

SCO INTERNATIONAL OLYMPIAD

CLASS 11 BIOLOGY

OFFICIAL QUESTION PAPER SET H

SCO International Biology Olympiad | Class 11 | Official question paper

Prepared with answers, explanations and compact academic question blocks.

- Focuses on conceptual understanding, numerical reasoning, scientific communication, and real-life application.
- Useful for schools, teachers, parents, mentors, and students preparing for SCO International Biology Olympiad.

Living World	Cell Biology	Plant Physiology	Human Physiology	Biotechnology
Classification	Genetics & Cell Cycle	Reasoning	Achievers	Global Standard

SCO International Biology Olympiad - Class 11

This PDF-ready booklet is prepared for academic website publication. The layout uses compact inline question labels, not large question-number blocks. All questions, passages, options, answers, and explanations are placed inside the main question block for a clean student-friendly reading flow.

Field	Details
Exam Name	SCO International Biology Olympiad
Class / Grade	Class 11
Paper Type	Objective MCQ with application, case-based, assertion-reason and achievers-level questions
Duration	60 minutes
Number of Questions	50 questions
Answering Rule	Choose only one correct option for each question
Edition	Official rebranded edition

Candidate Guidelines

- Read each question carefully before selecting the answer.
- Use only one option as the final answer for every question.
- For assertion-reason questions, judge both statements first and then decide whether the reason explains the assertion.
- No calculator or external help is required for this paper unless the official examination instructions state otherwise.
- This version is designed for website PDF viewing and student practice with explanations.

Section A: Core Concepts and Applied Biology (Q1-Q20)

Q1. A mutation in the p53 gene is identified in a tumor biopsy. Which of the following best describes the role of p53 in normal cell cycle regulation and its implication in cancer development?

- A) p53 promotes the G₂/M transition by activating cyclin B.
- B) p53 acts as a transcription factor that induces cell cycle arrest at the G₁ checkpoint and initiates apoptosis if DNA damage is irreparable.
- C) p53 directly phosphorylates retinoblastoma protein to release E2F.
- D) p53 facilitates DNA replication during the S phase.

Answer: B

Explanation: p53 is known as the “guardian of the genome” because it monitors DNA integrity. In response to DNA damage, p53 induces G₁ cell cycle arrest, allowing for repair. If repair is not possible, it can trigger apoptosis. A mutation in p53 impairs these functions, contributing to uncontrolled cell proliferation and tumorigenesis.

Q2. C₄ plants possess specialized leaf anatomy known as Kranz anatomy. Which advantage does this anatomical adaptation confer in comparison with C₃ plants?

- A) It increases photorespiration, thereby reducing energy wastage.
- B) It enables a spatial separation of initial CO₂ fixation and the Calvin cycle, minimizing photorespiration in hot, arid conditions.
- C) It enhances the absorption of blue light by chloroplasts.
- D) It facilitates the direct utilization of atmospheric nitrogen.

Answer: B

Explanation: C₄ plants concentrate CO₂ in bundle sheath cells, reducing oxygenase activity of Rubisco and thereby minimizing photorespiration—a wasteful process. This adaptation increases photosynthetic efficiency, particularly in high temperature and low CO₂ conditions.

Q3. Photorespiration is often considered a wasteful pathway in C₃ plants. Which statement best explains its effect on photosynthetic efficiency?

- A) Photorespiration produces additional ATP that increases net photosynthesis.
- B) Photorespiration competes with the Calvin cycle by consuming O₂ and releasing CO₂, thereby reducing the net fixation of carbon.
- C) Photorespiration enhances the production of NADPH, improving biosynthetic pathways.
- D) Photorespiration exclusively occurs in the mitochondria, bypassing the chloroplast.

Answer: B

Explanation: Photorespiration occurs when Rubisco oxygenates RuBP, leading to the release of CO₂ and the consumption of energy without producing sugars. This process reduces the overall efficiency of photosynthesis, particularly in C₃ plants under high oxygen or low CO₂ conditions.

Q4. Phloem loading in higher plants can occur via symplastic or apoplastic pathways. Which of the following best characterizes apoplastic phloem loading?

- A) Direct movement of sugars through plasmodesmata.
- B) Active transport of sugars into companion cells against a concentration gradient via membrane transporters.
- C) Passive diffusion of water molecules across the cell membrane.
- D) Transport of ions exclusively via the xylem.

Answer: B

Explanation: In apoplastic phloem loading, sugars (usually sucrose) are actively transported into companion cells and sieve elements from the cell wall space (apoplast) using specific membrane transporters. This process establishes a high sugar concentration, driving bulk flow in the phloem.

Q5. Baroreceptors play a crucial role in maintaining blood pressure. Which mechanism best explains how baroreceptors respond to a sudden drop in blood pressure?

- A) They increase sympathetic activity, causing vasoconstriction and an elevated heart rate.
- B) They decrease parasympathetic activity, leading to vasodilation.
- C) They secrete hormones that directly increase blood volume.
- D) They reduce the release of norepinephrine, leading to a slower heart rate.

Answer: A

Explanation: Baroreceptors, located in the carotid sinus and aortic arch, sense changes in blood pressure. A sudden drop in blood pressure leads to decreased stretch of these receptors, which triggers an increase in sympathetic output. This response causes vasoconstriction and a faster heart rate to restore blood pressure.

Q6. Long-term potentiation (LTP) is a cellular mechanism underlying learning and memory. Which process is most directly involved in establishing LTP at synapses?

- A) Increased synthesis of neurotransmitters in the presynaptic neuron.
- B) Enhanced postsynaptic receptor density and sensitivity through NMDA receptor activation.
- C) Decreased release of neurotransmitters due to presynaptic inhibition.
- D) Rapid reuptake of neurotransmitters from the synaptic cleft.

Answer: B

Explanation: LTP involves a sustained strengthening of synapses, primarily through the activation of NMDA receptors in the postsynaptic neuron. This activation increases calcium influx, which triggers intracellular signaling cascades that enhance receptor density and synaptic strength.

Q7. The hypothalamic-pituitary-adrenal (HPA) axis is regulated by a negative feedback loop. Which of the following best describes how this negative feedback operates?

- A) Elevated cortisol levels stimulate further release of CRH and ACTH.
- B) Elevated cortisol levels inhibit the release of CRH and ACTH from the hypothalamus and pituitary.
- C) Reduced cortisol levels lead to decreased ACTH secretion while increasing CRH production.
- D) The HPA axis functions independently of cortisol levels.

Answer: B

Explanation: In the HPA axis, high levels of cortisol provide negative feedback to the hypothalamus and pituitary gland, inhibiting the release of corticotropin-releasing hormone (CRH) and adrenocorticotropic hormone (ACTH). This regulation helps maintain hormonal balance and prevent excessive cortisol production.

Q8. In the phenomenon of phototropism in plants, auxin distribution plays a critical role. Which of the following best explains the effect of auxin redistribution on a plant's stem when subjected to a directional light stimulus?

- A) Uniform auxin distribution leads to equal growth on all sides of the stem.
- B) Auxin accumulates on the shaded side, promoting cell elongation and causing the stem to bend toward the light.
- C) Auxin is degraded in the presence of light, preventing growth altogether.
- D) Auxin accumulates on the illuminated side, inhibiting cell elongation and causing the stem to bend away from the light.

Answer: B

Explanation: In tropic responses, auxin tends to accumulate on the side of the stem that receives less light (or is lower due to gravity), promoting cell elongation on that side. This differential growth causes the stem to bend toward the light in phototropism or reorient in gravitropism.

Q9. Skeletal muscles contain different fiber types with varying metabolic and functional properties. Which statement best characterizes the differences between slow-twitch (Type I) and fast-twitch (Type II) fibers?

- A) Type I fibers have high glycolytic capacity and fatigue rapidly, whereas Type II fibers are rich in mitochondria and sustain long-duration contractions.

- B) Type I fibers contain numerous mitochondria and rely on aerobic metabolism for endurance, whereas Type II fibers generate rapid, powerful contractions but fatigue quickly due to reliance on anaerobic glycolysis.
- C) Both fiber types have similar mitochondrial content but differ in myosin isoforms only.
- D) Type I fibers are exclusively found in cardiac muscle, while Type II fibers are in skeletal muscle.

Answer: B

Explanation: Type I (slow-twitch) fibers are rich in mitochondria, myoglobin, and capillaries, making them ideal for sustained, endurance activities. Type II (fast-twitch) fibers, on the other hand, produce quick, forceful contractions using anaerobic metabolism, which leads to faster fatigue.

Q10. In a recent study on enzyme kinetics, researchers observed that the addition of a competitive inhibitor increased the apparent K_m of an enzyme-catalyzed reaction without affecting the maximum velocity (V_{max}). What does this indicate about the type of inhibition?

- A) The inhibitor binds to the enzyme-substrate complex only.
- B) The inhibitor binds to an allosteric site, causing non-competitive inhibition.
- C) The inhibitor competes with the substrate for binding to the active site.
- D) The inhibitor causes irreversible inactivation of the enzyme.

Answer: C

Explanation: Competitive inhibitors bind reversibly to the active site, preventing substrate binding. This increases the apparent K_m (indicating a lower affinity for the substrate) while the maximum velocity (V_{max}) remains unchanged, because a sufficiently high substrate concentration can outcompete the inhibitor.

Q11. A biopsy from a malignant tumor shows cells with abnormal nuclear morphology and an unusually high number of cells in the S phase. Genetic sequencing reveals a mutation in a key gene responsible for the G_1/S checkpoint, leading to loss of its normal function.

Question:

Which gene is most likely mutated in this tumor, and what is its primary role in normal cells?

- A) RB - prevents cells from entering S phase by binding E2F transcription factors
- B) p53 - induces cell cycle arrest and apoptosis in response to DNA damage
- C) Cyclin D1 - promotes the G_1/S transition by activating CDKs
- D) p21 - accelerates cell cycle progression in response to growth signals

Answer: B

Explanation: p53 is known as the “guardian of the genome.” In normal cells, it arrests the cell cycle at the G_1/S checkpoint in response to DNA damage and can trigger apoptosis if the damage is irreparable. A mutation in p53 leads to loss of this critical checkpoint control, permitting abnormal cells to proliferate.

Q12. A soybean crop is showing interveinal chlorosis and reduced growth. Soil testing indicates a deficiency of molybdenum.

Question:

Which enzyme’s activity is most directly impaired by molybdenum deficiency, affecting nitrogen assimilation?

- A) Nitrogenase
- B) Nitrate reductase
- C) Glutamine synthetase
- D) RuBisCO

Answer: B

Explanation: Molybdenum is a cofactor essential for nitrate reductase activity. This enzyme catalyzes the reduction of nitrate to nitrite in plants, a key step in nitrogen assimilation. Its impairment leads to symptoms like chlorosis and stunted growth.

Q13. A tomato plant exhibits symptoms of vascular browning, wilting leaves, and dry rot of the stem. Laboratory tests isolate a *Fusarium* species.

Question:

Which disease is the tomato plant most likely suffering from?

- A) Botrytis cinerea infection
- B) Fusarium wilt
- C) Alternaria leaf spot
- D) Powdery mildew

Answer: B

Explanation: Fusarium wilt, caused by *Fusarium oxysporum* f. sp. *lycopersici*, is characterized by vascular browning and wilting in tomatoes. The isolation of a *Fusarium* species and the described symptoms confirm this diagnosis.

Q14. A 16-year-old boy presents with stunted growth, fatigue, and delayed puberty. Radiological imaging reveals a small stature, and laboratory tests indicate low serum levels of growth hormone.

Question:

Which gland is primarily responsible for secreting growth hormone, and what is the likely diagnosis?

- A) Thyroid gland - hypothyroidism
- B) Adrenal gland - adrenal insufficiency
- C) Anterior pituitary gland - growth hormone deficiency
- D) Parathyroid gland - hypoparathyroidism

Answer: C

Explanation: The anterior pituitary gland secretes growth hormone. Low levels of this hormone, as seen in the patient, indicate growth hormone deficiency, which leads to stunted growth and delayed puberty.

Q15. A 55-year-old patient with a history of smoking presents with chronic cough, shortness of breath, and reduced exercise tolerance. Arterial blood gas analysis reveals a reduced PaO_2 and an increased alveolar-arterial oxygen gradient.

Question:

Which pulmonary condition is most consistent with these findings?

- A) Asthma
- B) Chronic Obstructive Pulmonary Disease (COPD)
- C) Pulmonary embolism
- D) Acute respiratory distress syndrome (ARDS)

Answer: B

Explanation: COPD, commonly associated with smoking, leads to impaired gas exchange resulting in a reduced PaO_2 and an increased alveolar-arterial gradient. These findings, along with the patient's clinical history, are typical of COPD.

Q16. A 35-year-old woman presents with persistent leg swelling, high blood pressure, and proteinuria. A renal biopsy reveals thickening of the glomerular basement membrane and mesangial expansion.

Question:

Which renal disorder is most likely diagnosed in this patient?

- A) Minimal change disease
- B) Focal segmental glomerulosclerosis
- C) Diabetic nephropathy
- D) IgA nephropathy

Answer: C

Explanation: The histological features-thickened glomerular basement membrane and mesangial expansion-are characteristic of diabetic nephropathy, a common complication of long-term diabetes that results in proteinuria and hypertension.

Q17. A 28-year-old male presents with unsteady gait, tremors, and difficulty with coordinated movements. MRI reveals focal demyelination in the cerebellum.

Question:

Which clinical syndrome is most directly reflected by these findings?

- A) Parkinson's disease
- B) Cerebellar ataxia
- C) Multiple sclerosis
- D) Amyotrophic lateral sclerosis

Answer: B

Explanation: The patient's symptoms-unsteady gait, tremors, and coordination problems-combined with cerebellar demyelination on MRI, point toward cerebellar ataxia. While multiple sclerosis can cause demyelination, the localized cerebellar findings and specific clinical symptoms support cerebellar ataxia.

Q18. A family history reveals multiple cases of early-onset colon cancer. Genetic testing of an affected individual identifies a mutation in the APC gene.

Question:

Which condition is most consistent with this genetic finding?

- A) Lynch syndrome
- B) Familial Adenomatous Polyposis (FAP)
- C) Peutz-Jeghers syndrome
- D) Li-Fraumeni syndrome

Answer: B

Explanation: Mutations in the APC gene are hallmark features of Familial Adenomatous Polyposis (FAP), a condition that predisposes affected individuals to develop hundreds to thousands of colonic polyps and, eventually, colon cancer if untreated.

Q19. An agricultural study on a wheat crop shows that older leaves exhibit interveinal chlorosis. Soil testing indicates a deficiency in magnesium.

Question:

Which key process in the plant is directly affected by magnesium deficiency?

- A) Cell wall synthesis
- B) Chlorophyll synthesis
- C) DNA replication
- D) Root elongation

Answer: B

Explanation: Magnesium is a central component of the chlorophyll molecule. Its deficiency directly impairs chlorophyll synthesis, leading to interveinal chlorosis, particularly in older leaves.

Q20. A 40-year-old patient presents with weight loss, rapid heartbeat, and heat intolerance. Laboratory tests show elevated levels of thyroid hormones. A thyroid scan reveals diffuse uptake of radioisotope.

Question:

Which condition is most consistent with these findings, and what is the underlying hormonal imbalance?

- A) Hypothyroidism due to low T3 and T4 levels
- B) Hyperthyroidism due to excessive production of T3 and T4
- C) Cushing's syndrome due to high cortisol levels
- D) Addison's disease due to low adrenal hormones

Answer: B

Explanation: The patient's symptoms and lab results are indicative of hyperthyroidism, characterized by elevated levels of thyroid hormones (T3 and T4). Diffuse uptake on the thyroid scan supports the diagnosis of Graves' disease, a common cause of hyperthyroidism.

Section B: Contemporary Biology and Case Applications (Q21-Q30)

Q21. Recent advances in mRNA vaccine technology have played a crucial role in the rapid development of COVID-19 vaccines. What is the primary advantage of mRNA vaccines over traditional vaccine platforms?

- A) They use live attenuated viruses, providing stronger immunity.
- B) They enable rapid design and scalable manufacturing due to synthetic production processes.
- C) They integrate into the host genome to ensure long-lasting expression.
- D) They require no cold-chain storage.

Answer: B

Explanation: mRNA vaccines can be quickly designed and synthesized using genetic sequence information of the target pathogen, allowing for fast development and scalable production. Unlike traditional vaccines, they do not require live viruses or long culture periods, although cold-chain storage can still be necessary.

Q22. Recent developments in CRISPR technology, such as prime editing and base editing, have expanded its therapeutic potential. What distinguishes prime editing from traditional CRISPR-Cas9 gene editing?

- A) It relies solely on non-homologous end joining for repair.
- B) It enables precise editing without creating double-strand breaks in DNA.
- C) It introduces random mutations to increase genetic diversity.
- D) It is only applicable to bacterial cells.

Answer: B

Explanation: Prime editing uses a fusion protein that combines Cas9 nickase with a reverse transcriptase enzyme and a prime editing guide RNA (pegRNA) to directly write new genetic information into a target DNA site without generating double-strand breaks, reducing off-target effects and unintended insertions/deletions.

Q23. Chimeric Antigen Receptor T-cell (CAR-T) therapy has revolutionized the treatment of certain hematologic cancers. Which of the following best describes the mechanism by which CAR-T cells target cancer cells?

- A) They directly secrete chemotherapeutic agents to kill tumor cells.
- B) They are engineered to express receptors that recognize specific antigens on tumor cells, leading to targeted immune cell activation.
- C) They block angiogenesis to starve tumors of nutrients.
- D) They induce apoptosis by releasing cytokines that act systemically.

Answer: B

Explanation: CAR-T cells are modified to express chimeric antigen receptors that specifically bind to antigens present on cancer cells, thereby activating T-cell responses directly at the tumor site. This targeted approach minimizes collateral damage to normal cells.

Q24. Recent research in nanoparticle-based drug delivery has aimed to improve the precision of chemotherapy. What is the primary benefit of using nanoparticles for targeted drug delivery in cancer treatment?

- A) They increase the total systemic dosage of chemotherapeutic agents.
- B) They deliver drugs directly to tumor cells, minimizing side effects on healthy tissues.
- C) They prevent drug degradation by completely avoiding the bloodstream.
- D) They eliminate the need for any conventional chemotherapy.

Answer: B

Explanation: Nanoparticles can be engineered to target specific tumor antigens or exploit enhanced permeability and retention (EPR) effects, enabling the direct delivery of chemotherapy agents to tumor sites. This targeted delivery reduces systemic exposure and minimizes adverse side effects.

Q25. Recent advances in artificial intelligence have led to significant improvements in diagnostic imaging. Which of the following best describes how deep learning algorithms contribute to medical imaging diagnostics?

- A) They replace the need for human radiologists by providing absolute diagnostic certainty.
- B) They automatically analyze complex imaging data to detect subtle abnormalities, improving early disease detection.
- C) They generate synthetic images to replace conventional radiographs.
- D) They are used exclusively for image enhancement, not for diagnostic interpretation.

Answer: B

Explanation: Deep learning algorithms can analyze large sets of imaging data to identify patterns and subtle features that may be indicative of disease. While they do not replace radiologists entirely, they serve as powerful tools for enhancing diagnostic accuracy and facilitating early intervention.

Q26. Recent advancements in organoid technology have enabled researchers to create miniaturized, simplified versions of organs in vitro. How are organoids primarily used in personalized medicine?

- A) To serve as a complete replacement for human organs in transplantation.
- B) To model patient-specific disease and screen potential drugs, thereby tailoring treatment strategies.
- C) To study viral replication exclusively in a controlled environment.
- D) To determine the nutritional needs of individual patients.

Answer: B

Explanation: Organoids derived from a patient's own cells can recapitulate key aspects of organ function and disease pathology. This allows researchers and clinicians to test drug responses in vitro and develop personalized treatment regimens.

Q27. Recent clinical trials have demonstrated the efficacy of immune checkpoint inhibitors in treating various cancers. Which of the following best describes the mechanism of action of PD-1 inhibitors?

- A) They stimulate the production of new T cells in the thymus.
- B) They block the interaction between PD-1 on T cells and PD-L1 on tumor cells, thereby restoring T-cell activity.
- C) They enhance the secretion of immunosuppressive cytokines by tumor cells.
- D) They directly kill tumor cells by inducing DNA damage.

Answer: B

Explanation: PD-1 inhibitors work by preventing PD-1, a receptor on T cells, from binding to PD-L1 on tumor cells. This blockade releases T cells from inhibitory signals, reactivating them to attack cancer cells effectively.

Q28. Recent advancements in single-cell sequencing have provided insights into tumor heterogeneity. What is the primary advantage of single-cell sequencing over bulk tissue sequencing in cancer research?

- A) It is faster and less expensive than bulk sequencing.
- B) It allows for the identification of rare cell subpopulations and distinct genetic profiles within a tumor.
- C) It only detects the most abundant cell types in the sample.
- D) It eliminates the need for subsequent bioinformatic analysis.

Answer: B

Explanation: Single-cell sequencing analyzes individual cells, revealing the genetic and transcriptomic heterogeneity within a tumor. This approach can identify rare subpopulations that may contribute to treatment resistance and disease progression.

Q29. In recent research, chimeric antigen receptor (CAR) natural killer (NK) cell therapy has emerged as a potential alternative to CAR-T cell therapy for cancer treatment. What is a significant advantage of CAR NK cell therapy over CAR-T cell therapy?

- A) CAR NK cells require complete matching of donor and recipient HLA types.
- B) CAR NK cells have a lower risk of inducing cytokine release syndrome and graft-versus-host disease.
- C) CAR NK cell therapy is only effective in hematologic malignancies.
- D) CAR NK cells require permanent engraftment in the patient's body.

Answer: B

Explanation: CAR NK cell therapy leverages the natural cytotoxic properties of NK cells and generally exhibits a lower risk of severe adverse events such as cytokine release syndrome and graft-versus-host disease compared to CAR-T cell therapy, making them a promising alternative for cancer treatment.

Q30. Recent innovations in CRISPR technology have led to the development of rapid diagnostic tools such as SHERLOCK and DETECTR. What is the primary advantage of these CRISPR-based diagnostic platforms?

- A) They require expensive and time-consuming sequencing procedures.
- B) They provide highly specific and rapid detection of nucleic acid sequences, enabling point-of-care diagnostics.
- C) They are only capable of detecting bacterial pathogens.
- D) They eliminate the need for any laboratory equipment.

Answer: B

Explanation: CRISPR-based diagnostic platforms like SHERLOCK and DETECTR leverage the specificity of CRISPR systems to detect target nucleic acid sequences quickly and accurately. This allows for rapid, point-of-care testing for various pathogens, including viruses and bacteria, without the need for complex equipment.

Section C: Reason and Assertion (Q31-Q40)

Q31. Assertion (A1): mRNA vaccines can be rapidly developed and deployed in response to emerging infectious diseases.

Reason (R1): mRNA vaccines are produced by in vitro synthesis of messenger RNA encoding the antigen, bypassing the need for cultivation of live pathogens.

Answer: A

Explanation: Both statements are true, and the fact that mRNA vaccines can be synthesized in vitro without culturing live pathogens is a major reason why they can be developed quickly.

Q32. Assertion (A): CRISPR-Cas9 technology has revolutionized genetic engineering in agriculture.

Reason (R): CRISPR-Cas9 enables precise, targeted gene modifications with minimal off-target effects compared to previous genome-editing methods.

Answer: A

Explanation: Both the assertion and the reason are true, and the precision of CRISPR-Cas9 is indeed a key factor in its revolutionary impact on agriculture, allowing targeted improvements in crops.

Q33. Assertion (A): CAR-T cell therapy has been highly effective in treating certain hematologic cancers.

Reason (R): The therapeutic effect of CAR-T cell therapy is primarily due to its induction of a robust cytokine release syndrome that directly kills tumor cells.

Answer: C

Explanation: The assertion is true; CAR-T cell therapy has shown remarkable success in treating hematologic malignancies. However, the reason is false. Cytokine release syndrome is an adverse side effect of CAR-T cell therapy, not the mechanism by which tumor cells are eliminated. The therapy works by redirecting T cells to specifically target and kill cancer cells.

Q34. Assertion (A): Horizontal gene transfer (HGT) is a major mechanism contributing to the spread of antibiotic resistance among bacteria.

Reason (R): HGT enables bacteria to acquire resistance genes via plasmids, transposons, and bacteriophages, even across different species.

Answer: A

Explanation: Both statements are true, and the ability of bacteria to exchange genetic material (including antibiotic resistance genes) through HGT is a well-documented mechanism that accelerates the spread of resistance.

Q35. Assertion (A): Some epigenetic modifications can be inherited across generations, affecting the phenotype of offspring without altering the DNA sequence.

Reason (R): DNA methylation patterns are completely erased during gametogenesis, which prevents the transmission of epigenetic marks to the next generation.

Answer: C

Explanation: The assertion is true—there is evidence that some epigenetic marks, such as certain DNA methylation patterns or histone modifications, can escape reprogramming and be inherited. However, the reason is false because although much DNA methylation is reset during gametogenesis, some epigenetic modifications can persist and be transmitted across generations.

Q36. Assertion (A): Genetic drift has a more pronounced effect in small populations than in large populations.

Reason (R): In small populations, random fluctuations in allele frequencies due to sampling error can lead to rapid fixation or loss of alleles.

Answer: A

Explanation: Both statements are true, and in small populations, the impact of random sampling (genetic drift) is much greater, leading to significant changes in allele frequencies over relatively few generations.

Q37. Assertion (A): Exposure to endocrine disruptors in the environment can have transgenerational effects on reproductive health.

Reason (R): Endocrine disruptors can induce heritable epigenetic changes during critical periods of development.

Answer: A

Explanation: Both the assertion and the reason are true. Research shows that exposure to endocrine disruptors during sensitive developmental windows can cause epigenetic modifications that may be passed on to subsequent generations, affecting reproductive health.

Q38. Assertion (A): Microplastics are persistent pollutants that accumulate in the food chain, posing significant risks to both wildlife and human health.

Reason (R): Microplastics readily biodegrade in natural environments, thereby minimizing their long-term ecological impact.

Answer: C

Explanation: The assertion is true—microplastics are persistent and tend to accumulate, potentially causing harm throughout the food chain. However, the reason is false because microplastics are notoriously resistant to biodegradation, which contributes to their persistence in the environment.

Q39. Assertion (A): Bioremediation is an environmentally friendly method for cleaning up polluted ecosystems.

Reason (R): Bioremediation employs living organisms to degrade or detoxify contaminants, converting them into less harmful substances.

Answer: A

Explanation: Both statements are true, and the use of living organisms to transform harmful pollutants into benign substances is the fundamental advantage of bioremediation, making it an eco-friendly remediation strategy.

Q40. Assertion (A): Tissue engineering holds promise for overcoming the shortage of donor organs in transplantation.

Reason (R): Tissue engineering relies exclusively on synthetic scaffolds and bypasses the need for any biological components, making it universally applicable.

Answer: C

Explanation: The assertion is true; tissue engineering is a promising approach to creating functional tissue substitutes for transplantation. However, the reason is false because tissue engineering typically combines both synthetic scaffolds and biological components (such as cells and growth factors) to create functional tissues—it does not rely exclusively on synthetic materials.

Section D: Achievers Section - Higher Order Biology (Q41-Q50)

Q41. A 50-year-old patient with refractory B-cell lymphoma is treated with CAR-T cell therapy. Within days of the infusion, the patient develops high fever, hypotension, and respiratory distress. Laboratory tests reveal markedly elevated levels of interleukin-6 (IL-6).

Question:

What is the most likely cause of the patient's symptoms, and which therapeutic agent is indicated?

- A) Direct cytotoxicity from CAR-T cells; treat with high-dose corticosteroids.
- B) Cytokine release syndrome (CRS) due to excessive T-cell activation; treat with an IL-6 receptor antagonist (tocilizumab).
- C) Bacterial sepsis secondary to neutropenia; treat with broad-spectrum antibiotics.
- D) Autoimmune-mediated colitis; treat with immunosuppressive agents.

Answer: B

Explanation: CAR-T cell therapy can lead to CRS, a hyperinflammatory state triggered by massive cytokine release, particularly IL-6. Tocilizumab is used to block IL-6 receptors, mitigating CRS symptoms.

Q42. Researchers are developing a CRISPR-Cas9-based gene therapy for Duchenne muscular dystrophy (DMD). In preclinical models, a micro-dystrophin gene is delivered via an adeno-associated virus (AAV) vector to restore muscle function.

Question:

What is the primary goal of using a micro-dystrophin construct in this therapy?

- A) To completely replace the full-length dystrophin protein.
- B) To express a truncated but functional version of dystrophin that retains essential domains.
- C) To induce an immune response against muscle fibers.
- D) To promote non-specific muscle regeneration.

Answer: B

Explanation: DMD is caused by mutations in the dystrophin gene. Micro-dystrophin constructs are designed to encode a shortened dystrophin that retains critical functional domains, improving muscle stability and function without needing to express the full-length protein.

Q43. A 38-year-old patient with metastatic melanoma receives a PD-1 inhibitor. After several treatment cycles, the patient develops severe autoimmune colitis characterized by abdominal pain and diarrhea.

Question:

What is the most plausible explanation for the development of autoimmune colitis in this patient?

- A) PD-1 inhibitors induce direct cytotoxicity on colon epithelial cells.
- B) Inhibition of PD-1 removes inhibitory signals on T cells, leading to autoimmune attacks on normal tissues.
- C) PD-1 inhibitors cause depletion of regulatory T cells, reducing overall immune surveillance.
- D) PD-1 inhibitors increase antibody production that targets colon tissues.

Answer: B

Explanation: PD-1 inhibitors block inhibitory pathways that normally keep T-cell responses in check. This can lead to an overactive immune response, with T cells attacking normal tissues such as the colon, resulting in autoimmune colitis.

Q44. During a hospital outbreak, multiple isolates of *Klebsiella pneumoniae* exhibit resistance to carbapenems. Molecular analysis reveals that the bacteria carry a plasmid encoding the bla_{KPC} gene.

Question:

What is the most significant mechanism underlying the spread of carbapenem resistance in this outbreak?

- A) Vertical transmission through clonal expansion
- B) Horizontal gene transfer via plasmids

- C) Spontaneous mutation during antibiotic exposure
- D) Enhanced biofilm formation

Answer: B

Explanation: Horizontal gene transfer, particularly via plasmids, enables bacteria to rapidly share antibiotic resistance genes like *bla_KPC* across different strains and species, leading to widespread resistance.

Q45. A clinical trial investigates a nanoparticle formulation designed to deliver chemotherapeutic agents to glioblastoma. The nanoparticles are functionalized with transferrin to enhance crossing of the blood-brain barrier (BBB).

Question:

What is the key rationale behind functionalizing nanoparticles with transferrin in this context?

- A) Transferrin increases nanoparticle size to improve retention.
- B) Transferrin facilitates receptor-mediated transcytosis across the BBB due to its receptor's overexpression on brain endothelial cells.
- C) Transferrin prevents nanoparticle degradation in circulation.
- D) Transferrin reduces the immunogenicity of the nanoparticles.

Answer: B

Explanation: Functionalizing nanoparticles with transferrin targets the transferrin receptor, which is abundantly expressed on brain capillary endothelial cells. This enhances the transport of nanoparticles across the BBB, delivering the chemotherapeutic agent directly to the tumor site.

Q46. Researchers have developed patient-derived tumor organoids to screen for effective drugs in personalized cancer therapy. These organoids mimic the patient's tumor heterogeneity and microenvironment.

Question:

What is the primary advantage of using tumor organoids in personalized medicine?

- A) They allow for high-throughput genomic sequencing of tumors.
- B) They enable the prediction of individual patient drug responses by closely mimicking the tumor's characteristics.
- C) They are less expensive than traditional cell lines.
- D) They eliminate the need for in vivo testing in animal models.

Answer: B

Explanation: Tumor organoids are three-dimensional cell culture systems that replicate the heterogeneity and microenvironment of the original tumor. This makes them valuable for testing drug responses and tailoring personalized treatment strategies.

Q47. A research team uses single-cell RNA sequencing (scRNA-seq) to analyze a heterogeneous tumor sample. They identify a small subpopulation of cells with stem-like properties that may contribute to therapy resistance.

Question:

What is the primary benefit of using single-cell sequencing in tumor analysis?

- A) It reduces the cost of genomic analysis.
- B) It allows the identification of rare cell populations with distinct genetic profiles within a tumor.
- C) It simplifies the data analysis compared to bulk sequencing.
- D) It increases the overall sequencing speed without loss of resolution.

Answer: B

Explanation: Single-cell RNA sequencing enables researchers to analyze the transcriptome of individual cells. This approach reveals tumor heterogeneity, including rare cell subpopulations that may drive therapy resistance and relapse.

Q48. A long-term animal study investigates the effects of prenatal exposure to bisphenol A (BPA), an endocrine disruptor. Offspring exhibit altered reproductive function and epigenetic modifications in germ cells that persist into adulthood.

Question:

What is the most likely implication of these findings?

- A) BPA exposure only affects the directly exposed individual.
- B) BPA-induced epigenetic changes can be transmitted to subsequent generations, affecting reproductive health.
- C) BPA exposure enhances reproductive function.
- D) Epigenetic changes due to BPA are rapidly reversible upon cessation of exposure.

Answer: B

Explanation: Studies indicate that exposure to endocrine disruptors like BPA during critical developmental periods can lead to heritable epigenetic modifications. These changes can affect gene expression and reproductive health in subsequent generations.

Q49. Patients with metastatic melanoma treated with a combination of BRAF and MEK inhibitors initially respond well, but many eventually develop resistance. Molecular analyses reveal activation of alternative signaling pathways in resistant tumors.

Question:

Which mechanism is most commonly associated with the development of resistance to BRAF/MEK inhibitor therapy?

- A) Loss of BRAF expression
- B) Activation of alternative pathways such as PI3K-AKT
- C) Enhanced drug efflux from tumor cells
- D) Increased immune cell infiltration

Answer: B

Explanation: Tumors can bypass the inhibited BRAF/MEK pathway by activating alternative signaling pathways like the PI3K-AKT pathway, which promotes cell survival and proliferation, leading to drug resistance.

Q50. A novel CRISPR-Cas12a diagnostic platform has been developed for rapid detection of SARS-CoV-2. This system uses Cas12a's collateral cleavage activity to cleave reporter molecules upon recognition of viral RNA.

Question:

What is the primary advantage of CRISPR-based diagnostics over conventional RT-PCR in detecting infectious agents like SARS-CoV-2?

- A) They require thermal cycling and complex equipment.
- B) They offer rapid, highly specific, and portable detection suitable for point-of-care testing.
- C) They are less sensitive than RT-PCR.
- D) They are only applicable to DNA viruses.

Answer: B

Explanation: CRISPR-based diagnostics leverage the high specificity of CRISPR systems and the collateral cleavage activity of enzymes like Cas12a to provide fast, sensitive detection of target nucleic acids without the need for complex instrumentation, making them ideal for point-of-care settings.

Answer Key

Q	Ans.	Q	Ans.	Q	Ans.	Q	Ans.	Q	Ans.
1	B	2	B	3	B	4	B	5	A
6	B	7	B	8	B	9	B	10	C
11	B	12	B	13	B	14	C	15	B
16	C	17	B	18	B	19	B	20	B
21	B	22	B	23	B	24	B	25	B
26	B	27	B	28	B	29	B	30	B
31	A	32	A	33	C	34	A	35	C
36	A	37	A	38	C	39	A	40	C
41	B	42	B	43	B	44	B	45	B
46	B	47	B	48	B	49	B	50	B

