CBSE EXAMINATION PAPER-2022

BIOLOGY

(Solved)

Time allowed : 3 hours | Maximum Marks : 59

General Instructions :

Read the following instructions carefully and follow them :

i. This question paper contains **31 questions.** All questions are **compulsory.**

ii. This question paper is divided into **5 sections.**

iii. **Section A** – questions number **1 to 4** are case based questions

iv. **Section B** – questions number **5 to 14** are multiple choice questions

v. **Section C** – questions number **15 to 22** are very short answer

vi. **Section D** – questions number **23 to 28** are short answer

vii. **Section E** – questions number **29 to 31** are long answer

viii. There is no overall choice given in the question paper. However, an internal choice has been provided in few questions.

ix. Use of calculator is NOT allowed.

Section A

Question 1.

Question 2.

Read the paragraph given below and answer the questions that follow :

Enzyme Taq polymerase, is extracted from a eubacterial microorganism *Thermus aquaticus* from Yellowstone National Park in Montana, USA and isolated by Chien et al. (1976). Taq polymerase

successfully replaced the DNA polymerase from E.coli that was being used in PCR earlier and this shift revolutionised the PCR technique.

(1)

(i) Taq polymerase after its discovery replaced E.coli DNA polymerase in PCR technique. Explain giving reasons why was the need felt for the change?

[1 Marks]

Answer: The need for replacing E.coli DNA polymerase with Taq polymerase in PCR arose due to the higher thermal stability of Taq polymerase. E.coli DNA polymerase would denature at the high temperatures required for denaturation of DNA during PCR cycles, leading to loss of activity and efficiency. In contrast, Taq polymerase, derived from the thermophilic bacterium Thermus aquaticus, remains active and functional at elevated temperatures, enabling the amplification of DNA in multiple cycles without the need for frequent enzyme replenishment.

Key Points: Higher thermal stability of Taq polymerase-E.coli DNA polymerase denatures at high temperatures-Taq polymerase supports efficient amplification in PCR cycles.

(2)

(ii) What is a primer and its importance in PCR ?

[2 Marks]

Answer: A primer is a short, chemically synthesized single-stranded DNA molecule that is complementary to the specific region of the template DNA that needs to be amplified. In PCR, two primers are used to flank the target DNA sequence and provide a starting point for the Taq polymerase to initiate DNA replication. Primers are essential for the specificity of the PCR process, as they ensure that only the desired DNA fragment is amplified, allowing for accurate gene cloning and further genetic analysis.

Key Points: Short DNA molecule-Complementary to target DNA-Sets stage for Taq polymerase specificity

(3)

(iii) Write the importance of PCR as a diagnostic tool.

[2 Marks]

Answer: Polymerase Chain Reaction (PCR) is a crucial diagnostic tool due to its ability to amplify minute amounts of DNA, enabling the detection of pathogens even in early stages of infection. It is widely used for diagnosing conditions such as HIV and identifying genetic mutations related to cancer, thus allowing for timely and accurate diagnosis of various genetic disorders.

> **Key Points: Detection of low DNA amounts-Used for HIV diagnosis-Identifies genetic mutations**

(4)

From which microorganism is Taq polymerase extracted, and who first isolated it?

[1 Marks]

Answer: Taq polymerase is extracted from the eubacterial microorganism Thermus aquaticus, and it was first isolated by Chien et al. in 1976.

> **Key Points: Taq polymerase-Thermus aquaticus-Chien et al. (1976)**

Question 3.

Question 4.

Read the following paragraph and answer the questions that follow : Biotechnology revolves around the "gene of interest", with an objective to open various avenues for human welfare in health, medicine, pharma, agriculture etc. using different techniques, tools and processes. One of the breakthroughs of biotechnology in medicine is the gene therapy.

(1)

(i) Name the human disease for which the gene therapy was used for the first time.

[1 Marks]

Answer: The first human disease for which gene therapy was used is Severe Combined Immunodeficiency (SCID), often referred to as 'bubble boy disease'. This disease is characterized by a crucial defect in the immune system, which leaves individuals highly vulnerable to infections. Gene therapy was employed to correct the genetic defect causing SCID by inserting a functional copy of the gene into the patients' cells.

Key Points: Severe Combined Immunodeficiency (SCID) - first disease treated with gene therapy - genetic defect in immune system - insertion of functional gene

(2)

(ii) Explain the steps of gene therapy carried to cure the disease using the lymphocytes of the patient. Why is this therapy not a permanent cure of the disease ?

[2 Marks]

Answer: Gene therapy involves several key steps aimed at treating genetic disorders. First, lymphocytes, which are white blood cells, are extracted from the patient's blood. These cells are then cultured in a lab to allow for further manipulation. The next crucial step is to use a retroviral vector to introduce a functional copy of the ADA gene, which is missing or defective in the patient's cells, into these lymphocytes. After the insertion of this functional gene, the lymphocytes are multiplied and then reinfused back into the patient’s body. However, gene therapy is not a permanent cure because the modified lymphocytes may not survive long-term or divide indefinitely in the body. As a result, the therapy needs to be repeated periodically, and it may not fully replace the original gene function, leading to the possibility of the disease resurfacing.

Key Points: Step 1: Extract lymphocytes from patient; Step 2: Culture lymphocytes; Step 3: Introduce functional gene using retroviral vector; Step 4: Reinstate the modified lymphocytes into the patient; Reason for not being a permanent cure: Modified cells may not persist long-term in the body.

(3)

(iii) Write the possible permanent cure of the disease by the gene therapy that is in progress.

[2 Marks]

Answer: Gene therapy is a revolutionary approach that aims to treat or potentially cure genetic disorders by directly modifying the genes responsible for the disease. One of the possible permanent cures currently in progress through gene therapy is the treatment of certain inherited diseases such as Cystic Fibrosis, Hemophilia, and Spinal Muscular Atrophy (SMA). For instance, in the case of SMA, gene therapy has shown promise by delivering a copy of the SMN1 gene directly to the patient's cells, effectively addressing the underlying genetic deficiency. This innovative technique enables the production of functional proteins, thereby alleviating symptoms and improving the quality of life for patients, demonstrating the transformative potential of gene therapy in modern medicine.

Key Points: Gene therapy for genetic disorders - examples like Cystic Fibrosis - delivers functional genes - addresses genetic deficiencies - potential for permanent cures

Section B

Question 5.

Which of the following is a vestigial organ in humans?

[1 Marks]

(A) Liver

(B) Appendix

(C) Pancreas

(D) Kidney

Explanation: The correct answer is 'Appendix' because it is considered a vestigial organ in humans, as it no longer serves a critical digestive function like it does in herbivorous ancestors.

Question 6.

In which part of the nephron does selective reabsorption of glucose occur?

[1 Marks]

(A) Bowmans capsule

(B) Distal convoluted tubule

(C) Loop of Henle

(D) Proximal convoluted tubule

Explanation: The correct answer is 'Proximal convoluted tubule' since it is the segment of the nephron where the majority of glucose reabsorption occurs through active transport mechanisms. The context details that the reabsorption and secretion of major substances take place in different parts of the nephron, and the proximal convoluted tubule is known for absorbing nutrients including glucose.

Question 7.

3. Which plant hormone is responsible for cell elongation?

[1 Marks]

(A) Cytokinin

(B) Abscisic acid

(C) Gibberellin

(D) Auxin

Explanation: The correct option is Gibberellin. Gibberellins are known to promote cell elongation and are involved in various growth processes, including leaf and shoot development. While auxins also play a role in growth, the specific function of promoting cell elongation is particularly attributed to gibberellins.

Question 8.

DNA replication occurs during which phase of the cell cycle?

[1 Marks]

(A) G1 phase

(B) G2 phase

(C) S phase

(D) M phase

Explanation: DNA replication occurs during the S phase of the cell cycle, also known as the Synthesis phase. During this phase, the amount of DNA in the cell doubles from 2C to 4C, as DNA synthesis takes place and chromosomes are duplicated.

Question 9.

Which of the following diseases is caused by a protozoan?

[1 Marks]

(A) Tuberculosis

(B) Malaria

(C) Typhoid

(D) Influenza

Explanation: The correct answer is Malaria. According to the provided context, malaria is caused by a protozoan called Plasmodium, specifically different species such as P. vivax, P. malaria, and P. falciparum. Other options listed (Tuberculosis, Typhoid, and Influenza) are not caused by protozoans; they are caused by bacteria and viruses.

Question 10.

What is the function of the xylem in plants?

[1 Marks]

(A) Transport of food

(B) Transport of water

(C) Photosynthesis

(D) Reproduction

Explanation: The function of the xylem in plants is to transport water and minerals from the roots to the rest of the plant. The provided context mentions that the vascular tissue system, which includes xylem, translocates water and minerals, confirming that its primary role is indeed the transport of water.

Question 11.

Mendels law of segregation states that:

[1 Marks]

(A) Genes are linked together

(B) Genes mutate spontaneously

(C) Alleles separate during gamete formation

(D) All traits blend in offspring

Explanation: The correct option is 'Alleles separate during gamete formation.' This is because Mendel's law of segregation explains that during the formation of gametes, the two alleles for each gene segregate from each other so that each gamete carries only one allele for each gene, as stated in the relevant context.

Question 12.

Which gas is produced during anaerobic respiration in muscles?

[1 Marks]

(A) Methane

(B) Carbon dioxide

(C) Lactic acid

(D) Oxygen

Explanation:

When you exercise intensely, your muscles require energy faster than your blood can deliver oxygen. To compensate, the cells switch to anaerobic respiration. In this state, glucose is partially broken down to provide a quick burst of energy. While this process creates lactic acid as a liquid byproduct, it still results in the release of carbon dioxide as the primary gaseous waste. This carbon dioxide is then carried by the blood back to the lungs so you can exhale it. This is why you continue to breathe heavily even after you stop moving; your body is working to flush out the excess gas and provide the oxygen needed to clear away the accumulated lactic acid.

Question 13.

Which blood group is called the universal donor?

[1 Marks]

(A) A

(B) B

(C) AB

(D) O

Explanation: Group ‘O’ blood can be donated to persons with any other blood group, making individuals with ‘O’ group blood the universal donors. This is because it does not have A or B antigens on the surface of red blood cells, thus avoiding immune reactions in recipients of other blood types.

Question 14.

Which vitamin is essential for blood clotting?

[1 Marks]

(A) Vitamin A

(B) Vitamin C

(C) Vitamin D

(D) Vitamin K

Explanation: Vitamin K is essential for blood clotting because it is required for the synthesis of certain proteins that are necessary for coagulation. The context describes the coagulation process and the role of various factors without specifically mentioning Vitamin K, but its importance is well established in the medical and biological literature.

Section C

Question 15.

A boy developed some allergic reactions when he straight entered into his air conditioned room after a game of football outside his house. Write any two symptoms that could be noticed in such condition. How does our body combat such conditions ?

[2 Marks]

Answer: The boy may experience symptoms such as sneezing and a running nose due to an allergic reaction triggered by allergens present in his environment. When exposed to these allergens, the immune system mistakenly identifies them as harmful, releasing antibodies of the IgE type. This response leads to the common symptoms associated with allergies, reflecting the body's effort to combat what it perceives as threats, thus triggering inflammation and respiratory discomfort.

Key Points: sneezing-running nose-immune response

Question 16.

(i) Write the Scientific name of the plant from where natural cannabinoids are obtained.

(ii) Mention the parts of the plant that are used for extracting the drug.

(iii) How does the drug affect human body?

[2 Marks]

Answer: The scientific name of the plant from which natural cannabinoids are obtained is Cannabis sativa. The parts of the plant used for extracting the drug include the flower tops, leaves, and resin. The drug affects the human body by interacting with cannabinoid receptors in the brain, leading to various effects such as altered mood, relaxation, and increased heart rate, which can influence the cardiovascular system significantly.

> **Key Points: Cannabis sativa-flower tops-leaves-resin-cannabinoid receptors-altered mood-cardiovascular system**

Question 17.

Farmers are often suggested to use the following organisms in their crop land so as to improve the soil fertility.

(i) *Rhizobium*

(ii) *Anabaena*

Explain.

[2 Marks]

Answer: Farmers are advised to use Rhizobium and Anabaena to enhance soil fertility. Rhizobium, a bacteria, forms symbiotic relationships with leguminous plants, fixing atmospheric nitrogen into a form usable by plants. This nitrogen is essential for plant growth and increases crop yield. Anabaena, a cyanobacterium, also fixes nitrogen and is particularly beneficial in paddy fields. It enriches the soil and contributes organic matter, promoting overall soil health and fertility while reducing reliance on chemical fertilizers.

> **Key Points: Rhizobium fixes atmospheric nitrogen; relationship with leguminous plants; benefits crop growth; Anabaena as a biofertilizer in paddy fields; contributes organic matter; enhances soil health; reduces reliance on chemical fertilizers.**

Question 18.

Organic farmer use *Trichoderma* and *Baculovirus* as biological control agents. Explain.

[2 Marks]

Answer: Organic farmers use Trichoderma and Baculovirus as biological control agents to manage plant pathogens and pests. Trichoderma is a beneficial fungus that helps control soil-borne plant diseases by outcompeting harmful pathogens. Baculovirus, particularly from the genus Nucleopolyhedrovirus, targets specific insect pests, ensuring minimal impact on beneficial insects. By utilizing these biological agents, organic farmers promote biodiversity, reduce dependency on harmful chemicals, and enhance overall ecosystem health in agriculture.

Key Points: Trichoderma as a fungus combating plant pathogens-Baculovirus targeting specific insect pests-Promotes biodiversity and ecosystem health-Reduces dependence on chemical pesticides

Question 19.

Mammals are capable of maintaining homeostasis. But, very few smaller animals can survive in polar regions. Give reasons.

[2 Marks]

Answer: Mammals maintain homeostasis through thermoregulation, which allows them to survive in various climates, including polar regions. However, smaller animals struggle due to extreme cold, limited food availability, and harsh environmental conditions. Smaller body sizes lead to a higher surface area-to-volume ratio, causing quicker heat loss. Additionally, they may lack the fat reserves or fur insulation found in larger mammals, making them less adapted to survival in these frigid habitats.

Key Points: thermoregulation; extreme cold challenges; limited food supply; higher surface area-to-volume ratio; rapid heat loss; lack of insulation; large mammals' advantages

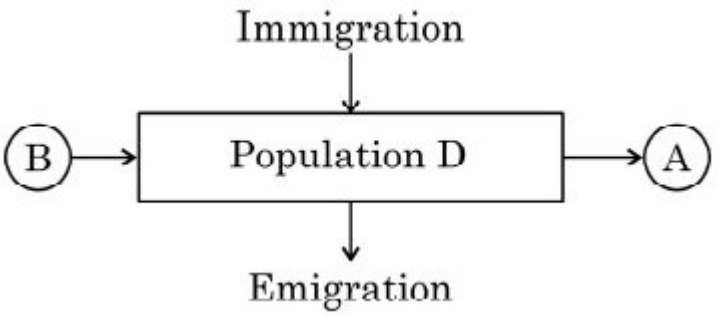
Question 20.

Observe the schematic representation given above and answer the following questions:

(i) Identify A and B.

(ii) Calculate the growth rate of bacteria in a curd sample,where**1** million bacteria increased to two million, within a period of one hour.

[2 Marks]



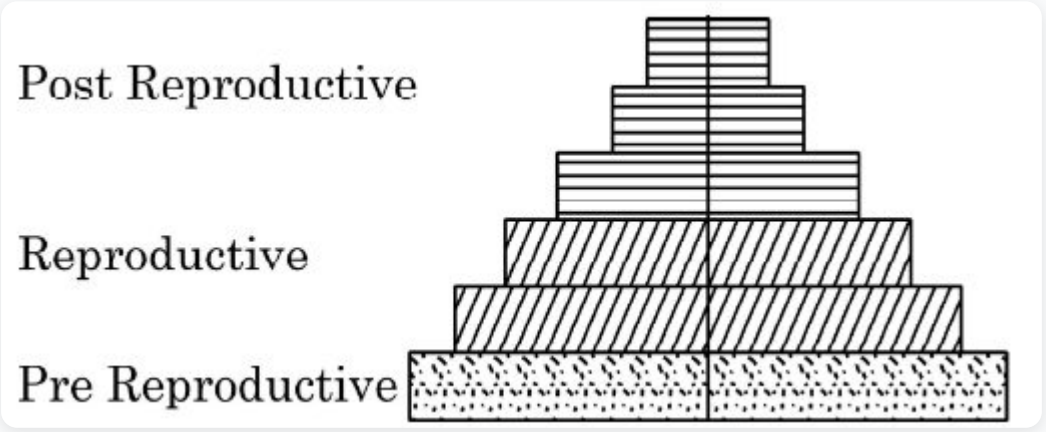
Answer: A is the leaf with an initial area of 10 cm² that increased to 15 cm², and B has an initial area of 50 cm², growing to 55 cm². The growth rate of the bacteria can be calculated as follows: Initial count = 1 million, final count = 2 million, time = 1 hour. Growth rate = (Final count - Initial count) / Time = (2 million - 1 million) / 1 hour = 1 million per hour.

Key Points: A identifies as 10 cm² leaf; B is 50 cm² leaf; bacteria grew from 1 million to 2 million; growth rate = 1 million/hour.

Question 21.

Identify the type of pyramid given above. Write the identifying feature on the basis of which you identified it.

[2 Marks]



Answer: The type of pyramid is the pyramid of number. This is identified by the broad base representing the large number of producers, which narrows towards the apex showing fewer consumers. In this pyramid, the number of organisms decreases at each trophic level, which reflects the energy transfer in an ecosystem.

Key Points: pyramid of number - broad base - large number of producers - narrows towards apex - fewer consumers

Question 22.

Epithelial lining of our intestine is considered as secondary lymphoid organ. Justify the statement.

[2 Marks]

Answer: The epithelial lining of the intestine is classified as a secondary lymphoid organ due to its rich association with mucosa-associated lymphoid tissue (MALT). MALT constitutes around 50% of the lymphoid tissue in the human body and plays a critical role in the immune response. The intestine contains lymphoid structures, such as Peyer's patches, which facilitate interactions between immune cells and antigens, enabling the proliferation of lymphocytes. This ensures effective immune surveillance.

Key Points: Epithelial lining contains MALT-50% of lymphoid tissue-Peyer's patches facilitate lymphocyte interaction with antigens

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Section D

Question 23.

(a) Write the complete name of the diagnostic test for AIDS. Explain the principle it works on.

(b) Name the type of genetic material present in AIDS causing pathogen.

[3 Marks]

Answer: The complete name of the diagnostic test for AIDS is Enzyme Linked Immuno-Sorbent Assay (ELISA). This test works on the principle of antigen-antibody interaction, where the patient's blood sample is tested for the presence of antibodies against HIV. If HIV is present, specific antibodies are produced by the immune system, which can then be detected by the ELISA method. The type of genetic material present in the AIDS-causing pathogen, Human Immunodeficiency Virus (HIV), is RNA, as it belongs to the retrovirus family.

Key Points: Enzyme Linked Immuno-Sorbent Assay (ELISA)-Principle of antigen-antibody interaction-Detection of antibodies against HIV-RNA is the genetic material of HIV

Question 24.

A patient complains of suffering from constipation, stomach ache, stool with blood clots and excess mucous. The physician diagnosed it as amoebiasis, after stool test.

(a) Write the scientific name of the microbe identified in the stool sample.

(b) How do you think, the patient must have contracted it?

(c) Write your suggestions to the patient to avoid infection in future.

[3 Marks]

Answer: The scientific name of the microbe identified in the stool sample is Entamoeba histolytica. This protozoan parasite causes amoebiasis, which presents symptoms such as constipation, abdominal pain, and mucus in stools, along with possible blood clots. The patient may have contracted the infection through contaminated food or water, where the parasite was present due to hygienic lapses or unsanitary living conditions. To prevent future infections, maintaining proper hygiene practices such as washing hands regularly, consuming clean water, and properly cooking food are essential.

Key Points: Entamoeba histolytica; transmission through contaminated food/water; prevention through hand hygiene, clean water, safe food preparation

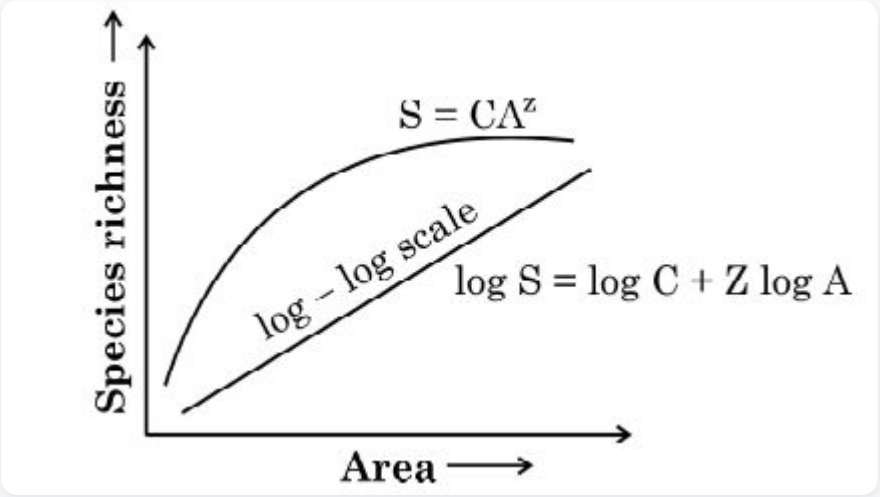
Question 25.

(a) Write the inference drawn by Alexander von Humboldt after his extensive explorations of South Americal jungle.

(b) Study the graph given below:

As per Alexander von Humboldt, what do the symbols S, A, Z and C in the graph stand for, in respect of a species and area relationship ?

[3 Marks]



Answer: Alexander von Humboldt concluded that species richness in a region increases with the explored area, but only up to a certain limit. This observation led him to formulate the species-area relationship that significantly influences biodiversity studies. In this relationship, 'S' represents species richness, which increases as 'A', or area, increases. 'Z' indicates the slope of the relationship, demonstrating how steeply species richness grows with area; 'C' is the Y-intercept, representing the baseline level of species richness irrespective of area. His findings have been foundational in ecology.

Key Points: Species richness increases with area; Species-area relationship; 'S' = Species richness; 'A' = Area; 'Z' = slope of relationship; 'C' = Y-intercept; observations based on extensive explorations.

Question 26.

Explain the concept of "co-extinction" by taking two examples.

[3 Marks]

Answer: Co-extinction refers to the phenomenon where the extinction of one species leads to the extinction of another species that is dependent on it. One clear example is the relationship between a specific host fish species and its unique parasites. If the host fish were to become extinct, the parasites that rely on that fish would also disappear, as they cannot survive without their host. Another example involves coevolved plant-pollinator relationships. If a particular pollinator species goes extinct, the plants that depend on that specific pollinator for reproduction may also face extinction. This interconnectedness highlights the delicate balance of ecosystems and the potential ripple effects of species loss.

Key Points: Definition of co-extinction-Example of host fish and parasites-Example of plant-pollinator mutualism-Interdependence of species in ecosystems

Question 27.

(a) Given below is the stepwise schematic representation of the process of electrophoresis. Identify the 'alphabets' representing

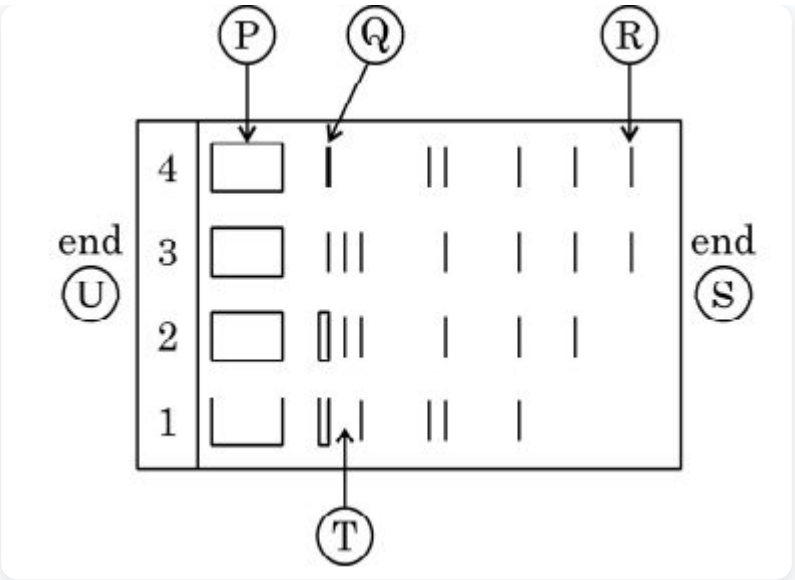
(i) Anode end

(ii)smallest/lightest DNA strand in the matrix

(iii)Agarose gel

(b) What is elution? State the importance of elution in this process.

[3 Marks]



Answer: (a) In the electrophoresis diagram, the 'anode end' is represented by alphabet 'A', indicating the positive electrode where the negatively charged DNA migrates towards. The 'smallest/lightest DNA strand' can be identified with alphabet 'C', which moved the farthest due to its smaller size. The 'agarose gel' is designated by alphabet 'B', which serves as the medium for DNA separation based on size. (b) Elution is the process of extracting DNA fragments from the agarose gel after electrophoresis. This step is crucial as it allows for the purification of DNA, making it available for further applications such as cloning or analysis.

Key Points: A represents the anode end-B represents agarose gel-C represents smallest DNA strand-Elution is extraction-Purification of DNA for further use

Question 28.

"Forests provide intangible benefits to us." Explain by taking three different areas, how.

[3 Marks]

Answer: Forests offer significant intangible benefits that enrich our lives beyond their direct economic contributions. Firstly, they provide aesthetic pleasure; walking through forests, surrounded by greenery and wildlife, can enhance mental well-being and reduce stress. Secondly, they play a crucial role in supporting biodiversity, which ensures ecosystem stability and resilience, promoting natural processes like pollination and pest control essential for food production. Lastly, forests contribute to cultural values by serving as sites for recreation, spiritual connections, and inspiration for art and literature, facilitating a deeper appreciation of nature's beauty and importance in our lives.

Key Points: Aesthetic pleasure and mental well-being - Support for biodiversity and natural processes - Cultural values and connection to nature

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Section E

Question 29.

Explain the process of DNA replication in eukaryotes.

[5 Marks]

Answer: DNA replication in eukaryotes is a highly organized and complex process that occurs during the S-phase of the cell cycle. The process begins at specific sites along the DNA known as origins of replication. Enzymes, particularly DNA-dependent DNA polymerases, play a crucial role by catalyzing the addition of nucleotides to form new DNA strands. Unlike prokaryotes, eukaryotic DNA is linear and associated with histones, requiring multiple replication forks to ensure efficient duplication. As the double helix unwinds, each original strand serves as a template for complementary nucleotide pairing, forming new strands. The synthesis occurs in a semiconservative manner, meaning that each new DNA molecule contains one original and one newly synthesized strand. Leading strands are synthesized continuously, while lagging strands are synthesized discontinuously in fragments known as Okazaki fragments, which are later joined by DNA ligase. Throughout the process, various other enzymes assist in maintaining order and accuracy, ensuring that the genetic material is replicated faithfully. This coordination is vital for cell division, as errors can lead to conditions like polyploidy, underscoring the importance of precise DNA replication.

Key Points: 1. Replication occurs during the S-phase of the cell cycle. 2. Begins at origins of replication. 3. DNA-dependent DNA polymerases synthesize new strands. 4. Semiconservative replication with one original and one new strand. 5. Leading and lagging strands: continuous and discontinuous synthesis, respectively. 6. DNA ligase joins Okazaki fragments. 7. High accuracy is crucial to prevent genetic anomalies such as polyploidy.

Question 30.

Discuss the process of protein synthesis (translation) in eukaryotes.

[5 Marks]

Answer: The process of translation in eukaryotes involves several key steps that occur in the ribosome, where proteins are synthesized from mRNA. Initially, the mRNA molecule, which carries the genetic information transcribed from DNA, binds to the small subunit of the ribosome. Transfer RNA (tRNA) molecules, each carrying a specific amino acid, then align with the corresponding codons on the mRNA strand through complementary base pairing between the tRNA's anticodon and the mRNA codon. As the ribosome moves along the mRNA, amino acids are sequentially added, forming peptide bonds between them. This process requires energy, which assists in the formation of these bonds. The ribosome consists of a large and a small subunit, which function together during translation. Eukaryotic translation has additional complexities, such as multiple RNA polymerases transcribing different types of RNA and the compartmentalization of the transcription and translation processes. Finally, translation terminates when a release factor recognizes a stop codon on the mRNA, leading to

the release of the completed polypeptide chain. Overall, translation is a highly coordinated process critical for protein synthesis in eukaryotic cells.

Key Points: Ribosome as the site of protein synthesis - mRNA defines amino acid sequence - tRNA brings amino acids with anticodon matching mRNA codon - Peptide bonds formed between amino acids requiring energy - Two ribosomal subunits function together - Translation terminates with release factor at stop codon - Additional complexity in eukaryotes with multiple RNA polymerases.

Question 31.

What is the role of biotechnology in agriculture? Give examples.

[5 Marks]

Answer: Biotechnology plays a crucial role in modern agriculture by enhancing crop production, improving resistance to pests and diseases, and reducing dependence on chemical pesticides. One significant application is the development of genetically modified organisms (GMOs). For instance, Bt cotton has been engineered to express a toxin from Bacillus thuringiensis, which makes it resistant to certain pests, thereby reducing pesticide usage and increasing yield. Additionally, biotechnology facilitates the process of tissue culture, allowing for the cultivation of disease-free plants and the development of hybrid varieties with desired traits. Other applications include bioremediation, which helps in detoxifying polluted soils and waste, and the production of biofuels from agricultural waste. Overall, biotechnology not only improves agricultural efficiency but also contributes to sustainable practices by decreasing environmental impact and resource utilization.

Key Points: 1. Improvement of crop yields through GMOs 2. Pest-resistant crops like Bt cotton 3. Tissue culture for disease-free plant production 4. Bioremediation and environmental sustainability 5. Reduction of chemical pesticide use