BITSAT Biology Sample Paper-17

Duration: 60 Minutes **Maximum Marks: 120**

Instructions

- This paper contains **40** Multiple Choice Questions (Single Correct).
- Each correct answer carries **+3 marks**. Each incorrect answer carries **-1 mark**. Unattempted question carries **0 marks**.
- Only **one** option is correct for each question.
- Use of mobile phones, smartwatches, or any electronic gadgets is strictly prohibited.

Q1. A researcher isolated a mutant strain of bacteria in which the lac repressor protein could no longer bind lactose, although it retained normal affinity for the operator region. When lactose was added to the medium, the mutant cells failed to synthesize β-galactosidase. Which conclusion best explains this observation?

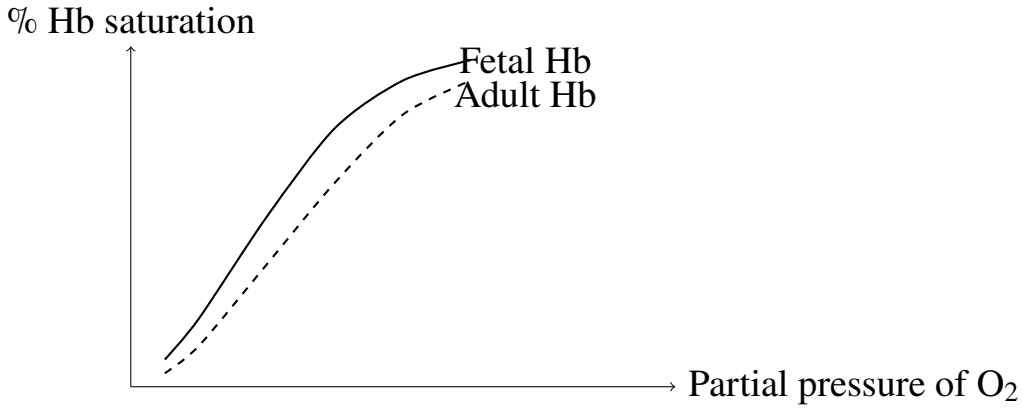
(A) RNA polymerase permanently detached from the promoter

(B) Structural genes became constitutively active

(C) The operon remained repressed despite lactose availability

(D) Translation occurred independently of transcription

Q2. The following graph represents oxygen dissociation curves of fetal and adult haemoglobin.



The leftward shift of the fetal haemoglobin curve indicates that fetal haemoglobin:

(A) Releases oxygen more readily to tissues

(B) Has lower affinity for oxygen than adult haemoglobin

(C) Has higher affinity for oxygen facilitating placental transfer

(D) Cannot bind carbon dioxide efficiently

Q3. A eukaryotic cell was experimentally treated with a drug that completely inhibited formation of spindle microtubules during mitosis. Which immediate consequence would most likely occur?

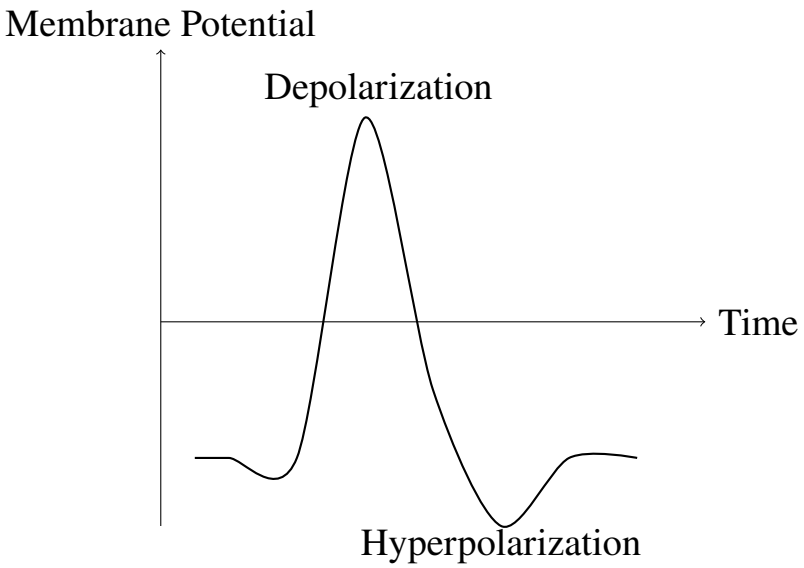
(A) DNA replication would stop during S-phase

(B) Chromosomes would fail to segregate toward opposite poles

(C) Cytoplasmic enzymes would cease functioning

(D) Ribosomes would detach from endoplasmic reticulum

Q4. The figure below represents changes in membrane potential during an action potential in a neuron.



Depolarization of the neuronal membrane occurs primarily due to:

(A) Efflux of potassium ions

(B) Influx of sodium ions through voltage-gated channels

(C) Active transport of calcium ions outward

(D) Closure of all ion channels simultaneously

Q5. A scientist discovered a plant species in which bundle sheath cells were completely absent. Which physiological process would be most severely affected?

(A) CAM metabolism

(B) C_4 photosynthesis

(C) Glycolysis

(D) Photorespiration in C_3 plants

Q6. A population of insects was exposed to a pesticide over several generations. Initially rare resistant individuals survived and reproduced, eventually dominating the population. This observation is a direct example of:

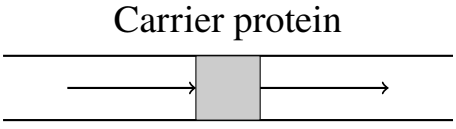
(A) Lamarckian inheritance

(B) Stabilizing selection

(C) Natural selection acting on genetic variation

(D) Hybrid vigor

Q7. The following diagram represents transport through a plasma membrane.



If molecules are transported against their concentration gradient through the carrier protein shown above, the process would require:

(A) ATP expenditure

(B) No membrane proteins

(C) Only osmotic pressure

(D) Destruction of phospholipid bilayer

Q8. A child with blood group AB is born to parents where one parent has blood group A and the other has blood group B. This inheritance pattern demonstrates:

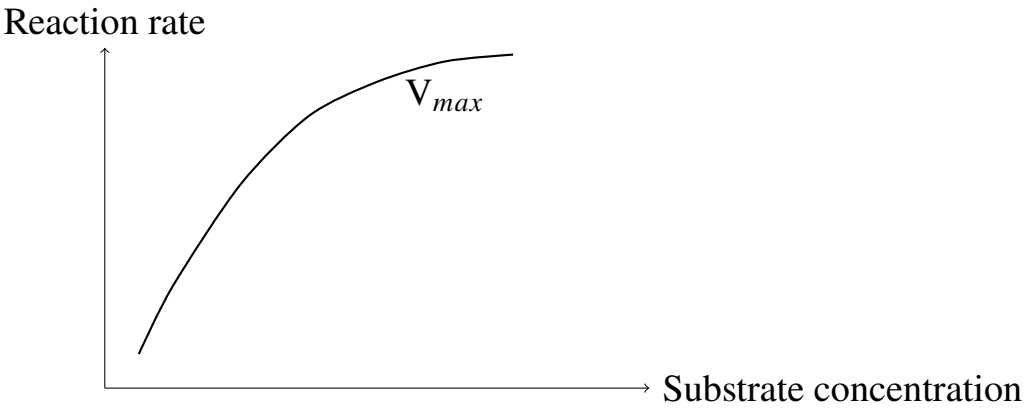
(A) Incomplete dominance

(B) Polygenic inheritance

(C) Codominance

(D) Linkage

Q9. The following graph represents enzyme activity against substrate concentration.



The plateau observed at higher substrate concentration occurs because:

(A) Enzyme molecules become saturated with substrate

(B) Substrate concentration becomes zero

(C) Product molecules permanently inhibit enzymes

(D) Enzymes are converted into lipids

Q10. A researcher observed that a mutation in mitochondrial DNA was inherited only through the mother and never through the father. This pattern occurs because:

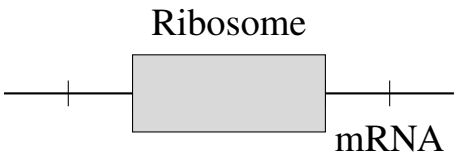
(A) Sperm mitochondria usually do not contribute significantly to the zygote

(B) Mitochondria replicate only in male gametes

(C) Mitochondrial genes are located on the Y chromosome

(D) Maternal chromosomes suppress paternal genes completely

Q11. The figure below represents stages during translation.



Which molecule directly carries amino acids to the ribosome during translation?

(A) mRNA

(B) tRNA

(C) rRNA

(D) DNA polymerase

Q12. In ecological pyramids, energy pyramids are always upright because:

(A) Producers contain maximum biomass at all times

(B) Energy transfer between trophic levels is inefficient

(C) Carnivores synthesize their own food

(D) Decomposers recycle all available energy completely

Q13. A molecular biologist inserted a foreign DNA fragment into a plasmid vector containing an antibiotic resistance gene. After transformation, bacterial colonies that failed to grow on antibiotic-containing medium most likely:

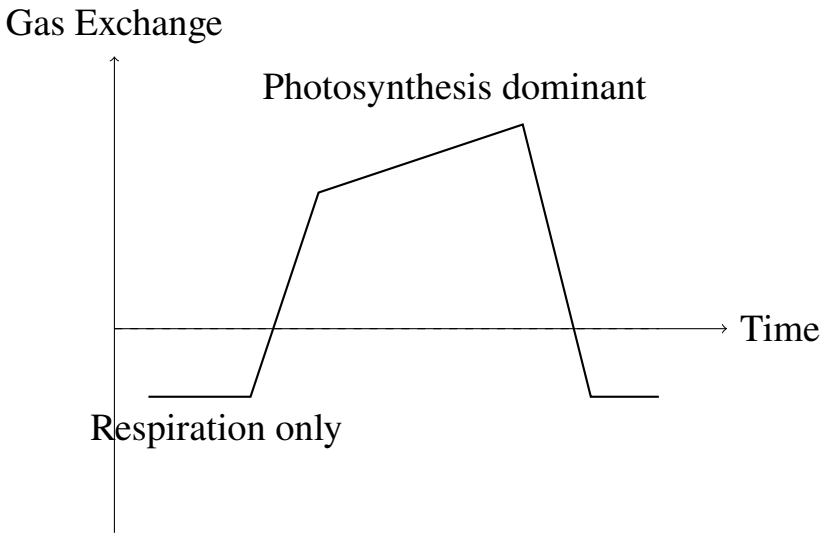
(A) Successfully expressed the resistance gene

(B) Did not take up the recombinant plasmid

(C) Produced excessive restriction enzymes

(D) Underwent rapid conjugation

Q14. The following diagram represents the oxygen evolution and carbon dioxide uptake in a plant over a 24-hour period.



During the interval where the graph lies below the horizontal axis, the plant is primarily:

(A) Performing only photosynthesis

(B) Releasing more oxygen than carbon dioxide

(C) Carrying out respiration without net photosynthesis

(D) Fixing carbon dioxide at maximum rate

Q15. A patient suffering from severe liver damage showed impaired conversion of ammonia into urea. Accumulation of ammonia in blood is especially dangerous because ammonia:

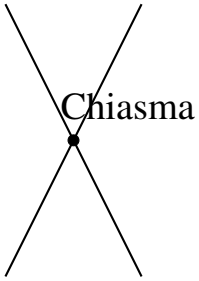
(A) Causes rapid polymerization of proteins

(B) Is highly toxic to neural tissues

(C) Completely inhibits oxygen transport by haemoglobin

(D) Prevents ATP synthesis in chloroplasts

Q16. The following figure represents homologous chromosomes during meiosis.



The structure labelled chiasma represents the site where:

(A) DNA replication occurs

(B) Crossing over between homologous chromatids takes place

(C) Centromeres undergo division

(D) Spindle fibres originate

Q17. A certain species of plant shows very high rates of photorespiration under hot and dry conditions. Which immediate consequence would most likely result from increased photorespiration?

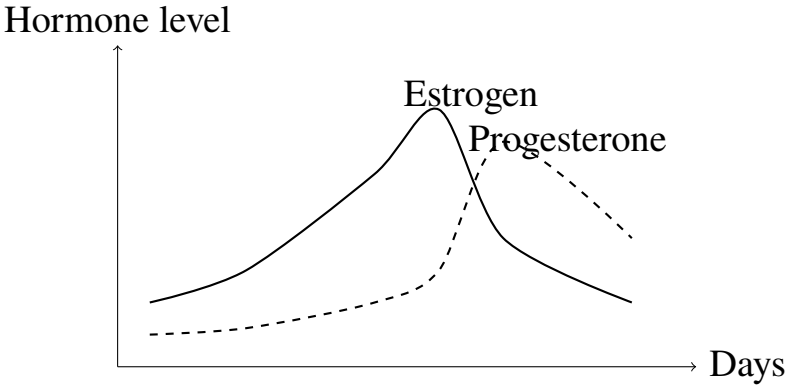
(A) Increased glucose synthesis efficiency

(B) Reduced photosynthetic productivity

(C) Complete absence of ATP formation

(D) Enhanced nitrogen fixation

Q18. The graph below represents changes in concentration of ovarian hormones during the menstrual cycle.



The sharp rise in progesterone after ovulation is primarily due to secretion by the:

(A) Primary follicle

(B) Corpus luteum

(C) Endometrium

(D) Pituitary gland

Q19. In a stable ecosystem, decomposers are indispensable because they:

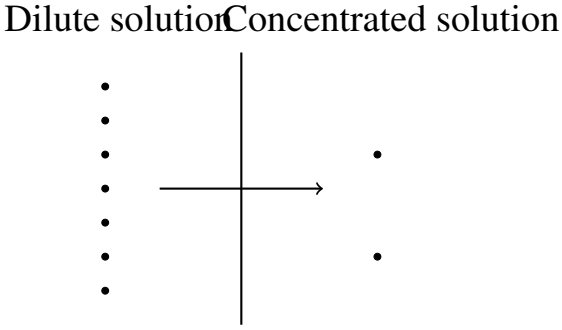
(A) Convert solar energy directly into biomass

(B) Transfer energy back to producers

(C) Recycle nutrients from dead organic matter

(D) Prevent all forms of ecological succession

Q20. The following diagram represents movement of water molecules across a selectively permeable membrane.



The movement shown above continues until:

(A) Both sides contain identical solute molecules

(B) Dynamic equilibrium of water potential is achieved

(C) The membrane becomes freely permeable to solutes

(D) All dissolved substances diffuse equally in both directions

Q21. A researcher observed that in a certain mutant plant, ATP synthesis in chloroplasts stopped completely when the proton gradient across thylakoid membranes was experimentally disrupted. This observation directly supports the role of the proton gradient in:

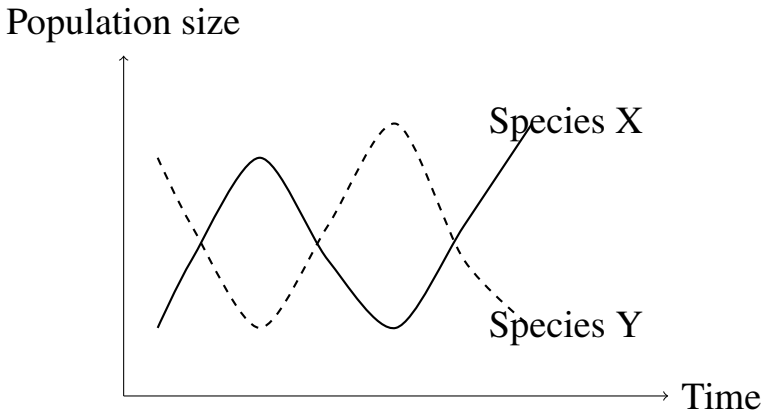
(A) Photolysis of water

(B) Chemiosmotic ATP synthesis

(C) Carbon fixation by RuBisCO

(D) Chlorophyll biosynthesis

Q22. The following graph represents population interactions between two species over time.



The oscillating relationship shown above is most characteristic of:

(A) Mutualism

(B) Predator-prey interaction

(C) Commensalism

(D) Interspecific hybridization

Q23. In humans, the failure of chromosomes to separate during meiosis may produce gametes with abnormal chromosome numbers. Fertilization involving such gametes can lead to disorders such as:

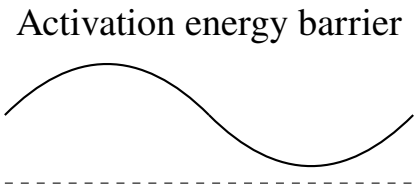
(A) Sickle-cell anaemia

(B) Turner syndrome

(C) Haemophilia

(D) Colour blindness

Q24. The figure below represents a generalized enzyme-catalyzed reaction.



Enzymes accelerate biochemical reactions primarily by:

(A) Increasing the free energy change of the reaction

(B) Lowering activation energy

(C) Permanently altering equilibrium constants

(D) Supplying ATP directly to substrates

Q25. A patient was unable to clot blood efficiently after severe liver damage. Which plasma protein synthesized in the liver is directly involved in blood clotting?

(A) Albumin

(B) Fibrinogen

(C) Globulin

(D) Haemoglobin

Q26. During translation, a ribosome encounters the codon UGA on mRNA. What is the most likely immediate consequence?

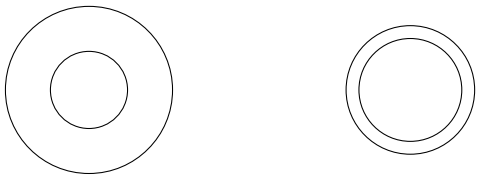
(A) Addition of methionine to the polypeptide chain

(B) Initiation of protein synthesis

(C) Termination of translation

(D) Replication of the mRNA strand

Q27. The following diagram represents the structure of an artery and a vein.



X Y

Structure X is most likely an artery because it possesses:

(A) Thin elastic walls and wider lumen

(B) Thick muscular walls and narrow lumen

(C) Valves throughout its length

(D) Absence of connective tissue

Q28. A xerophytic plant closes its stomata during daytime and opens them at night. This adaptation primarily helps the plant to:

(A) Increase photorespiration

(B) Reduce transpiration water loss

(C) Enhance oxygen evolution only

(D) Eliminate carbon fixation completely

Q29. A scientist studying evolution observed structures in different organisms that performed similar functions but developed from different evolutionary origins. Such structures are termed:

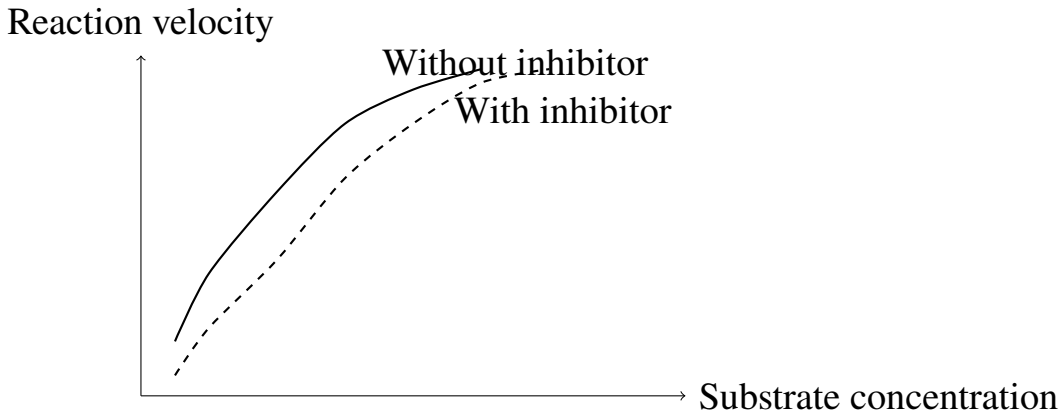
(A) Homologous organs

(B) Vestigial organs

(C) Analogous organs

(D) Rudimentary appendages

Q30. The following graph represents the effect of substrate concentration on reaction velocity in presence and absence of a competitive inhibitor.



The competitive inhibitor shown above most likely acts by:

(A) Binding irreversibly to the enzyme permanently

(B) Competing with substrate for the active site

(C) Destroying the substrate molecule chemically

(D) Reducing temperature of the reaction mixture

Q31. A researcher studying DNA replication discovered that removal of RNA primers from newly synthesized lagging strands was defective in a mutant bacterial strain. Which enzyme is most directly responsible for replacing these RNA segments with DNA nucleotides in prokaryotes?

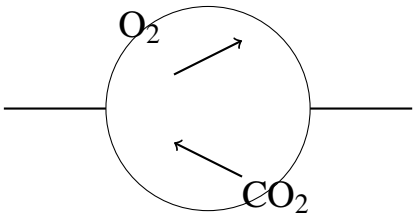
(A) DNA polymerase I

(B) Helicase

(C) Primase

(D) DNA ligase

Q32. The following figure represents gaseous exchange in human alveoli.



Alveolus

Diffusion of oxygen from alveoli into blood occurs primarily because:

(A) Oxygen concentration is higher in blood than alveoli

(B) Partial pressure of oxygen is higher in alveoli than deoxygenated blood

(C) Haemoglobin actively pumps oxygen into plasma

(D) Carbon dioxide concentration becomes zero in alveoli

Q33. In a flowering plant, a diploid megaspore mother cell undergoes meiosis to produce four megaspores, of which only one remains functional. The functional megaspore ultimately develops into the:

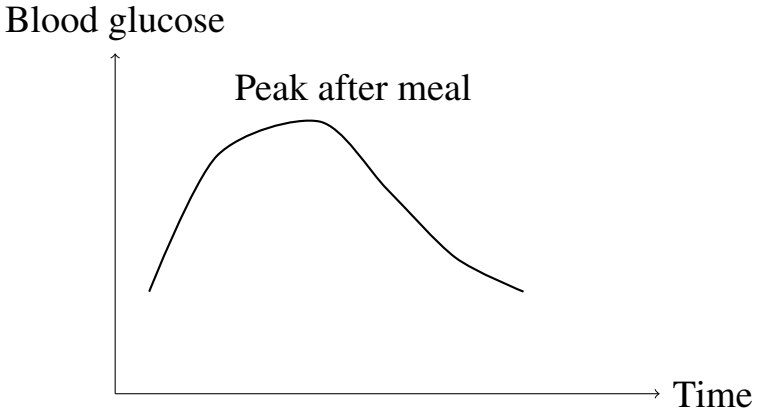
(A) Pollen grain

(B) Embryo sac

(C) Endosperm

(D) Zygote

Q34. The graph below represents changes in blood glucose concentration after a carbohydrate-rich meal in a healthy individual.



The decrease in blood glucose concentration after the peak is mainly due to increased secretion of:

(A) Glucagon

(B) Insulin

(C) Thyroxine

(D) Adrenaline

Q35. A scientist observed that a certain species of bacteria survived in extremely hot acidic springs where most organisms could not survive. Such organisms are best classified under:

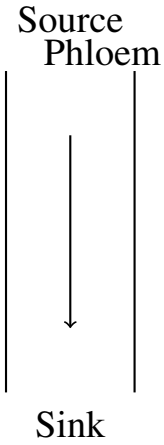
(A) Cyanobacteria

(B) Archaebacteria

(C) Mycoplasma

(D) Viroids

Q36. The following diagram represents transport of sugars in plants.



The movement shown above occurs through:

(A) Xylem vessels by transpiration pull

(B) Phloem sieve tubes by translocation

(C) Cortex by diffusion only

(D) Epidermal cells through osmosis

Q37. A mutation changed the DNA triplet sequence from CAA to CTA in the template strand. Which corresponding change would most likely occur in the mRNA codon produced during transcription?

(A) GUU to GAU

(B) GUU to GAA

(C) GAA to GAU

(D) CUA to CAA

Q38. In an ecosystem, energy transfer between trophic levels is generally inefficient because a large proportion of energy is:

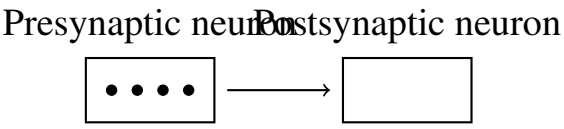
(A) Converted completely into minerals

(B) Lost as heat during metabolic activities

(C) Stored permanently in producer biomass

(D) Destroyed by decomposers

Q39. The following diagram represents the structure of a synapse.



Transmission across the synaptic cleft occurs mainly through release of:

(A) DNA fragments

(B) Neurotransmitter molecules

(C) ATP directly into axons

(D) Ribosomal proteins

Q40. A population initially in Hardy–Weinberg equilibrium began showing rapid changes in allele frequencies after large-scale migration of individuals from another population. This change is best explained by:

(A) Genetic drift

(B) Gene flow

(C) Stabilizing selection

(D) Artificial hybridization

Detailed Solutions

Q1.

Solution

Concept: The *lac* operon is a classic genetic model for transcriptional regulation in bacteria. Under normal conditions, transcription of the structural genes is regulated by the interaction between the regulatory repressor protein, the operator region, and an inducer (allolactose, a lactose derivative).

Solution: Step 1: Understand the normal regulatory mechanism of the *lac* operon:

- **In the absence of lactose:** The active *lac* repressor protein binds tightly to the operator region (O), physically blocking RNA polymerase from binding to the promoter (P) and preventing transcription of the structural genes (*lacZ*, *lacY*, and *lacA*).
- **In the presence of lactose:** Lactose is converted into allolactose, which binds to the repressor protein. This binding induces a conformational change in the repressor, reducing its affinity for the operator. The repressor detaches, allowing RNA polymerase to transcribe the operon.

Step 2: Analyze the mutant strain's defect:

- In this mutant, the repressor protein has lost its ability to bind to lactose (and allolactose).
- However, the repressor retains its normal, high affinity for the operator region of DNA.

Step 3: Determine the physiological consequence of lactose addition:

- When lactose is added, it cannot bind to the mutant repressor.
- Consequently, the repressor remains permanently in its active conformation and remains bound to the operator region.
- RNA polymerase remains blocked from transcribing the structural genes, leaving the *lac* operon in a permanently repressed state. This is why the cells fail to synthesize β-galactosidase.

Step 4: Match with the options: Option C correctly explains that the operon remains repressed despite lactose availability.

Final Answer: The operon remained repressed despite lactose availability

Answer: (C)

Go Back to Question 1

Q2.

Solution

Concept: The oxygen dissociation curve represents the relationship between the partial pressure of oxygen (pO_2) and the percentage saturation of hemoglobin (O_2 saturation). A shift in the position of this curve reflects a change in hemoglobin's affinity for oxygen.

Solution: Step 1: Analyze shifts in the oxygen dissociation curve:

- **Rightward shift:** Indicates a decrease in oxygen affinity (hemoglobin binds oxygen less tightly, promoting oxygen release to metabolizing tissues).
- **Leftward shift:** Indicates an increase in oxygen affinity (hemoglobin binds oxygen more tightly at any given partial pressure, absorbing oxygen more readily).

Step 2: Compare fetal hemoglobin (HbF) and adult hemoglobin (HbA):

- The fetal hemoglobin curve is shifted to the left relative to the adult hemoglobin curve.
- This leftward shift means fetal hemoglobin has a significantly higher affinity for oxygen than adult hemoglobin.

Step 3: Relate to physiological significance: This higher affinity is a crucial adaptation that enables the fetus to extract oxygen from maternal blood across the placenta, where oxygen levels are relatively low.

Step 4: Therefore, Option C is correct.

Final Answer: Has higher affinity for oxygen facilitating placental transfer

Answer: (C)

Go Back to Question 2

Q3.

Solution

Concept: Cell division (mitosis) requires a highly organized cytoskeletal apparatus to ensure that duplicated chromosomes are partitioned equally between two daughter cells.

Solution: Step 1: Identify the role of the mitotic spindle: The mitotic spindle is composed of microtubule polymers. These spindle microtubules originate from centrosomes and attach to the kinetochores of sister chromatids at their centromeres.

Step 2: Analyze the dynamic action during mitosis: During anaphase, the shortening of kinetochore microtubules, coupled with the action of motor proteins, pulls sister chromatids toward opposite poles of the dividing cell.

Step 3: Determine the consequence of drug treatment: If a drug (such as colchicine or nocodazole) completely inhibits the formation of spindle microtubules:

- The cell cannot organize a mitotic spindle.
- Chromosomes cannot align at the metaphase plate and, most importantly, fail to segregate toward opposite poles during anaphase.
- The cell will arrest in mitosis, preventing cytokinesis and resulting in an abnormal chromosome count (aneuploidy or polyploidy).

Step 4: Therefore, Option B is the direct and immediate consequence.

Final Answer: Chromosomes would fail to segregate toward opposite poles

Answer: (B)

Go Back to Question 3

Q4.

Solution

Concept: An action potential is a rapid, temporary change in the membrane potential of an excitable cell (such as a neuron). It is mediated by the selective opening and closing of voltage-gated ion channels.

Solution: Step 1: Understand the resting membrane potential: At rest, a neuron maintains a negative membrane potential (≈ -70 mV), driven primarily by potassium leak channels and the sodium-potassium pump.

Step 2: Explain the phase of depolarization:

- When a stimulus depolarizes the membrane to a certain threshold (≈ -55 mV), it triggers the rapid opening of voltage-gated sodium (Na^+) channels.
- Because the concentration of Na^+ is much higher outside the cell and the inside of the cell is negatively charged, Na^+ ions rush into the cell down their steep electrochemical gradient (influx).
- This rapid influx of positive charge makes the membrane potential highly positive ($\approx +30$ mV), causing depolarization.

Step 3: Contrast with repolarization: Repolarization, which returns the potential to a negative state, is mediated by the efflux (outward movement) of potassium (K^+) ions.

Step 4: Thus, depolarization is caused by the influx of sodium ions (Option B).

Final Answer: Influx of sodium ions through voltage-gated channels

Answer: (B)

Go Back to Question 4

Q5.

Solution

Concept: Different plant lineages have evolved alternative photosynthetic adaptations to optimize carbon fixation in response to their environments.

Solution: Step 1: Analyze the structural requirements of C_4 plants:

- C_4 photosynthesis relies on a specialized leaf anatomy known as **Kranz anatomy**.
- This anatomy features two distinct, biochemically specialized photosynthetic cell types: mesophyll cells and bundle sheath cells.
- In C_4 plants, initial carbon fixation occurs in the mesophyll cells to form a 4-carbon acid (malate/aspartate). This acid is then transported to the bundle sheath cells, where it is decarboxylated to release a high concentration of CO_2 directly to the enzyme RuBisCO.

Step 2: Determine the impact of lacking bundle sheath cells:

- Without bundle sheath cells, a plant cannot separate the initial CO_2 capture and the Calvin cycle.
- Consequently, the metabolic reactions of the C_4 pathway cannot occur, severely disabling C_4 photosynthesis.

Step 3: Analyze the other options:

- **CAM metabolism** (Option A) separates these steps temporally (night vs. day) within the same mesophyll cell, and does not require Kranz anatomy.
- **Glycolysis** (Option C) is a universal cytosolic pathway present in all cells.
- **Photorespiration in C_3 plants** (Option D) occurs in standard mesophyll cells and does not require bundle sheath cells.

Final Answer: C_4 photosynthesis

Answer: (B)

Go Back to Question 5

Q6.

Solution

Concept: Evolution is driven by several mechanisms, the most prominent of which is natural selection. Natural selection acts on existing genetic variation within a population under specific environmental pressures.

Solution: Step 1: Break down the observed scenario:

- **Genetic Variation:** A population of insects possessed pre-existing genetic variations, including rare alleles that conferred resistance to a pesticide.
- **Environmental Selection Pressure:** The application of the pesticide acted as a harsh selective agent.
- **Differential Survival and Reproduction:** Non-resistant insects died, while the rare resistant individuals survived and reproduced, passing their resistance alleles to their offspring.
- **Evolutionary Shift:** Over several generations, the frequency of the resistance alleles increased dramatically, leading to a population dominated by resistant insects.

Step 2: Evaluate the evolutionary mechanisms:

- **Lamarckian inheritance** (Option A) proposes that acquired traits (gained during an organism's lifetime through use/disuse) are passed on, which is not the case here (resistance arose from pre-existing genetic variation).
- **Stabilizing selection** (Option B) favors intermediate phenotypes, reducing variation.
- **Natural selection acting on genetic variation** (Option C) describes this phenomenon, which is a classic example of directional selection (microevolution).

Final Answer: Natural selection acting on genetic variation

Answer: (C)

Go Back to Question 6

Q7.

Solution

Concept: The transport of molecules or ions across a biological membrane can occur down a concentration gradient (passive transport) or against a concentration gradient (active transport).

Solution: Step 1: Identify the direction of transport relative to the concentration gradient: The problem specifies that molecules are being moved **against their concentration gradient** (from an area of lower concentration to an area of higher concentration).

Step 2: Understand the thermodynamic requirements of uphill transport: Moving substances against a concentration gradient is a non-spontaneous process ($\Delta G > 0$) and cannot occur via simple or facilitated diffusion. To overcome this thermodynamic barrier, the process must be coupled to an exergonic reaction, which in cells is typically the hydrolysis of adenosine triphosphate (ATP).

Step 3: Analyze the carrier protein: Active transport proteins (often called pumps) undergo conformational changes driven by phosphorylation from ATP to actively transport the substrate across the membrane.

Step 4: Therefore, the process is active transport and requires ATP expenditure.

Final Answer: ATP expenditure

Answer: (A)

Go Back to Question 7

Q8.

Solution

Concept: In Mendelian genetics, simple dominance involves one allele masking the expression of another. However, many traits exhibit non-Mendelian inheritance patterns, such as codominance.

Solution: Step 1: Understand the genetics of the ABO blood group system: The ABO blood group is determined by three alleles: I^A, I^B, and i.

- I^A and I^B code for different carbohydrate antigens on the surface of red blood cells.
- i is a recessive allele that produces no antigen.

Step 2: Define codominance: **Codominance** is a genetic relationship in which both alleles in a heterozygote are fully and simultaneously expressed, resulting in a phenotype that displays features of both homozygous phenotypes.

Step 3: Analyze the genotype of a person with blood group AB: A person with blood group AB has the genotype $I^A I^B$. Both the A antigen (from the I^A allele) and the B antigen (from the I^B allele) are fully and equally expressed on the membrane of their erythrocytes.

Step 4: Therefore, this inheritance pattern is a classic example of codominance.

Final Answer: Codominance

Answer: (C)

Go Back to Question 8

Q9.

Solution

Concept: Enzymes are biological catalysts with a finite number of active sites. The relationship between substrate concentration and reaction rate is described by Michaelis-Menten kinetics.

Solution: Step 1: Analyze the curve of reaction rate vs. substrate concentration:

- At low substrate concentrations, the reaction rate increases linearly with substrate concentration because many active sites on the enzyme molecules are unoccupied (free).
- As substrate concentration increases, a higher percentage of the enzyme active sites become bound to substrate.

Step 2: Explain the plateau (V_{max}): At very high substrate concentrations, the reaction rate reaches a maximum limit (V_{max}) and plateaus. This occurs because all available active sites on the enzyme molecules are constantly occupied by substrate molecules. The enzyme is said to be **saturated**.

Step 3: Conclude: Adding more substrate at this point cannot increase the rate of reaction further because there are no free enzymes available to bind the additional substrate.

Final Answer: Enzyme molecules become saturated with substrate

Answer: (A)

Go Back to Question 9

Q10.

Solution

Concept: Mitochondria are double-membrane organelles that possess their own circular DNA (mtDNA), independent of the nuclear genome. Mitochondria exhibit a unique non-Mendelian mode of inheritance.

Solution: Step 1: Understand the composition of male and female gametes during fertilization:

- The female gamete (ovum or egg cell) is exceptionally large and contains a vast amount of cytoplasm rich in organelles, including hundreds of thousands of mitochondria.
- The male gamete (sperm) is specialized for motility. It is small, carrying its haploid nucleus in the head, and contains only a few mitochondria packed in its midpiece to generate energy for swimming.

Step 2: Examine what happens during fertilization: Upon fertilization, only the sperm head containing the paternal nucleus typically enters the egg. In cases where the midpiece does enter, the paternal mitochondria are selectively targeted, tagged with ubiquitin, and destroyed by the egg's autophagic machinery.

Step 3: Analyze the inheritance pattern: Because virtually 100% of the zygote's cytoplasm and organelles originate from the egg, the mitochondrial genome is inherited exclusively from the mother (**maternal inheritance**). Consequently, any mutations in mtDNA are passed solely from mothers to all of their offspring.

Final Answer: Sperm mitochondria usually do not contribute significantly to the zygote

Answer: (A)

Go Back to Question 10

Q11.

Solution

Concept: Translation is the process of synthesizing a polypeptide chain from an mRNA template. It requires cooperation between several types of RNA molecules and the ribosome.

Solution: Step 1: Understand the roles of different RNA molecules in translation:

- **mRNA (messenger RNA):** Carries the genetic code transcribed from DNA in the form of three-nucleotide codons.
- **rRNA (ribosomal RNA):** Forms the structural and catalytic core of the ribosome, aligning mRNA and catalyzing peptide bond formation.
- **tRNA (transfer RNA):** Acts as a physical adaptor molecule.

Step 2: Analyze the role of tRNA: Each tRNA molecule has two critical sites:

(a) An amino acid attachment site (at the 3′ end) where a specific amino acid is covalently bound.

(b) An anticodon loop containing a three-nucleotide sequence that base-pairs with its complementary codon on the mRNA.

Step 3: Conclude: During translation, tRNA molecules carry specific amino acids directly to the ribosome, matching their anticodons with the codons on the mRNA to assemble the growing polypeptide chain in the correct sequence.

Final Answer: tRNA

Answer: (B)

Go Back to Question 11

Q12.

Solution

Concept: An ecological pyramid of energy depicts the flow of energy through successive trophic levels in an ecosystem over a given period.

Solution: Step 1: Analyze how energy is transferred in food chains: When energy is transferred from one trophic level to the next, a large portion of it is lost to the environment. This is governed by thermodynamic laws:

- **Lindeman's 10% Law:** On average, only about 10% of the energy stored as biomass at one trophic level is transferred and incorporated into the biomass of the next trophic level.
- The remaining 90% of the energy is lost as heat through respiration, metabolic activities, and excretion of waste.

Step 2: Relate this loss to the shape of the energy pyramid: Because energy is continuously lost at each successive step, the amount of energy available at a higher trophic level is always strictly less than the energy available at the level below it.

$$\text{Producers } (100\%) \longrightarrow \text{Primary Consumers } (10\%) \longrightarrow \text{Secondary Consumers } (1\%) \longrightarrow \ldots$$

Step 3: Conclude: Since energy can never be created or increased as it moves up the food chain, an energy pyramid can never be inverted or flat; it must always be upright due to the inherent inefficiency of energy transfer between trophic levels.

Final Answer: Energy transfer between trophic levels is inefficient

Answer: (B)

Go Back to Question 12

Q13.

Solution

Concept: Bacterial transformation is the process by which bacterial cells take up foreign plasmid DNA from their surrounding environment. To identify cells that have successfully taken up the plasmid (transformants), selection markers, such as antibiotic resistance genes, are engineered into the plasmid.

Solution: Step 1: Understand the selective selection mechanism:

- The plasmid vector contains an antibiotic resistance gene (e.g., ampicillin or tetracycline resistance).
- Host bacterial cells are normally sensitive to this antibiotic and cannot grow in its presence.
- When bacteria take up the plasmid containing the resistance gene during transformation, they express the resistance protein and gain the ability to grow on agar containing the corresponding antibiotic.

Step 2: Analyze the experimental outcome: The question describes bacterial colonies that *failed to grow* on the antibiotic-containing selective medium.
Step 3: Evaluate the options:

- If the bacteria had successfully taken up the plasmid and expressed the resistance gene, they would survive and grow (ruling out Option A).
- The failure to grow indicates that these bacterial cells remained sensitive to the antibiotic. This is because they **did not take up the recombinant plasmid** during the transformation process (Option B).

Final Answer: Did not take up the recombinant plasmid

Answer: (B)

Go Back to Question 13

Q14.

Solution

Concept: The net gaseous exchange in plants over a 24-hour period is a balance between two competing biological processes: photosynthesis and cellular respiration.

Solution: Step 1: Understand the gaseous exchange of the two processes:

- **Photosynthesis** takes up carbon dioxide (CO_2) and releases oxygen (O_2). It is light-dependent and dominates during the day.
- **Cellular Respiration** takes up oxygen (O_2) and releases carbon dioxide (CO_2). It occurs continuously day and night.

Step 2: Interpret the axes of the graph:

- The horizontal axis (dashed line) represents the point of compensation or zero net gas exchange (where photosynthesis rate equals respiration rate).
- The region **above** the horizontal axis represents net O_2 release (or CO_2 uptake), indicating that the rate of photosynthesis exceeds the rate of respiration.
- The region **below** the horizontal axis represents net O_2 uptake (or CO_2 release), indicating that the rate of cellular respiration exceeds the rate of photosynthesis.

Step 3: Analyze the specified interval: When the graph lies below the horizontal axis (typically during the night or low-light hours), there is no net photosynthesis occurring. The plant is primarily **carrying out respiration without net photosynthesis** (Option C).

Final Answer: Carrying out respiration without net photosynthesis

Answer: (C)

Go Back to Question 14

Q15.

Solution

Concept: Nitrogenous waste metabolism is a critical physiological process. Deamination of amino acids produces ammonia (NH_3), a highly toxic byproduct. In healthy individuals, the liver rapidly converts ammonia into non-toxic urea via the urea cycle.

Solution: Step 1: Understand the physiological impact of liver damage: Severe liver damage disrupts the urea cycle, leading to a build-up of unprocessed ammonia in the bloodstream (hyperammonemia).

Step 2: Analyze the molecular toxicity of ammonia:

- Ammonia readily crosses the blood-brain barrier because it exists in equilibrium with ammonium ions (NH_4^+) and can also pass through gaseous channels.
- Once in the brain, excess ammonia is taken up by astrocytes, which use it to convert glutamate into glutamine.
- This causes osmotic swelling of astrocytes, brain edema, disruption of neurotransmission (depletion of the neurotransmitter glutamate and α-ketoglutarate from the citric acid cycle), and severe neurotoxicity.

Step 3: Evaluate the options: Ammonia accumulation is primarily dangerous because it is **highly toxic to neural tissues** (Option B), causing hepatic encephalopathy, neurological deficits, and potentially coma.

Final Answer: Is highly toxic to neural tissues

Answer: (B)

Go Back to Question 15

Q16.

Solution

Concept: During Prophase I of meiosis, homologous chromosomes pair up in a process called synapsis, forming tetrads where non-sister chromatids can physically interact.

Solution: Step 1: Define a chiasma (plural: chiasmata): A chiasma is the physical point of contact and connection between non-sister chromatids of homologous chromosomes.

Step 2: Relate chiasmata to genetic recombination:

- During the pachytene stage of Prophase I, non-sister chromatids break and exchange homologous segments of DNA in a process called **crossing over**.
- As the synaptonemal complex disassembles during the diplotene stage, the homologous chromosomes begin to repel each other but remain held together at the exact sites where recombination occurred.
- These physical cross-over points are visible under a microscope as X-shaped structures called chiasmata.

Step 3: Thus, the chiasma represents the site where crossing over between homologous chromatids takes place (Option B).

Final Answer: Crossing over between homologous chromatids takes place

Answer: (B)

Go Back to Question 16

Q17.

Solution

Concept: Photorespiration (C_2 cycle) is a metabolic pathway that occurs when the enzyme RuBisCO (Ribulose-1,5-bisphosphate carboxylase-oxygenase) binds to oxygen (O_2) instead of carbon dioxide (CO_2).

Solution: Step 1: Understand why photorespiration occurs under hot and dry conditions: To minimize water loss in hot, dry environments, plants close their stomata. This causes internal CO_2 levels to decline while O_2 (produced by light reactions) accumulates, prompting RuBisCO to function as an oxygenase.

Step 2: Analyze the metabolic cost of photorespiration:

- Unlike the Calvin cycle, photorespiration does not produce sugar (carbohydrates) or ATP.
- Instead, it results in the loss of previously fixed carbon as CO_2 and consumes energy in the form of ATP and NADPH to reclaim the toxic byproduct phosphoglycolate.

Step 3: Determine the physiological consequence: Because photorespiration wastes energy and releases fixed carbon without synthesizing sugar, an increase in photorespiration severely reduces the net photosynthetic productivity and yield of the plant (Option B).

Final Answer: Reduced photosynthetic productivity

Answer: (B)

Go Back to Question 17

Q18.

Solution

Concept: The menstrual cycle is regulated by the coordinated secretion of hormones from both the pituitary gland (gonadotropins: LH and FSH) and the ovaries (estrogen and progesterone).

Solution: Step 1: Analyze the timeline of the ovarian cycle:

- **Follicular phase (pre-ovulatory):** Developing ovarian follicles primarily secrete estrogen, which stimulates the repair and proliferation of the uterine endometrium.
- **Ovulation (around Day 14):** A surge in LH triggers the release of the secondary oocyte from the mature Graafian follicle.
- **Luteal phase (post-ovulatory):** After the egg is released, the remnants of the ruptured follicle transform into a temporary endocrine gland called the **corpus luteum**.

Step 2: Relate the corpus luteum to hormone secretion: The corpus luteum immediately begins synthesizing and secreting large quantities of **progesterone** (along with some estrogen). Progesterone acts on the endometrium, making it highly vascularized and secretory to prepare for potential embryo implantation.

Step 3: Conclude: The sharp post-ovulatory rise in progesterone shown in the graph is driven directly by secretion from the corpus luteum (Option B).

Final Answer: Corpus luteum

Answer: (B)

Go Back to Question 18

Q19.

Solution

Concept: Ecosystems rely on a continuous flow of energy and the cyclic movement of chemical nutrients. Decomposers (bacteria, fungi, detritivores) occupy a crucial position in this cycle.

Solution: Step 1: Examine the flow of resources in an ecosystem:

- Energy enters the ecosystem as sunlight, is converted by producers, flows through consumers, and is eventually lost as heat. It is a one-way flow and cannot be recycled.
- Nutrients (atoms like Carbon, Nitrogen, Phosphorus) are finite and must be continuously recycled within the ecosystem.

Step 2: Understand the function of decomposers: Decomposers secrete extracellular enzymes to break down the complex organic molecules in dead plants, animal carcasses, and wastes into simple, inorganic chemical nutrients.

Step 3: Determine their ecological significance: By converting organic waste back into inorganic forms, decomposers return these essential elements to the soil and water, making them available once again for uptake by primary producers. Without them, nutrients would remain locked in dead matter, and the ecosystem would collapse due to nutrient depletion.

Final Answer: Recycle nutrients from dead organic matter

Answer: (C)

Go Back to Question 19

Q20.

Solution

Concept: Osmosis is a specific type of passive transport involving the net movement of water molecules across a selectively permeable membrane.

Solution: Step 1: Define water potential (Ψ_w): Water potential is a measure of the free energy of water molecules in a system.

- A dilute solution has a high concentration of free water molecules, which corresponds to a **high (less negative) water potential**.
- A concentrated solution has a lower concentration of free water molecules due to solute-water interactions, corresponding to a **low (more negative) water potential**.

Step 2: Describe the direction of osmotic flow: Water molecules spontaneously diffuse from a region of higher water potential (dilute side) to a region of lower water potential (concentrated side) across the selectively permeable membrane.

Step 3: Identify when net movement stops: Water will continue to flow until the concentration of free water molecules, and thus the water potential (Ψ_w), becomes equal on both sides of the membrane. At this point, a state of **dynamic equilibrium of water potential** is achieved, meaning water molecules still cross the membrane in both directions but at equal rates, resulting in no net change.

Final Answer: Dynamic equilibrium of water potential is achieved

Answer: (B)

Go Back to Question 20

Q21.

Solution

Concept: ATP synthesis in chloroplasts occurs via the light-dependent reactions of photosynthesis. According to Peter Mitchell's **chemiosmotic hypothesis**, the flow of electrons through the thylakoid membrane's electron transport chain is coupled to the active pumping of protons (H^+) from the stroma into the thylakoid lumen, generating a proton-motive force.

Solution: Step 1: Understand the role of the thylakoid proton gradient:

- The active accumulation of protons in the thylakoid lumen creates a high electrochemical concentration gradient across the membrane (low pH in lumen, high pH in stroma).
- The only pathway through which these accumulated protons can diffuse back down their gradient into the stroma is through the transmembrane channel of the enzyme ATP synthase (CF_0-CF_1 complex).

Step 2: Relate proton flow to ATP generation:

- As protons flow down their electrochemical gradient through ATP synthase, the kinetic energy of this flow is used to catalyze the phosphorylation of ADP:

$$ADP + P_i \xrightarrow{\text{ATP Synthase}} ATP$$

Step 3: Analyze the experimental observation: When the proton gradient is disrupted, the proton-motive force drops to zero. Consequently, ATP synthase lacks the physical drive required to produce ATP, and synthesis stops. This directly demonstrates the core principle of chemiosmotic ATP synthesis (Option B).

Final Answer: Chemiosmotic ATP synthesis

Answer: (B)

Go Back to Question 21

Q22.

Solution

Concept: In population ecology, the interactions between coexisting species shape their respective population dynamics over time. Some relationships produce distinct cyclic patterns.

Solution: Step 1: Analyze the graph's curves:

- The population sizes of Species X (solid line) and Species Y (dashed line) oscillate over time.
- Importantly, the oscillations are out of phase: a peak in the population of Species X is followed shortly after by a peak in Species Y, which then triggers a sharp decline in Species X.

Step 2: Identify the ecological interaction:

- This classic, paired lagging-oscillation cycle is described mathematically by the Lotka-Volterra equations.
- As the prey population (e.g., Species X) increases, food becomes abundant, allowing the predator population (e.g., Species Y) to grow.
- The rising predator population consumes more prey, causing the prey population to decline. This decline in food subsequently leads to a drop in the predator population, restarting the cycle.

Step 3: Therefore, this out-of-phase oscillation is highly characteristic of a predator-prey interaction (Option B).

Final Answer: Predator-prey interaction

Answer: (B)

Go Back to Question 22

Q23.

Solution

Concept: During meiosis, homologous chromosomes must segregate evenly in meiosis I, and sister chromatids must segregate in meiosis II. The failure of this segregation process is termed nondisjunction.

Solution: Step 1: Understand the genetic consequence of nondisjunction: Nondisjunction leads to gametes carrying an abnormal number of chromosomes (either $n + 1$ or $n - 1$).

Step 2: Analyze what happens during fertilization: When an abnormal gamete fuses with a normal gamete, the resulting zygote will exhibit aneuploidy (an abnormal chromosome number, such as $2n + 1$ or $2n - 1$).

Step 3: Evaluate the options to identify which disorder is caused by aneuploidy:

- **Sickle-cell anaemia** (Option A) is caused by a point mutation in the autosomal β-globin gene.
- **Turner syndrome** (Option B) is a chromosomal disorder in females characterized by monosomy of the X chromosome $(45, X0)$, which is a direct result of chromosomal nondisjunction.
- **Haemophilia** (Option C) and **Colour blindness** (Option D) are single-gene mutations inherited as X-linked recessive traits.

Step 4: Therefore, Turner syndrome is the only disorder listed that results from chromosomal non-segregation.

Final Answer: Turner syndrome

Answer: (B)

Go Back to Question 23

Q24.

Solution

Concept: Chemical reactions require reactants to absorb a specific amount of energy to reach an unstable transition state before they can transform into products. This energy barrier is known as the activation energy (E_a).

Solution: Step 1: Analyze how enzymes interact with biochemical reactions: Enzymes are protein catalysts that bind to substrate molecules at their active sites to form an enzyme-substrate complex.

Step 2: Understand the mechanism of catalysis:

- By stabilizing the transition state, straining substrate bonds, or providing an alternative chemical pathway, enzymes significantly **lower the activation energy barrier** of the reaction.
- This enables a much higher fraction of reactant molecules to overcome the energy barrier and convert into products per unit of time, accelerating the reaction rate.

Step 3: Evaluate the options:

- Enzymes do not alter the overall free energy change (ΔG) of a reaction (Option A).
- They do not change the chemical equilibrium constant (K_{eq}) of a reaction (Option C); they only accelerate how quickly equilibrium is reached.
- Therefore, enzymes accelerate biochemical reactions primarily by lowering the activation energy (Option B).

Final Answer: Lowering activation energy

Answer: (B)

Go Back to Question 24

Q25.

Solution

Concept: The liver is the primary metabolic organ of the body, responsible for synthesizing many essential blood plasma proteins.

Solution: Step 1: Understand the physiological effects of severe liver damage: Liver failure reduces the synthesis of various circulating proteins, including those involved in maintaining fluid balance, transporting materials, and mediating the coagulation cascade.

Step 2: Evaluate the proteins listed to identify their roles in blood clotting:

- **Albumin** (Option A) maintains plasma colloid osmotic pressure and transports hormones/drugs, but does not clot blood.
- **Fibrinogen** (Option B, Coagulation Factor I) is a soluble, high-molecular-weight glycoprotein synthesized exclusively by hepatocytes in the liver. During the final steps of the coagulation cascade, thrombin cleaves fibrinogen into insoluble fibrin monomers, which polymerize to form a mesh that stabilizes the platelet plug, forming a clot.
- **Globulins** (Option C) are involved in immunity (immunoglobulins) and transport, but do not directly form blood clots.
- **Haemoglobin** (Option D) is an oxygen-transport protein found inside red blood cells, not synthesized by hepatocytes.

Step 3: Thus, fibrinogen is the clotting factor synthesized by the liver.

Final Answer: Fibrinogen

Answer: (B)

Go Back to Question 25

Q26.

Solution

Concept: Translation is the process of translating genetic code on mRNA into a sequence of amino acids to form a protein. This process has distinct initiation, elongation, and termination phases.

Solution: Step 1: Identify the function of codon UGA: The codon **UGA** is one of the three universal stop codons (nonsense codons) along with UAA and UAG.

Step 2: Understand how the ribosome processes a stop codon:

- Stop codons do not specify any amino acid and do not have complementary tRNAs.
- When the ribosome encounters UGA in the A-site, it is recognized by specific proteins called release factors.
- The release factors catalyze the hydrolysis of the ester bond linking the finished polypeptide chain to the tRNA in the P-site.

Step 3: Determine the immediate consequence: The completed polypeptide is released, and the ribosomal subunits dissociate from the mRNA strand, resulting in the **termination of translation** (Option C).

Final Answer: Termination of translation

Answer: (C)

Go Back to Question 26

Q27.

Solution

Concept: Arteries and veins are structural blood vessels adapted to the different pressures and directions of blood flow in the circulatory system.

Solution: Step 1: Compare the structural differences between arteries and veins:

- **Arteries (Structure X):** Carry blood away from the heart under high hydrostatic pressure. To withstand this pressure, their walls (specifically the tunica media containing smooth muscle and elastic fibers) are thick and elastic. This thick wall limits the internal diameter, resulting in a narrow lumen.
- **Veins (Structure Y):** Return blood to the heart under very low pressure. Consequently, they possess thinner, less muscular walls and a much wider lumen to facilitate flow, alongside internal valves to prevent the backflow of blood.

Step 2: Match with the options: Structure X is identified as an artery because it exhibits thick muscular walls and a narrow lumen (Option B).

Final Answer: Thick muscular walls and narrow lumen

Answer: (B)

Go Back to Question 27

Q28.

Solution

Concept: Stomata are microscopic pores on leaf surfaces that facilitate gas exchange (CO_2 intake and O_2 release). However, open stomata also allow water to escape via transpiration.

Solution: Step 1: Identify the challenge faced by xerophytes: Xerophytic plants grow in hot, dry, arid environments where fresh water is extremely limited and transpirational demand is high.

Step 2: Analyze the adaptive value of closing stomata during the day: During the day, temperatures are high and relative humidity is low. If stomata were open, the plant would lose water rapidly via transpiration, leading to dehydration.

Step 3: Analyze the adaptive value of opening stomata at night: At night, temperatures are lower and humidity is higher. Opening stomata during this time minimizes water loss while allowing the plant to absorb and store CO_2 (often via the CAM pathway) to fuel photosynthesis during the day.

Step 4: Therefore, this diurnal pattern primarily serves to reduce transpiration water loss (Option B).

Final Answer: Reduce transpiration water loss

Answer: (B)

Go Back to Question 28

Q29.

Solution

Concept: Evolutionary biology distinguishes between anatomical structures in different species based on their evolutionary origin and functional adaptations.

Solution: Step 1: Define the terms used to classify anatomical structures:

- **Homologous organs (Option A):** Structures that share a common evolutionary origin and basic anatomical plan, but may perform different functions in different species due to divergent evolution (e.g., the forelimbs of humans, bats, and whales).
- **Analogous organs (Option C):** Structures that perform similar functions but have entirely different evolutionary origins and anatomical developments due to convergent evolution (e.g., the wings of a butterfly and the wings of a bird).
- **Vestigial organs (Option B):** Reduced or non-functional structures that were functional in an ancestral species.

Step 2: Match with the described observation: The scientist observed structures that performed similar functions but developed from different evolutionary origins. This is the definition of analogous organs.

Final Answer: Analogous organs

Answer: (C)

Go Back to Question 29

Q30.

Solution

Concept: Enzyme inhibitors can be classified based on their mechanism of inhibition. A competitive inhibitor shares structural similarities with the enzyme's natural substrate.

Solution: Step 1: Analyze competitive inhibition:

- Because the competitive inhibitor structurally resembles the substrate, it binds reversibly to the enzyme's **active site**.
- This creates competition between the substrate and the inhibitor for access to the active site.

Step 2: Relate to the provided graph:

- At low substrate concentrations, the inhibitor successfully blocks many active sites, reducing the reaction velocity (as shown by the lower dashed curve).
- At extremely high substrate concentrations, the substrate molecules vastly outnumber the inhibitor molecules. The substrate virtually always wins the competition for the active site, allowing the reaction to eventually reach its maximum velocity (V_{max}, where both curves converge).

Step 3: Conclude: The competitive inhibitor acts by competing directly with the substrate for binding to the active site of the enzyme (Option B).

Final Answer: Competing with substrate for the active site

Answer: (B)

Go Back to Question 30

Q31.

Solution

Concept: During DNA replication in prokaryotes, the lagging strand is synthesized discontinuously as short segments called Okazaki fragments. Each fragment must be initiated by an RNA primer synthesized by the enzyme primase. For replication to be finalized, these RNA primers must be removed and replaced with DNA nucleotides, and the remaining nicks must be sealed.

Solution: Step 1: Identify the roles of the enzymes involved in processing Okazaki fragments:

- **DNA polymerase III:** Extends the Okazaki fragments but cannot remove RNA primers because it lacks a $5' \rightarrow 3'$ exonuclease activity.
- **DNA polymerase I:** Possesses three distinct catalytic activities:
  (a) $5' \rightarrow 3'$ polymerase activity (to synthesize DNA).
  (b) $3' \rightarrow 5'$ proofreading exonuclease activity.
  (c) $5' \rightarrow 3'$ exonuclease activity (specifically used to recognize and hydrolyze the RNA nucleotides of the primer ahead of it, while simultaneously replacing them with complementary DNA nucleotides behind it).
- **DNA ligase:** Seals the single-strand nick between the newly synthesized DNA fragments by forming covalent phosphodiester bonds.

Step 2: Relate to the mutant strain: Because the mutant strain is defective in removing RNA primers and replacing them with DNA nucleotides, the enzyme most directly affected is **DNA polymerase I** (Option A).

Final Answer: DNA polymerase I

Answer: (A)

Go Back to Question 31

Q32.

Solution

Concept: Gaseous exchange across the respiratory membrane in the human lungs occurs via simple passive diffusion. The rate and direction of diffusion for any gas are determined by its partial pressure gradient.

Solution: Step 1: Understand the partial pressure values of oxygen in different compartments:

- **In the Alveoli:** The partial pressure of oxygen (pO_2) is relatively high, approximately 104 mmHg.
- **In Deoxygenated Blood:** The deoxygenated blood arriving at the pulmonary capillaries from the right side of the heart has a low pO_2, approximately 40 mmHg.

Step 2: Describe the diffusion process:

- This creates a steep pressure gradient (104 mmHg vs. 40 mmHg) favoring the movement of oxygen.
- Oxygen molecules spontaneously diffuse from the region of higher partial pressure (alveolar air space) to the region of lower partial pressure (blood plasma and erythrocytes) across the thin alveolar-capillary membrane.

Step 3: Evaluate the options: Option B correctly states that diffusion occurs because the partial pressure of oxygen is higher in the alveoli than in deoxygenated blood.

Final Answer: Partial pressure of oxygen is higher in alveoli than deoxygenated blood

Answer: (B)

Go Back to Question 32

Q33.

Solution

Concept: In angiosperms (flowering plants), the development of female gametophyte occurs inside the ovule through two processes: megasporogenesis and megagametogenesis.

Solution: Step 1: Trace the steps of megasporogenesis:

- A diploid megaspore mother cell ($2n$) located within the nucellus of the ovule undergoes meiosis to form a linear tetrad of four haploid megaspores (n).
- In a majority of angiosperms, three of these megaspores degenerate, and only one megaspore (usually the chalazal one) remains functional.

Step 2: Trace the development of the functional megaspore (megagametogenesis):

- The nucleus of the functional megaspore undergoes three sequential mitotic divisions without immediate cytokinesis, producing an 8-nucleate structure.
- These nuclei are subsequently organized into cells, yielding a 7-celled, 8-nucleate structure consisting of three antipodal cells, one central cell (with two polar nuclei), and an egg apparatus (one egg cell and two synergids).
- This mature female gametophyte is called the **embryo sac**.

Step 3: Therefore, the functional megaspore develops directly into the embryo sac (Option B).

Final Answer: Embryo sac

Answer: (B)

Go Back to Question 33

Q34.

Solution

Concept: Blood glucose homeostasis is maintained by the opposing actions of pancreatic hormones secreted by the islets of Langerhans.

Solution: Step 1: Analyze the blood glucose spike: After a carbohydrate-rich meal, digestion and absorption of sugars cause a rapid increase in blood glucose concentration, reaching a peak.

Step 2: Describe the body's physiological response:

- The elevated blood glucose is detected by the beta cells of the pancreatic islets.
- In response, the beta cells secrete the hormone **insulin** into the bloodstream.

Step 3: Explain how insulin lowers blood glucose:

- It stimulates target cells (skeletal muscle and adipose tissue) to insert glucose transporters (GLUT4) into their membranes, accelerating glucose uptake.
- It promotes glycogenesis (conversion of glucose to glycogen) in the liver and skeletal muscle, and inhibits gluconeogenesis.
- This combined action causes blood glucose levels to fall back toward baseline, as shown by the post-peak decline in the graph.

Final Answer: Insulin

Answer: (B)

Go Back to Question 34

Q35.

Solution

Concept: The biological domain Archaea contains prokaryotes that differ significantly in their cell wall, cell membrane composition, and genetic machinery from standard bacteria (Eubacteria).

Solution: Step 1: Define the organisms described: Organisms that thrive in extreme conditions, such as high temperatures (thermophiles) and high acidity (acidophiles), are collectively called thermoacidophiles.

Step 2: Understand the classification of extremophiles:

- These specialized organisms are categorized under **Archaebacteria** (Archaea).
- Their cell membranes contain unique ether-linked lipids (instead of ester-linked lipids found in Eubacteria and Eukaryotes), and their cell walls lack peptidoglycan. This structural modification provides extreme chemical stability, allowing them to survive in boiling, acidic springs.

Step 3: Evaluate the options:

- **Cyanobacteria** (Option A) are photosynthetic Eubacteria.
- **Mycoplasma** (Option C) are cell-wall-less pathogenic bacteria.
- **Viroids** (Option D) are infectious single-stranded RNA molecules.
- Therefore, Archaebacteria (Option B) is the correct classification.

Final Answer: Archaebacteria

Answer: (B)

Go Back to Question 35

Q36.

Solution

Concept: Plants possess two major vascular systems for long-distance transport: xylem and phloem. Each is specialized for carrying different classes of materials.

Solution: Step 1: Identify the source-to-sink movement: The diagram shows the movement of sugars from a source (such as photosynthesizing leaves, where sugars are produced) to a sink (such as roots, fruits, or growing shoots, where sugars are consumed or stored).

Step 2: Define the pathway and process:

- This movement of organic nutrients (sugars) is called translocation.
- Translocation takes place through the living cells of the **phloem**, specifically the sieve tubes, via a pressure-flow (mass-flow) mechanism.

Step 3: Compare with xylem: Xylem vessels (Option A) are dead cells specialized for transporting water and mineral ions upward from the roots driven by transpiration pull, not for transporting sugars from source to sink.

Final Answer: Phloem sieve tubes by translocation

Answer: (B)

Go Back to Question 36

Q37.

Solution

Concept: During transcription, RNA polymerase synthesizes a single-stranded mRNA molecule using one of the DNA strands (the template strand) as a guide. The base-pairing rules govern this complementary sequence generation.

Solution: Step 1: Understand the base-pairing rules between DNA template and mRNA:

- Cytosine (C) in DNA pairs with Guanine (G) in mRNA.
- Guanine (G) in DNA pairs with Cytosine (C) in mRNA.
- Adenine (A) in DNA pairs with Uracil (U) in mRNA.
- Thymine (T) in DNA pairs with Adenine (A) in mRNA.

Step 2: Transcribe the original template sequence (CAA):

- C $\longrightarrow$ G
- A $\longrightarrow$ U
- A $\longrightarrow$ U
- The original complementary mRNA codon is **GUU**.

Step 3: Transcribe the mutated template sequence (CTA):

- C $\longrightarrow$ G
- T $\longrightarrow$ A
- A $\longrightarrow$ U
- The mutated complementary mRNA codon is **GAU**.

Step 4: Combine the results: The transcription change is from **GUU to GAU** (Option A).

Final Answer: GUU to GAU

Answer: (A)

Go Back to Question 37

Q38.

Solution

Concept: Energy flow through an ecosystem is unidirectional. The efficiency of energy transfer between successive trophic levels in a food chain is governed by thermodynamic principles.

Solution: Step 1: Understand the magnitude of energy transfer: As formulated by Lindeman's 10% Rule, only approximately 10% of the energy locked in the biomass of one trophic level is captured and stored as biomass in the next trophic level.

Step 2: Identify where the remaining 90% of energy goes:

- The vast majority of the consumed energy is used by organisms to fuel their own cellular maintenance, growth, movement, active transport, and reproduction.
- According to the Second Law of Thermodynamics, these metabolic reactions are inefficient, and a large portion of this chemical energy is inevitably **lost as heat to the environment** (Option B).
- Heat energy cannot be re-captured or used by living systems to perform work, representing a permanent loss of usable energy from the food web.

Step 3: Conclude: The low efficiency of energy transfer is primarily due to metabolic heat loss.

Final Answer: Lost as heat during metabolic activities

Answer: (B)

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Q39.

Solution

Concept: A synapse is the specialized junction where a neuron communicates with another neuron or an effector cell. Communication across a chemical synapse requires converting an electrical signal into a chemical one.

Solution: Step 1: Trace the sequence of synaptic transmission:

- When an electrical action potential reaches the axon terminal of the presynaptic neuron, it triggers the opening of voltage-gated calcium (Ca^{2+}) channels.
- The influx of calcium causes synaptic vesicles to fuse with the presynaptic membrane, releasing their contents into the narrow synaptic cleft.

Step 2: Identify the signaling molecules: The chemical messengers stored in these vesicles are neurotransmitter molecules (such as acetylcholine, dopamine, or glutamate).

Step 3: Complete the signal transmission: These neurotransmitters diffuse across the synaptic cleft and bind to specific receptor proteins on the postsynaptic membrane, generating a new electrical response in the postsynaptic cell.

Step 4: Therefore, transmission across the synaptic cleft occurs via the release of neurotransmitter molecules (Option B).

Final Answer: Neurotransmitter molecules

Answer: (B)

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Q40.

Solution

Concept: The Hardy-Weinberg principle states that allele and genotype frequencies in a population will remain constant from generation to generation in the absence of evolutionary influences. Five main factors disrupt this equilibrium: mutation, natural selection, non-random mating, genetic drift, and gene flow.

Solution: Step 1: Define the evolutionary forces listed:

- **Genetic drift (Option A):** Fluctuation of allele frequencies due to random chance events, typically in small populations.
- **Gene flow (Option B):** The movement of alleles into or out of a population due to the migration of fertile individuals or gametes.
- **Stabilizing selection (Option C):** Natural selection that favors intermediate variants by acting against extreme phenotypes.

Step 2: Analyze the described event: The question notes that the changes in allele frequencies began after the **large-scale migration** of individuals from another population.

Step 3: Conclude: The physical movement of individuals carrying different alleles into the resident population introduces new alleles and alters the existing allele frequencies. This process is called gene flow, making Option B the correct explanation.

Final Answer: Gene flow

Answer: (B)

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Answer Key

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