

CBSE 2015
Biology

Time: 3 hrs

Total Marks: 70

General Instructions:

1. There are total **26** questions and five sections in the question paper. All questions are compulsory.
 2. Section A contains questions number **1 to 5**; very short answer type questions of **1** mark each.
 3. Section B contains questions number **6 to 10**, short-answer type **I** questions of **2** marks each.
 4. Section C contains questions number **11 to 22**, short answer type **II** questions of **3** marks each.
 5. Section D contains question number **23**, value based question of **4** marks.
 6. Section E contains questions number **24 to 26**, long-answer type questions of **5** marks each.
 7. There is no overall choice in the question paper; however, an internal choice is provided in one question of **2** marks, one question of **3** marks and all the three questions of **5** marks. In these questions, an examinee is to attempt any of the two given alternatives.
-

SECTION A

1. How many chromosomes do drones of honey bees possess? Name the type of cell division involved in the production of sperms by them.

Solution

Drones hatch from unfertilized eggs, thus they possess 16 chromosomes that were present in the egg. Therefore, drones are haploid as they have only one set of chromosomes. They produce sperm by the process of mitosis.

2. What is a cistron?

Solution

Cistron is section of DNA which codes for a single polypeptide. It functions as a hereditary unit.

3. Retroviruses have no DNA. However, the DNA of the infected host cell does possess viral DNA. How is it possible?

Solution

Retroviruses comprise of viral RNA that code for reverse transcriptase. On infecting a cell, the reverse transcriptase form copies of viral DNA using the template of viral RNA.

4. Why do children cured by enzyme-replacement therapy adenosine deaminase deficiency need periodic treatment?

Solution

The deficiency of the enzyme Adenosine deaminase can be cured by the enzyme replacement therapy. Patients need regular infusion of genetically engineered lymphocytes. It is because these cells are not immortal.

5. List two advantages of the use of unleaded petrol in automobiles as fuel.

Solution

Two of the advantages of using unleaded petrol in automobiles as fuel are:

- (a) Unleaded petrol precludes the release of poisonous gases like nitrous oxide into the environment.
- (b) In automobiles that are equipped with catalytic converter only unleaded petrol should be used, as lead present in the petrol can inactivate the catalysts of the converter.

SECTION B

6. Why do moss plants produce very large number of male gametes? Provide one reason? What are these gametes called?

Solution

Moss plants require water as a medium of propagation for male gametes to female gametes. These male gametes are prone to many hazards during their travel to the female gamete. Hence, a large number of male gametes are produced to enhance the chances of fertilization. Male gametes are produced in antheridia and are known as sperms or antherozoids.

7.

(a) Select the homologous structures from the combinations given below:

- (i) Forelimbs of whales and bats
 - (ii) Tuber of potato and sweet potato
 - (iii) Eyes of octopus and mammals
 - (iv) Thorns of *Bougainvillea* and tendrils of *Cucurbita*
- (b) State the kind of evolution they represent.

Solution

(a) The combinations representing homologous structures are:

- (i) Forelimbs of whales and bats
- (ii) Thorns of *Bougainvillea* and tendrils of *Cucurbita*

(b) These homologous structures are derived from the same embryological tissues but they are designed to do different jobs and hence they have adapted to different needs. This type of evolution is known as divergent evolution.

8. (a) Why are the plants raised through micropropagation are termed as somaclones?

(b) Mention two advantages of this technique.

Solution

(a) The plants produced through micropropagation are genetically identical to the plant from which they were grown. They are hence called somaclones. This allows one to obtain a uniform population of plants.

(b) Two advantages of this technique are:

- (i) A large number of plants are produced in a short period of time in very little space as compared to the conventional methods such as cutting or grafting.
- (ii) The growth of these plants is not dependent on the external factors such as temperature, rainfall, etc., as they grow under *in vitro* under controlled conditions

9. Explain the different steps involved during primary treatment phase of sewage.

Solution

In the primary phase of sewage treatment:

- Large pieces of floating debris are removed by screens and oily substances are removed by skimmers.
- Water is then allowed to pass through a series of sedimentation tanks, where small particles settle out. This procedure removes about 50% of the solid matter.
- Addition of flocculating agents increases the amount of solids that settle out.
- Sludge is then removed from the sedimentation tanks.

10. What is mutualism? Mention any two examples where the organisms involved are commercially exploited in agriculture.

Solution

When the bacteria form a relationship with the plants they reside on, that is mutually beneficial for both the plants and the bacteria, this relationship is called symbiotic relationship or mutualism. Examples include *Rhizobium* spp., *Frankia*, etc.

Two of its examples where it has been commercially exploited are:

- (i) Plant growth promoting rhizobacteria (PGPR) are present in the root nodules of leguminous plants. They help in fixation of atmospheric nitrogen. Therefore, these leguminous plants are also cultivated as green manure.
- (ii) An important association is that of a fresh water fern *Azolla* and cyanobacterium *Anabaena azollae*. The cyanobacterium is present in the leaf cavities of *Azolla*, fixes atmospheric nitrogen and releases the nitrogenous compounds in the leaf cavity. This symbiotic association is commonly used as a biofertilizer for rice

OR

List any four techniques where the principle of *ex-situ* conservation of biodiversity has been employed.

Solution

Ex-situ conservation involves the conservation of genetic resources of species away from their area of origin or development. The various ways in which *ex-situ* conservation can be achieved are:

(i) *Off site collection*: The best method of maximizing a species chance of survival is by relocating part of the population to a less threatened location. Collecting wild and domesticated organisms in botanical gardens, nurseries, aquaria and zoos, etc., are examples of off-site collection.

(ii) *Gene banks*: *Ex-situ* conservation occurs mainly in gene banks that can be categorized into seed gene banks and field gene banks. Gene banks are generally maintained by institutes. These seed gene banks can be orthodox seed banks or recalcitrant seed banks.

Field gene banks are used to conserve genes of perennials, recalcitrant species, vegetatively propagated species, etc., by planting them in an artificial ecosystem requiring more land, adequate soil, suitable weather conditions, etc. For example, orchards, plantations and botanical gardens

(iii) *In vitro* preservation: The following methods are generally used in *in vitro* preservation:

(a) Tissue culture: In laboratories (*in vitro* preservation), tissue culture is used to propagate plants by developing callus, embryoids, pollen grains, shoot tips, etc. Rapid multiplication of endangered plants is possible with this method. Shoot tip culture maintains virus free plants.

(b) Cryopreservation: The gametes, embryos, cells, etc., are preserved at very low temperatures, generally -196°C , thawed and reused whenever needed.

SECTION C

11. State what is apomixis. Comment on its significance. How can it be commercially used?

Solution

The term apomixis (apo = without; mixis = mixing) was coined by Winkler in 1908. It is a type of asexual reproduction that resembles sexual reproduction. In this, seeds are produced without fertilization. Hence, all the individuals produced apomictically are genetically similar to the parents producing them.

Significance of apomixis:

(i) Adventives embryos are better clones than cuttings.

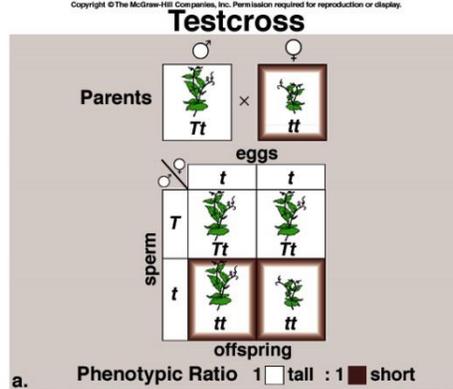
(ii) Embryos formed through apomixes are generally free from infections.

Apomixis has a lot of significance in hybrid seed industry and a lot of research is being carried out in this direction to better the understanding of genetics of apomixis. Their cost of production is high and hence the expenses incurred increase tremendously, thereby, reflecting in the cost of product. The hybrid characters are also not maintained as these characters segregate during meiosis. If these hybrids are made into apomicts (plants that reproduce by apomixis), then the farmer will not have to worry about losing the desirable characters as these will not segregate. Hence, hybrid seeds will not be required every year.

12. During a monohybrid cross involving a tall pea plant with a dwarf pea plant, the offspring populations were tall and dwarf in equal ratio. Work out a cross to show how it is possible.

Solution

A testcross between a homozygous recessive pea plant (*tt*) and a heterozygous pea plant (*Tt*) will result in 50% offspring showing dominant traits and 50% showing recessive traits.



13. Explain the significance of satellite DNA in DNA fingerprinting technique.

Solution

The satellite DNAs in eukaryotes have long repetitive sequences. On the basis of the number of repetitive units, length of DNA segment and the base composition, satellite DNAs are classified as micro- or mini-satellites. These repetitive sequences form the main component (15 to 80%) of eukaryotic genomes. They do not code for any proteins but exhibit polymorphism on which DNA fingerprinting is based. DNA fingerprint is the same for every cell, tissue and organ of a person. Therefore, saliva, hair follicle, skin, bone, sperm, blood, etc., are generally used for forensic investigations. DNA fingerprinting can be used to ascertain the identity. Since polymorphism is inherited, it is also used for testing paternity.

14. What does the following equation represent? Explain.

$$p^2 + 2pq + q^2 = 1$$

Solution

The given equation:

$$p^2 + 2pq + q^2 = 1$$

represents Hardy-Weinberg equation. It is a binomial expansion of $(p + q)^2$. It explains the basic principle of population genetics. It is an expression of Hardy-Weinberg equilibrium, which states that the amount of genetic variation in a population will remain constant from one generation to the next if the disturbing factors are absent.

Here, p = frequency of the *A* allele in the population; q = frequency of the *a* allele in the population; p^2 = frequency of the homozygous genotype *AA*; q^2 = frequency of the homozygous genotype *aa* and $2pq$ = frequency of the heterozygous genotype *Aa*.

The sum of the allele frequencies for all the alleles at the locus must be 1, so $p + q = 1$. If the p and q allele frequencies are known, then the frequencies of the three genotypes may be calculated using the Hardy-Weinberg equation. If the values of the frequencies measured are different from the expected values, then the difference indicates the extent of evolution.

15. A heavily bleeding and bruised road accident victim was brought to a nursing home. The doctor immediately gave him an injection to protect him against a deadly disease.

(a) Write what did the doctor inject into the patient's body.

(b) How do you think this injection would protect the patient against the disease?

(c) Name the disease against which this injection was given and the kind of immunity it provides.

Solution

- (a) The doctor injected the preformed tetanus antitoxin inside the patient's body.
- (b) The vaccine would induce the production of antibodies against the antigen by stimulating active acquired immunity.
- (c) The injection was given against the tetanus disease. It provides active acquired immunity.

16. Enumerate any six essentials of good, effective Dairy Farm Management Practices.

Solution

Proper management practices include:

- (i) *Safety rules during milking*: During milking stringent cleanliness and hygiene of both cattle and handlers should be followed. All the persons concerned with milking and handling of milk must be in good health and must follow procedures consistent with good sanitary techniques.
- (ii) *Proper housing facilities for animals*: Adequate space should be provided in the housing facilities to ensure healthy and comfortable living conditions. There should be adequate ventilations, light, humidity, temperature, etc.
- (iii) *Regular monitoring*: The farm animals should be regularly monitored and any change in the physiological or behavioral condition should be immediately brought into the notice of a veterinary doctor. Routine measures such as vaccination, therapeutic drugs and antibiotics should be administered. The veterinary doctor should visit the farms regularly.
- (iv) *Sufficient quantity of good quality fodder*: Emphasis on good quality fodder in sufficient quantities should be laid. This fodder should be well-balanced in nutrients to ensure good health of the animals.
- (v) *Maintenance of records*: All the records of a dairy farm should be properly maintained regarding the breed of animals, their health, their meal timings, etc.
- (vi) *Initiatives by Government*: The state and the central government have several disease control programs to ensure animal health.

17. State the medicinal value and the bioactive molecules produced by *Streptococcus*, *Monascus* and *Trichoderma*.

Solution

- (i) *Streptococcus*: The bacteria *Streptococcus* produces bioactive molecule enzyme. They clot bluster for removing clots from blood vessels of heart attack patients.
- (ii) *Monascus*: The yeast *Monascus purpureus* produces bioactive molecule statins. They are used as agents that lower the blood-cholesterol.
- (iii) *Trichoderma*: The fungus *Trichoderma polysporum* produces bioactive molecule Cyclosporin A. It is used as an immunosuppressive agent that prevents rejection in patients who have had transplants of kidney, bone marrow, liver, pancreas, etc.

OR

What are methanogens? How do they help to generate biogas?

Solution

Natural gas is a biogas which results after long period of decay of animal and vegetable matter brought about by bacteria in the presence of high pressure and optimum temperature. Methane is produced along with CO₂ and other gases during anaerobic digestion of cellulosic material. These strictly anaerobic bacteria are called methanogens. Some examples of methanogens are Methanobacterium, Methanococcus, etc.

Naturally-occurring anaerobic bacteria grow, multiply, and convert manure into biogas and a low-odor effluent. The methanogenic bacteria breakdown the organic mass and produce marsh gas. Marsh gas is a mixture of methane, hydrogen sulphide and carbon dioxide that combine to form biogas.

18. Rearrange the following in the correct sequence to accomplish an important biological reaction:

- (a) In vitro synthesis of copies of DNA of interest
- (b) Chemically synthesized oligonucleotides
- (c) Enzyme DNA-polymerase
- (d) Complementary region of DNA
- (e) Genomic DNA template
- (f) Nucleotides provided
- (g) Primers
- (h) Thermostable DNA-polymerase (from *Thermus aquaticus*)
- (i) Denaturation of ds-DNA

Solution

The correct sequence of the steps involved in Polymerase chain reaction (PCR) reaction is:

- (e) Genomic DNA template
- (i) Denaturation of ds-DNA
- (f) Nucleotides provided
- (g) Primers
- (h) Thermostable DNA-polymerase (from *Thermus aquaticus*)
- (c) Enzyme DNA-polymerase
- (b) Chemically synthesized oligonucleotides
- (d) Complementary region of DNA
- (a) In vitro synthesis of copies of DNA of interest

19. Describe any three potential applications of genetically modified plants.

Solution

Some of the potential applications of genetically modified plants in agricultural biotechnology are:

- (i) GMO crops have better nutritional quality such as vitamin A-enriched rice
- (ii) They are diseases resistant and are more tolerant to abiotic stresses.
- (iii) They have pest resistant and hence have reduced the dependency on the chemical pesticides.
- (iv) They are better nitrogen fixers.

20. How did an American Company, Eli Lilly use the knowledge of r-DNA technology to produce human insulin?

Solution

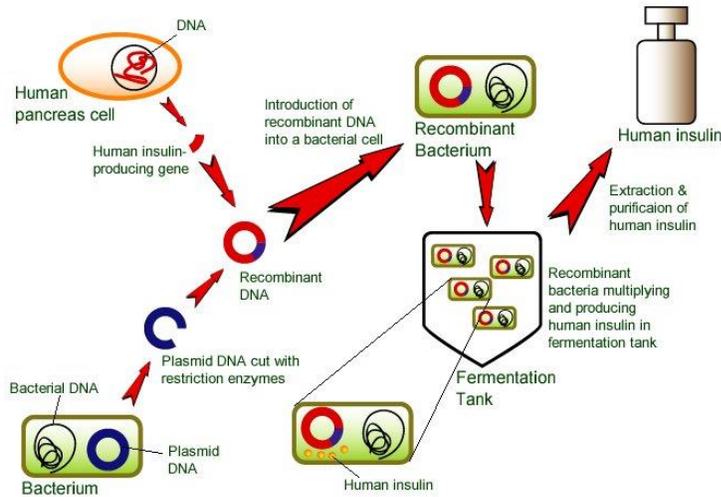
The technology of rDNA has been used for the production of safe and more active therapeutic drugs.

- Human insulin contains two short polypeptide chains: chain α and chain β , these chains are linked to each other by disulphide bridges.
- Insulin is secreted as prohormone. It is processed to turn into mature and functional insulin.
- The prohormone comprises of a polypeptide called C- peptide. This polypeptide is removed during the process of maturation.

In 1983, Eli Lilly, an American company, prepared two DNA sequences coding for α and β chains of human insulin. These DNA sequences were introduced into the plasmids of *Escherichia coli* to produce insulin as shown in Fig. The two chains that were produced were extracted and combined by forming

disulfide bridges between them.

Human Insulin Production



21. How do snails, seeds, bears, zooplanktons, fungi and bacteria adapt to conditions unfavorable for their survival?

Solution

The adaptations of these organisms in unfavorable conditions for their survival are listed in the table below:

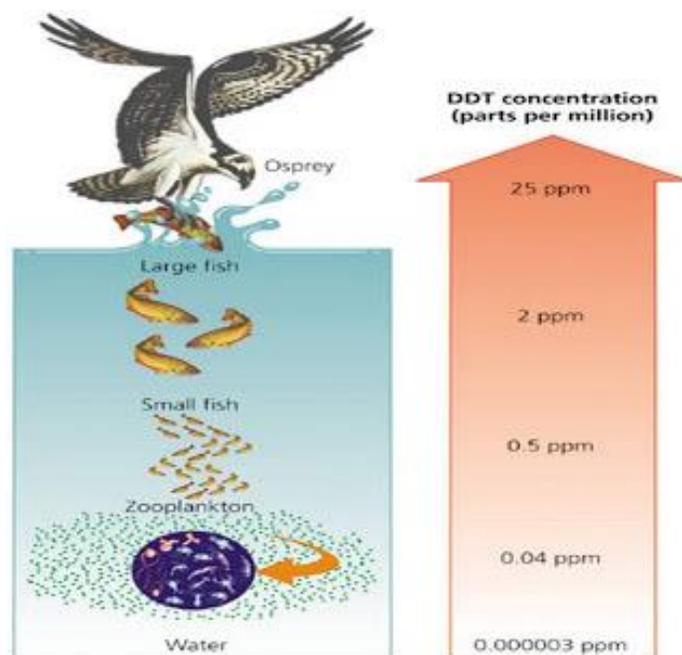
Organism	Adaptation
Snails	Snails bury deep into the mud forming a gelatinous cocoon during summer months, when their habitat dries up. This phenomenon is called aestivation.
Seeds	The seeds undergo dormancy in higher plants and germinate under ambient conditions.
Bears	Polar bears hibernate in winter months.
Zooplankton	Zooplanktons suspend their growth and development in adverse conditions such as in winter when the days are shorter, they are known to enter diapause.
Fungi	The thick walled spores formed in fungi germinate under favorable conditions. They help these organisms to tide over unfavorable conditions.
Bacteria	The thick walled spores formed in bacteria germinate under favorable conditions. They help these organisms to tide over unfavorable conditions.

22. With the help of a flow chart, show the phenomenon of biomagnifications of DDT in an aquatic food chain.

Solution

Biomagnification is the accumulation or increase in the concentration of a substance in living tissue as it moves through a food web (also known as bioaccumulation).

When dichlorodiphenyltrichloroethane (DDT) is sprayed in the agricultural fields, it is carried to the nearby water bodies in low concentration. In these small water bodies, it gets accumulated by the zooplankton. Its concentration increases at each trophic level in the food chain—from zooplankton to small fish to large fish and finally to birds.



SECTION D

23. Your school has been selected by the Department of Education to organize and host an interschool seminar on “Reproductive Health – Problems and Practices”. However, many parents are reluctant to permit their wards to attend it. Their argument is that the topic is “too embarrassing.” Put forth four arguments with appropriate reasons and explanation to justify the topic to be very essential and timely.

Solution

In this era it is quite important for students to be aware of ‘*Reproductive Health – Problems and Practices*’. It is an opportunity for them to attend a seminar on this topic organized by their school. In these seminars problems related to reproductive health are discussed. It makes students conscious of the following points:

- (i) These seminars help in making students aware about reproduction.
- (ii) It helps in prevention of sexual abuse and sex-related crime. Children will get aware of these and will take necessary steps to prevent these acts of sexual abuse. It will help in building a reproductively healthy society.
- (iii) Students will gain suitable knowledge about their reproductive organs, adolescence and about sexually transmitted diseases specially AIDS.
- (iv) These seminars give information regarding menstrual problems and reproduction-related problems. Here, students can freely ask for medical help.

SECTION E

24.

- (a) Plan an experiment and prepare a flow chart of the steps that you would follow to ensure that the seeds are formed only from the desired sets of pollen grains. Name the type of experiment that you carried out.
- (b) Write the importance of such experiments.

Solution

(a) Artificial hybridization is an important step. It is a crossing that involves intervention of plant breeder for selection of egg nucleus and sperm nucleus which are fertilized artificially to produce hybrid. It is also known as controlled pollination. It involves following steps:

(i) *Emasculation*: The process of removing anthers or stamens or killing the pollen grains in a bisexual flower of a plant to be used as the female parent in a cross is called emasculation. After emasculation, the flower contains only female reproductive organs. So for pollination, desired pollen from male plant will be provided by breeder.

(ii) *Bagging*: Emasculated flower or inflorescence is immediately bagged to avoid pollination by any foreign pollen grains. These bags are made up of butter paper, fine cloth or polythene depending on the inflorescence.

(iii) *Tagging*: The emasculated and bagged flowers or inflorescence are tagged bearing the date of emasculation, date of pollination and name of cross with name of female parent followed by X and then name of male parents for keeping proper record of artificial hybridization.

(iv) *Pollination*: Mature and fertile pollen grains are collected from male parent, bag is opened and pollen grains are dusted on receptive stigma with the help of brush.

(b) Significance of artificial hybridization:

(i) The artificial pollination plays an important role in completing plant's life cycle. Pollination brings male gametophyte closer to female gametophyte for fertilization, which results in formation of new plants.

(ii) The agency of pollination gives idea of evolution as lower plants were dependent on water but as land plants developed the dependency on water ended.

(iii) Plants co-evolved with the requirement of pollinators to enhance chances of pollination by various agencies. For example, insect pollinated flowers modified their shape according to their pollinator insects.

(iv) Understanding mechanism of pollination helps in development of pure lines as well as varieties by manipulating pollination as required.

OR

Describe the role of pituitary and ovarian hormones during the menstrual cycle in a human female.

Solution

During menstrual cycle the role of pituitary and ovarian hormones are listed in the table below:

Hormone	Functions
Pituitary hormones	
Follicle-stimulating Hormone (FSH)	<ul style="list-style-type: none"> i. FSH initiates follicular growth. ii. FSH stimulates the ovarian follicles to secrete estrogens. iii. Under the influence of FSH, the androgens are taken up by the granulosa cells of the follicle and then converted into estrogens.
Luteinizing Hormone (LH)	<ul style="list-style-type: none"> i. LH stimulates development of the ovarian follicles. ii. LH stimulates the ovarian follicles to secrete estrogens. iii. LH stimulates the theca cells of a developing follicle to produce androgens. iv. At midcycle, LH triggers ovulation and then promotes formation of the corpus luteum. v. Stimulated by LH, the corpus luteum produces and secretes estrogens, progesterone, relaxin and inhibin.
Ovarian hormones	
Oestrogen	Oestrogen is responsible for the development of the female secondary sex characters, such as change in voice, external genitalia, breasts, body hair, pubic hair, fatty deposits on thighs, face, buttocks, widening of pelvis
Progesterone	<ul style="list-style-type: none"> i. Progesterone facilitates the preparation of the endometrium for implantation. ii. Progesterone inhibits the contraction of the uterus and the

25.

(a) Why are thalassemia and haemophilia categorized as Mendelian disorders? Write the symptoms of these diseases? Explain their pattern of inheritance in humans.

(b) Write the genotypes of the normal parents producing a haemophilic son.

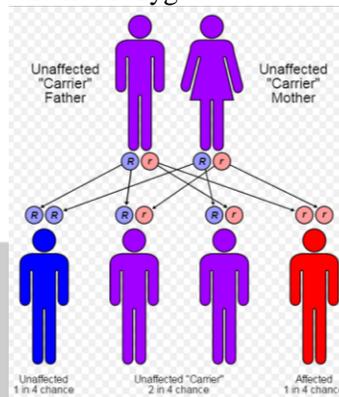
Solution

(a) Thalassemia and haemophilia are mainly caused by alterations or mutation in alleles of a single gene. Thus, they have been categorized as Mendelian disorders as they are inherited by the offspring following principle of inheritance. They can be traced in family by pedigree analysis.

Thalassemia

Symptoms: It is characterized by anaemia, jaundice, hepatosplenomegaly, cardiac enlargement and skeletal deformities.

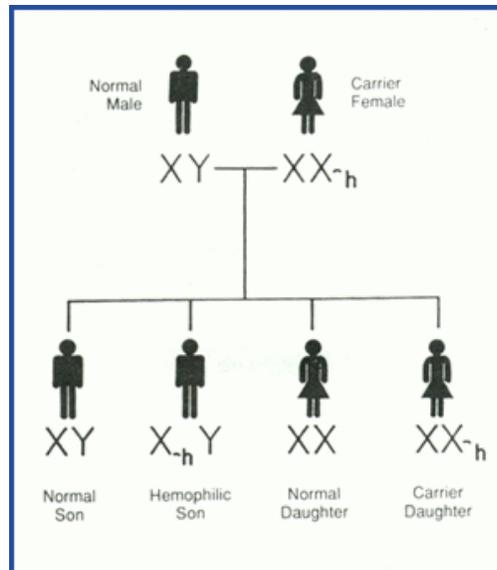
Pattern of inheritance: It is an autosomal recessive form of anaemia which occurs due to mutation or deletion of the genes controlling the synthesis of globin chains of hemoglobin. It is transmitted to the offspring only when both the parents are heterozygous.



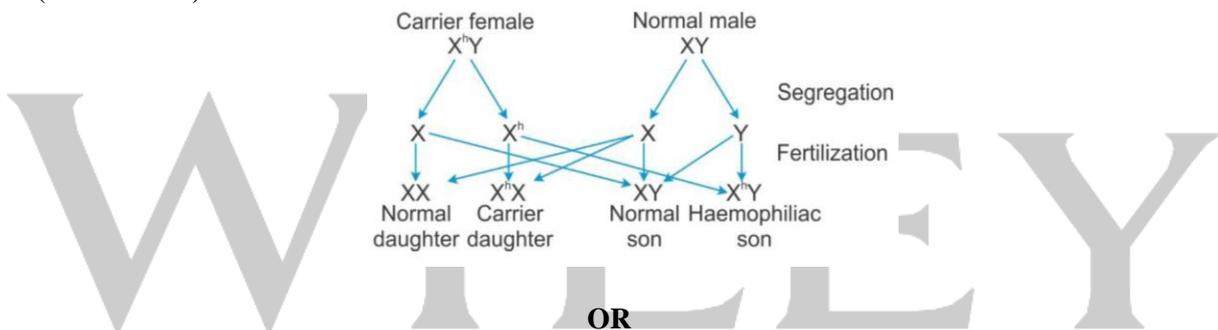
Haemophilia

Symptoms: It is characterized by spontaneous or traumatic subcutaneous and intramuscular haemorrhaging, nosebleeds, blood in the urine and haemorrhages in joints that produce pain and tissue damage.

Pattern of inheritance: This disease is inherited through an X-linked recessive gene. Thus, a single gene will produce the diseases in males, while two genes will produce the diseases in female. Female in heterozygous condition appear to be normal. But, the carrier female can transmit the diseases to 50% of her sons. This disease is expressed in males, but is transmitted by females.



- (b) The genotype of normal parents producing a haemophiliac son can be X^hX (carrier female) and XY (normal male).



How do m-RNA, t-RNA and ribosomes help in the process of translation?

Solution

The process by which amino acids are polymerized to form polypeptide is known as translation. It is a process of protein synthesis that is carried out in the cytoplasm. The role of m-RNA, t-RNA and ribosomes in this process are:

- (i) *m-RNA*: The sequence in which bases are present in the mRNA determines the sequence in which amino acids will be present in the polypeptide.
- (ii) *t-RNA*: It is a set of small, compact molecules that function to deliver amino acids to the ribosomes for assembly into proteins. They function as adaptors between amino acids and the codons in mRNA during translation (or protein synthesis).
- (iii) *Ribosomes*: Ribosomes are also known as protein factories. Ribosomes are made up of two subunits—smaller and larger. They join at the beginning of protein synthesis. Their three-dimensional structure helps in bringing mRNA and appropriate tRNAs together. They help in making peptide linkages between amino acids that have been bought together.

26.

- (a) List the different attributes that a population has and not an individual organism.
- (b) What is population density? Explain any three different ways the population density can be measured, with the help of an example each.

Solution

- (a)

The different attributes which a population possesses are natality, mortality, population density, population growth, population dispersal, sex ratio and age distribution.

(b) Population size helps in determining the position of a population in a given habitat and is expressed in terms of population density (N), which is defined as the number of individuals per unit area, or per unit volume. The relative population density of organisms can be measured using different methods.

(i) *Sampling Method*: In this method, samples are selected and the organisms are counted per unit of the sample. For example, population density of Paramecium is determined by sampling method. It is counted for different samples. The average of these samples is considered as population density. The number of fish per catch is another sampling method.

(ii) *Tagging and recounting Method*: It is used for counting the larger animals such as squirrels, birds, etc. A definite number of animals, say 100, is captured, tagged and then released. On another day 100 more animals are trapped. The tagged and untagged individuals in the count of second 100 animals help in determining the total density of population. If 20 tagged are captured out of 100 individuals, the total population is $(100/20) \times 100 = 500$.

(iii) *Pug marks (footprints) or faecal pellets*: These are also used in estimation of population density of megafauna, such as tigers. Besides, calculating % cover or biomass, it is a better method of measuring population size while comparing many small plants with a huge tree.

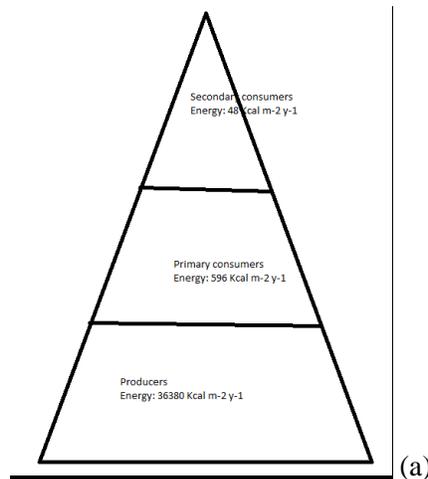
OR

“It is often said that the pyramid of energy is always upright. On the other hand, the pyramid of biomass can be both upright and inverted.”

Explain with the help of examples and sketches.

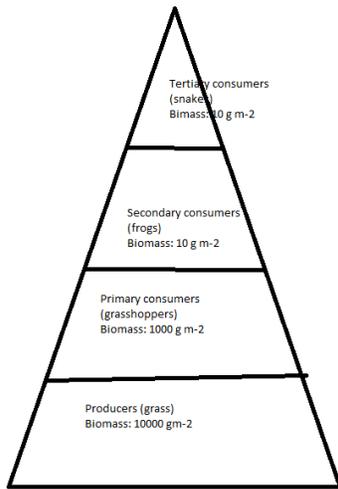
Solution

Pyramid of energy is a graphical representation of amount of energy accumulated per unit area in different trophic levels (Fig.a). Each step in energy pyramid indicates the amount of energy present at each trophic level at a given time or annually per unit area. It is observed that the pyramids of energy are never inverted. Such a property of the pyramids of energy is due to the first law of thermodynamics or the law of conservation of energy, which states that energy can neither be created nor destroyed but can only be conserved. In every food chain, there is some loss as energy flows from one trophic level to the other. As a result, the total amount of energy that is conserved by a top carnivore can be a magnitude lower than that conserved by an herbivore.

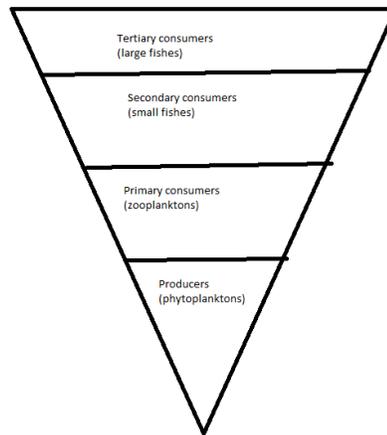


Pyramid of biomass is a graphical representation of biomass present per unit area at different trophic levels. It can also be upright, as in grassland and forest ecosystems (Fig. b) or inverted as in aquatic ecosystems (Fig. c). In Fig.b for grassland ecosystem, the biomass of primary producers (grass) is $10,000 \text{ g m}^{-2}$ while that of primary consumers grasshoppers is 1000 g m^{-2} . At the next level, toads, the secondary consumers, weigh only 100 g m^{-2} and the tertiary consumers, snakes weigh 10 g m^{-2} . Pyramids of

biomass in oceans are generally “inverted” because the total biomass of consumers (fish) outweighs the biomass of producers (phytoplankton) (Fig. c).



(b)



(c)

WILEY