

Date: 23/11/2025

23



Corporate Office: AESL, 3rd Floor, Incuspaze Campus-2, Plot-13, Sector-18,
Udyog Vihar, Gurugram, Haryana-122015

Answers & Solutions

Time : 120 Minute

for

Max. Marks : 216

Association of Teachers in Biological Sciences (ATBS) National Standard Examination in BIOLOGY (NSEB)-2025

INSTRUCTIONS TO CANDIDATES

- (1) There are 60 questions in this paper. Attempt all the 60 Questions.
- (2) Question paper has two parts. In **Part A-1** (Q. No. 1 to 48) each question has four alternatives, out of which **only one** is correct. Choose the correct alternative and fill the appropriate bubble, as shown.

Q. No. 12 a b c d

In **Part A-2** (Q. No. 49 to 60) each question has four alternatives, out of which **any number of alternative (s)** (1, 2, 3 or 4) may be correct. You have to choose ALL correct alternative(s) and fill the appropriate bubble(s), as shown.

Q. No. 52 a b c d

- (3) For **Part A-1**, each correct answer carries **3 marks** whereas 1 mark will be deducted for each wrong answer. In **Part A-2**, you get **6 marks** if all the correct alternatives are marked. No negative marks in this part.

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A - 1 (Attempt All Sixty Questions)

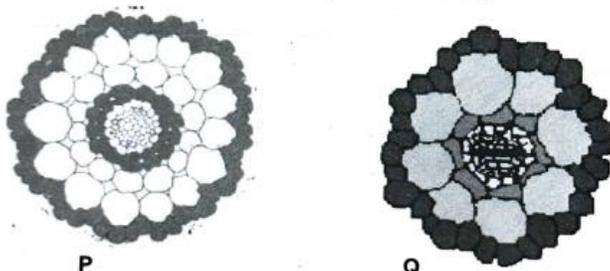
ONLY ONE OUT OF FOUR OPTIONS IS CORRECT. BUBBLE THE CORRECT OPTION

1. Researchers conducted a study comparing two distinct successional systems:
 Site 1: Occurring on a sterile, newly exposed volcanic ash substrate.
 Site 2: Taking place in an abandoned agricultural field with pre-existing soils.
 Over time, both sites showed an increase in soil nutrient levels, but the underlying processes differed between the two.
 Which of the following statement is true about these succession processes?
- Site 1 is an example of primary succession.
 - Succession at site 1 is likely to be a faster process due to rapid nutrient input from invasive species than site 2.
 - Soil nutrient enhancement will be more pronounced at site 1 due to availability of inorganic nutrients in the form of ash.
 - Both the sites will have a completely novel flora and fauna as a result of succession.

Answer (a)

Sol. Succession occurring on a sterile, newly exposed volcanic ash substrate is an example of primary succession because the process of succession begins on a site that is devoid of any pre-existing soil, organic matter or life. In such an area, soil nutrient enhancement is very slow initially, as the primary process of soil formation takes thousands of years, whereas, an abandoned agricultural field has the pre-existing soil structure and biological components.

2. Cross sections of the roots of two plants P and Q are shown below;



P and Q most likely represent:

- Floating hydrophyte and a halophyte
- Halophyte and a hydrophyte
- Submerged hydrophyte and halophyte
- Halophyte and a mesophyte

Answer (d)

Sol. The cross section P represents the root of a halophyte. It shows the presence of two-layered endodermis which is a feature of some halophytes as it provides an effective anatomical barrier to regulate the flow of minerals into the vascular bundles.

The cross section Q represents the root of a mesophyte. It shows the presence of single-layered epidermis, a large region of parenchymatous cortex, distinct endodermis and well-developed vascular bundles.

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3. During prolonged fasting, the liver ramps up gluconeogenesis to maintain blood glucose levels. However, gluconeogenic flux draws off oxaloacetate from the TCA cycle, risking the depletion of key intermediates required for both energy production and biosynthesis. Which of the following reactions most directly and efficiently replenishes the TCA cycle during fasting, thereby supporting both ATP generation and gluconeogenesis?
- Conversion of pyruvate to acetyl-CoA via the pyruvate dehydrogenase complex, providing acetyl-CoA to combine with residual oxaloacetate.
 - Deamination of glutamate to form α -ketoglutarate via glutamate dehydrogenase, channelling amino acid carbon into the TCA cycle.
 - Carboxylation of pyruvate to oxaloacetate catalyzed by pyruvate carboxylase, directly restoring the oxaloacetate pool.
 - Transamination of alanine to pyruvate via alanine aminotransferase, indirectly supplying substrate for subsequent TCA cycle replenishment.

Answer (c)

Sol. During prolonged fasting, as the liver enhances the synthesis of glucose, it utilizes OAA from the TCA cycle. In order to replenish OAA, carboxylation of pyruvate to oxaloacetate is catalysed by pyruvate carboxylase. This restores the oxaloacetate pool, supporting both energy production and gluconeogenesis.

4. Which of the following cells show least telomerase activity?
- Sperm cells
 - Embryonic stem cells
 - Carcinoma cells
 - Mature adipose cell

Answer (d)

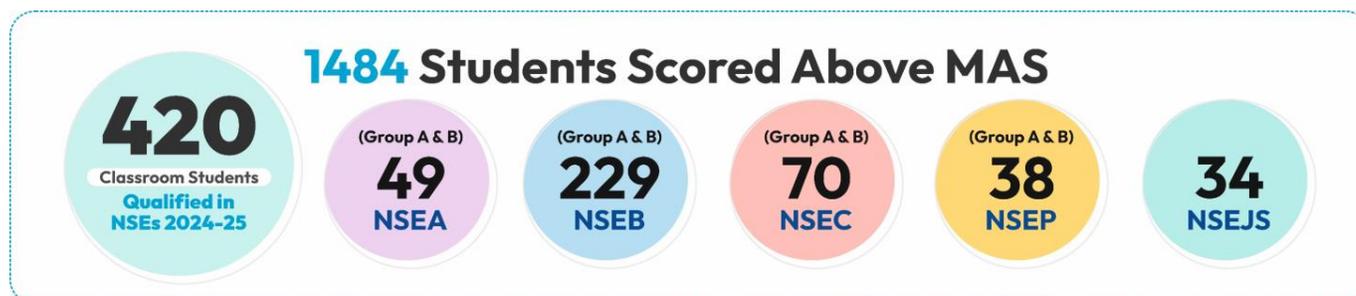
Sol. The correct answer is option (d).

Telomerase is the enzyme responsible for the maintenance of the length of telomerase by addition of guanine-rich repetitive sequences. Telomerase activity is exhibited in gametes, stem cells and tumor cells.

Thus, since adipose tissue consists of somatic cells (adipocytes) which are terminally differentiated cells, the mature adipose cells show the least telomerase activity.

5. A researcher is attempting to amplify a specific gene fragment using PCR. The designed primer pair has a high GC content (~60%) and, upon analysis, exhibits regions of self-complementarity near the 3' termini. When the PCR is run under standard cycling conditions, gel electrophoresis reveals only a faint band corresponding to the expected amplicon, but a dominant, sharp band appears at a size roughly twice the length of the individual primers. Which of the following best explains this observation?
- The 3' self-complementarity in the forward primer alone leads to intra-molecular hairpin formation that completely sequesters the primer, resulting in inefficient target binding.
 - The complementary 3' ends of the forward and reverse primers facilitate dimerization, producing a primer-dimer that is preferentially amplified over the target sequence.
 - The high GC content increases the melting temperature so dramatically that only non-specific, off-target binding occurs at the lower annealing temperature, yielding spurious short products.
 - The primers undergo self-extension during the elongation phase due to internal priming on partially complementary regions within themselves, creating a consistent artifact of double-primer length.

Answer (b)



Sol. The correct answer is option (b).

Option (a) is incorrect because if hairpin loops are formed in the primer, a dominant, sharp band of twice the length of the individual primers will not be formed.

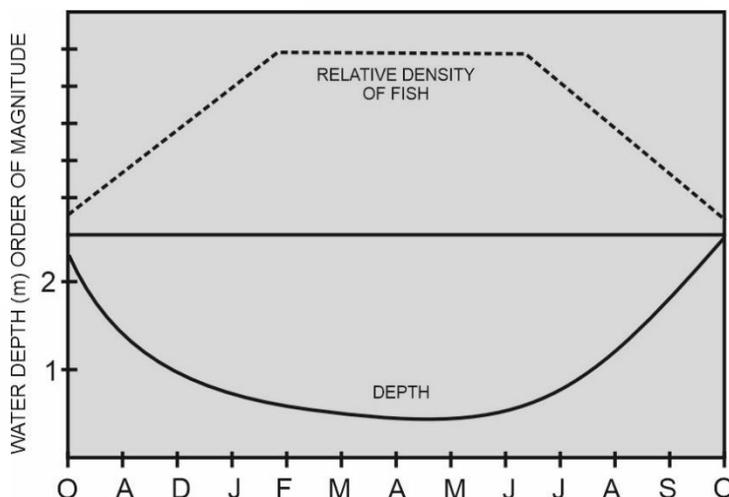
Option (b) is correct as in the question, it is clearly mentioned that a sharp band of size roughly twice the length of the individual primer is formed, which indicates primer-dimer formation.

A primer-dimer formation occurs when the 3' ends of the forward and reverse primers bind to each other.

Option (c) is incorrect as spurious short products are formed when there is non-specific binding of products, which will likely result in the formation of smear or multiple bands of varying sizes; no sharp bands will be formed.

Option (d) is incorrect as internal priming does not occur in primer-dimer formation, rather it is an intermolecular process.

6. In a tropical lake, the depth as well as expanse of the water goes on reducing as the summer progresses. This causes the ecological density of fish to increase, dropping again in monsoon as water fills in. A bird species feeds on these fish. The bird needs to incubate its eggs for one month and then feed the nestlings for another four months. The accompanying figure depicts changes in depth and fish density from October to October. What should be the ideal duration in which the bird needs to lay eggs?



- (a) November-December
- (b) January- February
- (c) March-April
- (d) May- June

Answer (b)

Sol. In a tropical lake, as summer progresses, the depth as well as expanse of water goes on reducing. When monsoon begins, lake refills and ecological density of fishes as well as birds increases.

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The bird needs 1 month for incubation and 4 months for feeding. So, it requires four months of high fish density after laying eggs.

Above figure depicts that the relative density of fish is highest in between February to June, so the bird must lay eggs slightly before the rise begins. *i.e.*, January-February.

7. Which of the following statements best describes the role of the origin of replication (*ori*) in a recombinant plasmid used for bacterial transformation?
- The *ori* is responsible for the antibiotic resistance of the plasmid.
 - The *ori* ensures the plasmid is integrated into the bacterial chromosome.
 - The *ori* allows the plasmid to replicate independently within the bacterial cell.
 - The *ori* is involved in the transcription of the inserted gene.

Answer (c)

Sol. The correct answer is option (c).

In a plasmid, the *ori* is the site where DNA replication begins, enabling the plasmid to reproduce itself. Most importantly, the *ori* allows the plasmid to replicate independently from the host cell's chromosomal DNA.

8. In the dense jungles of India, a male deer (stag) with massive branching antlers engages in fierce battles with rivals to gain access to a harem of females. While these antlers provide a competitive edge during fights, they also slow the stag down, making it an easier target for predators. Interestingly, females still prefer males with the largest antlers.

In this context, which of the following scenarios BEST supports the Handicap Principle?

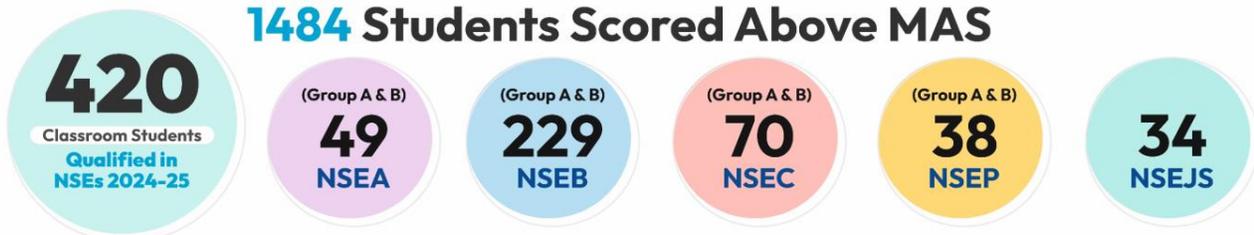
- The Antlers as Honest Signals:** The size of the antlers demonstrates the stag's ability to survive despite the handicap, signalling superior strength and genetic quality to potential mates.
- The Antlers as Weaponry:** The stag's antlers are primarily used to defeat rivals, ensuring reproductive success by physically eliminating competition.
- Runaway Sexual Selection:** Female preference for larger antlers evolves independently of their utility, causing the trait to become exaggerated over generations.
- The Antlers as Camouflage:** The antlers resemble branches, providing the stag with protection from predators and simultaneously increasing its attractiveness.

Answer (a)

Sol. The correct answer is option (a).

Zahavi's handicap theory suggests that the bigger and most beautiful ornaments—for instance, the largest and most imposing antlers – are damaging to their bearer's health. However, ornaments are symbols of genetic quality, as they prove that their carriers can survive the challenge of carrying such heavy architecture, and thus females will prefer to mate with males carrying larger antlers. So, despite the increased risk, massive branching in antlers provides an honest signal of male phenotypic quality.

Runaway selection is a mechanism whereby a secondary sexual trait expressed in one sex becomes genetically correlated with a preference for the trait in the other sex.



9. A researcher grows an *E. coli* culture in a batch medium that contains both glucose and lactose. The growth curve clearly exhibits an initial exponential phase on glucose, followed by a pronounced lag, and then a second exponential phase once lactose metabolism has initiated. Which of the following best explains the molecular mechanism underlying the lag period observed between the two exponential phases?
- The accumulation of acidic byproducts from rapid glucose metabolism induces transient cellular repair pathways, temporarily halting cell division until these byproducts are neutralized.
 - Catabolite repression mediated by the cAMP-CRP complex suppresses the transcription of lactose-metabolizing enzymes while glucose is abundant, delaying the induction of the lac operon until glucose levels decline.
 - An osmotic shock is incurred due to the simultaneous uptake of high concentrations of both sugars, necessitating a transient adjustment of the cell's internal solute balance before normal division resumes.
 - The metabolic shift from aerobic to strictly anaerobic energy production during glucose consumption forces a reconfiguration of the electron transport chain, leading to a delay in the resumption of exponential growth on lactose

Answer (b)

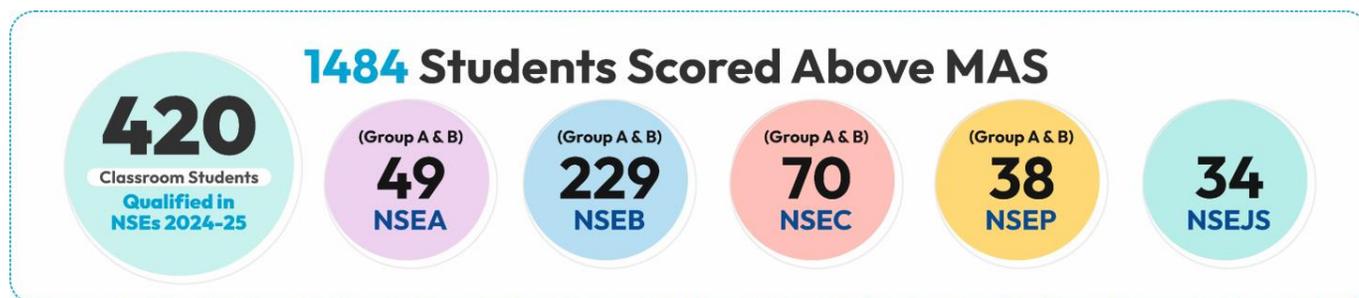
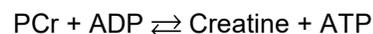
Sol. Diauxic growth is a two-phase growth pattern observed when *E. coli* is cultured in a medium containing both glucose and lactose. When glucose is abundant, it is the cell's preferred energy source. The lag period occurs after glucose is depleted. When there is no glucose in the medium, adenylate cyclase is activated leading to an increase in the intracellular cAMP level, cAMP switches on catabolite repression when it binds to the CRP/CAP protein that interacts with RNA polymerase to activate transcription of specific operon, and then cAMP combines with CRP to form the cAMP-CRP complex that controls certain metabolic pathway genes to use the sugar other than glucose, allowing the bacteria to use alternative carbon sources.

10. Elite sprinters often need to perform repeated maximal sprints with only brief recovery periods. One key factor in maintaining high power across bouts is the rapid replenishment of intramuscular phosphocreatine (PCr) during recovery. Which of the following muscular adaptations most directly enhances the rate of PCr resynthesis between sprint efforts?
- Upregulation of creatine kinase activity, thereby accelerating the immediate equilibrium between ADP and PCr.
 - Increased mitochondrial density coupled with enhanced oxidative enzyme capacity, facilitating rapid ATP generation via oxidative phosphorylation.
 - Elevated glycolytic enzyme activity, which boosts anaerobic ATP production during recovery intervals.
 - Improved sarcoplasmic reticulum Ca^{2+} -ATPase function, leading to faster calcium clearance and increased overall energy turnover.

Answer (b)

Sol. The correct answer is option (b)

Upregulation of creatine kinase activity is an adaptation that enhances the rate of PCr resynthesis between sprint efforts, but the enzyme catalyses the reaction as shown below:



Thus, there will be no equilibrium established between ADP and PCr, thus option (a) is incorrect.

The rate of PCr synthesis is increased by enhancing the muscle's oxidative capacity (aerobic metabolism) as this process requires ATP production by oxidative phosphorylation within the mitochondria.

Thus, an increased mitochondrial density and enhanced oxidative enzyme capacity allows for faster ATP generation.

Option (c) is incorrect because production of anaerobic ATP will not be helpful in recovery.

Option (d) is incorrect because Ca^{2+} -ATPase functions to perform calcium clearance and muscle relaxation.

11. Kidneys are essential organs in vertebrates that play a vital role in maintaining homeostasis by excreting metabolic waste and reabsorbing necessary substances. Which of the following mechanisms is primarily responsible for the countercurrent multiplication process in the Loop of Henle?

- (a) Secretion of urea in the collecting duct (b) Passive diffusion of water in the descending limb
(c) Filtration of blood in the glomerulus (d) Active transport of sodium ions in the ascending limb

Answer (d)

Sol. The correct answer is option (d)

The countercurrent mechanism in the loop of Henle is a process where the filtrate flows in opposite directions in its ascending and descending limbs, creating a concentration gradient in the renal medulla.

The process primarily responsible for countercurrent multiplication is the active transport of Na^+ and Cl^- out of the thick ascending limb of loop of Henle. This active transport creates a high solute concentration in the surrounding interstitial fluid. Then, the high solute concentration in the interstitium drives passive reabsorption of water from the descending limb of loop of Henle.

12. In an isolated lung preparation subjected to sudden hypoxia, the pulmonary arteries exhibit an immediate vasoconstrictor response that is rapidly reversed when normoxic conditions are restored. Processes involved in the pathway to vasoconstriction are listed below.

- I. Closure of oxygen sensitive K^+ channels
- II. Opening of voltage dependent Ca^{++} channels
- III. Reduction in mitochondrial Reactive Oxygen Species (ROS) production
- IV. Increase in intracellular Ca^{++}
- V. Membrane depolarization

The correct order of these processes is:

- (a) I \rightarrow III \rightarrow V \rightarrow IV \rightarrow II (b) V \rightarrow IV \rightarrow II \rightarrow I \rightarrow III
(c) II \rightarrow IV \rightarrow I \rightarrow V \rightarrow III (d) III \rightarrow I \rightarrow V \rightarrow II \rightarrow IV

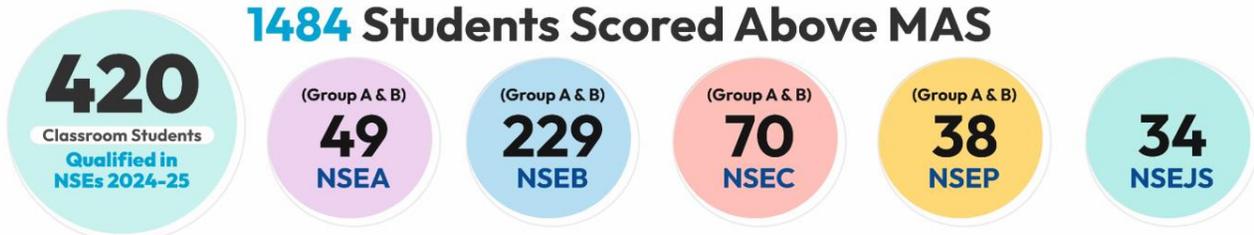
Answer (d)

Sol. The correct answer is option (d)

Pulmonary arteries exhibit a marked vasoconstriction when exposed to hypoxic condition.

Smooth muscles of pulmonary artery recognise low O_2 level which leads to reduction in mitochondrial reactive oxygen (ROS) production, (III).

The decrease in ROS leads to inhibition of oxygen sensitive voltage-gated K^+ channels in smooth muscle membrane of pulmonary artery, (I).



This leads to membrane to remain in condition of depolarisation, (V).

It will cause opening of voltage dependent Ca^{++} channels and cause rapid influx of a Ca^{++} in the cell, (II).

Influx of Ca^{++} lead to increase in intracellular Ca^{++} level, (IV).

Hence the correct sequence is

III \rightarrow I \rightarrow V \rightarrow II \rightarrow IV

13. Angiotensin-Converting Enzyme (ACE) converts Angiotensin I to II which acts as vasoconstrictor. Another endocrine hormone, namely vasopressin, also known as anti-Diuretic Hormone (ADH) increases water reabsorption from kidneys. Patients treated with ACE inhibitors are known to show reduced vasopressin levels over time. Which of the following is correct statement about these two molecules?
- Both are useful as anti-hypertensive drugs.
 - Administering vasopressin along with ACE inhibitors will increase the efficacy of the later.
 - The effectiveness of ACE inhibitors will reduce over time due to reduced vasopressin levels in the blood.
 - Vasopressin can be used as a drug in case of accidental overdose of ACE inhibitors.

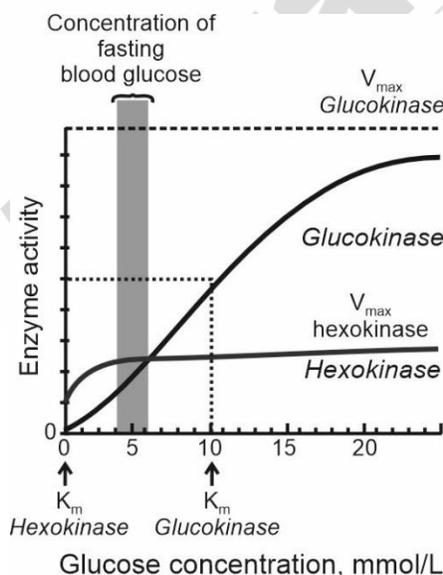
Answer (d)

Sol. The correct answer is option (d)

ACE inhibitors lower the blood pressure by blocking the conversion of angiotensin I to angiotensin II (a vasoconstrictor). Vasopressin (ADH) secreted from hypothalamus helps in absorption of water from renal tubules, hence help in maintaining blood volume and blood pressure.

So in a case of accidental overdose of ACE inhibitors (which decreases blood pressure), vasopressin (ADH) can be used to maintain a normal blood pressure as a drug, as higher ADH will increase water reabsorption hence will help in maintaining blood volume as well as pressure.

14. The kinetic parameters of two enzymes, namely hexokinase and glucokinase, that both use glucose as a substrate are depicted in the graph.



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The reduction in filling leads to lesser end diastolic volume (EDV).

Decreased EDV leads to decreased SV, which can limit cardiac output despite the high heart rate.

16. Physiological mechanisms of C_3 and C_4 plants highlight fundamental differences in how they cope with stressors like water loss, high temperatures and photorespiration. C_3 plants rely on the Calvin cycle for carbon fixation while C_4 plants have a mechanism to concentrate CO_2 around Rubisco. The reason for C_3 plants to experience higher levels of photorespiration under environmental stress could be because
- C_3 plants have RuBisCO which has greater affinity for oxygen as compared to carbon dioxide.
 - C_3 plants are unable to survive in high-temperature environments.
 - C_3 plants cannot concentrate CO_2 effectively around RuBisCO, increasing oxygen interference.
 - C_3 plants cannot utilize ETS effectively during photosynthesis whereby there is excess production of oxygen free radicals.

Answer (c)

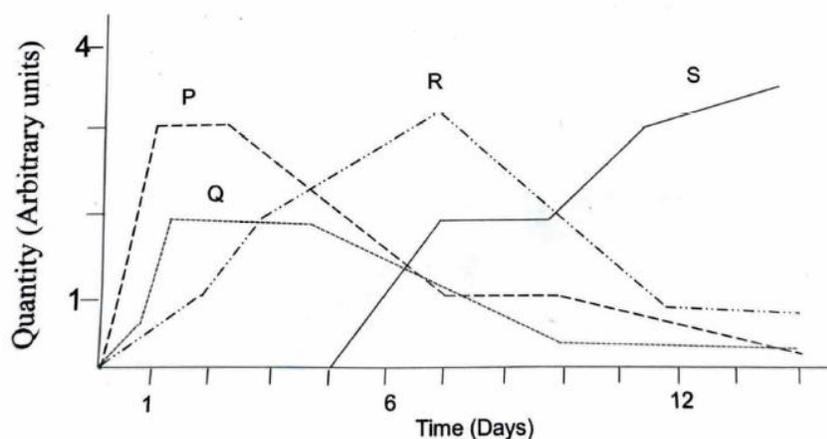
Sol. RuBisCO is the most abundant enzyme in the world and it is characterised by the fact that its active site can bind to both CO_2 and O_2 .

RuBisCO has a much greater affinity for CO_2 when $CO_2 : O_2$ is nearly equal.

In C_3 plants some O_2 does bind to RuBisCO, and hence CO_2 fixation is decreased.

In C_4 plants photorespiration does not occur. This is because they have mechanism that increases the concentration of CO_2 at the enzyme site. This takes place when the C_4 acid from the mesophyll is broken down in bundle sheath cells to release CO_2 , this results in increasing the intracellular concentration of CO_2 . In turn, this ensures that the RuBisCO functions as carboxylase minimising the oxygenase activity.

17. During wound healing, different cell populations occupy the wound site as time proceeds. The four types of cells/structures (P-S) that appear at wound healing site are depicted in the graph. They respectively indicate



- Monocytes, Fibroblasts, Neutrophils, Collagen
- Monocytes, Neutrophils, Collagen, Fibroblasts
- Neutrophils, Monocytes, Fibroblasts, Collagen
- Fibroblasts, Neutrophils, Monocytes, Collagen

Answer (c)

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Sol. The correct answer is option (c)

The graph is showing the sequence of cells along with their amount at the site of wound as time proceeds.

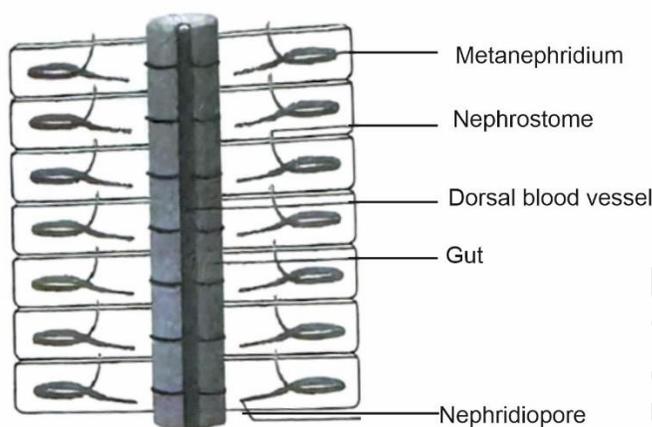
'P' is representing neutrophils, as after infection (injury) inflammatory process starts and neutrophils are the first responders to phagocitise cell debris and foreign particles.

'Q' is representing monocytes (which differentiate into macrophages) as the inflammatory response continues, monocytes follow neutrophils into the infected area.

'R' representing fibroblast, which starts to appear after initial days of infection and peaking after 6th day (as per graph) and secreting collagen fibres.

And 'S' is representing collagen, the structural protein produced by 'R' (fibroblast) which is going to help the healing process.

18. Dorsal view of 7 segments of earthworm is shown in the figure. The correct pathway of excretion in this animal is



- (a) Metanephridium → Nephrostome → Gut → Nephridiopore
 (b) Nephridiopore → Metanephridium → Gut → Exterior
 (c) Coelom → Nephrostome → Nephridiopore → Exterior
 (d) Dorsal blood vessel → Gut → Nephrostome → Nephridiopore → Exterior

Answer (c)

Sol. The correct answer is option (c).

The excretory organ of earthworms are called nephridia and nephridia are present in almost all segments of earthworm (except first three). They function like the kidneys in mammals.

The nephridia shown in image, collect waste from the coelom through a ciliated funnel called nephrostome.

The waste travel through the nephridial tubules and enters in a terminal duct which open via a pore into the exterior called nephridiopores.

Hence the pathway from the given options will be

Coelom → Nephrostome → Nephridiopore → Exterior

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19. For plants to survive in environments with high salinity, salt tolerance is a crucial adaptation. Salt tolerance involves various physiological and biochemical adaptations that help plants to manage the stress caused by excess salt. Understanding these mechanisms is essential for developing salt-tolerant crops and improving agricultural productivity in saline soils. Which of the following statements best describes a key mechanism of salt tolerance in plants?
- Plants increase the uptake of sodium ions to enhance growth under high salinity.
 - Plants produce osmoprotectants to stabilize proteins and membranes under salt stress.
 - Plants reduce the production of potassium ions to avoid toxicity in saline environments.
 - Plants enhance photosynthesis to counter the effects of salt stress by increased ETS activity.

Answer (b)

Sol. One of the most detrimental effects of salinity stress is accumulation of Na^+ and Cl^- ions in tissues of plants exposed to soils with high NaCl concentration. High Na^+ concentration inhibits uptake of K^+ ions which is an essential element for growth and development that results into lower productivity and may even lead to death. During salinity stress, Na^+ ion competes with K^+ for transporter as they both share the same transport mechanism. So, option (a), (c) and (d) are incorrect as photosynthetic rate will decrease to counter the effect of salt stress. Na^+ ion compartmentalization occur (into vacuole), biosynthesis of osmoprotectants take place as a coping mechanism for stress tolerance.

20. Muscle function in obese runners can be significantly different from that in non-obese runners due to various factors. These factors can affect the overall performance. Which of the following statements best describes the muscle functions namely muscle strength (ability to exert force) and muscle endurance (ability to sustain the force) in obese runners compared to non-obese runners?
- Obese runners have higher muscle endurance but lower muscle strength compared to non-obese runners.
 - Obese runners have lower muscle endurance and lower muscle strength compared to non-obese runners.
 - Obese runners have higher muscle strength but lower muscle endurance compared to non-obese runners.
 - Obese runners have similar muscle strength and endurance compared to non-obese runners.

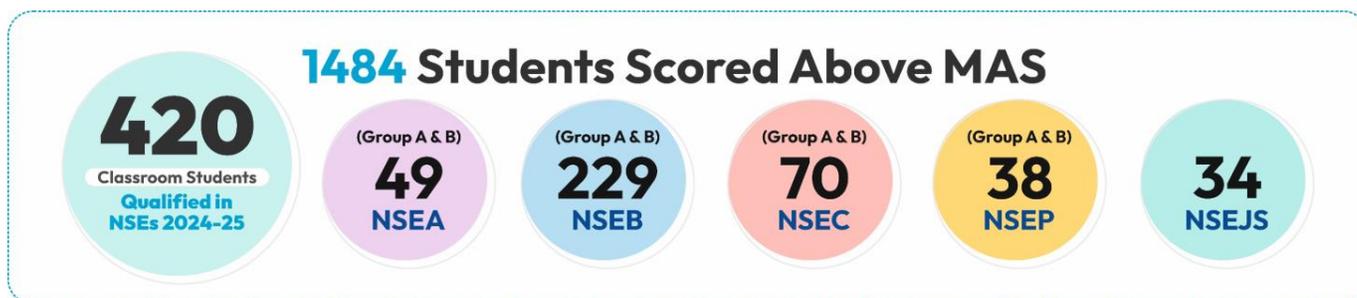
Answer (c)

Sol. The correct answer is option (c).

Obese runner typically has a higher overall body mass and have lower muscle endurance compared to non-obese runners.

Obese person, particularly in lower body parts has increased muscle strength as their muscles adapt to supporting heavier body load.

But, the excess body weight also increases the metabolic demand and physiological stress during exertion, which reduce muscle endurance. Muscle endurance significantly negatively correlated with age, BMI and body fats.



21. Heart of fish is two-chambered with one atrium and one ventricle. The fish's respiratory system involves gills for oxygen exchange. Which of the following statement best describes the flow of blood through the heart of a fish?
- Blood flows from the ventricle to the atrium, then to the gills.
 - Blood flows from the atrium to the ventricle, then to the gills.
 - Blood flows from the gills to the atrium, then to the ventricle.
 - Blood flows from the gills to the ventricle, then to the atrium.

Answer (b)

Sol. Correct answer is option (b)

Fishes show single circulation and oxygenation of blood occurs in gills. From gills oxygenated blood is sent to different body parts. From body tissues deoxygenated blood is sent to the atrium, from where blood moves to the ventricle. Finally ventricle pumps deoxygenated blood to gills.

Atrium → Ventricle → Gills → Body tissues.

22. Which of the following mechanisms is primarily responsible for the osmotic regulation in catadromous fishes like eels, when they migrate from freshwater and transition into seawater?
- Increased production of dilute urine.
 - Active uptake of salts through the gills.
 - Drinking of seawater and active excretion of salts.
 - Decreased permeability of the skin.

Answer (c)

Sol. Correct answer is option (c)

When freshwater fishes migrate from freshwater to marine/seawater, water from their body comes out due to higher osmotic pressure/concentration in the surrounding seawater. To compensate this loss of water these fishes drink seawater and with the help of ionocytes in their gills, actively excrete the excess of salt to maintain their internal environment.

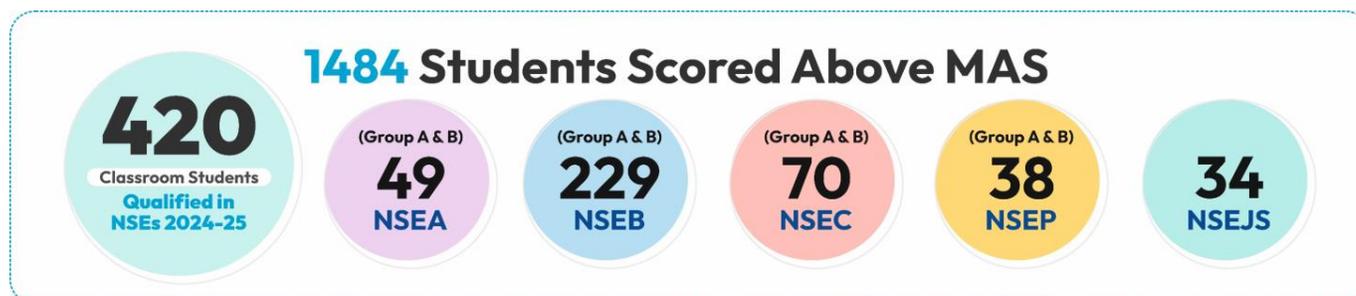
23. Which of the following statements best describes the role of restriction enzymes in the process of DNA amplification using primers?
- Restriction enzymes are used to synthesize primers that bind to specific DNA sequences.
 - Restriction enzymes cut the DNA at specific sites, allowing primers to bind and initiate replication.
 - Restriction enzymes are responsible for the elongation of primers during DNA synthesis.
 - Restriction enzymes modify the primers to enhance their binding affinity to the target DNA.

Answer (b)

Sol. Correct answer is option (b)

In PCR multiple copies of the gene (or DNA) of interest is synthesised using primer. This multiplication is done by replication of DNA multiple times.

Restriction enzymes cut the DNA at specific sites, allowing primers to bind and initiate the replication.



24. In chemosynthetic bacteria, the electron transport system is crucial for energy production. Which of the following statements accurately describes the mechanism by which the electron transport system contributes to ATP synthesis?
- The electron transport system directly phosphorylates ADP to ATP without the involvement of a proton gradient.
 - The electron transport system generates a proton gradient across the bacterial membrane, which drives ATP synthesis through chemiosmosis.
 - The electron transport system uses chemical energy from organic molecules to excite electrons, which are then transferred to oxygen to produce ATP.
 - The electron transport system incorporates carbon dioxide into organic molecules, which are then used to generate ATP.

Answer (b)

Sol. Chemosynthetic bacteria are the organism that obtain energy by oxidising inorganic chemicals such as ammonia, hydrogen sulphide or ferrous ions.

As electrons move through the carrier molecules in the ETS and it will pump the protons or H^+ ions across bacterial membrane, creating electrochemical gradient across membrane.

This proton gradient across membrane drive ATP synthesis through chemiosmosis.

25. In a small population of beetles, the frequency of a particular allele (A) is 0.6, and the frequency of the alternative allele (a) is 0.4. Due to genetic drift, what is the most likely outcome for the allele frequencies after several generations?
- The frequency of allele A will increase to 1.0, and allele a will be lost.
 - The frequency of allele a will increase to 1.0, and allele A will be lost.
 - The frequencies of alleles A and a will change and lead to loss of one allele that is less fit.
 - The frequencies of alleles A and a will fluctuate randomly and may lead to loss of either allele.

Answer (d)

Sol. Correct answer is option (d)

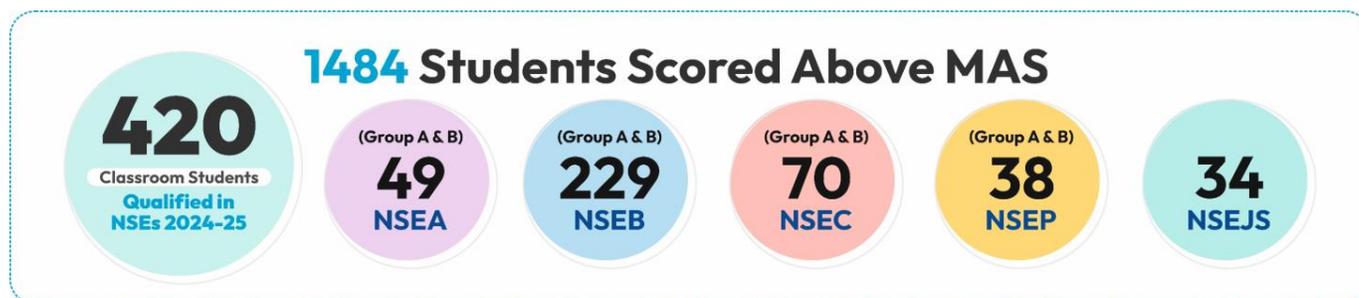
The change in the allele frequency by chance is called genetic drift.

Due to genetic drift in the given beetle population either of the alleles may lost after several generation, as the frequencies of both alleles A and a will fluctuate randomly.

26. The antibodies secreted by B-cells upon stimulation are classified according to the amino acid sequence of the
- light chain
 - heavy chain
 - both light and heavy chain
 - hinge region

Answer (b)

Sol. Correct answer is option (b)



B-cells upon antigenic stimulation produce antibodies. Chemically these are proteins. Monomer of each antibody possesses 2 light chains and 2 heavy chains. Antibodies are classified on the basis of types of heavy chain *i.e.*, specific sequence of amino acids in heavy chain. On this basis antibodies are IgA, IgM, IgE, IgG and IgD types.

27. The r and K selections are two contrasting strategies in the reproductive ecology of organisms. The r-selected species are characterized by high reproductive rates while K-selected species have lower reproductive rates. Which of the following characteristics is most likely to be observed in a K-selected species?
- Long life span and early maturity
 - Short life span and rapid population growth
 - High parental investment and low offspring mortality
 - Opportunistic reproduction and high dispersal ability

Answer (c)

Sol. K selected species are species like humans who produce offspring less frequently and in smaller numbers.

r-selected species reproduce just once in their lifetime and produce many offspring.

K-selected species generally have long life span and they typically reach sexual maturity at a later age. They invest significant time and energy in raising their young ones, which result in a higher survival rate for their offspring.

r selected species are 'opportunistic', producing large number of offspring rapidly to take advantage of temporary resource.

28. The efficiency and regulation of gene expression in an operon are significantly influenced by the promoter's strength and its interaction with regulatory proteins. Which of the following statements is the correct description of the role of the promoter in the regulation of the *trp* operon in *Escherichia coli*?
- The promoter of the *trp* operon is always active, leading to continuous transcription of the operon genes regardless of tryptophan levels.
 - The promoter of the *trp* operon is only active in the presence of tryptophan, leading to the transcription of the operon genes.
 - The promoter of the *trp* operon is repressed by the *trp* repressor protein in the presence of tryptophan, preventing transcription of the operon genes.
 - The promoter of the *trp* operon is activated by the *trp* repressor protein in the absence of tryptophan, leading to the transcription of the operon genes.

Answer (c)

Sol. *Trp* operon in *E.coli* is a repressible operon that means when tryptophan is present in the growth medium, the genes encoding the enzymes for biosynthesis of tryptophan are turned off. So, option (a) and (b) are incorrect as under severe tryptophan starvation, *trp* genes are expressed maximally while under less severe starvation conditions, *trp* genes are expressed at less than maximal levels. The proportion of transcripts that include structural genes is inversely related to amount of tryptophan in cell. Option (d) is also incorrect as in absence of tryptophan, repressor protein is inactive as it is not binding with tryptophan to become active here so, it does not activate the promoter.

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The promoter of *trp* operon is repressed by *trp* repressor protein in presence of abundant Tryptophan, preventing transcription.

29. In a routine medical check-up, it was found that Ms. Prishali's maternal grandmother is a carrier of the recessive allele for haemophilia. Her maternal grandfather does not have haemophilia. Prishali is not haemophilic and is married. Her husband does not have haemophilia. If Prishali gets two children: a son and a daughter, which of the following statements is correct?
- The son has a 0.5 probability of having haemophilia, while the daughter has a 0.5 probability of being a carrier.
 - The son has a 0.125 probability of being haemophilic, while the daughter has a 0.125 probability of being a carrier.
 - The son has a 0.25 probability of having haemophilia, while the daughter has a 0.25 probability of being a carrier.
 - The son has a 0.75 probability of being haemophilic, while the daughter has a 0.25 probability of having haemophilia.

Answer (b)

Sol. Maternal grandmother (carrier) × Maternal grandfather

	X^cX	×	XY	
				↓
	X^c		X	
X	$X X^c$		XX	50% chances of Prishali's mother being a carrier.
Y	X^cY		XY	

Prishali's mother (carrier) × father

	X^cX	×	XY
			↓
	X^c		X
X	X^cX		XX
Y	X^cY		XY

50% chances of Prishali's being a carrier.

Prishali × husband

	X^cX	×	XY
			↓
	X^c		X
X	X^cX		XX
Y	XY		XY

Probability of Prishali's daughter being carrier of haemophilia disorder is $\frac{1}{2}$ or 0.5

Probability of Prishali's son being affected by haemophilia is $\frac{1}{2}$ or 0.5



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Therefore, the cumulative probability of having a haemophilic son = $\frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} = \frac{1}{8} = 0.125$

Therefore, the cumulative probability of having a carrier daughter = $\frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} = \frac{1}{8} = 0.125$

30. Origin of life on primordial earth began with the earliest replicators like
- (a) short RNA-like molecules (b) long RNA-like molecules
(b) short DNA-like molecules (d) long DNA-like molecules

Answer (a)

Sol. Correct answer is option (a)

The origin of life on primordial Earth is believed to have begun with the formation of self-replicating molecules like short RNA-like molecules.

31. In a population of eusocial insects, how would kin selection influence the allocation of resources among offspring, considering the varying degrees of relatedness within the colony?
- (a) Kin selection leads to equal resource allocation among all offspring, regardless of relatedness.
(b) Kin selection causes workers to allocate more resources to offspring that are less related to them to increase genetic diversity.
(c) Kin selection results in preferential resource allocation to offspring with the highest genetic relatedness to the queen.
(d) Kin selection promotes random resource allocation to avoid favouritism and maintain colony harmony.

Answer (c)

Sol. Correct answer is option (c)

Sterile workers in the colonies of eusocial insects gain only a tiny indirect fitness advantage from helping their siblings survive to reproduce. Kin selection results in preferential resource allocation to offspring with the highest genetic relatedness to the queen.

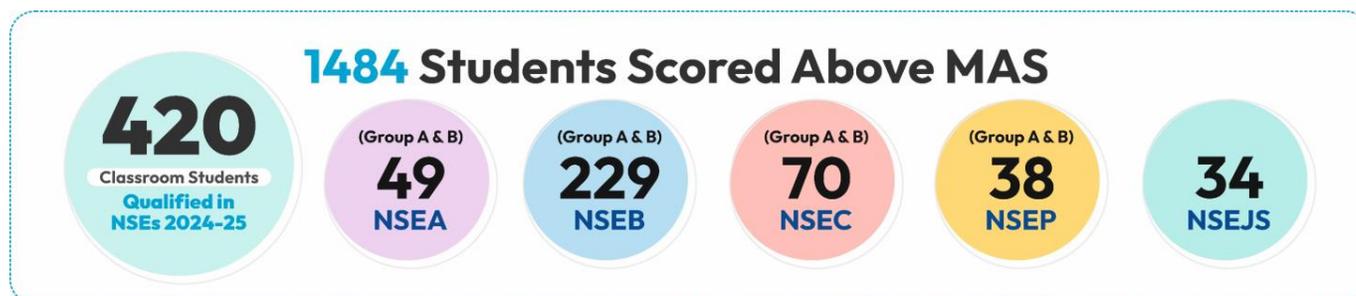
32. The length of Loop of Henle (LH) in nephron plays a crucial role in regulation of water in mammals. While considering beaver, otter, camel and hippopotamus, which of the following would be a correct depiction of the trend in the length of LH?
- (a) Camel > Otter > Hippopotamus > Beaver (b) Otter > Hippopotamus > Camel
(c) Camel > Hippopotamus > Beaver (d) Beaver > Camel > Hippopotamus > Otter

Answer (a/c*)

Sol. Correct answer can be option (a) or option (c). Usually animals inhabiting water scanty areas have longer loop of Henle in comparison to those living in marine and fresh water habitats. Among the given four animals camel should have longest loop of Henle and Beaver should have smallest loop of Henle.

33. In animals, many embryonic cells are capable of crawling over a substrate using
- (a) Extracellular matrix (b) Integrins
(c) Pseudopodia (d) lamellipodia

Answer (d)



Sol. Lamellipodia are broad, flat, dynamic protrusions formed at the leading edge of a migrating cell. Their development is powered by the rapid polymerization and branching of actin filaments just beneath the plasma membrane. These structures play a vital role in several biological processes, and movement of embryonic cells during embryonic development.

34. The CORRECT assumption on Hardy-Weinberg equilibrium is

- (a) Small population size, random mating, no selection, no migration, no mutation
- (b) Large population size, random mating, no selection, no migration, no mutation
- (c) Large population size, random mating, heterozygotes survive the best, no migration, no mutation
- (d) Large population size, random mating, no selection, migrants enter from other populations, no mutation

Answer (b)

Sol. Hardy-Weinberg principle stated that allele frequencies in a population are stable and is constant from generation to generation. The gene pool remains constant. This is called genetic equilibrium. Five factors are known to affect Hardy-Weinberg equilibrium. These are gene migration or gene flow, genetic drift, mutation, genetic recombination and natural selection.

Some other factors like small population and selective mating also affects the equilibrium.

35. Based on the data on trophic niches and two reproductive strategies namely K-, r- strategies, a very primitive table (also called as periodic table of niche) can be constructed. In the context of the following table identify the correct option that places appropriate organisms in their proper niches.

Strategy	Trophic niche		
	Primary producer	Herbivore	Carnivore
r	P	Q	R
Intermediate			
K	S	T	V

- (a) P = Annual plants, R = Eagle, T = Antelope
- (b) S = Shrubs, Q = Caterpillars, V = Mantid
- (c) S = Perennial plants, Q = Bees, V = Falcons
- (d) Q = Parrots, R = Dragonflies, S = Perennial plants

Answer (c)

Sol. r-selected species are those that emphasize high growth rates, typically exploit less-crowded ecological niches, and produce many offspring, each of which has a relative low probability of surviving to adulthood.

K-selected species display traits associated with living at densities close to carrying capacity and typically are strong competitors in such crowded niches, that invest more heavily in fewer offspring, each of which has a relatively high probability of surviving to adulthood.

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	Primary producer	Herbivore	Carnivore
r-strategy	Annual plants	Bees, Caterpillars	Dragonflies
K-strategy	Perennial plants, Shrubs	Antelope	Falcons, Eagle

36. In molecular phylogenetics of vertebrates, which of the following gene markers would be least preferred for resolving deep divergences (hundreds of millions of years ago) due to its high substitution rate and risk of saturation?
- 12S ribosomal RNA mitochondrial gene
 - Cytochrome b mitochondrial protein-coding gene
 - RAG1 nuclear protein-coding gene
 - 18S ribosomal RNA nuclear gene

Answer (b)

Sol. RAG1 is frequently used as a marker in phylogenetic studies. It is often used to construct phylogenetic trees in order to investigate the relationships between species or higher taxa.

In many cases, RAG1 is used together with mitochondrial sequences as these evolve much faster and thus provide information about more closely related taxa.

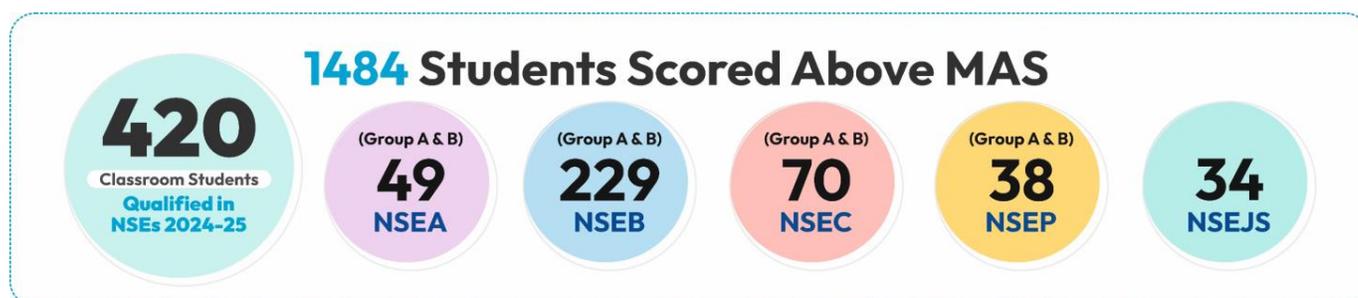
For deep evolutionary divergence (hundreds of millions of years), we prefer slow-evolving, conserved markers so that the signal is not erased by multiple substitution (saturation).

Cytochrome *b* (mtDNA) evolves very rapidly, making it excellent for recent divergence, but poor for deep-time phylogeny because the site undergo multiple hits, losing phylogenetic signal therefore least preferred.

37. The 16S rRNA gene is commonly used for bacterial identification and phylogenetic studies. In a 16S rRNA gene sequencing analysis, it was observed that a particular operational taxonomic unit (OTU) is present in high abundance in the sample. When this OTU is compared to a reference database, however, it is found that it matches multiple different bacterial species with high similarity scores. What is the most likely explanation for this observation?
- The OTU represents a novel bacterial species that is not present in the reference database.
 - The OTU is a result of sequencing errors and does not represent a real bacterial species.
 - The OTU represents a highly conserved region of the 16S rRNA gene that is shared by multiple bacterial species.
 - The OTU is a chimera formed during the PCR amplification process.

Answer (c)

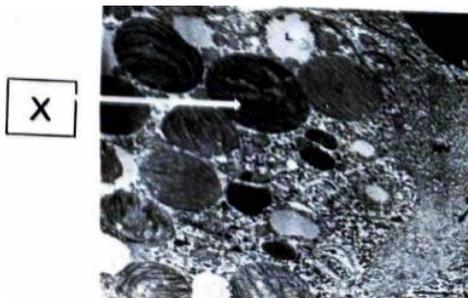
Sol. If an OTU present in the sample is shared by multiple different bacterial species of the reference database, it shows that the OTU is a gene sequence that evolved much earlier and has remained unchanged or conserved



overtime. It is highly unlikely that a sequencing error or chimera formed during PCR is misidentified as an OTU and also found similarly in several different bacterial species in the reference database.

If the OTU represents a novel bacterial species it should not be present in multiple species already present in the database or at least such an OTU is not sufficient that the species is a novel one.

38. *Elysia clarki*, a sea slug, after feeding is known to utilize photosynthesis for a period of time, essentially becoming a "solar-powered" organism. An electron micrograph of a section of the diverticulum (a digestive organ) of this organism is shown.



The structure labelled as X is:

- (a) Mitochondrion
- (b) Chloroplast
- (c) Peroxisome
- (d) Food vacuole

Answer (b)

Sol. *Elysia clarki*, a sea slug after feeding on algal is known to utilise the borrowed chloroplasts to perform photosynthesis for a period of time.

The electron micrograph of a section of the organism diverticulum shows chloroplast that is represented as 'X'.

39. During 'Fight or flight response, both epinephrine and norepinephrine are secreted that lead to several physiological responses. Which of the following is NOT a 'Fight or flight' response?
- (a) Vasoconstriction in the skin
 - (b) Dilatation of bronchioles
 - (c) Increased peristalsis
 - (d) Vasodilatation in skeletal muscles

Answer (c)

- Sol.**
- Adrenaline and noradrenaline are called catecholamines. These hormones are secreted in response to stress of any kind and during emergency situations and are called emergency hormones or hormones of Fight or flight. These hormones increase alertness, pupillary dilation, piloerection (raising of hair), sweating, etc. Both the hormones increase the heart beat rate, the strength of heart contraction and the rate of respiration.
 - These hormones dilate the airways, allowing faster movement of air into and out of the lungs.

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- They also regulate blood vessels that supply organs involved in exercise or fighting off danger like skeletal muscles causing vasodilation to increase blood supply .
 - They inhibits the process that are not essential for meeting the stressful situation like muscular movements of the digestive canal (peristalsis).
40. In an experiment studying neuronal transmission, researchers observed that the application of a specific neurotransmitter resulted in a prolonged depolarization of the postsynaptic neuron. Which of the following mechanisms is most likely responsible for this observation?
- Activation of voltage-gated sodium channels leading to an influx of sodium ions.
 - Inhibition of potassium channels preventing the efflux of potassium ions.
 - Activation of ligand-gated ion channels allowing the influx of calcium ions.
 - Inhibition of chloride channels preventing the influx of chloride ions.

Answer (b)

- Sol.**
- When a stimulus is applied at polarised membrane, the membrane becomes permeable to Na^+ . This leads to rapid influx of Na^+ inside the neuronal membrane leading to depolarization.
 - The rise in the stimulus-induced permeability to Na^+ is extremely short lived. It is quickly followed by a rise in permeability to K^+ . Within a fraction of a second, K^+ diffuses outside the membrane and restores the membrane at the site of excitation and the fibre becomes once more responsive to further stimulation. So, inhibition of K^+ channels will prevent the efflux of potassium ions leading to prolonged prepared depolarization of post-synaptic neuron.

41. In a population of butterflies, the allele for blue wings (B) is dominant over the allele for white wings (b). If the frequency of the blue-winged phenotype in the population is 84%, what is the frequency of the heterozygous genotype (Bb) assuming the population is in Hardy-Weinberg equilibrium?
- 0.16
 - 0.32
 - 0.48
 - 0.64

Answer (c)

Sol. The correct option is (c) as

Blue-winged phenotype (B) = Dominant

White-winged phenotype (b) = Recessive

Blue-winged phenotype = $\text{BB} + \text{Bb} = p^2 + 2pq = 0.84$

White-winged phenotype = $\text{bb} = q^2 = 1 - 0.84 = 0.16$

So,

$$q^2 = 0.16$$

$$q = 0.4$$

$$p = 1 - q = 0.6$$

$$2pq = 2 \times 0.4 \times 0.6$$

$$= 0.48$$

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42. Which of the following movements of water is prevented by the casparian strip in plants?
- Symplastic water movement from endodermal cell to xylem cell.
 - Apoplastic water movement from cortical cell to xylem cell.
 - Symplastic water movement from cortical cell to xylem cell.
 - Apoplastic water movement from pericycle cell to xylem cell.

Answer (b)

Sol. The apoplast is the system of adjacent cell walls that is continuous throughout the plant, except at the Casparian strips of the endodermis in the roots.

The symplastic system is the system of interconnected protoplasts. Neighbouring cells are connected through cytoplasmic strands that extend through plasmodesmata.

Most of the water flow in the roots occurs via the apoplast since the cortical cells are loosely packed, hence offer no resistance of water movement.

However, the inner boundary of the cortex, the endodermis, due to presence of Casparian strip is impervious to water.

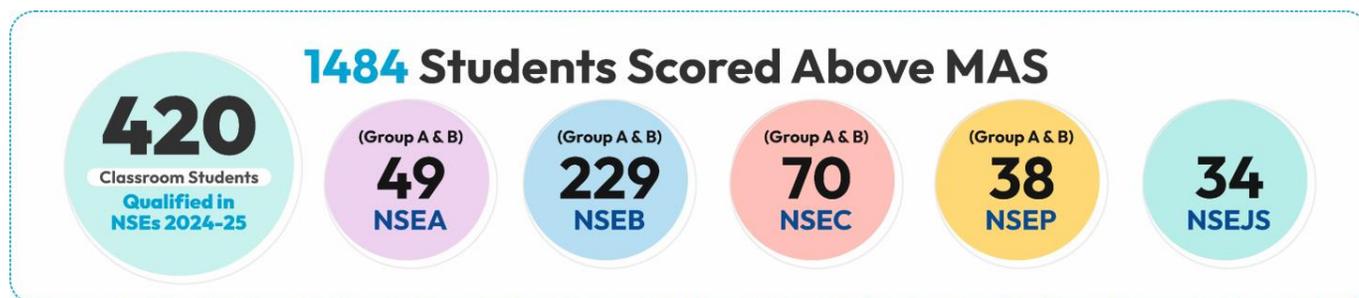
43. Which of the following statements best describes the key advantage of using cDNA over genomic DNA in gene expression studies?
- cDNA contains introns, which are useful for studying gene regulation.
 - cDNA is more stable than genomic DNA, making it easier to work with in the lab.
 - cDNA represents only the expressed genes, providing a snapshot of gene activity.
 - cDNA can be directly sequenced without the need for amplification.

Answer (c)

Sol. The correct option is (c) as cDNA (complementary DNA) is synthesised from messenger RNA (mRNA) template. Since mRNA molecules are produced only when a gene is actively expressed (transcribed and processed) it lacks introns while genomic DNA contains all of an organism's genes including those that are unexpressed and silent (introns and exons). cDNA generally requires amplification to generate enough material for most sequencing platforms due to the very low quantities of starting mRNA in a biological sample.

44. How do deep diving marine mammals, such as whales and seals, avoid nitrogen bends (decompression sickness) during their prolonged and deep dives?
- They have a higher concentration of red blood cells that store more oxygen, reducing the need to breathe frequently.
 - They collapse their lungs at depth, preventing nitrogen from dissolving into their blood.
 - They have a unique enzyme that breaks down nitrogen bubbles in their bloodstream.
 - They exhale completely before diving, eliminating nitrogen from their lungs.

Answer (b)



- Sol.** The correct answer is (b) as whales and seals avoid nitrogen bends, or decompression sickness through a combination of physiological adaptations such as long collapse or compress due to increased external pressure on rib cage, reducing the amount of air that can enter bloodstream. They do not exhale completely before diving as they need the remaining oxygen in their lungs to survive the duration of dive. They do not possess a unique enzyme that can break down nitrogen bubbles in their bloodstream.
45. Torpor is a state of decreased physiological activity in animals, characterized by a reduced body temperature and metabolic rate. During torpor, which of the following mechanisms involving brown fat is most critical for preventing hypothermia in small mammals?
- Brown fat generates heat through shivering, which increases metabolic rate and body temperature during torpor.
 - Brown fat stores energy in the form of triglycerides, which are oxidized to provide heat during torpor.
 - Brown fat uncouples oxidative phosphorylation in mitochondria, leading to heat production without ATP synthesis.
 - Brown fat generates heat through non-shivering thermogenesis, which helps maintain body temperature without increasing metabolic rate during torpor.

Answer (c)

Sol. Brown fat (Brown adipose tissue) is a site of non-shivering thermogenesis. Thus, statement (a) is incorrect.

Brown fat does not store energy rather, it dissipates it through hydrolysis. Thus, statement (b) is incorrect.

Brown fat is essential for energy metabolism, stimulating non-shivering thermogenesis through uncoupled oxidative phosphorylation to activate the mitochondrial respiratory chain which stimulates thermogenesis without producing ATP. Thus, statement (c) is correct.

Brown fat generates heat through non-shivering thermogenesis, which helps maintain body temperature and increases metabolic rate.

46. Which combination of relative concentrations of hormones is responsible for apical dominance seen in plants?
- Auxins and gibberellins
 - Auxins and cytokinins
 - Cytokinins and gibberellins
 - Auxins and abscisic acid

Answer (b)

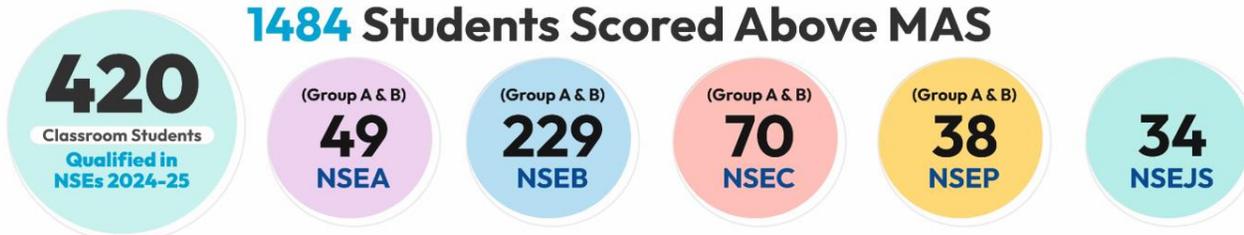
Sol. Auxins and cytokinins relative concentration is responsible for apical dominance seen in plants.

In the presence of apical bud, the outgrowth of the lateral bud is inhibited by auxin.

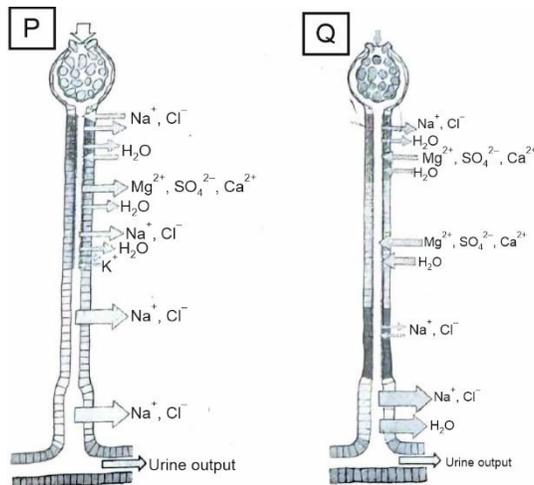
Auxins in the shoot apex maintains apical dominance by stimulating strigolactone synthesis.

The strigolactone activates the BRC1 gene, the product of BRC1 gene inhibits lateral bud growth.

Cytokinin antagonize the effects of strigolactones.



47. Structures of nephrons along with permeabilities of different sections of renal tubule from two teleost fishes (P and Q) are depicted. Which of the following statements is correct?



- (a) Fish P is likely to excrete concentrated urine as compared to Q.
 (b) Fish Q is likely adapted to sea water habitat.
 (c) In fish P, most of the ions are reabsorbed along the entire segment of renal tubule followed by water absorption by osmosis.
 (d) Plasma osmolarity of fish P is likely to be higher than fish Q.

Answer (b)

Sol. The correct option is (b) as fish P is freshwater teleost and fish Q is marine (sea water) teleost.

Plasma osmolarity of fish Q is higher than fish P.

In fresh water teleost, the walls of the distal convoluted tubules and collecting ducts have low or minimal water permeability. This is crucial because it allows for the reabsorption of solutes without the osmotic movement of water, thus producing copious and highly dilute urine.

48. In vertebrate systematics, which of the following correctly reflects a *monophyletic group* while excluding paraphyletic or polyphyletic groupings?
- (a) Reptilia, excluding birds, because they are ectothermic and share similar skin morphology.
 (b) "Fishes" including jawless, cartilaginous, and bony fishes, due to their shared aquatic habitat and gills.
 (c) Tetrapoda, including amphibians, reptiles, birds and mammals, based on shared limb morphology.
 (d) "Warm-blooded animals" including birds and mammals, based on convergent endothermy.

Answer (c)

Sol. The correct option is (c) as monophyletic group includes a common ancestor and all of its descendants that is represented by superclass Tetrapoda and its descendants including amphibians, reptiles, birds and mammals. Fishes possess jaws.

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Reptilia is a paraphyletic group because it includes the common ancestor of reptiles but excludes birds, which is also its descendant.

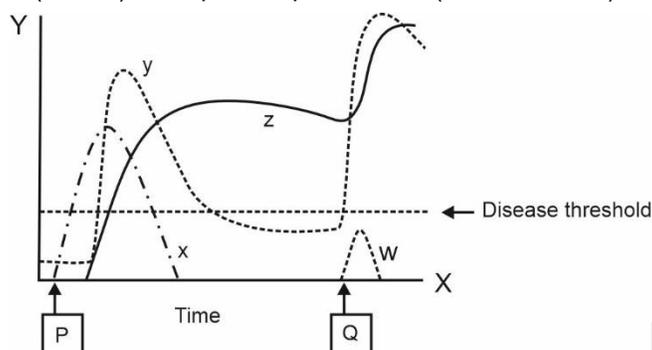
“Warm-blooded animals” is a polyphyletic group because it includes both birds and mammals which evolved warm-bloodedness independently from different ancestors.

A – 2

ANY NUMBER OF OPTIONS (4, 3, 2 or 1) MAY BE CORRECT

MARKS WILL BE AWARDED ONLY IF ALL THE CORRECT OPTIONS ARE BUBBLED AND NO INCORRECT

49. Adaptive immune responses following infection or vaccination are graphically shown below. X axis indicates time while Y-axis indicates titres (values) of respective parameters (W, X, Y and Z).



Mark the correct option(s):

- (a) Y and Z most likely indicate T-cell and antibody response respectively.
- (b) P and Q indicate vaccination and active infection respectively.
- (c) Z indicates killer T cell response as a result of active infection.
- (d) X and W indicate first and second infectious particle load of the same infective agent.

Answer (b, d)

Sol. The correct options are (b) and (d) as P and Q indicate vaccination and active infection respectively due to respective antibody titers in primary and secondary immune response.

X indicates infectious particle load of first interaction of antigen with the host due to vaccination and W indicates particle load of interaction with the same antigen leading to heightened secondary immune response.

50. An animal is repeatedly exposed to a conditional neutral stimulus without any consequential unconditioned stimulus (US). If the same animal is later exposed to the conditional stimulus (CS) paired with an unconditional stimulus, there is slower rate of subsequent associative learning. This is latent inhibition. Which of the following factor(s) account for the manifestation of latent inhibition?
- (a) Repeated non-reinforced exposure to the CS leads to habituation, reducing the animal's attention to the stimulus and thus lowering its associability when later paired with a US.
 - (b) Pre-exposure of the CS elicits a robust dopaminergic surge that oversaturates reward pathways, in turn diminishing synaptic plasticity required for new associative learning.

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- (c) Repeated CS presentations without the US result in diminished prediction error (difference between predicted and actual outcome) signals, thereby reducing the learning drive when the CS is eventually paired with the US.
- (d) The continual exposure to the CS transforms it into a conditioned inhibitor that signals the non-occurrence of the US, actively blocking subsequent excitatory conditioning.

Answer (a, c)

Sol. The correct options are (a) and (c) as latent inhibition is a learning phenomenon where an organism is slower to associate a previously familiar, but inconsequential, stimulus with a new outcome compared to a completely novel stimulus. During this, repeated non-reinforced exposure to the conditional stimulus leads to habituation reducing the animal's attention to the stimulus and thus lowering its associability when later paired with US. Repeated CS representation without the US result in diminished prediction error signals, thereby reducing the learning drive. Studies show that increased dopaminergic activity particularly in nucleus accumbens, disrupts the latent inhibition (LI) effect, leading to faster learning of associations.

51. In a pond dug recently and filled with rain water, the water was assessed for various parameters, periodically during the development of the ecosystem. The likely observation(s) is/are
- (a) day time net production exceeds night time respiration in initial stages.
 - (b) the gross production/standing biomass (P/B) ratio would remain steady.
 - (c) entropy in the system, initially being low, would go on increasing.
 - (d) food chains would become progressively more complex.

Answer (a, c, d)

Sol. In the initial stages of hydrarch succession, as the environment available is inorganic, autotrophic succession takes place. It starts in a predominantly inorganic environment and energy flow is maintained indefinitely, followed by increase in the organic matter content in the ecosystem. In this succession, rate of production is more than the rate of respiration because, if opposite happens, the succession becomes futile. Thus, statement (a) is correct.

As in the initial stages, photosynthesis (P) exceeds respiration, organic matter and biomass (B) will accumulate in the system. Due to which P/B ratio will decrease. In such cases, the amount of standing crop biomass, supported by the available energy flow increases to maximum in the mature or climax stages. As a consequence, the net community production is more in young stages and lesser in mature stages. Thus, P/B ratio will vary. Thus, statement (b) is incorrect.

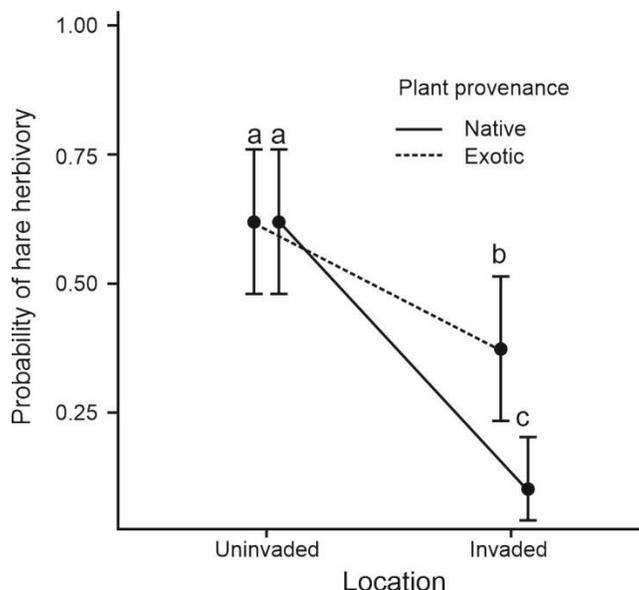
During succession, the ecosystem becomes more complex and thus, increased energy flow through different trophic levels is observed. Thus, from early to later stages, the entropy increases. Thus, statement (c) is correct.

During succession, linear food chains will be formed initially, which later converts into a complex food web. Thus, statement (d) is correct.

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52. The graph given below depicts the probability of European hare (*Lepus europaeus*) browsing [estimated marginal mean \pm 95% Confidence Interval (CI)] on native and exotic plants in communities invaded and uninvaded by Scotch broom (*Cytisus scoparius*). Different lowercase letters indicate significant differences among means ($p < 0.05$).



In the context of the graph, which of the following statement(s) is/are correct?

- Broom invasion can have negative impact on native species since it could cause cumulative damage by facilitating both herbivores; generalists and specialists.
- Invasion of broom can lead to increase in survival and growth of other plant species, indirectly by release from hare browsing.
- The lower hare browsing in the invaded community is behaviourally mediated, since the denser broom may limit hares' ability to visually locate plants.
- Broom invasion has facilitative effects on native plants through apparent competition mediated by both mammalian and insect herbivores.

Answer (b, c, d)

Sol. Scotch broom had a net positive impact on the survival and growth of native and exotic plant species, through sheltering them from abiotic stress, and indirectly via beneficial soil fungi and release from hare browsing. Thus, option (a) is incorrect but option (b) is correct.

The lower hare browsing in the invaded community was likely behaviourally mediated, due to decreased need for predator vigilance and thereby better browsing in open areas, or the denser broom and grass vegetation limiting hare's ability to visually locate plants. Thus option (c) is correct.

Facilitative effects of broom differs from studies that have demonstrated negative impacts of invasive plants on native plants through apparent competition mediated by both mammalian and arthropod herbivores. Thus, option (d) is correct.

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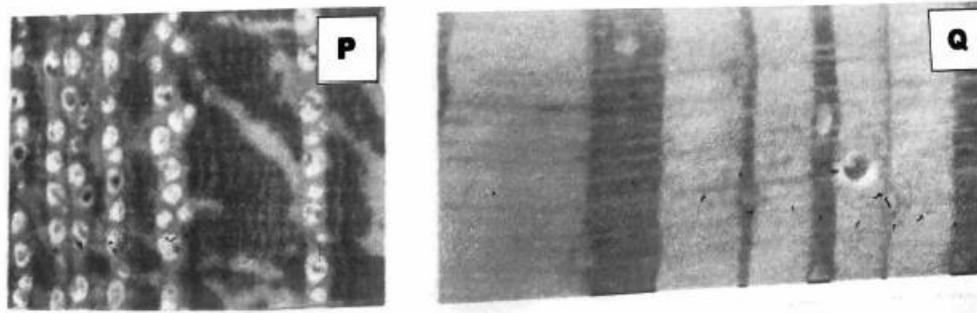
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53. Sections of Tree rings of Oak tree (P) and a pine tree (Q) are shown in the figure.



Which of the following is/are correct?

- (a) The two trees are of the same age.
- (b) It is likely that the oak tree faced a very severe winter in its second year of growth.
- (c) Larger vessels seen in Oak tree represent summer wood.
- (d) The tree rings patterns indicate that the two trees probably existed in the same environment.

Answer (b, d)

Sol. As the number of rings shown in the diagram P and Q are different, thus, these plants differ in age. Thus, statement (a) is incorrect.

We consider the arrangement of rings from centre (left) to the periphery (right). It can be clearly seen that the width of second growth ring is too reduced which could be due to exposure of severe winter. Thus, statement (b) is correct.

Larger vessels seen in Oak tree represent spring wood. In summer wood, the pores are relatively small. Thus, statement (c) is incorrect.

The tree ring pattern shows pronounced rings showing the existence of these plants in the same habitat. Thus, statement (d) is correct.

54. Though the lakes and the streams are fresh water environments, the communities inhabiting them show a drastic difference in behavior. Which of the following statement(s) seem(s) to explain it appropriately?

- (a) Oxygen tension is comparatively more uniform in streams.
- (b) Current is a major controlling and limiting factor in streams.
- (c) Stream metabolism is generally slower and less variable than the Lake metabolism.
- (d) Land-water interchange is relatively extensive in streams.

Answer (a, b and d)

Sol. The correct options are (a), (b) and (d) as continuous flow in streams results in a high degree of interaction with the surrounding land. Stream metabolism is generally more dynamic and variable than lake metabolism. Organisms in streams must adapt to flowing water thus current is a major controlling and limiting factor in streams. Oxygen tension is generally more uniform in streams compared to lakes due to constant, turbulent water flow in streams promotes constant aeration and mixing, preventing the formation of distinct oxygen layers.

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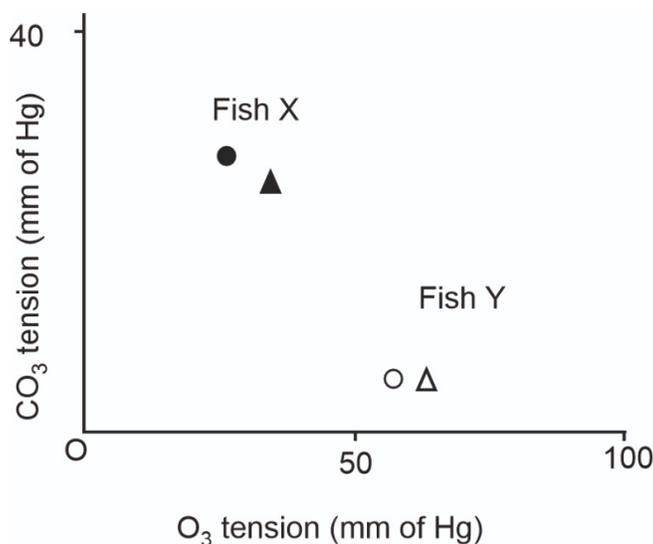
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55. Immunisation is a critical process in protecting individuals from infectious diseases. It involves the administration of vaccines, which stimulate the immune system to produce antibodies. When a vaccine is introduced into the body, it mimics an infection, prompting the immune system to respond. Which of the following statements best describe(s) the mechanism of antibody production and action in immunisation?
- Vaccines directly introduce antibodies into the bloodstream to provide immediate immunity against the pathogen.
 - Vaccines stimulate the production of B cells, which then produce antibodies specific to the pathogenic antigen.
 - Antibodies produced during immunisation can be effective against the toxins released during pathogenic infections.
 - Vaccines stimulate production of lymphocytes, which are responsible for producing antibodies after vaccination.

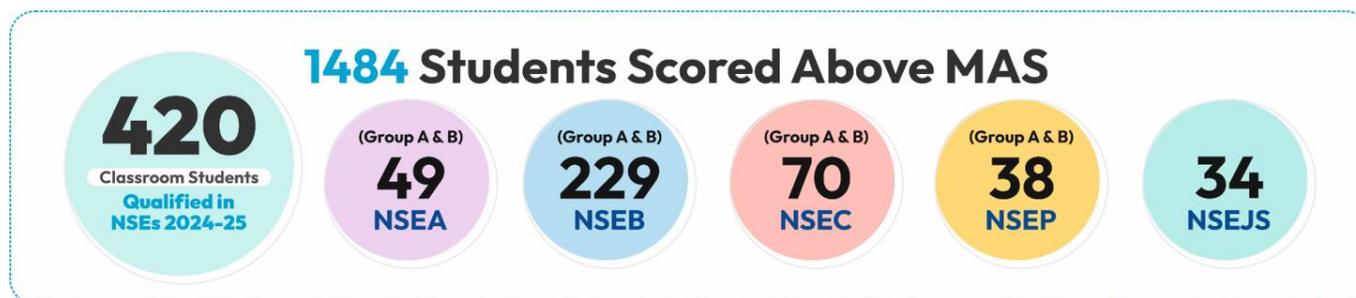
Answer (b, c, d)

Sol. The correct options are (b), (c) and (d) as immunisation triggers the body to produce antibodies by introducing a harmless form of pathogen's antigen, leading to an immune response where B-cells produce specific antibodies against pathogenic antigen. Some B-cells produce memory cells which retain memory of antigen. This allows for a much faster and stronger antibody response, if the body encounters the real infection. Vaccines contain an active ingredient that triggers an immune response, such as weakened virus, part of the micro-organism or genetic material of the causative organism.

56. Measurement of oxygen and carbon dioxide content of two species of lungfish (X and Y) was monitored. The graph was plotted to show oxygen saturation and CO_2 levels in blood going to and coming from the lungs of the two fishes under varying oxygen tensions. Circles (O) indicate blood going to lungs and triangles (Δ) indicate blood coming out from lungs.



Mark the correct interpretation(s):



- (a) Low CO₂ tension in fish Y reflects dominance of water-breathing over air-breathing.
- (b) Gills of fish X are more efficient in oxygenation compared to its lungs.
- (c) Higher saturation of oxygen in fish Y as compared to X is due to additional contribution from the lungs.
- (d) Fish X will survive out of water for longer duration than fish Y.

Answer (a, c, d)

Sol. The correct option is (a), (c) and (d) as lungfish with high CO₂ tension and low O₂ content will survive out of water for a longer duration than those with high O₂ and low CO₂ tension because accumulation of CO₂ will trigger the physiological state of aestivation which is essential for long-term survival. Higher oxygen saturation in lungfish, particularly African and south American species is a direct result of the additional and primary contribution of the lungs to gas exchange. Some Lungfish species rely primarily on water breathing for CO₂ elimination as their blood p_{CO₂} is characteristically low and O₂ content is high.

57. When Rh-negative mother carries Rh-positive baby, there's a risk of Rh incompatibility for the subsequent offspring. However, in about 20% of all the potential cases, the formation of antibodies is prevented, and risk of Rh sensitisation is reduced by protective mechanisms arising from interaction with other blood group genes

In which of the following situations this mechanism will be observed?

- (a) Rh negative mother with blood group O and Rh positive Baby with blood group A.
- (b) Rh negative mother with blood group A and Rh positive Baby with blood group B.
- (c) Rh negative mother with blood group B and Rh positive Baby with blood group O.
- (d) Rh negative mother with blood group AB and Rh positive Baby with blood group A.

Answer (a, b, c, d)

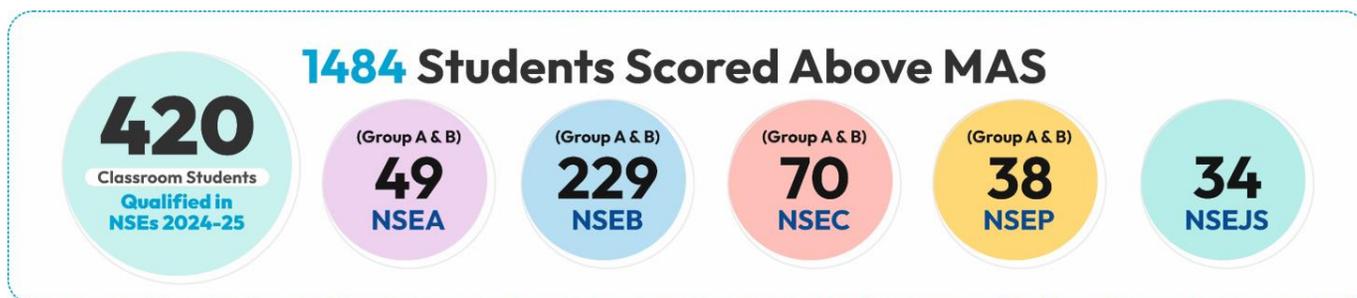
Sol. People whose RBCs have Rh antigens are designated Rh⁺ and those who lack Rh antigens are designated Rh⁻. Normally, blood plasma does not contain anti Rh antibodies. If an Rh⁻ person receives an Rh⁺ blood transfusion, however, the immune system starts to make anti-Rh antibodies that remain in the blood.

Haemolytic disease of new born where, Rh⁻ mother carrying Rh⁺ foetus, may rise during pregnancy. Normally no direct contact occurs between maternal and fetal blood while a woman is pregnant. However, if a small amount of Rh⁺ blood leaks from the fetus through the placenta into the blood stream of an Rh⁻ mother, the mother will start to make anti-Rh antibodies.

58. Batesian and Müllerian mimicry are the two forms of mimicry where one species evolves to resemble the other. Batesian mimicry involves a harmless species mimicking a dangerous one, while Müllerian mimicry involves two or more dangerous species mimicking each other. Which of the following is/are correct statement(s) about these?

- (a) Both types of the mimicry are the examples of coevolution.
- (b) In Batesian mimicry, mimic will offer benefit to model and vice versa.
- (c) Both the types are example of mutualistic relationships.
- (d) Mullerian mimicry primarily benefits the prey by reducing predation pressure.

Answer (a, d)



Sol. Batesian mimicry is when a harmless species imitates a harmful one to protect itself from predators.

Mullerian is when two or more dangerous species develop a similar appearance for mutual protection.

Both these types of mimicry are the examples of coevolution.

Mullerian mimicry confers mutual advantage *i.e.* primarily benefits the prey by reducing predation pressure.

59. Introduction of captive bred individuals into the wild is one of the conservation measures used for some species like the Bearded vulture (*Gypaetus barbatus*) which were wiped out from the European Alps. The problem with this conservation effort is not the size of the wild population; rather, it is the size of the captive population. Conservation biologists use effective population size (N_e) as a measure of the “genetic status” of a population which will sustain enough genetic variability in the captive birds to keep either the captive or the wild population thriving over the long term.

Which of the following measures would reduce the chance of the population losing its genetic variation due to genetic drift?

- Boosting the size of captive population of bearded vulture from its current level.
- Reduce the number of introduced birds per release to one per breeding season.
- Introduce male birds and female birds, alternately, after a “No-release” period in between.
- Recruiting additional founders into the captive population.

Answer (a, d)

Sol. Boosting the size of captive population will increase the number of individuals within a population which will increase the chances of mating and thus, increase the chances of sustenance of the species. Thus, approach (a) will reduce the chance of the population losing its genetic variation.

By reducing the number of introduced birds per release to one, will decrease the introduced genetic variation within the population inhabiting the area. It will result in declined population and promote genetic drift.

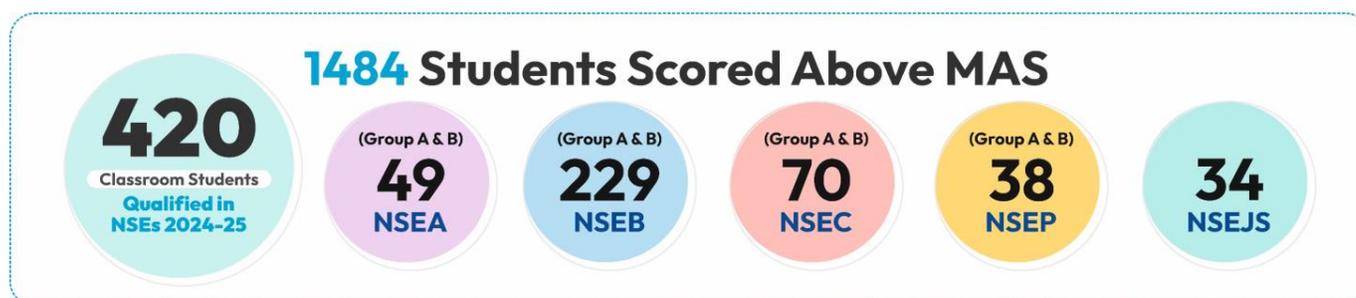
If male and female birds are introduced alternately, it will reduce the mating chances and thus, may result in no effect or declining effect on population.

Thus, approach (b) and (c) are not going to reduce the chance of the population losing its genetic variation.

By recruiting additional founders into the captive population will help in optimising the founder populations genetic diversity. This is paramount to avoid any negative genetic consequences on captive breeding like, genetic diversity loss, inbreeding etc.

60. C_3 and C_4 plants represents two different pathways of carbon fixation during photosynthesis. C_4 plants, possess specialized leaf anatomy and biochemical pathways that allow them to thrive in intense sunlight, making them more resilient to climate stress. Which of the following statements best describe(s) the primary difference between C_3 and C_4 plants?
- C_3 plants use the Calvin cycle for carbon fixation, whereas C_4 plants use a different pathway to minimize photorespiration.
 - C_3 plants have specialized leaf anatomy to reduce water loss, while C_4 plants do not.
 - C_4 plants have a higher water-use efficiency compared to C_3 plants.
 - C_4 plants can perform photosynthesis at lower carbon dioxide concentrations than C_3 plants.

Answer (a, c, d)



Sol. C_3 plants use the Calvin cycle for carbon fixation while C_4 plants use Hatch and Slack pathway for carbon fixation. Due to RuBisCO's oxygenase activity in C_3 plants, these plants are prone to photorespiration. In C_4 plants, encaging the RuBisCO in bundle sheath cells ensures the prevention of photorespiration. Thus, Statement (a) marks the difference between C_3 and C_4 .

C_4 plants have specialized leaf anatomy rather than C_3 plants. Thus statement (b) is incorrect.

C_4 plants have a higher water-use efficiency than C_3 plants, thus, statement (c) is correct.

C_4 plants can perform photosynthesis at lower carbon dioxide concentration than C_3 plants as they have a mechanism to concentrate CO_2 at the enzyme active site. Thus, statement (d) marks the difference between C_3 and C_4 .

