

CBSE Board
Class XII Biology
Board Paper 2014 – Outside Delhi (Set 2)

Time: 3 hrs

Total Marks: 70

General Instruction:

1. All questions are compulsory.
 2. This question paper consists of four Sections A, B C and D. Section A contains 8 questions of one mark each, Section B is of 10 questions of two marks each, Section C is of 9 questions of three marks each, and Section D is of 3 questions of five marks each.
 3. There is no overall choice. However an internal choice has been provided in one question of 2 marks, one question of 3 marks and all the three questions of 5 marks weight age. A student has to attempt only one of the alternatives in such questions.
 4. Wherever necessary, the diagrams drawn should be neat and properly labelled.
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SECTION A

1. Why is *Gambusia* introduced into drains and ponds? [1]
2. State Gause's Competitive Exclusion Principle. [1]
3. Name the enzymes that are used for the isolation of DNA from bacterial and fungal cells for recombinant DNA technology. [1]
4. State the role of C peptide in human insulin. [1]
5. Why is it not possible for an alien DNA to become part of a chromosome anywhere along its length and replicate normally? [1]
6. Why is secondary immune response more intense than the primary immune response in humans? [1]
7. Why are analogous structures a result of convergent evolution? [1]
8. Name the vegetative propagules in the following : [1]
(a) *Agave*
(b) *Bryophyllum*

SECTION B

9. List the symptoms of Ascariasis. How does a healthy person acquire this infection?[2]
10. Write the scientific name of the fruit-fly. Why did Morgan prefer to work with fruit-flies for his experiments? State any three reasons. [2]

OR

Linkage and crossing-over of genes are alternatives of each other. Justify with the help of an example.

11. State the difference between the structural genes in a Transcription Unit of Prokaryotes and Eukaryotes. [2]
12. In Snapdragon, a cross between true-breeding red flowered (RR) plants and true-breeding white flowered (rr) plants showed a progeny of plants with all pink flowers. [2]
- (a) The appearance of pink flowers is not known as blending. Why?
- (b) What is this phenomenon known as?
13. Write the location and functions of the following in human testes : [2]
- (a) Sertoli cells
- (b) Leydig cells
14. Construct an age pyramid which reflects an expanding growth status of human population. [2]
15. Describe the mutual relationship between fig tree and wasp and comment on the phenomenon that operates in their relationship. [2]
16. How have transgenic animals proved to be beneficial in : [2]
- (a) Production of biological products
- (b) Chemical safety testing
17. How does a restriction nuclease function? Explain. [2]
18. Explain the significant role of the genus *Nucleopolyhedrovirus* in an ecological sensitive area. [2]

SECTION C

19. Identify 'a', 'b', 'c', 'd', 'e' and 'f' in the table given below : [3]

No.	Syndrome	Cause	Characteristics of affected individuals	Sex Male/Female/Both
1.	Down's	Trisomy of 21	'a' (i) (ii)	'b'
2.	'c'	XXY	Overall masculine development	'd'
3.	Turner's	45 with XO	'e' (i) (ii)	'f'

20. Why is pedigree analysis done in the study of human genetics? State the conclusions that can be drawn from it. [3]

21. A woman has certain queries as listed below, before starting with contraceptive pills. Answer them. [3]

- (a) What do contraceptive pills contain and how do they act as contraceptives?
- (b) What schedule should be followed for taking these pills?

22. Make a list of any three out breeding devices that flowering plants have developed and explain how they help to encourage cross-pollination. [3]

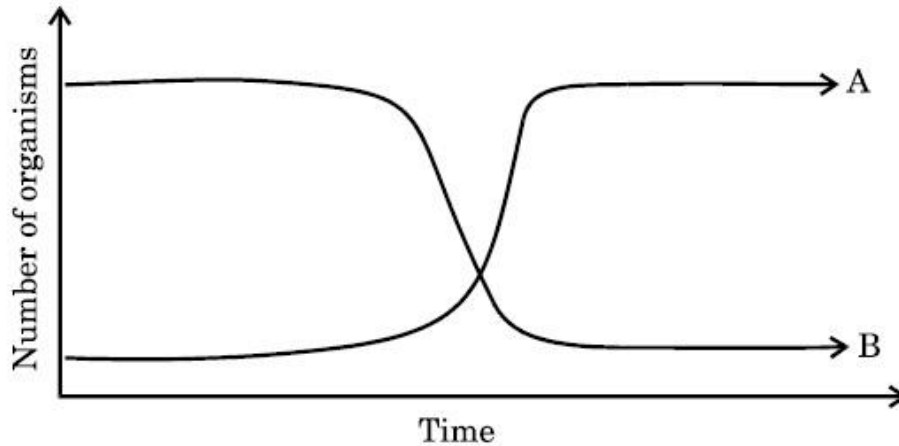
OR

Why are angiosperm anthers called dithecous? Describe the structure of its microsporangium.

23. Since the origin of life on Earth, there were five episodes of mass extinction of species. [3]

- (i) How is the 'Sixth Extinction', presently in progress, different from the previous episodes?
- (ii) Who is mainly responsible for the 'Sixth Extinction'?
- (iii) List any four points that can help to overcome this disaster.

24. Two types of aquatic organisms in a lake show specific growth patterns as shown below, in a brief period of time. The lake is adjacent to an agricultural land extensively supplied with fertilisers. [3]



Answer the questions based on the facts given above:

- Name the organisms depicting the patterns A and B.
- State the reason for the growth pattern seen in A.
- Write the effects of the growth patterns seen above.

25. Name and describe the technique that helps in separating the DNA fragments formed by the use of restriction endonuclease. [3]

26. Explain, giving three reasons, why tropics show greatest levels of species diversity. [3]

27. Community Service department of your school plans a visit to a slum area near the school with an objective to educate the slum dwellers with respect to health and hygiene. [3]

- Why is there a need to organise such visits?
- Write the steps you will highlight, as a member of this department, in your interaction with them to enable them to lead a healthy life.

SECTION D

28. Describe the Hershey and Chase experiment. Write the conclusion drawn by the scientists after their experiment.

[5]

OR

Work out a typical Mendelian dihybrid cross and state the law that he derived from it.

29. With advancements in genetics, molecular biology and tissue culture, new traits have been incorporated into crop plants.

Explain the main steps in breeding a new genetic variety of a crop. [5]

OR

- (a) State the objective of animal breeding.
- (b) List the importance and limitations of inbreeding. How can the limitations be overcome?
- (c) Give an example of a new breed each of cattle and poultry.

30. [5]

- (a) Where does fertilization occur in humans? Explain the events that occur during this process.
- (b) A couple where both husband and wife are producing functional gametes, but the wife is still unable to conceive, is seeking medical aid. Describe any one method that you can suggest to this couple to become happy parents.

OR

- (a) Explain the different ways apomictic seeds can develop. Give an example of each.
- (b) Mention one advantage of apomictic seeds to farmers.
- (c) Draw a labelled mature stage of a dicotyledonous embryo.

CBSE
Class XII Biology (Theory)
Board Paper 2014 – Outside Delhi (Set 2)
SOLUTION

Time: 3 hrs

Total Marks: 70

SECTION A

1. **Ans.** *Gambusia* is a natural enemy of larva and pupa of mosquitoes as it feeds upon them and thus helps control the breeding of mosquitoes. So, it is introduced into drains and ponds.
2. **Ans.** Gause's competitive exclusion principle states that two closely related species competing for the same resources cannot co-exist indefinitely and the competitively inferior will be eliminated eventually.
3. **Ans.** Lysozyme is used for the isolation of DNA from bacterial cells and chitinase is used for the isolation of DNA from fungal cells.
4. **Ans.** Mammalian insulin is synthesised as a prohormone which undergoes processing to become a fully mature and functional insulin molecule. The prohormone contains an extra chain called C peptide which is removed during the conversion of prohormone to the mature hormone, insulin.
5. **Ans.** It is not possible for an alien DNA to become part of a chromosome anywhere along its length and replicate normally because the replication process begins at a particular spot called the origin of replication. Also, replication in eukaryotes occurs in the nucleus during the S phase of the cell cycle when the chromosomes are in their extended form.
6. **Ans.** The secondary immune response is more intense than the primary immune response in humans because the memory B cells deal with the invading microbes by producing antibodies. The cells of the body remember that they have previously encountered this type of infection.
7. **Ans.** Analogous structures are the result of convergent evolution as they have arisen in the evolutionary process through adaptation of quite different organisms to a similar mode of life.
8. **Ans.**
 - (a) Bulbil of Agave
 - (b) Leaf bud of *Bryophyllum*

SECTION B

9. **Ans.** Symptoms of Ascariasis:

- (i) Abdominal discomfort
- (ii) Colic pain
- (iii) Fever
- (iv) Indigestion
- (v) Diarrhoea
- (vi) Vomiting

A healthy human being may acquire this infection directly and orally. It can occur through contaminated water, vegetables and fruits.

10. **Ans.** The scientific name of fruit fly is *Drosophila melanogaster*. Morgan preferred to work with fruit fly for his experiments because

- (i) It is simple and convenient to breed under laboratory conditions throughout the year.
- (ii) Its generation time is only 10–12 days.
- (iii) It breeds quickly and prolifically and so produces large progeny after each mating.
- (iv) Its contrasting features are easily observable.

OR

Linkage and crossing over of genes are alternatives of each other. Linkage is the tendency of the genes present in the same chromosome to stay together during hereditary transmission, while crossing over is the mutual exchange of segments of non-sister chromatids of homologous chromosomes during the process of meiosis.

An example of linkage: A double dominant female *Drosophila* homozygous for red eyes and normal wings is crossed with a double recessive male *Drosophila* homozygous for purple eyes and vestigial wings. The F_1 flies are heterozygous red-eyed and normal winged. It is then test crossed with a double recessive male having purple eyes and vestigial wings. The F_2 generation comprises two types of flies—red-eyed, normal winged and purple eyed, vestigial winged in the ratio of 1:1. No recombinant types are formed because linkage is complete and no crossing over occurs.

An example of crossing over: A double dominant sweet pea plant homozygous for blue flowers and long pollen grains is crossed with a double recessive plant homozygous for red flowers and round pollen grains. The F_1 flies are heterozygous blue flowered and with long pollen grains. It is then crossed with a double recessive plant having red flowers and round pollen grains. The F_2 generation of plants has a new combination of traits—blue flowers and round pollen grains and red flowers and long pollen grains. This is due to crossing over, i.e. separation of genes for flower colour and form of pollen grains during gamete formation.

11. Ans.

- (a) In prokaryotes, the structural genes are polycistronic and continuous, whereas in eukaryotes, the structural genes are monocistronic and split.
- (b) In prokaryotes, there is a single DNA-dependent RNA polymerase which synthesises all the types of RNAs (mRNA, tRNA and rRNA), whereas eukaryotes have three RNA polymerases—Pol I, Pol II and Pol III—to synthesise different types of RNAs.

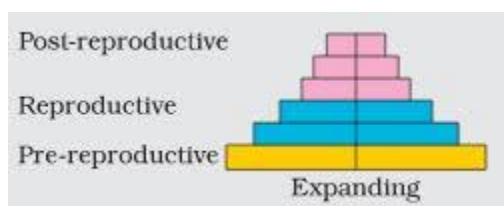
12.Ans.

- (a) When the red and white flower varieties of snapdragon are crossed, the F_1 progeny exhibits pink colour flowers. It is not known as blending inheritance because in blending inheritance, the characters are mixed in the offspring and do not segregate.
- (b) This phenomenon is known as incomplete dominance.

13.Ans.

- (a) Sertoli cells are found in the seminiferous epithelium within the seminiferous tubules of the testes. They provide nutrition and shape to the developing germ cells and spermatozoa.
- (b) Leydig cells are found in the connective tissue around the seminiferous tubules. They secrete testosterone into the blood.

14.Ans.



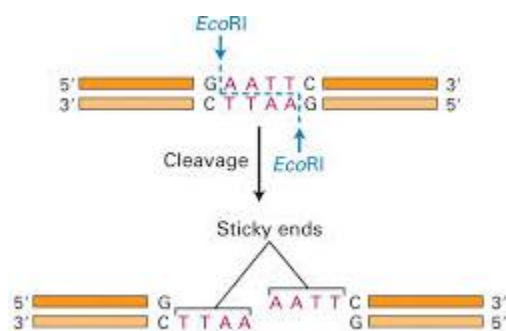
- 15.Ans.** Mutualism exists between fig tree and its pollinator species, wasp, where both individuals are benefited. A fig species can be pollinated only by its partner wasp species and no other species. The female wasp uses the fruit as the egg-laying site and the developing seeds within the fruit for nourishing its larvae. The wasp pollinates the fig inflorescence while finding egg-laying sites, and in turn, fig offers the wasp developing seeds as food for the developing larvae.

16.Ans.

- (a) Biological products: Many human diseases are controlled by biological products. The transgenic animals which produce these products are introduced with DNA which codes for a particular product such as human protein (α -1-antitrypsin) for treating emphysema. In 1997, the first transgenic cow (Rosie) was produced. She was capable of secreting human protein-enriched milk. The milk contained the human alpha-lactalbumin and was nutritionally a more balanced product for human babies than cow milk.

(b) Chemical safety testing: Transgenic animals are tested to study the sensitivity of the toxic substances. Toxicity testing in such animals helps obtain results in less time.

17.Ans. Restriction endonuclease functions by recognising its specific sequence. It binds to the DNA and cuts each to the two strands of the double helix at specific points in their sugar phosphate backbones. These enzymes cut the strand of DNA between the same two bases on the opposite strands leaving a single-stranded portion at their ends. These overhanging stretches are called sticky ends on each strand. The enzyme DNA ligase functions depending on the stickiness of these ends. For example, the restriction endonuclease EcoRI found in the colon bacteria *E. coli* recognises the base sequence GAATTC in the DNA duplex and cuts its strands between G and A.



18.Ans. Nucleopolyhedroviruses are biocontrol agents and useful in controlling many insects and arthropods. They are species-specific narrow spectrum bioinsecticides and have no negative impacts on plants and other organisms or even non-target insects.

SECTION C

19.Ans.

No.	Syndrome	Cause	Characteristics of affected individuals	Sex/Male/Female/Both
1.	Down's	Trisomy of 21	(i) Broad forehead (ii) Permanently open mouth, protruding and furrowed tongue and projecting lower lip	Both
2.	Klinefelter's	XXY	Overall masculine development	Male
3.	Turner's	45 with XO	(i) Short stature females with webbed neck (ii) Body hair absent	Female

20.Ans. Pedigree analysis is done in the study of human genetics as

- (i) It helps genetic counsellors to guide couples about the possibility of having children with genetic defects such as haemophilia.
- (ii) It indicates that Mendel's principles are also applicable to human genetics with some modifications found out later such as quantitative inheritance, sex-linked characters and other linkages.

Pedigree analysis is the study of the pedigree for the transmission of a particular trait and finding the possibility of the absence or presence of that trait in the homozygous or heterozygous state in a particular individual.

21. Ans.

- (a) Birth control pills or oral contraceptive pills contain two hormones—oestrogen and progesterone. They inhibit ovulation and implantation by making changes in the cervical mucus impairing its ability to allow the passage and transport of sperms and alters the uterine endometrium to make it unsuitable for implantation.
- (b) Oral pills have to be taken daily for a period of 21 days starting within the first five days of the menstrual cycle.

22.Ans. The outbreeding devices in flowering plants which encourage cross-pollination are

- (i) **Dicliny:** Flowers are unisexual so that self-pollination is not possible. The plants may be monoecious, bearing both male and female flowers (e.g. maize), or dioecious, bearing male and female flowers on individual plants (e.g. mulberry, papaya).
- (ii) **Prepotency:** Pollen grains of another flower germinate more rapidly over the stigma than pollen grains of the same flower. Examples: Apple, grape
- (iii) **Self-sterility:** Pollen grains of a flower do not germinate on the stigma of the same flower because of the presence of similar self-sterile genes. Examples: Tobacco, potato, crucifers

OR

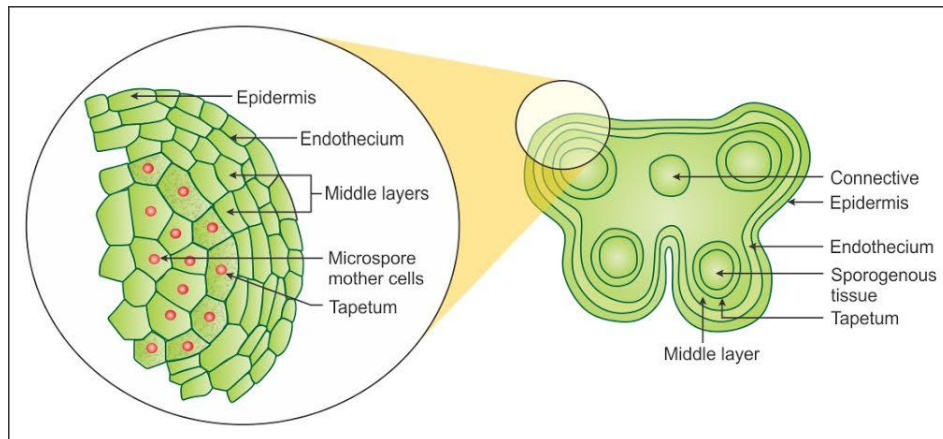
A typical angiosperm anther is broad, terminal and bilobed. Each lobe of the anther has two pollen sacs which, at maturity, fuse to form a single chamber called thecus, so it is called dithecal.

A microsporangium is a cylindrical sac which appears circular in transverse section. It contains the following parts:

- (i) Outer wall
- (ii) Central homogeneous sporogenous tissue
- (iii) Epidermis
- (iv) Endothecium
- (v) 1–3 middle layers and tapetum

The outer three layers perform the function of protection in the younger anther and the mechanism of dehiscence in the ripe anther.

The endothelial cells develop fibrous thickening of α -cellulose on the inner and radial walls and die. The innermost layer is called tapetum. It nourishes the developing pollen grain.



23. Ans.

- (a) The current rate of extinction is 100–1000 times faster than pre-human times. It seems that the Earth is heading for the sixth extinction, but it would be anthropogenic.

It is believed that (a) Tropical forests are losing 2–5 species per hour or 14,000–40,000 species per year. (b) Ten high diversity localities of tropical forests covering 3,00,000 km² area are liable to lose 17,000 endemic plant species and 3,50,000 endemic plant species in the near future. (c) If the current rate of species extinction goes on unabated, 50% of the species are liable to die out by the end of the 21st century.

- (b) They are extinctions abetted by human activities such as settlements, hunting, overexploitation and habitat destruction. Colonisation of the tropical Pacific islands by humans has resulted in the extinction of more than 2000 species of native birds. During the last 500 years, the Earth has lost some 784 species (IUCN, 2004). It includes 338 vertebrates, 359 invertebrates and 87 plants. Amphibians seem to be at a higher risk of extinction.

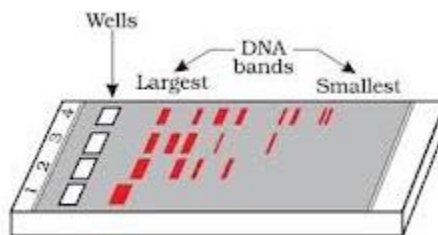
- (c)
- (i) All the threatened species should be protected. Priority should be given to ones belonging to monotypic genera, endangered over vulnerable, vulnerable over rare and rare over other species.
 - (ii) All the possible varieties, old or new, of food forage and timber plants, livestock, aquaculture animals and microbes are conserved.
 - (iii) Wild relatives of all the economically important organisms should be identified and conserved in protected areas.
 - (iv) Critical habitats for feeding/breeding/resting/nursing of each species should be identified and safeguarded.

24. Ans.

- (a) A - Fish and clean water organisms depict dissolved oxygen; B - Decomposers depicts biochemical oxygen demand (BOD).
- (b) As the sewage is decomposed, there is a gradual rise in the dissolved oxygen downstream with the reappearance of fish and other clean water organisms. This leads to the recovery of river from sewage water.
- (c) Effects on aquatic life:
- (iv) It causes high mortality rate among aquatic animals.
 - (v) The excessive nutrients facilitate algal growth causing algal bloom.

25.Ans. Gel electrophoresis is a technique of separating DNA fragments formed by the action of restriction endonucleases.

The fragments of DNA are placed in a typical agarose gel under an electric field. The DNA fragments move towards the anode as these fragments are negatively charged molecules. The DNA fragments separate according to their size through a sieving effect provided by the agarose gel. The smaller the fragment size, the farther it moves. The separated DNA fragments are stained with ethidium bromide followed by exposure to ultraviolet radiation. The DNA fragments are seen as orange-coloured and are cut out from the agarose gel and extracted from the gel piece. This step is called elution.



26.Ans. Tropics show the greatest levels of species diversity because

- (i) More solar energy is available in tropics which promote higher productivity and increased biodiversity.
- (ii) There is no favourable season in tropics. Continued favourable environment has helped tropical organisms to gain more niche specialisation and increased diversity.
- (iii) Resource availability is higher in tropics.

27.Ans.

(a) There is a need to organise such visits to make people aware of personal and public hygiene. Maintenance of personal and public hygiene is essential for prevention and control of many infectious diseases.

(b) Steps to be highlighted which enables them to lead a healthy life are

- (i) Intake of hygienic and balanced diet
- (ii) Consumption of clean drinking water
- (iii) Personal and community hygiene
- (iv) Regular physical exercise
- (v) Knowledge about diseases and their effects on the body
- (vi) Immunisation against infectious diseases
- (vii) Proper disposal of wastes and excreta
- (viii) Control of vectors
- (ix) Close contact with the infected persons or their belongings should be avoided in case of air-borne diseases

SECTION D

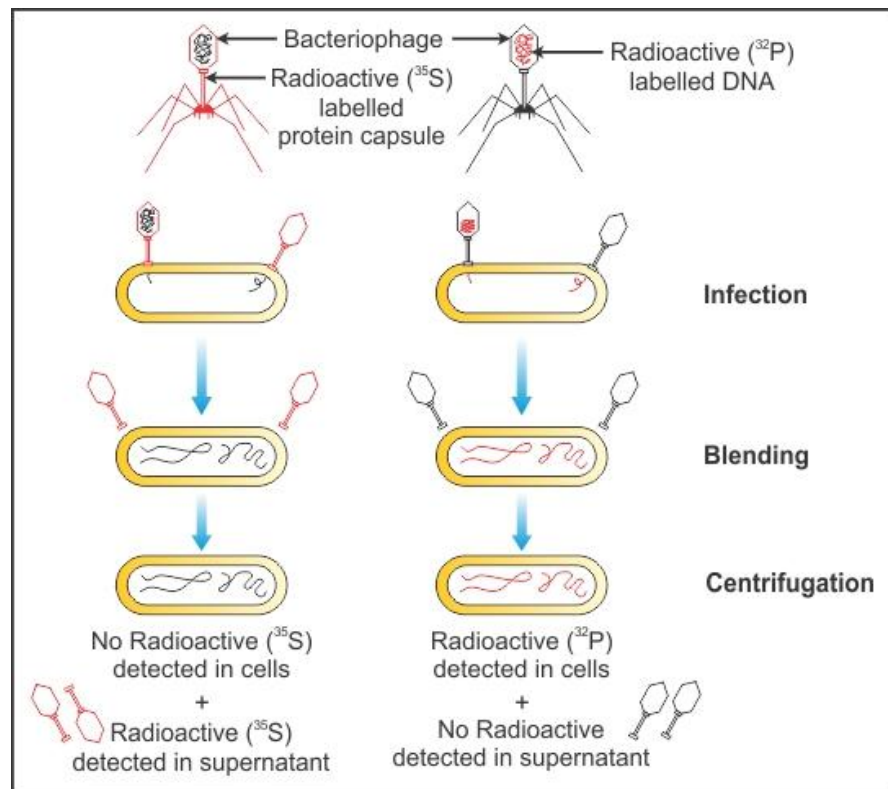
28.Ans. The proof for DNA as the genetic material came from the experiments of Alfred Hershey and Martha Chase (1952) who worked with bacteriophages.

The bacteriophage on infection injects only the DNA into the bacterial cell and not the protein coat. The bacterial cell treats the viral DNA as its own and subsequently manufactures more virus particles. They made two different preparations of the phage. In one, the DNA was made radioactive with ^{32}P . In the other, the protein coat was made radioactive with ^{35}S .

These two phage preparations were allowed to infect the bacterial cell separately. Soon after infection, the cultures were gently agitated in a blender to separate the adhering protein coats of the virus from the bacterial cells.

The culture was also centrifuged to separate the viral coat and the bacterial cells. When the phage containing radioactive DNA was used to infect the bacteria, its radioactivity was found in the bacterial cells (in the sediment) indicating that the DNA has been injected into the bacterial cell.

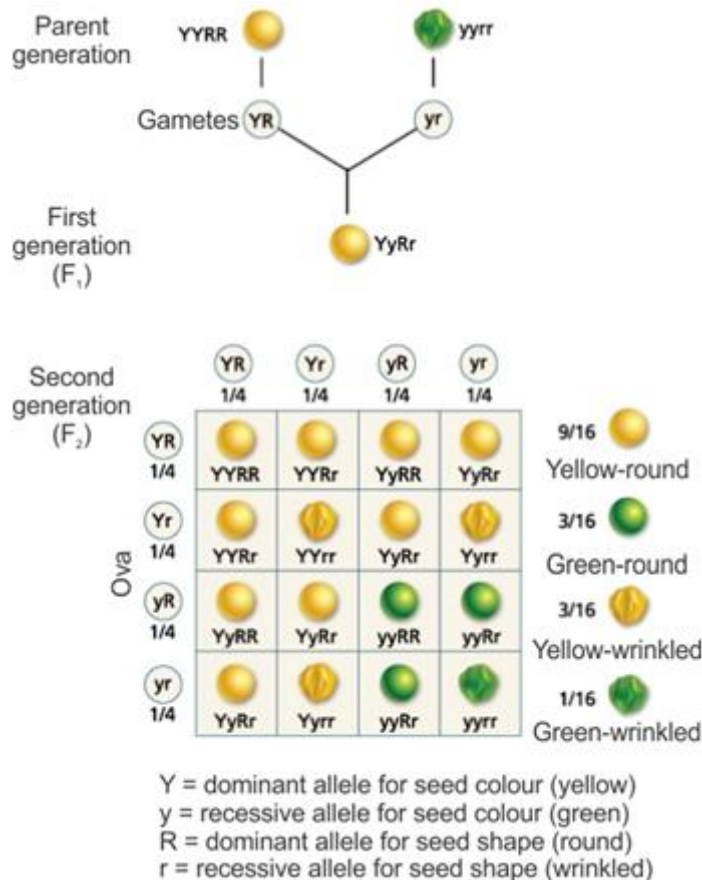
So, DNA is the genetic material and not proteins.



OR

Mendel derived 'the law of independent assortment' from a dihybrid cross.

This law states that the two factors of each character assort or separate independently of the factors of the other characters at the time of gamete formation and get randomly rearranged in the offspring producing both parental and new combinations of traits.



29.Ans. The main steps in breeding a new genetic variety of a crop are

- Collection of variability:** Germplasm is the total of all the alleles of the genes present in a crop and its related species. Collection and preservation of all the different wild varieties, species and relatives of the cultivated species is a pre-requisite for effective exploitation of natural genes available in the population. The entire collection of plants/seeds having all the diverse alleles for all genes in a given crop is called germplasm collection.
- Evaluation and selection of parents:** The germplasm is evaluated to identify plants with desirable combination of characters. Selection of parents is picking up seeds of only those plants for multiplication which have the desired traits. The selected plants are multiplied and used in the process of hybridisation. Pure lines are created wherever desirable and possible.
- Cross hybridisation among the selected parents:** Hybridisation is the most common method of creating genetic variation. It is crossing of two or more types of plants to produce their traits together in the progeny which helps bring about useful genetic or heritable variations of two or more lines together.

For example, high protein quality of one parent may need to be combined with disease resistance from another parent.

- (iv) Selection and testing of superior recombinants: The hybrids having desired characters are selected from the progeny and then self-pollinated for several generations to make them homozygous.
- (v) Testing, release and commercialisation of new cultivars: The selected plants are then evaluated for their yield and other agronomic traits of quality and disease resistance by growing them in the research fields under ideal fertiliser application, irrigation and other crop management practices. Testing is done in research fields for at least three growing seasons and then grown in different parts of the country. After thoroughly testing, the seeds of the selected variety are recommended to the farmers for large-scale cultivation.

OR

(a) Objectives of animal breeding:

- (i) Improved growth rate
- (ii) Increased production of milk, meat, egg, wool
- (iii) Superior quality of milk, meat, eggs, wool
- (iv) Improved resistance to various diseases
- (v) Increased productive life
- (vi) Increased or, at least, acceptable reproduction rate

(b) When breeding is between animals of the same breed for 4–6 generations, it is called inbreeding.

Importance of inbreeding:

- i. It helps in the accumulation of superior genes and elimination of undesirable genes.
- ii. It develops a homozygous pureline in an animal; thus, it increases homozygosity to evolve a pureline in any animal.
- iii. It exposes harmful recessive genes for undesirable characters which are eliminated by selection.

Limitation:

Continued inbreeding reduces fertility and even productivity. This is called inbreeding depression.

(c)

- (i) Karan Swiss and Sunandini are the new breeds of cattle.
- (ii) White Leghorn and New Hampshire are the improved breeds of chicken.

30.Ans.

(a) Fertilisation in humans occurs in the fallopian tube of the female reproductive system.

It is the process of fusion of a haploid sperm and a haploid ovum to form a diploid zygote. The process of fertilisation is completed under the following major steps:

- (i) Attraction: During copulation (intercourse of coitus), millions of sperms are inserted into the vagina of the female through the penis. The sperms swim in

the fluid mucous lining of the female genital tract at the rate of 1.5–3.0 mm per minute to reach the ovum in the upper part of fallopian tube where fertilisation occurs. The ova are formed in the ovaries, which are released, into the abdominal cavity through ovulation. One mature egg is released from the ovary on the 14–15 day of the menstrual cycle and is picked by the fimbriae of the ampulla of the fallopian tube. The ovum enters the fallopian tube and moves in it by the muscular contractions and ciliary action of the epithelium of the fallopian tube. The ovum secretes a chemical substance called fertilizin glycoprotein or mucopolysaccharide to attract the sperms. The sperms produce a chemical substance antifertilizin (protein). Each species produces a specific type of fertilizin and antifertilizin and the reactions between them bring about the process of fertilisation.

- (ii) Penetration of sperm into ovum: The human ovum is a rounded and non-motile structure surrounded by the vitelline membrane, zona pellucida and corona radiata. The radially arranged follicle cells of the corona radiata are attached by a complex organic substance called hyaluronic acid (a mucopolysaccharide) which acts as a barrier for the entry of sperms. The human sperm undergoes several changes so that it may be able to fertilise the ovum. This is called capacitation of sperm. The sperm attaches to the surface of the ovum near the animal pole and starts penetrating the various membranes of the egg. The acrosome of the sperm bursts and secretes sperm lysins containing the enzyme hyaluronidase to dissolve the adhesive substance and to disperse the cells of corona radiata. Ultimately, with the help of sperm lysin, one sperm penetrates the layers of the corona radiata and zona pellucida in about 30 minutes.
 - (iii) Activation of the ovum: After the penetration of sperm, the series of changes are brought about in the egg cortex. The dark cortical granules appear below the cell membrane in the cortex which migrates through the plasma membrane. These granules get attached along the inner surface of the vitelline membrane and make it thick. This thickened vitelline membrane is called the fertilisation membrane which prevents polyspermy by inhibiting the entry of other sperms.
 - (iv) Fusion of sperm and ovum nuclei: Sperm entry stimulates the ovum to undergo a second meiotic division for the removal of the last polar body. Usually the sperm head and middle piece enters the ovum through a definite path called the copulation path. The sperm nucleus acts as a male gamete and the egg nucleus as the female gamete. The centrioles of the middle piece of sperm form the spindle and the nuclear membranes of the sperm and ovum break down. This process of mixing up of haploid sperm nucleus with haploid egg nucleus is called amphimixis. The fusion product of the sperm and egg pronuclei results in the formation of a diploid zygote which initiates pregnancy in females.
- (b) *In vitro* fertilisation: In this method, fertilisation occurs outside the body and is followed by embryo transfer (ET). This technique is applied when the fallopian tube of the mother is blocked and she is unable to conceive. In this technique, the egg of a wife/donor is removed and fertilised (*in vitro*) by the husband/donor sperm outside her body under sterile conditions. When the fertilised egg reaches the 8-celled stage, it is transferred into the fallopian tube

and the embryos with more than 8 blastomeres into the uterus to complete their further development.

OR

- (a) Apomixis is the formation of new individuals through asexual reproduction without involving the formation and fusion of gametes.

The two common types of apomixis are recurrent agamospermy and adventive embryony.

- (i) Recurrent agamospermy: Agamospermy is the formation of seed and has an embryo formed without meiosis and syngamy. It is of two types—noncurrent and recurrent. In noncurrent agamospermy, the embryo is haploid. Therefore, the seed having it is nonviable. In recurrent agamospermy, all the cells of the embryo sac are diploid as it is formed directly either from a nucellar cell (apospory) or diploid megaspore mother cell (diplospory). The diploid egg and other diploid cells of the embryo sac can grow into normal embryos. The formation of the embryo directly from the diploid egg without fertilisation is called diploid parthenogenesis. Examples: Rubus, apple, poa

- (ii) Adventive embryony (sporophytic budding): Formation of an embryo directly from the diploid sporophytic cells such as the nucellus and integument of the ovule is called adventives embryony. Examples: Citrus, *Opuntia*. During embryogenesis, an embryo develops from the zygote inside the embryo sac and the embryo sac becomes an endosperm. Apomictic embryo, if developed, increases the number of embryos inside the seed, called polyembryony.

In gymnosperms, polyembryony can also occur because of cleavage of the growing embryo. It is called cleavage polyembryony. Occurrence of polyembryony because of fertilisation of more than one egg is called simple polyembryony. Formation of extra embryos through sporophytic budding is called adventives polyembryony. Polyembryony is quite common in onion, groundnut, mango, lemon and orange.

- (b) Embryos formed through apomixes are generally free from infection.

(c)

