skin ageing, mutation & eye cataract in organisms.

Q.11 What are the illeffects of Algalblooms. **[1]**

Sol. Algalbloom imparts a distinct colour to the water bodies. Algalbloom causes deterioration of the water quality and fish mortality. Some bloom forming algae are extremely toxic to human beings & animals.

Q.12 Define Recombinant DNA. **[1]**

Sol. Recombinant DNA is formed by linking a foreign gene with a plasmid & is then transferred into the host so that DNA replicates and many copies of foreign gene can be obtained.

Q.13 The Bt toxin produced by Bt does not kill bacillus but kills insect. Why ? **[1]**

Sol. Because Bt toxin is inactive in bacillus but when insect ingests it, it becomes active due to the alkaline pH of the gut of the insect and causes the death of the insect.

SECTION-B

Q.14 What is spermiogenesis ? Demonstrate diagrammatically the process of spermatogenesis. **[1 + 1 = 2]**

Sol. The process by which spermatids are transformed into spermatozoa (sperms) is called as Spermiogenesis.

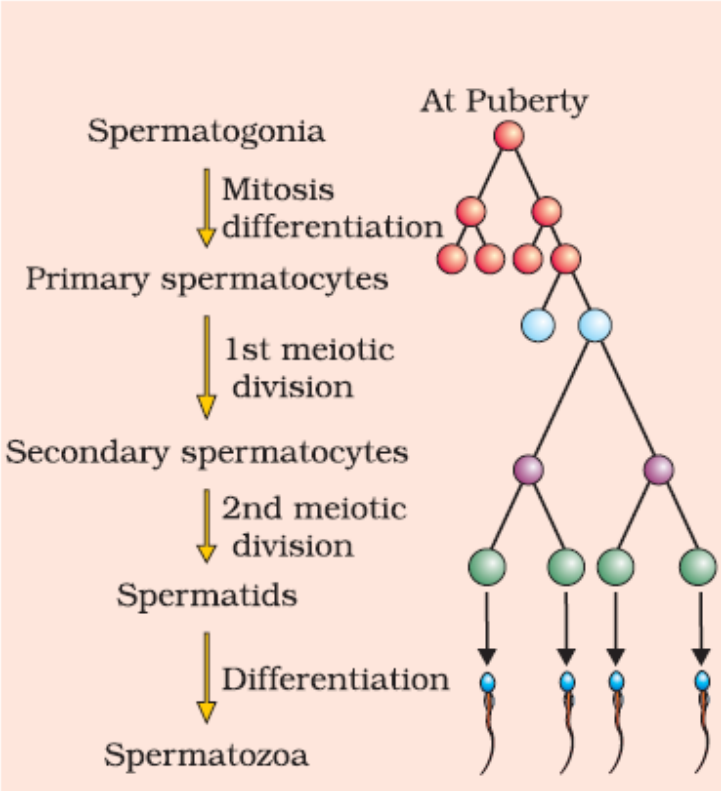


Fig.- Spermatogenesis

Q.15 What is transcription ? What are the different parts of a DNA transcription unit ? What is their role in the process of transcription ? **[½ +½ + 1 = 2]**

Sol. The process of copying genetic information from one strand of the DNA into RNA is called as TRANSCRIPTION.
Transcription Unit : - has 3 regions : -
(i) A promoter : - Start site of transcription.
(ii) The structural gene :- expressed as RNA
(iii) A Terminator : - end site of transcription.

Q.16 With the help of examples explain the process of biological evolution on the basis of morphological evidences. **[2]**

Sol. **Homologous organs :** - The structures which have same design and development but different functions are called HOMOLOGOUS ORGANS.

Eg : - (1) Forelimbs of Whales, Bats, Cheetah and human.

(2) Thorn and tendrils of Bougainvillea and Cucurbita.

Analogous Organs : - The structures which have different design and development but similar functions are called ANALOGOUS ORGANS.

Eg. : (1) Potato and Sweet Potato

(2) Wings of bats and insect

Q.17 Write down in sequence the main steps of plant breeding. What is its importance ? **[1 + 1 = 2]**

Sol. Plant Breeding is the purposeful manipulation of plant species in order to create desired plant types that are better suited to the cultivation, give better yields and are disease resistant.

Main steps : -

(1) Collection of Variability.

(2) Evaluation and selection of parents.

(3) Cross hybridisation among the selected parents.

(4) Selection and testing of superior recombinants.

(5) Testing, release and commercialisation of new cultivars.

Plant breeding results in the increase in production of grains which can feed the millions of people.

Q.18 What suggestion will you give a farmer to increase the productivity of his field ? Explain. **[2]**

Sol. **(i) To carry Plant Breeding : -**

Plant breeding is the purposeful manipulation of plant species in order to create desired plant types that are better suited for cultivation, give better yields and are disease resistant.

(ii) To carry Tissue Culture : -

Tissue Culture is the technique by which any cell, tissue or organ can be made to develop into many plants.

This method of producing thousands of plants through tissue culture is called **Micropropagation**.

Q.19 With reference to fermented beverages explain the role of microbes in Industrial products. **[2]**

Sol. Microbes especially yeasts have been used from time immemorial for the production of beverages like wine, beer, whisky, brandy or rum.

Yeast *Saccharomyces cerevisiae* is used for bread making and commonly called as brewer's yeast, is used for fermenting malted cereals and fruit juices to produce ethanol.

Wine and beer are produced without distillation whereas whisky, brandy and rum are produced by distillation.

Q.20 Explain carbon cycle in ecosystem. Give a linear diagram of carbon cycle. **[1½ + ½ = 2]**

Sol.

- C constitutes 49 percent of dry weight of organisms.
- 71% C is found dissolved in oceans.
- 4×10^{13} kg of carbon is fixed in the biosphere through photosynthesis, annually.
- Burning of wood, forest fires and combustion of organic matter, fossil fuel, volcanic activity are additional sources for releasing CO_2 in the atmosphere.

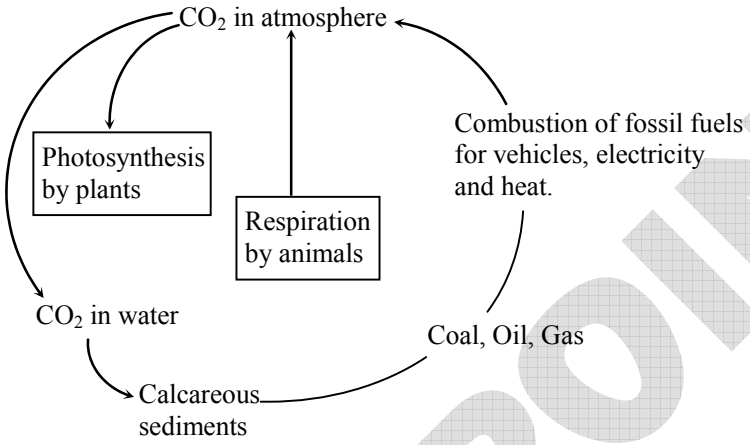


Fig. - Carbon Cycle

Q.21 What is adaptation ? Explain physiological adaptation taking an example of altitude illness. **[½ + 1½ = 2]**

Sol. Any attribute of the organism (morphological, physiological, behavioural) that enables the organisms to survive and reproduce in its habitat is called as **Adaptation**.

Physiological Adaptation : - At high altitude place (> 3500 m Rohtang Pass near Manali) we can experience **Altitude sickness**.

Its symptoms include nausea, fatigue and heart palpitations. This is because in the low atmospheric pressure of high altitudes, body does not get enough oxygen.

But gradually body get acclimatised and stop experiencing altitude sickness.

The body compensates low oxygen availability by increasing red blood cell production, decreasing the binding capacity of haemoglobin and by increasing breathing rate.

Q.22 Give four attributes of a population. Explain in detail the process of Mutualism. **[1 + 1 = 2]**

Sol. 4 attributes of population : -

(1) Population density.

(2) Birth Rate.

(3) Death Rate.

(4) Sex Ratio.

Mutualism is the symbiotic relationship where both the organisms are benefited.

eg. : - (i) Lichens is the symbiotic relationship of algae and fungi.

(ii) Mycorrhizae

(iii) Ophrys flower and bee.

Q.23 What is decomposition ? Write down its steps. Give a diagrammatic representation of decomposition cycle in a terrestrial ecosystem. **[½+½+1 = 2]**

Sol. The process of breakdown of complex organic matter into inorganic substance like carbon dioxide, water and nutrients is called as decomposition.

Its steps are : -

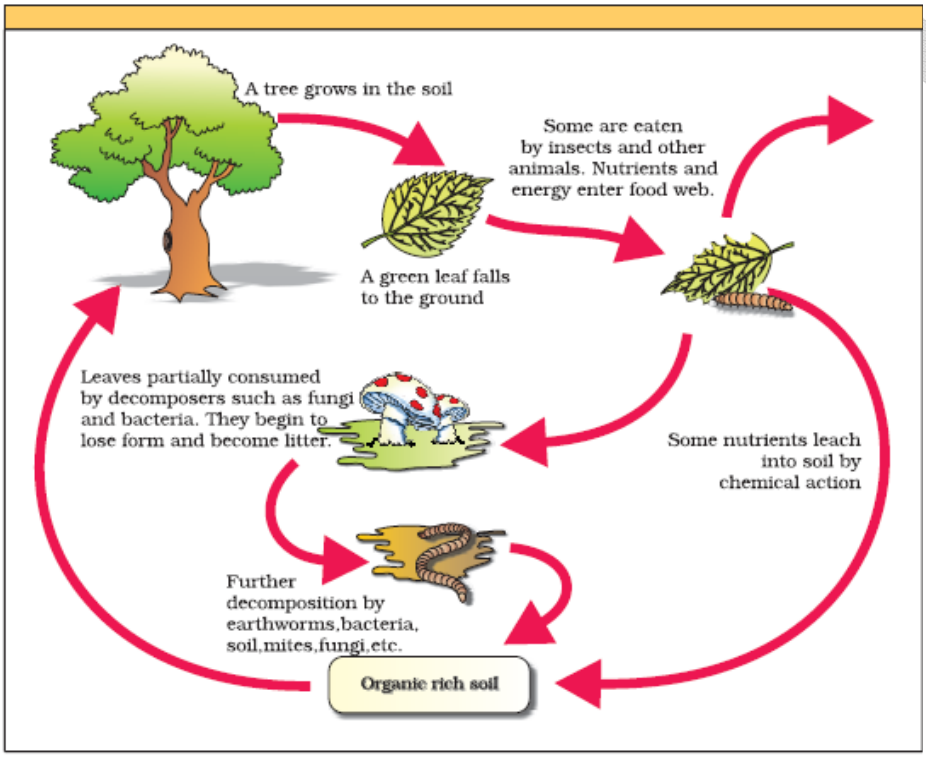
(1) Fragmentation

(2) Leaching

(3) Catabolism

(4) Humification

(5) Mineralisation



Diagrammatic representation of decomposition cycle in a terrestrial ecosystem

Q.24 Give four causes of loss in biodiversity. Explain the adverse effects on native species on invasion of Alien species in a habitat. **[1 + 1 = 2]**

OR

How is conservation of biodiversity done ? How will we conserve an animal to save it from extinction.

Sol. Four causes of loss in biodiversity : -

(i) Habitat loss and fragmentation

(ii) Over-exploitation

(iii) Alien species invasions

(iv) Co-extinctions

Alien species invasions : - When alien species are introduced unintentionally, some of them turn invasive, and causes decline or extinction of indigenous species. The Nile perch introduced into Lake Victoria in east Africa led eventually to the extinction of more than 200 species of cichlid fish in the lake.

OR

Conservation of biodiversity : -

(1) In situ conservation : - Animals are preserved and protected in their natural habitats.
India has 14 biosphere reserves, 90 national parks and 448 wildlife sanctuaries.

(2) Ex situ Conservation : - In this approach, threatened animals and plants are taken out from their natural habitats and placed in special setting where they can be protected and given special care.
Eg : - Zoological parks, botanical gardens and wildlife safari parks.
We can conserve an animal to save it from extinction by Ex. Situ Conservation.
Threatened species can be preserved by using cryopreservation techniques, eggs can be fertilised in vitro, and gametes can be stored etc.

SECTION-C

Q.25 How is the amplification of gene done using the technique of PCR ? Explain with the help of diagram. **[2+ 1 =3]**

Sol. PCR stands for **Polymerase Chain Reaction**.

In this reaction, multiple copies of gene of interest is synthesised in vitro using two sets of primers and the enzyme DNA polymerase.

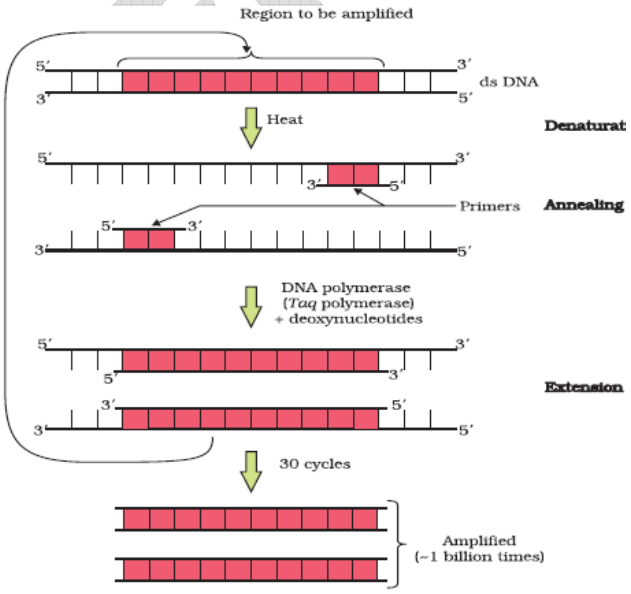
It has 3 steps : -

(1) Denaturation : - ds DNA is heated at 95ºC so that the two strands separate.

(2) Annealing : - Two sets of primers are added at the ends of the 2 strands of DNA.

(3) Extension : - The enzyme DNA polymerase extends the primers using the nucleotides.

If the process of replication repeated many times, 1 billion copies are made.



Polymerase chain reaction (PCR) : Each cycle has three steps:
(i) Denaturation; (ii) Primer annealing; and
(iii) Extension of primers

Q.26 What is the importance of biotechnology application in medicine ? How does biotechnology help in the production of human insulin. **[1 + 2 = 3]**

Sol. Biotechnology can be helpful in the production of α-1-antitrypsin protein to treat emphysema, human insulin, human growth hormone etc.

Genetically Engineered Insulin : -

Insulin consists of two short polypeptide chains: chain A and chain B, that are linked together by disulphide bridges.

When insulin is produced as pro-hormone it consists of an extra stretch C-peptide. In 1983, Eli Lilly an American company prepared two DNA sequences corresponding to A and B chains of human insulin. Chains A and B were produced separately, extracted and combined by creating disulfide bonds to form human insulin.

Q.27 'DNA is a genetic material'. Prove it with the help of Hershey - Chase experiment. Draw a linear diagram of the experiment. **[2 + 1 = 3]**

OR

'DNA replicates semiconservatively'. Prove it with the help of Matthew Meselson and Franklin stall experiment. Draw the linear diagram of the experiment.

Sol. The unequivocal proof that DNA is the genetic material came from the experiments of Alfred Hershey and Martha Chase (1952). They worked with viruses that infect bacteria called bacteriophages. The bacteriophage attaches to the bacteria and its genetic material then enters the bacterial cell. The bacterial cell treats the viral genetic material as if it was its own and subsequently manufactures more virus particles. Hershey and Chase worked to discover whether it was protein or DNA from the viruses that entered the bacteria. They grew some viruses on a medium that contained radioactive phosphorus and some others on medium that contained radioactive sulfur. Viruses grown in the presence of radioactive phosphorus contained radioactive DNA but not radioactive protein because DNA contains phosphorus but protein does not. Similarly, viruses grown on radioactive sulfur contained radioactive protein but not radioactive DNA because DNA does not contain sulfur.

Radioactive phages were allowed to attach to E. coli bacteria. Then, as the infection proceeded, the viral coats were removed from the bacteria by agitating them in a blender. The virus particles were separated from the bacteria by spinning them in a centrifuge.

Bacteria which was infected with viruses that had radioactive DNA were radioactive, indicating that DNA was the material that passed from the virus to the bacteria. Bacteria that were infected with viruses that had radioactive proteins were not radioactive. This indicates that proteins did not enter the bacteria from the viruses. DNA is therefore the genetic material that is passed from virus to bacteria.

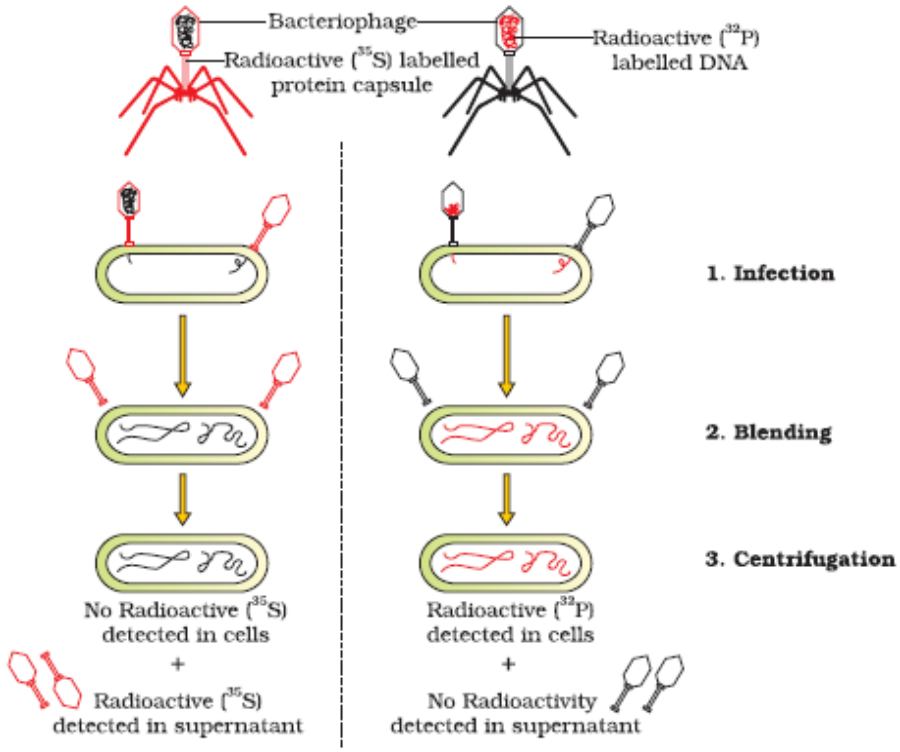


Fig. - The Hershey-Chase experiment

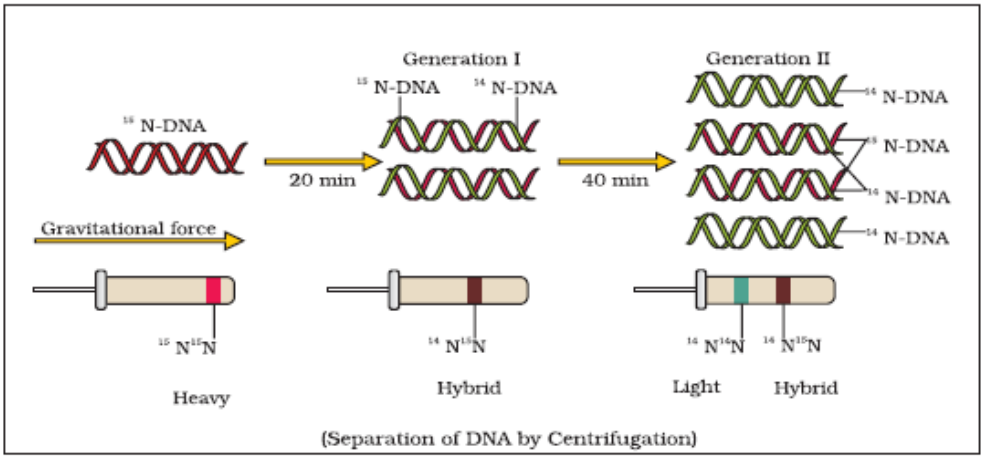
OR

Matthew Meselson and Franklin Stahl performed the following experiment in 1958:

(i) They grew *E. coli* in a medium containing $^{15}NH_4Cl$ (^{15}N is the heavy isotope of nitrogen) as the only nitrogen source for many generations. The result was that ^{15}N was incorporated into newly synthesised DNA (as well as other nitrogen containing compounds). This heavy DNA molecule could be distinguished from the normal DNA by centrifugation in a cesium chloride (CsCl) density gradient (Please note that ^{15}N is not a radioactive isotope, and it can be separated from ^{14}N only based on densities).

(ii) Then they transferred the cells into a medium with normal $^{14}NH_4Cl$ and took samples at various definite time intervals as the cells multiplied, and extracted the DNA that remained as double-stranded helices. The various samples were separated independently on CsCl gradients to measure the densities of DNA (Figure).

The results are shown in Figure.



Messelson and Stahl's Experiment

(iii) Thus, the DNA that was extracted from the culture one generation after the transfer from ^{15}N to ^{14}N medium [that is after 20 minutes; *E. coli* divides in 20 minutes] had a hybrid or intermediate density. DNA extracted from the culture after another generation [that is after 40 minutes, II generation] was composed of equal amounts of this hybrid DNA and of 'light' DNA.

If *E. Coli* was allowed to grow for 80 minutes then what would be the proportions of light and hybrid densities DNA molecule?

Very similar experiments involving use of radioactive thymidine to detect distribution of newly synthesised DNA in the chromosomes was performed on Vicia faba (faba beans) by Taylor and colleagues in 1958. The experiments proved that the DNA in chromosomes also replicate semiconservatively.

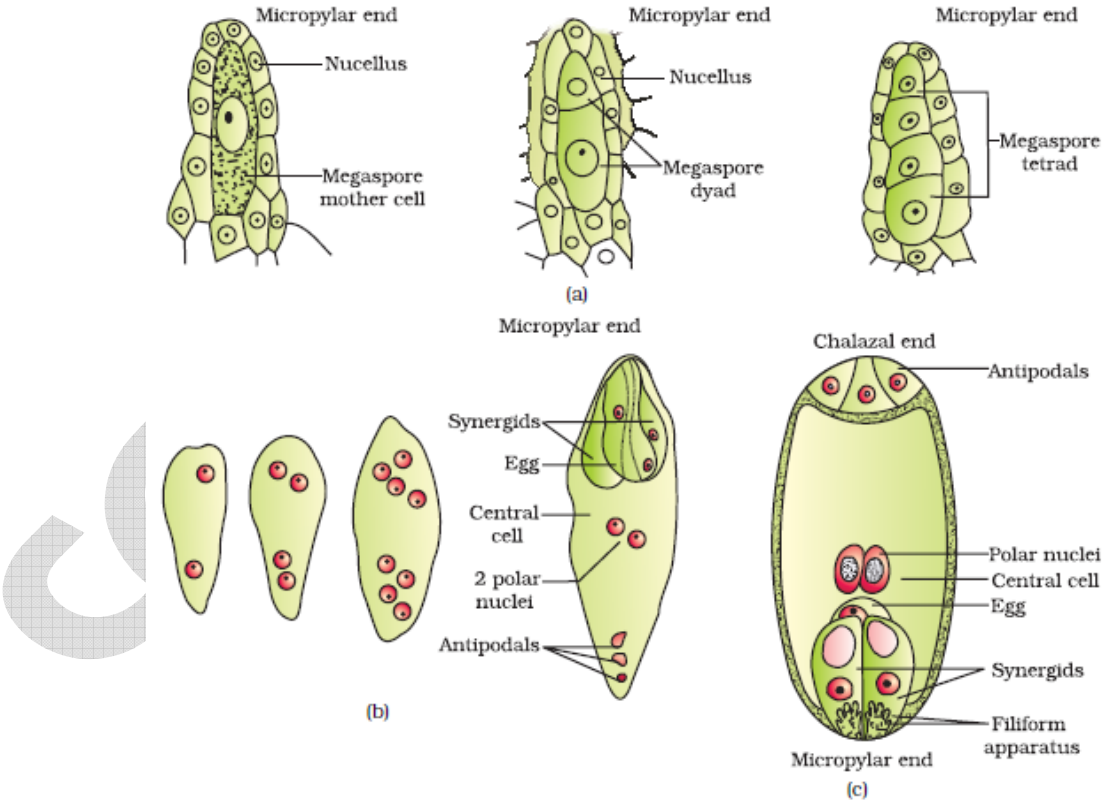
SECTION-D

Q.28 Explain in detail the process of development of female gametophyte. Draw diagram. **[3 + 1 = 4]**

OR

Explain the structure of microsporangium and write the functions of its different layers. Draw diagram of microsporangium showing wall layers.

Sol.



(a) Parts of the ovule showing a large megaspore mother cell, a dyad and a tetrad of megaspores; (b) 1,2, 4, and 8-nucleate stages of embryo sac and a mature embryo sac; (c) A diagrammatic representation of the mature embryo sac.

In a majority of flowering plants, one of the megaspores is **functional** while the other three degenerate. Only the **functional megaspore** develops into the **female gametophyte** (**embryo sac).** This method of embryo sac formation from a single megaspore is termed **monosporic** development.

The nucleus of the functional megaspore divides mitotically to form two nuclei which move to the opposite poles, forming the **2-nucleate** embryo sac. Two more sequential mitotic nuclear divisions result in the formation of the **4-nucleate** and later the **8-nucleate** stages of the embryo sac. It is of interest to note that these mitotic divisions are strictly free nuclear, that is, nuclear divisions are not followed immediately by cell wall formation. After the 8-nucleate stage, cell walls are laid down leading to the organisation of the typical **female gametophyte** or **embryo sac**. Observe the distribution of cells inside the embryo sac (Figure - b, c). Six of the eight nuclei are surrounded by cell walls and organised into cells; the remaining two nuclei, called polar nuclei are situated below the egg apparatus in the large **central cell.**

There is a characteristic distribution of the cells within the embryo sac. Three cells are grouped together at the micropylar end and constitute the **egg apparatus**. The egg apparatus, in turn, consists of two **synergids** and one **egg cell**. The synergids have special cellular thickenings at the micropylar tip called filiform apparatus, which play an important role in guiding the pollen tubes into the synergid. Three cells are at the chalazal end and are called the **antipodals**. The large central cell, as mentioned earlier, has two polar nuclei. Thus, a typical angiosperm embryo sac, at maturity, though **8-nucleate** is **7-celled**.

OR

Structure of microsporangium: In a transverse section, a typical microsporangium appears near circular in outline. It is generally surrounded by four wall layers (Figure)– the epidermis, endothecium, middle layers and the tapetum. The outer three wall layers perform the function of protection and help in dehiscence of anther to release the pollen. The innermost wall layer is the **tapetum.** It nourishes the developing pollen grains. Cells of the tapetum possess dense cytoplasm and generally have more than one nucleus.

When the anther is young, a group of compactly arranged homogenous cells called the **sporogenous tissue** occupies the centre of each microsporangium.

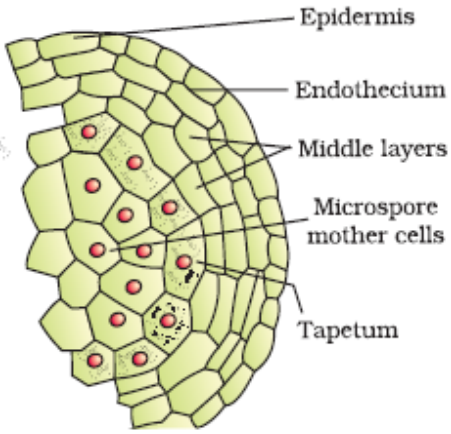


Fig.-Enlarged view of one microsporangium showing wall layers

Q.29 Describe AIDS disease on the basis of following points. **[½+½+1+1+1 = 4]**

(i) Name of pathogen

(ii) Test for confirmation of disease

(iii) Main symptoms of disease

(iv) Ways of prevention

(v) Diagram of replication of retrovirus.

OR

Describe Typhoid disease on the basis of following points -

(i) Name of pathogen

(ii) Test for confirmation of disease

(iii) Ways of infection

(iv) Main symptoms of disease

(v) Diagram showing structure of an antibody molecule.

Sol. (i) HIV → Human Immuno Deficiency virus.

(ii) ELISA Test → Enzyme linked Immuno Sorbent Assay.

(iii) Main symptoms : - Fever, diarrhoea, weight loss, hair loss, anaemia etc.

(iv) Ways of prevention : -

NACO → National AIDS Control Organisation and other NGO'S working to control Aids.

(i) Advocating safe sex.

(ii) Making blood in blood bank safe from HIV.

(iii) Free distribution of condoms.

(iv) Controlling Drug Abuse.

(v)

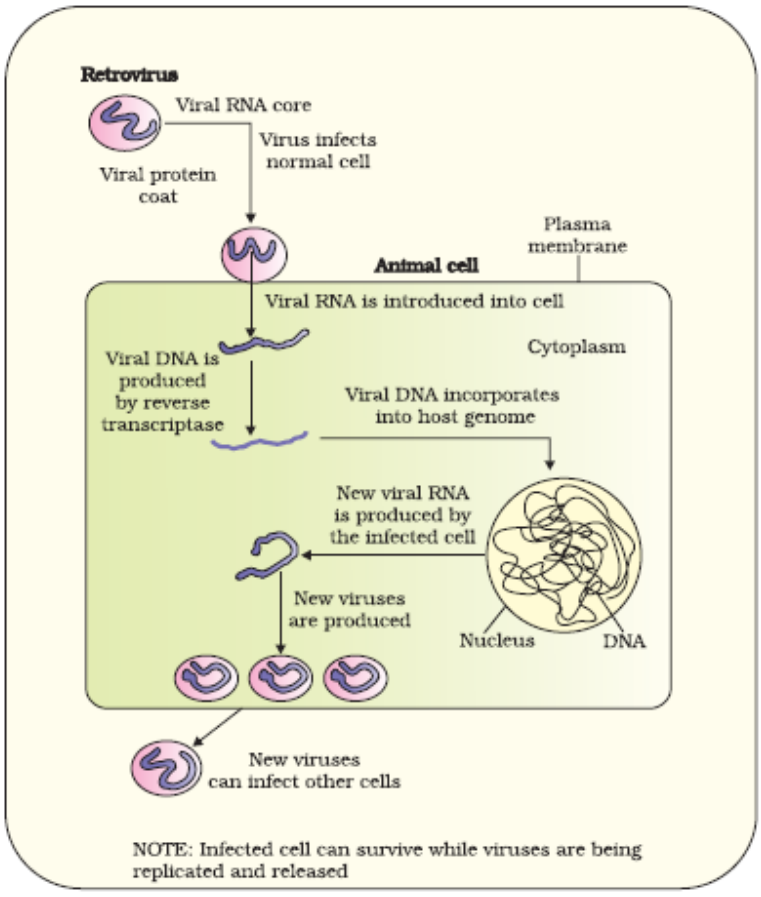


Fig. - Replication of retrovirus

OR

(i) Salmonella typhimurium.
(ii) Widol test
(iii) Through contaminated food and water
(iv) Main symptoms :

(i) Sustained high fever (39 to 40ºC) (ii) Weakness
(iii) Stomach pain (iv) Constipation
(v) Headache (vi) Loss of appetite

(v)

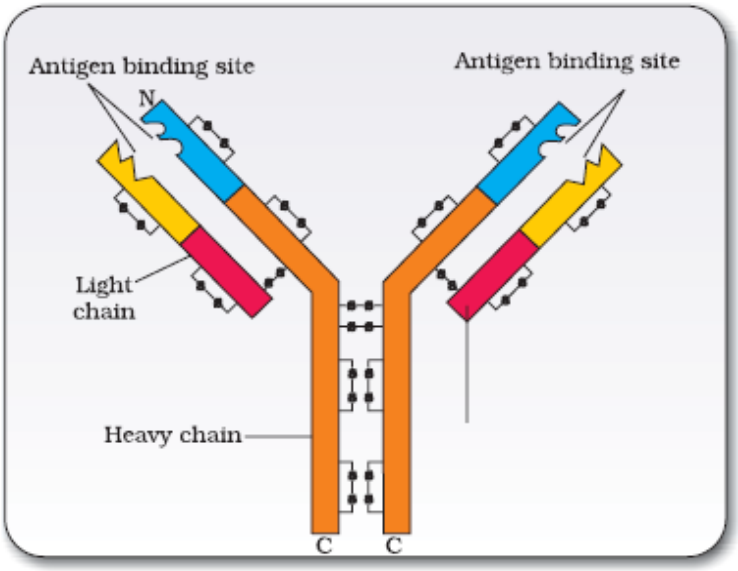


Fig. -Structure of an antibody molecule

Q.30 Explain Mendel's monohybridization experiment. Write the rules proposed on the basis of this experiment. Draw its diagram using punnet square. **[2 + 1 + 1 = 4]**

OR

What is co-dominance. Explain it through determination of blood groups in human. Draw a table showing the genetic basis of blood groups in Human population.

Sol. If we use alphabetical symbols for each gene, then the capital letter is used for the trait expressed at the F_1 stage and the small alphabet for the other trait. For example, in case of the character of height, ***T*** is used for the Tall trait and ***t*** for the 'dwarf', and ***T*** and ***t*** are alleles of each other. Hence, in plants the pair of alleles for height would be ***TT***, ***Tt*** or ***tt***. Mendel also proposed that in a true breeding, tall or dwarf pea variety the allelic pair of genes for height are identical or **homozygous**, ***TT*** and ***tt***, respectively. ***TT*** and ***tt*** are called the **genotype** of the plant while the descriptive terms **tall** and **dwarf** are the **phenotype**.

As Mendel found the phenotype of the F_1 heterozygote ***Tt*** to be exactly like the ***TT*** parent in appearance, he proposed that in a pair of dissimilar factors, one dominates the other (as in the F_1) and hence is called the **dominant** factor while the other factor is **recessive** . In this case ***T*** (for tallness) is dominant over ***t*** (for dwarfness), that is recessive. He observed identical behaviour for all the other characters/trait-pairs that he studied. It is convenient (and logical) to use the capital and lower case of an alphabetical symbol to remember this concept of dominance and recessiveness. (Do not use ***T*** for tall and ***d*** for dwarf because you will find it difficult to remember whether ***T*** and ***d*** are alleles of the same gene/character or not). Alleles can be similar as in the case of homozygotes ***TT*** and ***tt*** or can be dissimilar as in the case of the heterozygote ***Tt***. Since the ***Tt*** plant is heterozygous for genes controlling one character (height), it is a **monohybrid** and the cross between **TT** and **tt** is a **monohybrid cross**. From the observation that the recessive parental trait is

expressed without any blending in the F_2 generation, we can infer that, when the tall and dwarf plant produce gametes, by the process of meiosis, the alleles of the parental pair separate or **segregate** from each other and only one allele is transmitted to a gamete. This segregation of alleles is a random process and so there is a 50 per cent chance of a gamete containing either allele, as has been verified by the results of the crossings. In this way the gametes of the tall ***TT*** plants have the allele ***T*** and the gametes of the dwarf ***tt*** plants have the allele ***t***. During fertilisation the two alleles, ***T*** from one parent say, through the pollen, and ***t*** from the other parent, then through the egg, are united to produce zygotes that have one ***T*** allele and one ***t*** allele. In other words the hybrids have ***Tt***. Since these hybrids contain alleles which express contrasting traits, the plants are **heterozygous**. The production of gametes by the parents, the formation of the zygotes, the F_1 and F_2 plants can be understood from a diagram called **Punnett Square** as shown in Figure. It was developed by a British geneticist, Reginald C. Punnett. It is a graphical representation to calculate the probability of all possible genotypes of offspring in a genetic cross. The possible gametes are written on two sides, usually the top row and left columns. All possible combinations are represented in boxes below in the squares, which generates a square output form.

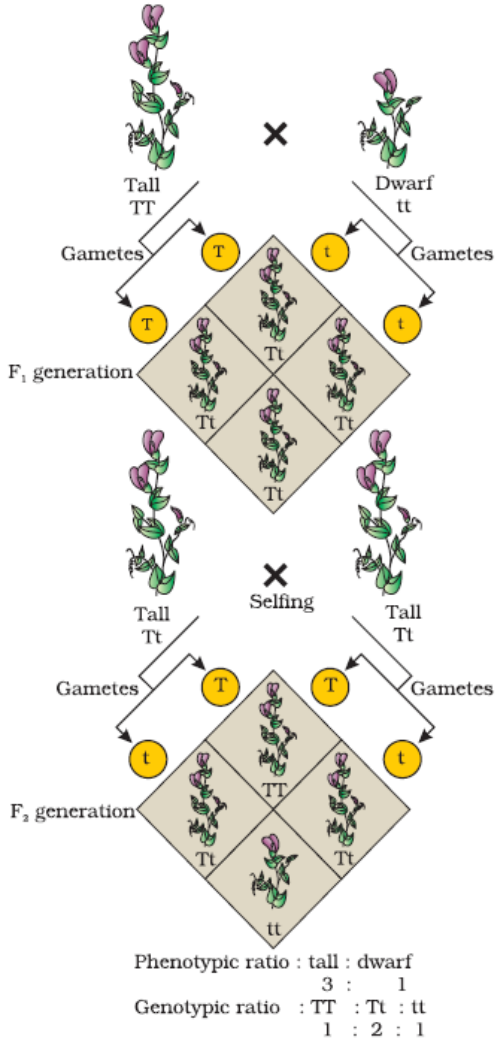


Fig. -A Punnett square used to understand a typical monohybrid cross conducted by Mendel between true-breeding tall plants and true-breeding dwarf plants

The Punnett Square shows the parental tall ***TT*** (male) and dwarf ***tt*** (female) plants, the gametes produced by them and, the F_1 ***Tt*** progeny. The F_1 plants of genotype ***Tt*** are self-pollinated. The symbols **&** and **%** are used to denote the female (eggs) and male (pollen) of the F_1 generation, respectively. The F_1 plant of the genotype ***Tt*** when self-pollinated, produces gametes of the genotype ***T*** and ***t*** in equal proportion. When fertilisation takes place, the pollen grains of genotype ***T*** have a 50 per cent chance to pollinate eggs of the genotype ***T***, as well as of genotype ***t***. Also pollen grains of genotype ***t*** have a 50 per cent chance of pollinating eggs of genotype ***T***, as well as of genotype ***t***. As a result of random fertilisation, the resultant zygotes can be of the genotypes ***TT***, ***Tt*** or ***tt.***

From the Punnet square it is easily seen that $1/4^{th}$ of the random fertilisations lead to ***TT***, 1/2 lead to ***Tt*** and $1/4^{th}$ to ***tt***. Though the F_1 have a genotype of **T*t***, but the phenotypic character seen is 'tall'. At F_2, $3/4^{th}$ of the plants are tall, where some of them are **TT** while others are ***Tt***. Externally it is not possible to distinguish between the plants with the genotypes ***TT*** and ***Tt***. Hence, within the genopytic pair ***Tt*** only one character '***T***' tall is expressed. Hence the character T or 'tall' is said to dominate over the other allele **t** or 'dwarf' character. It is thus due to this dominance of one character over the other that all the F_1 are tall (though the genotype is **T*t***) and in the F_2 $3/4^{th}$ of the plants are tall (though genotypically 1/2 are ***Tt*** and only $1/4^{th}$ are ***TT***). This leads to a phenotypic ratio of $3/4^{th}$ tall : (1/4 TT + 1/2 ***Tt***) and $1/4^{th}$ ***tt,*** i.e., a 3:1 ratio, but a genotypic ratio of 1:2:1.

The 1/4 : 1/2 : 1/4 ratio of ***TT***: ***Tt***: ***tt*** is mathematically condensable to the form of the binomial expression $(ax + by)_2$, that has the gametes bearing genes ***T*** or ***t*** in equal frequency of 1/2. The expression is expanded as given below : $(1/2T + 1/2\ t)^2 = (1/2T + 1/2t)\ X\ (1/2T + 1/2t) = 1/4\ TT + 1/2Tt + 1/4\ tt$

Law of Dominance :

(i) Characters are controlled by discrete units called **factors**.

(ii) Factors occur in pairs.

(iii) In a dissimilar pair of factors one member of the pair dominates (dominant) the other (recessive).

The law of dominance is used to explain the expression of only one of the parental characters in a monohybrid cross in the F_1 and the expression of both in the F_2. It also explains the proportion of 3:1 obtained at the F_2.

Law of Segregation : This law is based on the fact that the alleles do not show any blending and that both the characters are recovered as such in the F_2 generation though one of these is not seen at the F_1 stage. Though the parents contain two alleles during gamete formation, the factors or alleles of a pair segregate from each other such that a gamete receives only one of the two factors. Of course, a homozygous parent produces all gametes that are similar while a heterozygous one produces two kinds of gametes each having one allele with equal proportion.

OR

Till now we were discussing crosses where the F_1 resembled either of the two parents (dominance) or was in-between (incomplete dominance). But, in the case of co-dominance the F_1 generation resembles both parents. A good example is different types of red blood cells that determine ABO blood grouping in human beings. ABO blood groups are controlled by the gene ***I***. The plasma membrane of the red blood cells has sugar polymers that protrude from its surface and the kind of sugar is controlled by the gene. The gene **(*I*)** has three alleles I_A, I_B and ***i***. The alleles I_A and I_B produce a slightly different form of the sugar while allele i doesn't produce any sugar. Because humans are diploid organisms, each person possesses any two of the three ***I*** gene alleles. I_A and I_B are completely dominant over ***i***, in other words when I_A and *i* are present only I_A expresses (because *i* does not produce any sugar), and when I_B and *i* are present I_B expresses. But when I_A and I_B are present together they both express their own types of sugars: this is because of co-dominance. Hence red blood cells have both A and B types of sugars. Since there are three different alleles, there are six different combinations of these three alleles that are possible a total of six different genotypes of the human ABO blood types (Table).

Table Showing the Genetic Basis of Blood Groups in Human Population

Allele from Parent 1	Allele from Parent 2	Genotype of offspring	Blood types of offspring
I^A	I^A	$I^A I^A$	A
I^A	I^B	$I^A I^B$	AB
I^A	i	$I^A i$	A
I^B	I^A	$I^A I^B$	AB
I^B	I^B	$I^B I^B$	B
I^B	i	$I^B i$	B
i	i	$i\,i$	O

Do you realise that the example of ABO blood grouping also provides a good example of **multiple alleles**? Here you can see that there are more than two, i.e., three alleles, governing the same character. Since in an individual only two alleles can be present, multiple alleles can be found only when population studies are made. Occasionally, a single gene product may produce more than one effect. For example, starch synthesis in pea seeds is controlled by one gene. It has two alleles (**B** and **b**). Starch is synthesised effectively by **BB** homozygotes and therefore, large starch grains are produced. In contrast, bb homozygotes have lesser efficiency in starch synthesis and produce smaller starch grains. After maturation of the seeds, BB seeds are round and the bb seeds are wrinkled. Heterozygotes produce round seeds, and so **B** seems to be the dominant allele. But, the starch grains produced are of intermediate size in **Bb** seeds. So if starch grain size is considered as the phenotype, then from this angle, the alleles show incomplete dominance. Therefore, dominance is not an autonomous feature of a gene or the product that it has information for. It depends as much on the gene product and the production of a particular phenotype from this product as it does on the particular phenotype that we choose to examine, in case more than one phenotype is influenced by the same gene.