BITSAT Biology Sample Paper – 22

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 questions carry **0** marks.
- Only **one** option is correct for each question.
- Use of mobile phones, smartwatches, or any electronic gadgets is strictly prohibited.

Q1. A patient presents with acute abdominal pain, and an ultrasound reveals an obstruction in the hepatopancreatic duct. Which of the following digestive processes will remain completely unaffected?

(A) Emulsification of dietary lipids

(B) Neutralization of acidic chyme in the duodenum

(C) Hydrolysis of starch by salivary amylase

(D) Activation of trypsinogen to trypsin

Q2. During DNA replication in *E. coli*, if a mutation inactivates the $5'$ to $3'$ exonuclease activity of DNA Polymerase I, which of the following steps will be directly blocked?

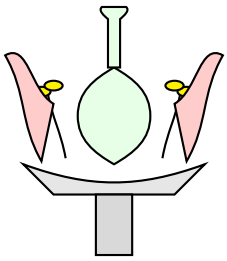
(A) Synthesis of the leading strand

(B) Removal of RNA primers

(C) Sealing of nicks between Okazaki fragments

(D) Proofreading of mismatched bases at the $3'$ end

Q3. In a flower showing hypogynous symmetry, which of the following arrangements of floral organs is correct?



(A) The ovary occupies the highest position while sepals, petals, and stamens are inserted below it.

(B) The thalami margin grows upward enclosing the ovary completely and getting fused with it.

(C) The ovary is situated in the center and other floral parts are located on the rim of the thalamus at the same level.

(D) Sepals and petals are attached above the level of the ovary while stamens are attached below.

Q4. Which of the following cellular events occurs exclusively during the G_2 phase of the cell cycle in a human somatic cell?

(A) Duplication of centrioles in the cytoplasm

(B) Synthesis of tubulin proteins required for spindle fibers

(C) Decondensation of chromosomes into chromatin network

(D) Semi-conservative replication of nuclear DNA

Q5. A certain double-stranded DNA molecule contains 34% cytosine bases. What will be the percentage of adenine bases in the primary mRNA transcript transcribed from this entire DNA molecule?

(A) 16%

(B) 34%

(C) 68%

(D) Cannot be determined from the given data

Q6. During the standard processing of a primary eukaryotic mRNA transcript, which of the following unusual nucleotides is added to the $5'$ end during the capping process?

(A) 7-methylguanosine triphosphate

(B) Poly-adenylate residue

(C) Deoxyadenosine monophosphate

(D) 5-methylcytosine triphosphate

Q7. In human females, the first meiotic division during oogenesis is completed within which of the following structures?

(A) Primary follicle

(B) Secondary follicle

(C) Tertiary follicle

(D) Graafian follicle

Q8. Which of the following elements is highly mobile in plants and its deficiency symptoms appear first in the older, senescent leaves?

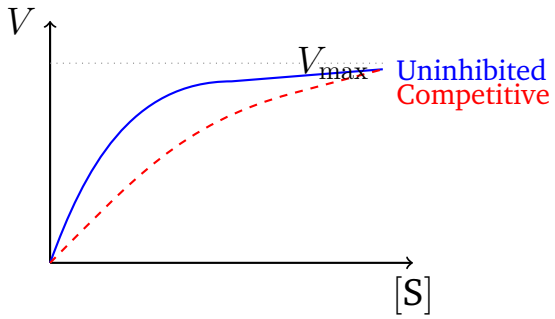
(A) Calcium

(B) Sulfur

(C) Magnesium

(D) Iron

Q9. In an enzyme-catalyzed reaction, a competitive inhibitor exhibits which of the following kinetics relative to the uninhibited reaction?



(A) It decreases the $V_{\max}$ and increases the K_m value.

(B) It leaves the $V_{\max}$ unaltered but increases the K_m value.

(C) It decreases both the $V_{\max}$ and the K_m value.

(D) It increases the $V_{\max}$ and leaves the K_m value unaltered.

Q10. An individual with blood group A marries an individual with blood group B. They have a child with blood group O. What is the probability that their next two children will both have blood group AB?

(A) $1/4$

(B) $1/8$

(C) $1/16$

(D) $1/2$

Q11. Which of the following options represents a non-medicated intrauterine device (IUD)?

(A) Lippes Loop

(B) Cu7

(C) LNG $-$ 20

(D) Progestasert

Q12. In the C_4 pathway of carbon fixation, the primary CO_2 acceptor and the first stable product formed are respectively:

(A) Ribulose-1,5-bisphosphate and 3-phosphoglyceric acid

(B) Phosphoenolpyruvate and Oxaloacetic acid

(C) Phosphoenolpyruvate and Malic acid

(D) Ribulose-1,5-bisphosphate and Oxaloacetic acid

Q13. In which of the following taxonomic groups would you expect to find a cell wall composed of chitin, heterotrophic nutrition, and a body organized into a mycelium?

(A) Ascomycetes

(B) Cyanobacteria

(C) Chrysophytes

(D) Bryophytes

Q14. The primary function of the juxtaglomerular apparatus (JGA) in the human kidney is to secrete renin in response to a:

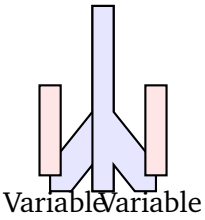
(A) Fall in glomerular filtration rate (GFR)

(B) Rise in systemic blood pressure

(C) Rise in blood volume

(D) Fall in blood osmolarity

Q15. An antibody molecule is represented as H_2L_2. The antigen-binding sites of this molecule are located at the:



(A) Constant regions of both heavy and light chains

(B) Variable regions of both heavy and light chains

(C) Constant regions of heavy chains only

(D) Variable regions of light chains only

Q16. During the transport of respiratory gases in human blood, approximately what percentage of carbon dioxide is carried as bicarbonate ions (HCO_3^-)?

(A) 7%

(B) 23%

(C) 70%

(D) 97%

Q17. Which of the following plant hormones acts as a general plant growth inhibitor and is responsible for stimulating the closure of stomata under water stress conditions?

(A) Indole-3-acetic acid

(B) Abscisic acid

(C) Gibberellic acid

(D) Kinetin

Q18. According to the binomial nomenclature system proposed by Carl Linnaeus, which of the following matches is written in the correct scientific format?

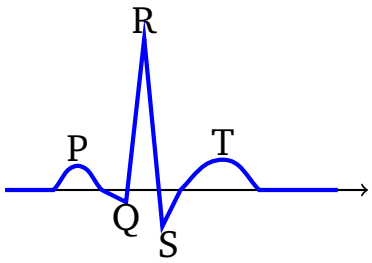
(A) Homo Sapiens

(B) *Homo sapiens*

(C) *homo sapiens*

(D) Homo sapiens

Q19. In a standard electrocardiogram (ECG) of a healthy individual, which of the following waves represents the depolarization of the ventricles?



(A) P-wave

(B) QRS complex

(C) T-wave

(D) U-wave

Q20. Which of the following mechanisms is primarily responsible for generating the massive diversity of antibodies found in the human adaptive immune system?

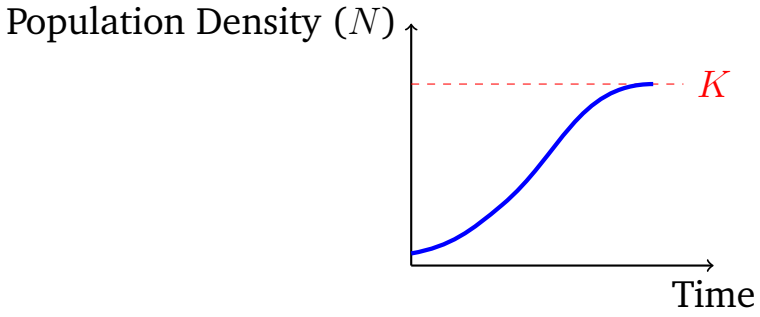
(A) Somatic hypermutation and V(D)J recombination

(B) Alternative splicing of a single pre-mRNA transcript

(C) High rates of crossing over during oogenesis

(D) Post-translational cleavage by specialized proteases

Q21. If a population growing exponentially in a resource-limited environment reaches its carrying capacity (K), the rate of population growth ($\mathrm{d}N/\mathrm{d}t$) becomes:



(A) Equal to the intrinsic rate of natural increase (r)

(B) Infinite

(C) Zero

(D) Equal to K

Q22. In a genetic cross between two plants with genotypes AaBbCc and AaBbCc, assuming independent assortment, what fraction of the progeny will be completely homozygous for all three loci?

(A) $1/8$

(B) $1/16$

(C) $1/32$

(D) $1/64$

Q23. Which of the following modifications or structures is uniquely characteristic of the phylum Chordata at some stage of their life cycle?

(A) Ventral, solid, double nerve cord

(B) Radial symmetry and pseudocoelom

(C) Pharyngeal gill slits and a post-anal tail

(D) Chitinous exoskeleton and open circulatory system

Q24. During a skeletal muscle contraction, which of the following structural bands or zones shortens and eventually disappears when the muscle is maximally contracted?

(A) A-band

(B) I-band

(C) H-zone

(D) Both B and C

Q25. Which restriction endonuclease creates blunt ends rather than sticky or cohesive ends upon digesting its target double-stranded DNA sequence?

(A) EcoRI

(B) HindIII

(C) EcoRV

(D) BamHI

Q26. A secondary oocyte completes its second meiotic division only upon:

(A) Ovulation from the mature Graafian follicle

(B) Implantation into the endometrial wall of the uterus

(C) Fusion of the plasma membranes of the sperm and the ovum

(D) Surging of luteinizing hormone (LH) during mid-cycle

Q27. According to the sliding filament theory, the hydrolysis of ATP by the myosin head is directly required for which of the following steps?

(A) Binding of calcium ions to troponin C

(B) Detachment of the cross-bridge from the actin filament

(C) Activation and cocking of the myosin head into a high-energy state

(D) Power stroke that pulls the actin filament toward the M-line

Q28. Which of the following vectors is most suitable for introducing a foreign gene into a dicotyledonous plant to generate a transgenic crop?

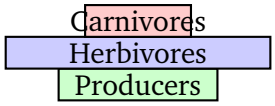
(A) pBR322

(B) Ti plasmid of *Agrobacterium tumefaciens*

(C) Lambda phage

(D) Retrovirus

Q29. In a terrestrial ecosystem like a temperate deciduous forest, which of the following ecological pyramids can sometimes be inverted?



(A) Pyramid of energy

(B) Pyramid of biomass

(C) Pyramid of numbers

(D) None of the ecological pyramids can be inverted

Q30. A point mutation that replaces a purine base with another purine base, or a pyrimidine base with another pyrimidine base, is classified as a:

(A) Transition mutation

(B) Transversion mutation

(C) Frameshift mutation

(D) Nonsense mutation

Q31. Which of the following matching pairs correctly associates a hominid ancestor with its approximate cranial capacity?

(A) *Homo habilis* — 650–800 cc

(B) *Homo erectus* — 1400 cc

(C) Neanderthal man — 900 cc

(D) *Australopithecus* — 1200 cc

Q32. In the human male reproductive system, the secretory products of which of the following accessory glands contain fructose, prostaglandins, and certain clotting enzymes?

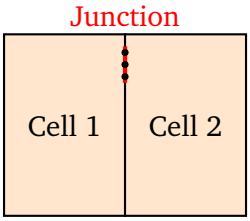
(A) Prostate gland

(B) Seminal vesicles

(C) Bulbourethral (Cowper's) glands

(D) Bartholin's glands

Q33. What type of cell junctions help to stop substances from leaking across a tissue layer, and are highly abundant in the epithelial lining of the human urinary bladder?



(A) Gap junctions

(B) Adhering junctions

(C) Tight junctions

(D) Desmosomes

Q34. The primary role of the tapetum layer in the microsporangium wall of angiosperms is to:

(A) Help in the dehiscence of the anther

(B) Provide protection to the developing pollen grains

(C) Nourish the developing microspores

(D) Synthesize the outer exine layer via sporopollenin deposition

Q35. Which of the following features is shared by both prokaryotic cells and eukaryotic plant cells?

(A) Presence of 70S ribosomes in the cytoplasm

(B) Presence of a cell wall composed primarily of cellulose

(C) Presence of a double-membrane-bound nucleus

(D) Presence of a plasma membrane containing phospholipids

Q36. During the process of photoperiodism, the perception of light stimulus is received by which specific organ of the plant?

(A) Shoot apex

(B) Lateral buds

(C) Leaves

(D) Roots

Q37. A specific bacterial pathogen causing typhoid fever in humans is diagnosed using which of the following serological assays?

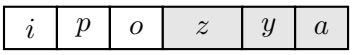
(A) Widal test

(B) ELISA

(C) Western blot

(D) Mantoux test

Q38. In a lac operon system, if the gene encoding the repressor protein undergoes a mutation making it completely unable to bind to the inducer (lactose), what will be the state of transcription of the structural genes?



(A) Constitutive transcription (always on)

(B) Transcription will be repressed permanently (always off)

(C) Transcription will occur only in the presence of glucose

(D) Transcription will fluctuate randomly independent of any signal

Q39. Which of the following conditions is a physiological response expected during acclimation to high altitudes in humans?

(A) Decreased production of red blood cells

(B) Increased binding affinity of hemoglobin for oxygen

(C) Increased breathing rate

(D) Decreased cardiac output

Q40. The structural and functional unit between the developing embryo and the maternal body is called the placenta. Which of the following hormones is NOT produced by the human placenta?

(A) Human chorionic gonadotropin (hCG)

(B) Human placental lactogen (hPL)

(C) Luteinizing hormone (LH)

(D) Progesterone

Detailed Solutions

Q1.

Solution

Concept:

Human digestive system anatomy and the specific sites of action for various digestive enzymes.

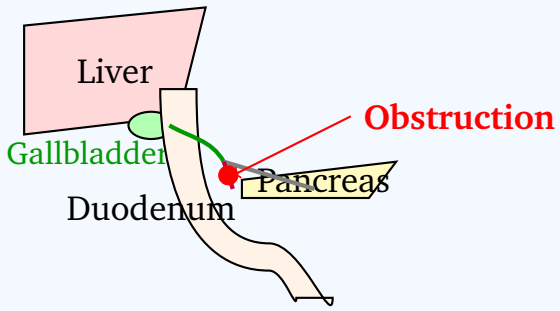
Solution:

Step 1: The hepatopancreatic duct (Ampulla of Vater) carries both bile (from the liver and gallbladder) and pancreatic juice (from the pancreas) into the duodenum.

Step 2: An obstruction here blocks bile flow, preventing the emulsification of dietary lipids (Option A). It also blocks pancreatic juice, which contains bicarbonate ions needed to neutralize acidic chyme (Option B) and proteolytic enzymes responsible for the activation of trypsinogen (Option D).

Step 3: Salivary amylase is secreted by the salivary glands in the mouth and performs the initial hydrolysis of starch in the oral cavity. Its function is completely localized to the upper digestive tract.

Step 4: Therefore, an obstruction at the hepatopancreatic duct deep in the abdomen will have absolutely no effect on salivary amylase activity.



Final Answer: Hydrolysis of starch by salivary amylase

Answer: (C) Go Back to Question 1

Q2.

Solution

Concept:

DNA Polymerase I in *E. coli* is a multi-functional enzyme with three distinct catalytic activities: $5' \to 3'$ polymerase activity, $3' \to 5'$ exonuclease activity (proofreading), and $5' \to 3'$ exonuclease activity. The $5' \to 3'$ exonuclease activity is uniquely responsible for removing the RNA primers from the $5'$ ends of newly synthesized Okazaki fragments on the lagging strand so that they can be replaced with DNA nucleotides.

Solution:

Step 1: Identify the roles of different DNA polymerases. DNA Polymerase III is the primary replicative enzyme that synthesizes both the leading and lagging strands.

Step 2: Analyze the specific functions of DNA Polymerase I. It fills the gaps left behind after primer removal and participates in DNA repair pathways.

Step 3: Analyze the role of the $5' \to 3'$ exonuclease activity of DNA Polymerase I. It moves ahead of the polymerase, breaking phosphodiester bonds to excise the ribonucleotides of the RNA primer.

Step 4: Determine the consequence of a loss-of-function mutation in this specific exonuclease domain. If the $5' \to 3'$ exonuclease activity is lost, the RNA primers cannot be degraded or excised from the lagging strand.

Step 5: Connect the block to the choices. The removal of RNA primers will be directly prevented, which subsequently halts lagging strand maturation and prevents DNA ligase from sealing the fragments.

Final Answer: Removal of RNA primers

Answer: (B) Go Back to Question 2

Q3.

Solution

Concept:

Based on the relative position of the calyx, corolla, and androecium with respect to the ovary on the thalamus, flowers are classified into three major types: hypogynous, perigynous, and epigynous. In a hypogynous flower, the gynoecium occupies the topmost position on the thalamus, while the other floral whorls (sepals, petals, and stamens) are situated below it. Such an ovary is referred to as a superior ovary.

Solution:

Step 1: Define hypogynous flower structural arrangements. The term "hypo" means below and "gynous" refers to the gynoecium. Therefore, other whorls develop below the level of the female reproductive organ.

Step 2: Examine the position of the ovary. In a hypogynous flower, the ovary sits proudly at the absolute peak of the thalamus. This makes the ovary superior. Examples include mustard, china rose, and brinjal.

Step 3: Evaluate Option B. This describes an epigynous flower arrangement where the thalamus grows upward, encloses the ovary completely, and fuses with it, making the ovary inferior (e.g., guava, cucumber).

Step 4: Evaluate Option C. This describes a perigynous flower arrangement where the gynoecium is in the center and other parts are on the rim of the thalamus at roughly the same level, making the ovary half-inferior (e.g., plum, rose, peach).

Step 5: Match the definition of hypogyny with Option A, which states that the ovary occupies the highest position while sepals, petals, and stamens are inserted below it.

Final Answer: The ovary occupies the highest position while sepals, petals, and stamens are inserted below it.

Answer: (A) Go Back to Question 3

Q4.

Solution

Concept:

The cell cycle consists of Interphase (G_1, S, and G_2 phases) and M phase (Mitosis). The G_2 phase, or Gap 2 phase, is the final sub-phase of interphase where intensive metabolic preparations for nuclear and cytoplasmic division occur. A hallmark biochemical event of the G_2 phase is the mass synthesis of tubulin proteins, which are structural subunits needed to assemble the mitotic spindle apparatus.

Solution:

Step 1: Break down the events of Interphase. The G_1 phase involves cellular growth and organelle duplication. The S phase involves nuclear DNA replication and centriole duplication.

Step 2: Analyze Option A. Centriole duplication occurs during the S phase in the cytoplasm, parallel to DNA replication in the nucleus. Thus, it does not occur in G_2.

Step 3: Analyze Option D. Semi-conservative replication of nuclear DNA is the defining event of the S (Synthesis) phase. Thus, it does not occur in G_2.

Step 4: Analyze Option C. Decondensation of chromosomes back into a relaxed chromatin network occurs during Telophase at the very end of the M phase.

Step 5: Analyze Option B. During the G_2 phase, the cell checks its replicated DNA and synthesizes specific proteins, primarily tubulin, required for the formation of spindle fibers during mitosis. Therefore, this event occurs during the G_2 phase.

Final Answer: Synthesis of tubulin proteins required for spindle fibers

Answer: (B) Go Back to Question 4

Q5.

Solution

Concept:

Chargaff's rules state that in any double-stranded DNA molecule, the ratio of adenine to thymine is equal (%A = %T) and the ratio of guanine to cytosine is equal (%G = %C). However, these base percentages reflect the entire double-stranded genomic molecule. Transcription is asymmetric, meaning only one specific strand (the template strand) is copied into a single-stranded mRNA molecule, and its individual base composition cannot be determined solely from the total genomic composition.

Solution:

Step 1: Apply Chargaff's rules to the double-stranded DNA molecule. Given that Cytosine (C) = 34%, it follows that Guanine (G) = 34%.

Step 2: Calculate the combined percentage of G + C:

$$\%\text{G} + \%\text{C} = 34\% + 34\% = 68\%$$

Step 3: Deduce the combined percentage of A + T in the double-stranded DNA:

$$\%\text{A} + \%\text{T} = 100\% - 68\% = 32\%$$

Step 4: Since $\%\text{A} = \%\text{T}$, we find individual percentages:

$$\%\text{A} = 16\%, \quad \%\text{T} = 16\%$$

Step 5: Understand mRNA transcription. The primary mRNA transcript is complementary to only the template strand of DNA. The distribution of bases between the template strand and the coding strand can be highly asymmetric. For instance, all 16% of the adenine bases could reside on one strand. Without explicit sequence data for the template strand, the exact percentage of adenine in the transcribed single-stranded mRNA cannot be determined.

Final Answer: Cannot be determined from the given data

Answer: (D) Go Back to Question 5

Q6.

Solution

Concept:

Post-transcriptional modifications are mandatory for converting raw eukaryotic primary transcripts (hnRNA) into mature, functional mRNA. These modifications include capping, splicing, and tailing. Capping occurs at the $5'$ end of the nascent pre-mRNA molecule and involves the enzymatic addition of a modified nucleotide. This cap protects the transcript from exonuclease degradation and facilitates ribosome binding during translation initiation.

Solution:

Step 1: Understand the nature of primary eukaryotic transcripts. Eukaryotic hnRNA undergoes processing inside the nucleus before moving to the cytoplasm.

Step 2: Detail the capping mechanism. During transcription elongation, a specialized capping enzyme adds a modified guanine nucleotide to the terminal $5'$ nucleotide of the transcript.

Step 3: Identify the specific molecule added. The chemical identity of this protective cap is 7-methylguanosine (m^7G), which is attached via an unusual $5'$-to-$5'$ triphosphate bridge.

Step 4: Eliminate incorrect choices. Poly-adenylate residue (Poly-A tail) is added to the $3'$ end during tailing, not the $5'$ end. Deoxyadenosine monophosphate is a DNA nucleotide. 5-methylcytosine is a epigenetic modification found in DNA, not mRNA caps.

Step 5: Conclude that 7-methylguanosine triphosphate is the correct nucleotide added during the capping process.

Final Answer: 7-methylguanosine triphosphate

Answer: (A) Go Back to Question 6

Q7.

Solution

Concept:

Stages of follicular development in relation to the phases of oogenesis in human females.

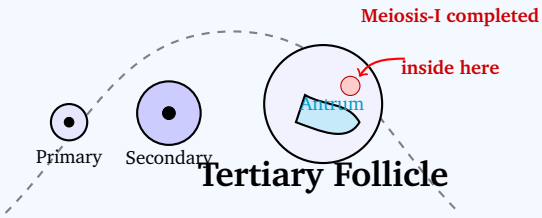
Solution:

Step 1: Oogenesis begins during the embryonic development stage, where millions of oogonia are formed. These cells enter prophase-I of meiotic division and get temporarily arrested at this stage; they are called primary oocytes.

Step 2: Each primary oocyte gets surrounded by layers of granulosa cells, forming a **primary follicle**. This is followed by the formation of a **secondary follicle**.

Step 3: The secondary follicle soon transforms into a **tertiary follicle**, which is structurally characterized by a fluid-filled cavity called the **antrum**.

Step 4: It is within this tertiary follicle that the primary oocyte completes its first meiotic division. This division is unequal, resulting in the formation of a large haploid **secondary oocyte** and a tiny **first polar body**. The tertiary follicle then matures further into the mature Graafian follicle.



Final Answer: Tertiary follicle

Answer: (C) Go Back to Question 7

Q8.

Solution

Concept:

Mineral elements in plants vary considerably in their mobility through vascular tissues. When a specific mineral nutrient is deficient in the soil, the plant remobilizes that element from older, mature tissues and transports it to young, developing regions via the phloem. Consequently, deficiency symptoms for highly mobile elements appear first in older, senescent organs. Conversely, immobile elements cannot be retrieved, causing deficiency symptoms to appear first in young leaves.

Solution:

Step 1: Identify mobile and immobile elements in plant physiology. Nitrogen, phosphorus, potassium, and magnesium are highly mobile elements. Calcium, sulfur, and iron are relatively immobile structural or functional components.

Step 2: Examine calcium (Ca). Calcium is an immobile component of the middle lamella (as calcium pectate) and cannot be remobilized. Deficiency symptoms appear first in young tissues.

Step 3: Examine sulfur (S) and iron (Fe). Both are structural components of proteins and electron carriers, behaving as immobile elements with initial deficiency symptoms in young leaves.

Step 4: Examine magnesium (Mg). Magnesium is a central component of the chlorophyll ring structure and acts as an enzyme activator. It is highly mobile. When soil magnesium is low, older leaves break down chlorophyll and export magnesium to young leaves, causing chlorosis to appear first in older, senescent leaves.

Final Answer: Magnesium

Answer: (C) Go Back to Question 8

Q9.

Solution

Concept:

Enzyme inhibitors can alter standard Michaelis-Menten enzyme kinetics. A competitive inhibitor structurally resembles the substrate and competes directly for binding at the active site of the enzyme. This competition can be overcome by significantly increasing the concentration of the substrate. Therefore, at infinitely high substrate levels, the maximum velocity ($V_{\max}$) remains achievable, but a higher substrate concentration is required to reach half of $V_{\max}$, increasing the Michaelis constant (K_m).

Solution:

Step 1: Understand $V_{\max}$ and K_m. $V_{\max}$ is the maximum rate of reaction when the enzyme is fully saturated with substrate. K_m is the substrate concentration at which the reaction rate is exactly half of $V_{\max}$.

Step 2: Analyze competitive inhibition mechanics. Because the substrate and inhibitor compete for the same active site, the presence of the inhibitor reduces the apparent affinity of the enzyme for the substrate, which manifests as an increase in the numerical value of K_m.

Step 3: Determine the effect on $V_{\max}$. Because the inhibitor binds reversibly, an overwhelming abundance of substrate will outcompete the inhibitor molecules. Thus, the enzyme can still reach its full catalytic maximum velocity, meaning $V_{\max}$ remains unchanged.

Step 4: Review the options. Option B correctly identifies that a competitive inhibitor leaves the $V_{\max}$ unaltered but increases the K_m value.

Final Answer: It leaves the $V_{\max}$ unaltered but increases the K_m value.

Answer: (B) Go Back to Question 9

Q10.

Solution

Concept:

ABO blood groups in humans are controlled by the gene I, which exhibits multiple allelism and codominance. The alleles are I^A, I^B, and i. Alleles I^A and I^B are completely dominant over i, while I^A and I^B are codominant with each other. If parents with phenotypes A and B have a child with blood group O, both parents must be heterozygous carriers of the recessive i allele.

Solution:

Step 1: Deduce the genotypes of the parents. The individual with blood group A must have the genotype I^Ai. The individual with blood group B must have the genotype I^Bi. If either were homozygous (I^AI^A or I^BI^B), they could not produce a child with blood group O (genotype ii).

Step 2: Set up a Punnett square for the cross $I^Ai \times I^Bi$. The resulting offspring genotypes are:

$$1/4\ I^AI^B \text{ (Blood group AB)}$$

$$1/4\ I^Ai \text{ (Blood group A)}$$

$$1/4\ I^Bi \text{ (Blood group B)}$$

$$1/4\ ii \text{ (Blood group O)}$$

Step 3: Identify the probability of having a child with blood group AB in any single pregnancy, which is $P(\text{AB}) = 1/4$.

Step 4: Apply the product rule for independent events. Each pregnancy is an independent event. The probability that the next two children will both have blood group AB is calculated as:

$$P(\text{AB and AB}) = P(\text{AB}) \times P(\text{AB}) = \frac{1}{4} \times \frac{1}{4} = \frac{1}{16}$$

Final Answer: $\boxed{1/16}$

Answer: (C) Go Back to Question 10

Q11.

Solution

Concept:

Intrauterine devices (IUDs) are highly effective contraceptive methods inserted into the uterus by medical professionals. IUDs are categorized into three major groups based on their mechanism of action and chemical composition: non-medicated IUDs, copper-releasing IUDs, and hormone-releasing IUDs. Non-medicated IUDs function primarily by eliciting a localized, sterile inflammatory foreign-body response within the endometrium, preventing implantation.

Solution:

Step 1: Classify the provided options according to standard pharmacological divisions.
Step 2: Examine Cu7. This is a copper-releasing IUD. It releases copper ions (Cu^{2+}) which suppress sperm motility and reducing the fertilizing capacity of sperms.
Step 3: Examine LNG $-$ 20 and Progestasert. These are hormone-releasing IUDs. They release progestogens, making the cervix hostile to sperms and altering the endometrium to prevent implantation.
Step 4: Examine Lippes Loop. Lippes Loop is a classic double-S-shaped plastic loop that does not release any chemicals or hormones. It is a non-medicated IUD that acts purely as a physical foreign body within the uterine cavity to stimulate phagocytosis of sperm.
Step 5: Conclude that Lippes Loop is the correct answer.

Final Answer: Lippes Loop

Answer: (A) Go Back to Question 11

Q12.

Solution

Concept:

Plants utilize different carbon fixation pathways (C_3 and C_4) to assimilate atmospheric carbon dioxide during photosynthesis. C_4 plants exhibit a spatial separation of carbon fixation steps between mesophyll cells and bundle sheath cells to minimize photorespiration. The biochemistry of the primary fixation step in the mesophyll cytoplasm involves a specific 3-carbon acceptor molecule and yields a 4-carbon organic acid.

Solution:

Step 1: Identify the primary carbon dioxide capture step in C_4 plants. This occurs in the cytoplasm of mesophyll cells.

Step 2: Name the primary enzyme and acceptor. The enzyme is phosphoenolpyruvate carboxylase (PEPcase), and it fixes atmospheric CO_2 (in the form of HCO_3^-) onto a 3-carbon substrate called phosphoenolpyruvate (PEP).

Step 3: Identify the first stable product. The carboxylation of PEP yields oxaloacetic acid (OAA), a 4-carbon dicarboxylic acid. This step gives the C_4 pathway its name.

Step 4: Trace the subsequent steps. OAA is quickly reduced to malic acid or aspartic acid, which is then transported across plasmodesmata into the bundle sheath cells for decarboxylation.

Step 5: Compare with the choices. The primary acceptor is Phosphoenolpyruvate and the first stable product is Oxaloacetic acid, making Option B correct.

Final Answer: Phosphoenolpyruvate and Oxaloacetic acid

Answer: (B) Go Back to Question 12

Q13.

Solution

Concept:

The Five-Kingdom Classification system proposed by R.H. Whittaker groups organisms based on cell structure, body organization, mode of nutrition, and phylogenetic relationships. Kingdom Fungi is uniquely defined as a eukaryotic group of heterotrophic, absorptive organisms possessing cell walls reinforced with chitin (a polymer of N-acetylglucosamine). Their body typically consists of an interconnected network of thread-like structures called hyphae, collectively termed a mycelium.

Solution:

Step 1: Match the anatomical descriptors given in the prompt: a cell wall made of chitin, heterotrophic mode of nutrition, and a body organized as a mycelium. These are diagnostic characteristics of Kingdom Fungi.

Step 2: Evaluate Cyanobacteria. These are prokaryotic autotrophic organisms belonging to Kingdom Monera with a peptidoglycan cell wall.

Step 3: Evaluate Chrysophytes. These are photosynthetic protists (diatoms and golden algae) belonging to Kingdom Protista with cellulosic cell walls embedded with silica.

Step 4: Evaluate Bryophytes. These are non-vascular plants belonging to Kingdom Plantae, possessing autotrophic nutrition and a cellulosic cell wall.

Step 5: Evaluate Ascomycetes. Ascomycetes (sac fungi) is a major class within Kingdom Fungi. They fit all the listed biological parameters, establishing them as the correct choice.

Final Answer: Ascomycetes

Answer: (A) Go Back to Question 13

Q14.

Solution

Concept:

Regulation of kidney function via the Renin-Angiotensin-Aldosterone System (RAAS) and the role of the Juxtaglomerular Apparatus (JGA).

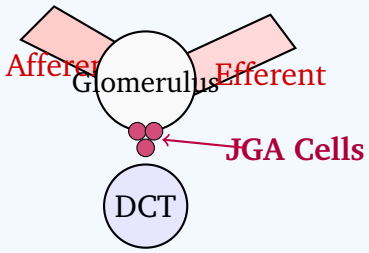
Solution:

Step 1: The Juxtaglomerular Apparatus (JGA) is a specialized microscopic structure formed by the modification of the distal convoluted tubule (DCT) smooth muscle cells and the afferent arteriole cells at their point of contact.

Step 2: The JGA plays a crucial regulatory role in monitoring blood pressure and fluid balance. When there is a decrease in blood volume, a drop in systemic blood pressure, or directly a **fall in glomerular filtration rate (GFR)**, the specialized juxtaglomerular cells are stimulated.

Step 3: Upon activation, these JGA cells synthesize and secrete the enzyme **renin** directly into the bloodstream. Renin acts enzymatically on angiotensinogen to initiate the RAAS cascade, which ultimately vasoconstricts blood vessels and reabsorbs water/salts to restore GFR back to normal.

Step 4: Conversely, a rise in blood pressure, rise in blood volume, or a fall in blood osmolarity would suppress renin secretion. Thus, a fall in GFR is the definitive trigger.



$\downarrow$ **Glomerular Filtration Rate (GFR)** $\rightarrow$ **Triggers Renin**

Final Answer: Fall in glomerular filtration rate (GFR)

Answer: (A) Go Back to Question 14

Q15.

Solution

Concept:

An antibody (immunoglobulin) molecule is a Y-shaped heterotetrameric protein consisting of four polypeptide chains linked by disulfide bridges. This structure comprises two identical, heavier polypeptide chains (heavy or H chains) and two identical, lighter polypeptide chains (light or L chains), designated as H_2L_2. Each chain contains distinct domains: constant regions, which determine biological effector functions, and variable regions, which provide antigen specificity.

Solution:

Step 1: Analyze the regional anatomy of an immunoglobulin. Each light chain consists of one variable domain (V_L) and one constant domain (C_L). Each heavy chain consists of one variable domain (V_H) and three to four constant domains (C_H).

Step 2: Define the antigen-binding site. The antigen-binding site, also known as the paratope, is located at the extreme tips of the Y-shaped molecule.

Step 3: Determine the composition of the paratope. The paratope is formed by the tight physical association of the variable region of a heavy chain (V_H) and the variable region of its neighboring light chain (V_L).

Step 4: Evaluate the options. The variable regions of both heavy and light chains form the highly specific cleft that binds to a specific epitope on an antigen. Thus, Option B is correct.

Final Answer: Variable regions of both heavy and light chains

Answer: (B) Go Back to Question 15

Q16.

Solution

Concept:

Carbon dioxide (CO_2) is generated as a metabolic waste product by tissues and must be efficiently transported to the lungs via the circulatory system for elimination. Blood transports carbon dioxide in three distinct chemical states: dissolved in physical solution within blood plasma, bound directly to hemoglobin as carbaminohemoglobin, or chemically converted into bicarbonate ions. The proportions transported by each method differ significantly.

Solution:

Step 1: Quantify the three modes of carbon dioxide transport in human blood according to physiological averages.

Step 2: Mode 1: Dissolved state in plasma. About 7% of all transported CO_2 is carried simply dissolved in the aqueous matrix of blood plasma.

Step 3: Mode 2: Bound to hemoglobin. Approximately $20 - 25\%$ (commonly rounded to 23%) of CO_2 binds reversibly to the amino groups of hemoglobin molecules inside erythrocytes, forming carbaminohemoglobin.

Step 4: Mode 3: As bicarbonate ions (HCO_3^-). The vast majority, roughly 70%, of CO_2 diffuses into red blood cells, where it is converted into carbonic acid (H_2CO_3) by the enzyme carbonic anhydrase. This acid dissociates into hydrogen and bicarbonate ions, which are then carried in the plasma.

Step 5: Select the percentage that corresponds to transport as bicarbonate ions, which is 70%.

Final Answer: 70%

Answer: (C) Go Back to Question 16

Q17.

Solution

Concept:

Plant Growth Regulators (PGRs) are organic compounds that influence physiological processes at minute concentrations. They are broadly divided into plant growth promoters (auxins, gibberellins, cytokinins) and plant growth inhibitors. Abscisic acid (ABA) is the premier growth inhibitor and plays a decisive role in regulating plant stress responses, earning it the designation "the stress hormone."

Solution:

Step 1: Identify the primary functions of the listed hormones. Indole-3-acetic acid (IAA) is an auxin that drives apical dominance, cell elongation, and rooting.

Step 2: Identify Gibberellic acid (GA_3). It promotes stem elongation, bolting, and breaks seed dormancy. Kinetin is a cytokinin that promotes cell division and delays senescence. These three are growth promoters.

Step 3: Analyze Abscisic acid (ABA). ABA acts as a general inhibitor of plant growth, metabolism, and seed germination.

Step 4: Examine the role of ABA under environmental stress. During severe drought conditions, roots perceive a lack of water and synthesize ABA, which is translocated via xylem to the leaves. In the leaves, ABA acts on guard cells to trigger a rapid efflux of ions, leading to a loss of turgor and stimulating the closure of stomata to prevent excessive water loss via transpiration.

Final Answer: Abscisic acid

Answer: (B) Go Back to Question 17

Q18.

Solution

Concept:

The binomial nomenclature system is a standardized method for naming living organisms using two distinct words. It follows strict universal rules governed by biological nomenclature codes. The complete scientific name consists of a generic name (genus) followed by a specific epithet (species). Proper typographical formatting is mandatory to distinguish scientific names from regular text.

Solution:

Step 1: Review the fundamental rules of binomial nomenclature. Rule 1: The generic name must always begin with a capitalized letter. Rule 2: The specific epithet must begin entirely with a lowercase letter.

Step 2: Review Rule 3 regarding typography. When printed, the scientific name must be completely italicized to indicate its Latin origin. If handwritten, the genus and species names must be underlined separately.

Step 3: Analyze Option A: "Homo Sapiens". The species name begins with a capital letter, and it is not italicized. This is incorrect.

Step 4: Analyze Option C: "*homo sapiens*". The genus name begins with a lowercase letter. This is incorrect. Analyze Option D: "Homo sapiens". The name is not italicized. This is incorrect.

Step 5: Analyze Option B: "*Homo sapiens*". The genus name is capitalized, the species name is in lowercase, and the entire binomial is correctly italicized. This satisfies all grammatical conventions of nomenclature.

Final Answer: *Homo sapiens*

Answer: (B) Go Back to Question 18

Q19.

Solution

Concept:

An Electrocardiogram (ECG) is a graphical recording of the electrical activity of the human heart during a cardiac cycle. A standard normal ECG tracing consists of a series of distinct electrical deflections or waves labeled alphabetically: P, Q, R, S, and T. Each component corresponds to a specific depolarization or repolarization event within the chambers of the heart.

Solution:

Step 1: Define the physiological meaning of the P-wave. The P-wave represents the electrical depolarization of the atria, which leads to atrial contraction.

Step 2: Define the physiological meaning of the T-wave. The T-wave represents the repolarization of the ventricles, marking their return from an excited state back to a relaxed state.

Step 3: Define the QRS complex. The QRS complex is a rapid sequence of deflections that represents the electrical depolarization of the ventricles.

Step 4: Relate the QRS complex to mechanical action. The depolarization wave spreads quickly through the Purkinje network, triggering ventricular systole (contraction). Because the ventricles have a large muscle mass, this complex is the most prominent feature of an ECG tracing.

Step 5: Conclude that the QRS complex is the specific wave component indicating ventricular depolarization.

Final Answer: QRS complex

Answer: (B) Go Back to Question 19

Q20.

Solution

Concept:

The human adaptive immune system can synthesize millions of unique, highly specific antibody molecules despite possessing a limited number of protein-coding genes in its genome. This immense diversity is generated by specialized, non-conservative somatic recombination pathways that restructure the DNA locus encoding immunoglobulin chains during B cell development in the bone marrow.

Solution:

Step 1: Understand the organization of immunoglobulin genes. The genomic loci for heavy and light chains contain clusters of variable (V), diversity (D), and joining (J) gene segments.

Step 2: Define V(D)J recombination. During B cell differentiation, a specialized recombinase enzyme complex physically cuts and splices these segments at random, joining one V, one D, and one J segment to form a unique functional heavy-chain exon. This combinatorial shuffling generates immense base diversity.

Step 3: Define somatic hypermutation. After a mature B cell encounters its corresponding antigen in secondary lymphoid organs, it undergoes rapid point mutations within the variable regions of its immunoglobulin genes. This refines antigen-binding affinity.

Step 4: Exclude alternative options. Alternative splicing of a single pre-mRNA can produce multiple isoforms, but it lacks the capacity to generate millions of hyper-specific variants. Crossing over during oogenesis shuffles existing maternal and paternal alleles but does not create new variable exons in somatic cells.

Step 5: Select Option A as the primary mechanism for generating antibody diversity.

Final Answer: Somatic hypermutation and V(D)J recombination

Answer: (A) Go Back to Question 20

Q21.

Solution

Concept:

Population growth models describe how the number of individuals in a population changes over time. When resources are unlimited, a population exhibits exponential growth. However, in realistic ecological scenarios, resources are finite, leading to logistic growth. This model is mathematically defined by the Verhulst-Pearl logistic growth equation:

$$\frac{\mathrm{d}N}{\mathrm{d}t} = rN\left(\frac{K-N}{K}\right)$$

where N is the population density, r is the intrinsic rate of natural increase, and K is the carrying capacity of the environment.

Solution:

Step 1: Analyze the mathematical components of the logistic growth equation. The term $\frac{\mathrm{d}N}{\mathrm{d}t}$ represents the rate of population change over an infinitesimal increment of time.

Step 2: Examine the environmental resistance factor, which is represented by the algebraic term $\left(\frac{K-N}{K}\right)$ or $\left(1-\frac{N}{K}\right)$.

Step 3: Evaluate the population state when it reaches carrying capacity. By definition, reaching carrying capacity means that the current population density (N) becomes exactly equal to the maximum sustainable population size (K), so we substitute $N = K$ into the equation.

Step 4: Perform the algebraic simplification:

$$\frac{\mathrm{d}N}{\mathrm{d}t} = rK\left(\frac{K-K}{K}\right) = rK\left(\frac{0}{K}\right) = rK(0) = 0$$

Step 5: Interpret the biological significance of a growth rate equal to zero. When $\frac{\mathrm{d}N}{\mathrm{d}t} = 0$, the population stops increasing and enters a stable, stationary plateau phase where birth rates roughly balance death rates. Thus, Option C is correct.

Final Answer: Zero

Answer: (C) Go Back to Question 21

Q22.

Solution

Concept:

According to Mendel's Law of Independent Assortment, alleles of distinct genetic loci segregate into gametes completely independently of one another, provided they reside on different chromosomes or are far apart. For a trihybrid cross involving three independently assorting genes, we can determine the final phenotypic or genotypic ratios by treating each gene locus as an independent monohybrid event and applying the product rule of probability.

Solution:

Step 1: Break down the trihybrid cross AaBbCc$\times$AaBbCc into three separate monohybrid crosses for each independent locus: Aa $\times$ Aa, Bb $\times$ Bb, and Cc $\times$ Cc.

Step 2: Analyze the first locus cross (Aa $\times$ Aa). The resulting progeny genotypes occur in a classic Mendelian $1:2:1$ ratio: $1/4$ AA, $2/4$ Aa, and $1/4$ aa. The total fraction that is completely homozygous at this locus (AA or aa) is:

$$P(\text{homozygous at A locus}) = \frac{1}{4} + \frac{1}{4} = \frac{2}{4} = \frac{1}{2}$$

Step 3: Analyze the second and third loci crosses (Bb $\times$ Bb and Cc $\times$ Cc). Because the same rules apply, the probability of obtaining a homozygous genotype at these loci is identical:

$$P(\text{homozygous at B locus}) = \frac{1}{2}, \quad P(\text{homozygous at C locus}) = \frac{1}{2}$$

Step 4: Use the product rule to calculate the joint probability for independent events. To find the fraction of progeny that is simultaneously homozygous at all three loci, multiply their individual probabilities:

$$P(\text{homozygous at all 3 loci}) = \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} = \frac{1}{8}$$

Step 5: Verify that this fraction encompasses all eight fully homozygous combinations (AABBCC, AABBcc, AAbbCC, AAbbcc, aaBBCC, aaBBcc, aabbCC, and aabbcc), each occurring with a frequency of $1/64$. Adding these gives $8/64 = 1/8$.

Final Answer: $1/8$

Answer: (A) Go Back to Question 22

Q23.

Solution

Concept:

Phylum Chordata is a diverse group of animals unified by a specific suite of fundamental structural characteristics that must be present at some point during their ontogeny or life cycle. These defining diagnostic features distinguish chordates from all non-chordate phyla (invertebrates) and include a dorsal hollow nerve cord, a longitudinal supporting rod called a notochord, paired pharyngeal gill slits, and a post-anal tail.

Solution:

Step 1: Analyze the core traits of Chordata. Chordates possess a dorsal, hollow, single nerve cord situated dorsal to the alimentary canal.

Step 2: Evaluate Option A. A ventral, solid, double nerve cord is a key diagnostic feature of higher non-chordate phyla, such as Annelida and Arthropoda. Thus, this option is incorrect.

Step 3: Evaluate Option B. Radial symmetry is characteristic of Cnidaria and Echinodermata, while a pseudocoelom is uniquely diagnostic of Aschelminthes (roundworms). Thus, this option is incorrect.

Step 4: Evaluate Option D. A chitinous exoskeleton and an open circulatory system are classic morphological adaptations of the phylum Arthropoda. Thus, this option is incorrect.

Step 5: Evaluate Option C. Paired pharyngeal gill slits (perforations in the pharyngeal wall for respiration or filter-feeding) and a muscular post-anal tail extending posterior to the anus are two of the four structural hallmarks unique to Phylum Chordata. This makes Option C the correct choice.

Final Answer: Pharyngeal gill slits and a post-anal tail

Answer: (C) Go Back to Question 23

Q24.

Solution

Concept:

The sliding filament theory explains how skeletal muscle contracts. According to this model, muscle contraction does not occur because the individual thick (myosin) or thin (actin) myofilaments shrink in length. Instead, contraction is driven by cross-bridge cycles that slide the thin actin filaments over the stationary thick myosin filaments, pulling them toward the center of the sarcomere (the M-line). This spatial shifting alters the widths of specific bands within the sarcomere.

Solution:

Step 1: Understand the anatomical landmarks of a sarcomere. The A-band represents the entire longitudinal length of the thick myosin filaments. The I-band is the region containing only thin actin filaments. The H-zone is the central portion of the A-band that contains only thick filaments, where thin filaments do not overlap in a relaxed state.

Step 2: Analyze the behavior of the A-band during contraction. Because the thick filaments do not change their physical length or move position, the absolute width of the A-band remains completely constant.

Step 3: Analyze the behavior of the I-band. As the actin filaments are pulled inward toward the M-line, they overlap more extensively with the thick filaments. This reduces the width of the I-band region that contains only thin filaments, causing it to shorten.

Step 4: Analyze the behavior of the H-zone. As the opposing thin filaments slide deep into the center of the sarcomere from both sides, they move into the H-zone. When the muscle is maximally contracted, the thin filaments meet or overlap in the middle, causing the H-zone to shorten and completely disappear.

Step 5: Combine these observations. Both the I-band and the H-zone narrow during contraction, making Option D the correct selection.

Final Answer: Both B and C

Answer: (D) Go Back to Question 24

Q25.

Solution

Concept:

Restriction endonucleases are bacterial enzymes used in recombinant DNA technology to cleave double-stranded DNA at specific palindromic recognition sequences. These enzymes break phosphodiester bonds on both strands via highly coordinated hydrolysis reactions. Based on their cleavage patterns, restriction enzymes are classified into two groups: those that generate staggered cuts yielding single-stranded overhanging regions (sticky or cohesive ends) and those that cut both strands at the exact same phosphodiester position, yielding fully base-paired termini (blunt or flush ends).

Solution:

Step 1: Examine the cleavage pattern of EcoRI. EcoRI recognizes the sequence $5'$-GAATTC-$3'$ and cuts staggered between the G and A residues, producing $5'$ cohesive overhanging sticky ends.

Step 2: Examine the cleavage pattern of HindIII. HindIII recognizes $5'$-AAGCTT-$3'$ and cleaves asymmetrical between the two adenine residues, creating sticky ends.

Step 3: Examine the cleavage pattern of BamHI. BamHI recognizes $5'$-GGATCC-$3'$ and cleaves between the two guanine bases, also yielding single-stranded sticky extensions.

Step 4: Examine the cleavage pattern of EcoRV. EcoRV recognizes the specific 6-base-pair symmetric sequence $5'$-GATATC-$3'$. It cleaves precisely down the center line of symmetry between the internal T and A bases on both strands:

$$5'\text{-GAT} \downarrow \text{ATC-}3'$$

$$3'\text{-CTA} \uparrow \text{TAG-}5'$$

Step 5: Note that this symmetrical cleavage leaves no single-stranded overhangs, producing blunt ends. Therefore, EcoRV is the correct enzyme.

Final Answer: EcoRV

Answer: (C) Go Back to Question 25

Q26.

Solution

Concept:

Human oogenesis is characterized by prolonged periods of developmental arrest. The second meiotic arrest occurs during ovulation, when the secondary oocyte is released from the mature Graafian follicle into the fallopian tube. At this stage, the oocyte is arrested specifically at metaphase of meiosis II. It remains locked in this state and will degenerate unless it is successfully penetrated by a viable spermatozoon.

Solution:

Step 1: Trace the hormonal events of ovulation. An LH surge causes the mature Graafian follicle to rupture, releasing a secondary oocyte that is arrested in metaphase II.

Step 2: Understand the trigger for resuming meiosis II. The oocyte cannot complete meiosis II on its own because it lacks active cell-cycle signaling factors to degrade cyclin B.

Step 3: Analyze the molecular event during fertilization. When a sperm successfully navigates the corona radiata and zona pellucida, its plasma membrane fuses with that of the secondary oocyte.

Step 4: Connect membrane fusion to cell cycle resumption. This fusion triggers a transient influx of intracellular calcium ions (Ca^{2+}) within the oocyte cytoplasm. This calcium spike activates the Anaphase-Promoting Complex (APC/C), which targets securin and cyclin B for destruction, lifting the metaphase II arrest.

Step 5: Conclude that the secondary oocyte completes its second meiotic division immediately following sperm penetration and membrane fusion. This division yields a large haploid ovum (ootid) and a tiny second polar body. Thus, Option C is correct.

Final Answer: Fusion of the plasma membranes of the sperm and the ovum

Answer: (C) Go Back to Question 26

Q27.

Solution

Concept:

The cross-bridge cycle describes the cyclic interaction between actin and myosin filaments that drives muscle contraction. The myosin globular head contains two distinct binding sites: an actin-binding site and an ATP-binding catalytic site that functions as an ATPase enzyme. The structural transitions and conformational states of the myosin head are tightly coupled to specific steps of ATP binding, hydrolysis, and product release.

Solution:

Step 1: Trace the steps of the cross-bridge cycle starting from a bound, rigor state.

Step 2: Analyze ATP binding. When a new ATP molecule binds to the catalytic site on the myosin head, it induces a conformational change that lowers myosin's affinity for actin, causing the myosin head to detach from the thin actin filament.

Step 3: Analyze ATP hydrolysis. Once detached, the ATPase domain of the myosin head hydrolyzes the bound ATP into adenosine diphosphate (ADP) and inorganic phosphate (P_i). Crucially, the chemical energy released by this cleavage is conserved within the protein structure.

Step 4: Identify the structural effect of hydrolysis. This energy transfer forces the flexible hinge region of the myosin molecule to spring back into a high-energy, perpendicular orientation. This step is known as the "cocking" or activation of the myosin head, priming it to bind to a new upstream actin monomer.

Step 5: Analyze the remaining options. Binding of calcium to troponin C is an upstream event regulated by depolarization. The power stroke occurs during the sequential release of P_i and ADP. Therefore, ATP hydrolysis is directly responsible for cocking the myosin head into its high-energy state.

Final Answer: Activation and cocking of the myosin head into a high-energy state

Answer: (C) Go Back to Question 27

Q28.

Solution

Concept:

In plant biotechnology, delivering a foreign gene into a host plant's genome requires an efficient vector system. The soil bacterium *Agrobacterium tumefaciens* is a natural genetic engineer that routinely infects wounded dicotyledonous plants, causing crown gall disease. It achieves this by transferring a specific segment of its large plasmid DNA directly into the nuclear genome of the host plant cells.

Solution:

Step 1: Understand the molecular biology of *Agrobacterium tumefaciens*. This bacterium contains a large tumor-inducing plasmid known as the Ti plasmid.

Step 2: Identify the mobile genetic segment on the Ti plasmid. This segment is called the T-DNA (transfer DNA), and it is flanked by conserved border sequences that direct its excision and integration into the plant genome.

Step 3: Explain vector modification for biotechnology. To utilize the Ti plasmid as a cloning vector, scientists "disarm" it by removing the oncogenes responsible for tumor formation while keeping the T-DNA border sequences intact.

Step 4: Evaluate alternative choices. The plasmid pBR322 is a standard cloning vector designed for transformation in prokaryotic *E. coli* cells. Lambda phage is a bacteriophage vector used exclusively for bacterial hosts. Retroviruses are highly efficient vectors used to deliver genes into mammalian and human cells, not plants.

Step 5: Conclude that the disarmed Ti plasmid of *Agrobacterium tumefaciens* is the premier vector for introducing recombinant DNA into dicotyledonous crops.

Final Answer: Ti plasmid of *Agrobacterium tumefaciens*

Answer: (B) Go Back to Question 28

Q29.

Solution

Concept:

Ecological pyramids graphically depict the trophic structure and energy efficiency of an ecosystem across successive levels (producers, primary consumers, secondary consumers, etc.). These pyramids can measure three different parameters: numbers, biomass, or energy. While some pyramids can be inverted depending on the ecosystem, the pyramid of energy must always be upright in every stable ecosystem due to the laws of thermodynamics.

Solution:

Step 1: Analyze the properties of the Pyramid of Energy. According to Lindeman's 10% law, only about 10% of the energy available at a given trophic level is transferred to the next level. The rest is lost as metabolic heat. Thus, the pyramid of energy is strictly upright in all ecosystems.

Step 2: Analyze the Pyramid of Biomass. In most terrestrial ecosystems, the biomass of producers (trees, grasses) is significantly greater than that of herbivores and carnivores, making the pyramid upright. However, in aquatic ecosystems (e.g., an ocean or lake), the pyramid of biomass is inverted because a small standing crop of phytoplankton supports a much larger biomass of zooplankton and fish.

Step 3: Analyze the Pyramid of Numbers. In a standard grassland ecosystem, producers are highly numerous, resulting in an upright pyramid. However, consider a tree ecosystem within a temperate deciduous forest: a single large producer (one oak tree) supports numerous herbivorous insects, which in turn support a smaller number of predatory or parasitic birds.

Step 4: Conclude that in a forest ecosystem, a single tree producer can support a vast number of primary consumers. This structural arrangement causes the pyramid of numbers to become partially or completely inverted, exhibiting a spindle-shaped or fully inverted profile. Thus, Option C is correct.

Final Answer: Pyramid of numbers

Answer: (C) Go Back to Question 29

Q30.

Solution

Concept:

Point mutations are genetic alterations that involve the substitution of a single nucleotide base pair within a DNA molecule. Based on the chemical structure of the nitrogenous bases involved, base substitution mutations are classified into two distinct mechanistic categories: transitions and transversions.

Solution:

Step 1: Classify the nitrogenous bases into their biochemical families. Purines are double-ringed structures encompassing Adenine (A) and Guanine (G). Pyrimidines are single-ringed structures encompassing Cytosine (C) and Thymine (T) in DNA.

Step 2: Define a transition mutation. A transition occurs when a purine is replaced by another purine (A $\leftrightarrow$ G) or when a pyrimidine is replaced by another pyrimidine (C $\leftrightarrow$ T). The structural configuration remains a purine-pyrimidine pair across the double helix.

Step 3: Define a transversion mutation. A transversion occurs when a purine is substituted by a pyrimidine, or vice versa (e.g., A $\leftrightarrow$ C or G $\leftrightarrow$ T). This changes the structural width of the DNA backbone.

Step 4: Evaluate alternative choices. A frameshift mutation involves the insertion or deletion of nucleotides, altering the translational reading frame. A nonsense mutation introduces a premature stop codon.

Step 5: Match the prompt's condition (purine-to-purine or pyrimidine-to-pyrimidine) with the definition of a transition mutation. Thus, Option A is correct.

Final Answer: Transition mutation

Answer: (A) Go Back to Question 30

Q31.

Solution

Concept:

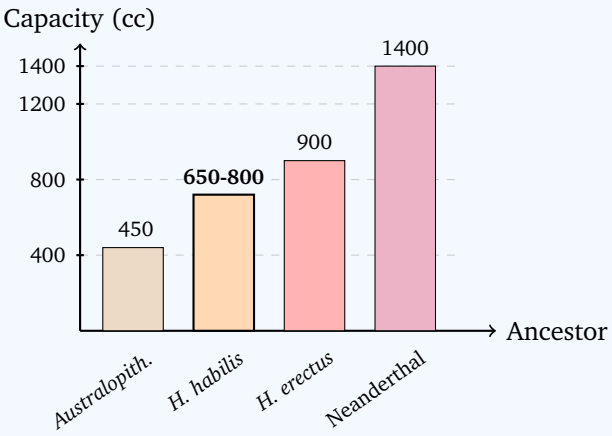
Human evolution and the characteristic cranial capacities of different hominid ancestors.

Solution:

Step 1: Let us evaluate the paleoanthropological facts alongside the given options:

- **Option A is correct**: *Homo habilis* was the first human-like hominid tool-maker with a cranial capacity of **650–800 cc**.
- **Option B is incorrect**: *Homo erectus* had a brain size of around **900 cc** (not 1400 cc).
- **Option C is incorrect**: Neanderthal man possessed a prominent cranial capacity of about **1400 cc** (not 900 cc).
- **Option D is incorrect**: *Australopithecus* was an earlier ancestor with a much smaller brain volume of **400–500 cc** (not 1200 cc).

Step 2: Therefore, Option A represents the only correctly matched pair.



Final Answer: *Homo habilis* — 650–800 cc

Answer: (A) Go Back to Question 31

Q32.

Solution

Concept:

The human male reproductive system contains three sets of accessory glands: a pair of seminal vesicles, a single prostate gland, and a pair of bulbourethral (Cowper's) glands. These glands secrete specific biochemical components into the vas deferens and urethra, forming seminal plasma. Seminal plasma provides a protective, nutrient-rich vehicle that supports sperm motility, survival, and transport through the female reproductive tract.

Solution:

Step 1: Analyze the secretions of the bulbourethral glands. They secrete an alkaline mucus fluid that lubricates the urethra and neutralizes acidic residual urine before ejaculation.

Step 2: Analyze the secretions of the prostate gland. The prostate secretes a thin, milky, slightly alkaline fluid containing citrate, calcium ions, and various proteolytic enzymes (such as fibrinolysin) that help liquefy semen.

Step 3: Analyze the secretions of the seminal vesicles. The paired seminal vesicles contribute approximately $60 - 70\%$ of the total volume of semen. Their secretion is a viscous, alkaline fluid containing high concentrations of fructose, prostaglandins, and clotting proteins (such as semenogelin).

Step 4: Connect these specific components to sperm function. Fructose acts as the primary nutrient source fueling sperm motility. Proandins stimulate reverse peristaltic contractions in the female reproductive tract to help sperm migrate. Clting enzymes cause the semen to coagulate after ejaculation, securing it near the cervix.

Step 5: Confirm that the seminal vesicles are the sole source of these specific secretions, making Option B correct.

Final Answer: Seminal vesicles

Answer: (B) Go Back to Question 32

Q33.

Solution

Concept:

Epithelial tissues line body cavities, organs, and external surfaces. To control the movement of solutes and water across these cellular barriers, individual epithelial cells are linked together by specialized protein networks called intercellular junctions. These junctions are categorized into three major functional classes: anchoring junctions (desmosomes), communicating junctions (gap junctions), and occluding junctions (tight junctions).

Solution:

Step 1: Identify the function of gap junctions. Gap junctions form hydrophilic transcellular channels that allow the direct passage of ions and small signaling molecules between adjacent cells.

Step 2: Identify the function of adhering junctions and desmosomes. These anchor cells mechanically to each other or to the extracellular matrix, providing structural integrity to tissues subjected to mechanical stress (e.g., skin and cardiac muscle).

Step 3: Identify the function of tight junctions (zonula occludens). Tight junctions are localized bands of transmembrane proteins (such as claudins and occludins) that fuse adjacent plasma membranes together, sealing the intercellular space.

Step 4: Relate tight junctions to organ physiology. This seal prevents paracelluar leakage, forcing substances to travel through regulated transcellular pathways.

Step 5: Consider the human urinary bladder. The bladder is lined with transitional epithelium that must prevent toxic metabolic waste products in urine from leaking back into underlying tissues. Consequently, tight junctions are highly abundant here to maintain an impermeable tissue barrier. Thus, Option C is correct.

Final Answer: Tight junctions

Answer: (C) Go Back to Question 33

Q34.

Solution

Concept:

In angiosperms, a microsporangium (pollen sac) within an anther is surrounded by a specialized four-layered cellular wall. From the outside inward, these layers are the epidermis, endothecium, middle layers, and the tapetum. The outer three layers are primarily protective and develop structural modifications to facilitate the physical opening (dehiscence) of the mature anther. The innermost layer, the tapetum, fulfills a vital physiological role in supporting pollen development.

Solution:

Step 1: Identify the structural role of the outer layers. The epidermis, endothecium (with its fibrous thickenings), and middle layers protect the microsporangium and shrink asymmetrically during dehydration, tearing open the anther at the stomium to release mature pollen grains.

Step 2: Analyze the cytological characteristics of the tapetum. The tapetum consists of large, metabolically active cells that often become multinucleated or polyploid due to endomitosis.

Step 3: Define the primary function of the tapetum. As microspore mother cells undergo meiosis to form haploid microspore tetrads, the tapetal cells synthesize and secrete nutrients, proteins, and hormones that sustain the developing microspores.

Step 4: Identify secondary functions of the tapetum. The tapetum produces Ubisch bodies, which contain sporopollenin, a highly resistant polymer used to build the outer exine layer of the pollen grain. However, its primary physiological role is to provide nutrition, making Option C the correct answer.

Final Answer: Nourish the developing microspores

Answer: (C) Go Back to Question 34

Q35.

Solution

Concept:

All cellular life forms can be categorized into two structural classes based on their internal compartmentalization: prokaryotes and eukaryotes. Prokaryotic cells (bacteria, archaea) lack internal membrane-bound organelles and a true nucleus, while eukaryotic cells (plants, animals, fungi) exhibit complex compartmentalization. Despite these differences, all cells share certain ancient structural components necessary for survival.

Solution:

Step 1: Evaluate Option A. Prokaryotes possess 70S ribosomes in their cytoplasm, whereas eukaryotic plant cells possess larger 80S ribosomes in their cytoplasm (though plant mitochondria and chloroplasts contain evolutionary remnants of 70S ribosomes). Thus, this feature is not shared in the cytoplasm.

Step 2: Evaluate Option B. Eukaryotic plant cells possess a cell wall composed primarily of the polysaccharide cellulose. In contrast, prokaryotic cell walls are composed of peptidoglycan (in eubacteria) or distinct pseudomurein polymers (in archaea), not cellulose.

Step 3: Evaluate Option C. A double-membrane-bound nucleus is a defining hallmark of eukaryotic cells. Prokaryotes lack a nuclear membrane, housing their genetic material in an irregular, open cytoplasmic region called the nucleoid.

Step 4: Evaluate Option D. Every living cell must be enclosed by a plasma membrane that regulates molecular transport. In both prokaryotes and eukaryotic plant cells, this membrane is structured as a fluid mosaic bilayer composed of amphipathic phospholipids embedded with functional proteins. This represents a universally shared structural feature.

Final Answer: Presence of a plasma membrane containing phospholipids

Answer: (D) Go Back to Question 35

Q36.

Solution

Concept:

Photoperiodism is the physiological response of a plant to the relative lengths of light and dark periods within a 24-hour cycle, which regulates the transition from vegetative growth to flowering. Plants use specialized photoreceptor proteins, such as phytochromes, to monitor these light intervals. While the physiological outcome of photoperiodism occurs at the shoot apical meristem, the initial light stimulus is detected by a different organ.

Solution:

Step 1: Understand the site of floral induction. The actual transformation of a vegetative bud into a floral bud occurs at the shoot apex, where the meristematic cells alter their gene expression profile.

Step 2: Identify where photoperiodic light is perceived. Physiological grafting experiments demonstrate that exposing the shoot apex alone to the correct photoperiod does not induce flowering. Instead, the light stimulus must be received by the leaves.

Step 3: Explain the signal transduction mechanism. When leaves are exposed to the inductive photoperiod, phytochromes detect the light qualities and activate the expression of a specific gene (the *CONSTANS* gene). This triggers the synthesis of a mobile chemical signal originally termed "florigen."

Step 4: Trace the movement of the signal. This florigen signal (identified as the Flowering Locus T or FT protein) travels from the leaf mesophyll through the phloem to the shoot apex, inducing flowering.

Step 5: Conclude that the leaves are the specific organs responsible for receiving the initial photoperiodic light stimulus, making Option C correct.

Final Answer: Leaves

Answer: (C) Go Back to Question 36

Q37.

Solution

Concept:

Typhoid fever is an acute, life-threatening systemic infection of the human digestive tract caused by the Gram-negative bacterium *Salmonella enterica* serovar Typhi. Accurate clinical diagnosis is essential for proper antibiotic selection. Typhoid can be diagnosed using several laboratory methodologies, including direct bacterial culture, molecular PCR assays, or serological tests that detect specific anti-typhoid antibodies in the patient's blood serum.

Solution:

Step 1: Analyze the diagnostic target of the Widal test. The Widal test is a classic serodiagnostic agglutination assay developed to detect antibodies against *Salmonella* Typhi.

Step 2: Detail the mechanism of the Widal test. The patient's blood serum is mixed with prepared bacterial suspensions containing specific antigens from *Salmonella* Typhi: the somatic O antigen and the flagellar H antigen. If the patient has typhoid, antibodies in their serum will bind to these antigens, causing visible cellular clumping (agglutination).

Step 3: Evaluate alternative choices. The ELISA (Enzyme-Linked Immunosorbent Assay) and Western blot are versatile laboratory techniques widely used to screen and confirm HIV infections, among other conditions.

Step 4: Evaluate the Mantoux test. The Mantoux test is an intradermal skin screening test used to detect cell-mediated hypersensitivity immunity against *Mycobacterium tuberculosis*, the causative agent of tuberculosis.

Step 5: Match typhoid diagnosis with the Widal test, confirming Option A as the correct selection.

Final Answer: Widal test

Answer: (A) Go Back to Question 37

Q38.

Solution

Concept:

The lac operon in *E. coli* is a classic genetic model of an inducible operon that regulates the transcription of structural genes involved in lactose metabolism. The operon consists of a regulatory gene (i), a promoter (p), an operator (o), and three structural genes (z, y, and a). The regulatory gene continuously synthesizes an active repressor protein that binds tightly to the operator, physically blocking RNA polymerase from transcribing the structural genes.

Solution:

Step 1: Understand standard induction kinetics. Under normal conditions, when lactose is present, it is converted into allolactose, which acts as an inducer. Allolactose binds to the repressor protein, causing a conformational change that prevents the repressor from binding to the operator. This unblocks the operator, allowing transcription to proceed.

Step 2: Analyze the specific mutation described in the prompt. The mutation alters the inducer-binding site of the repressor protein, rendering it completely unable to bind to allolactose. Crucially, the mutation does not impair the repressor's DNA-binding domain.

Step 3: Determine the functional state of this mutant repressor. Because the repressor cannot bind to allolactose, the presence of lactose has no effect on it. The mutant repressor remains continuously active and bound to the operator sequence.

Step 4: Conclude the effect on transcription. Because the operator is permanently blocked by the mutant repressor, RNA polymerase is indefinitely prevented from transcribing the structural genes (z, y, and a). Transcription remains repressed, or "always off," regardless of lactose levels. Thus, Option B is correct.

Final Answer: Transcription will be repressed permanently (always off)

Answer: (B) Go Back to Question 38

Q39.

Solution

Concept:

When a human moves from sea level to a high-altitude environment (typically above $2,500$ meters), they encounter a significant decrease in atmospheric barometric pressure. Although the percentage of oxygen in the air remains constant at roughly 21%, the lower total atmospheric pressure decreases the partial pressure of oxygen (pO_2). This reduces the concentration gradient driving oxygen diffusion across the alveolar-capillary membrane, leading to arterial hypoxia. The body initiates a suite of physiological adaptations known as altitude acclimation to maintain homeostatic oxygen delivery to tissues.

Solution:

Step 1: Analyze the respiratory compensation mechanism. To compensate for the reduced oxygen content per breath, peripheral chemoreceptors sense the drop in arterial pO_2 and signal the respiratory centers in the brainstem to increase the rate and depth of ventilation (hyperventilation). This respiratory response is an immediate and sustained feature of high-altitude acclimation.

Step 2: Analyze the erythropoietic response. In response to prolonged renal hypoxia, the kidneys secrete the hormone erythropoietin (EPO). EPO acts on bone marrow to stimulate erythroblast proliferation, leading to an *increased* production of red blood cells and elevated hematocrit levels over days to weeks. Thus, Option A is incorrect.

Step 3: Analyze changes in hemoglobin-oxygen binding affinity. At high altitudes, erythrocytes increase production of the metabolic intermediate 2,3-bisphosphoglycerate (2,3-BPG). 2,3-BPG binds to hemoglobin and decreases its oxygen affinity, shifting the oxygen-hemoglobin dissociation curve to the right. This change facilitates the release of oxygen into oxygen-deprived peripheral tissues. Thus, Option B is incorrect.

Step 4: Analyze cardiac dynamics. During initial altitude exposure, sympathetic nervous system activity increases, leading to an elevated resting heart rate and an *increased* total cardiac output to maintain tissue perfusion. Thus, Option D is incorrect.

Step 5: Conclude that an increased breathing rate is the correct physiological response to high-altitude exposure, making Option C the correct answer.

Final Answer: Increased breathing rate

Answer: (C) Go Back to Question 39

Q40.

Solution

Concept:

The placenta is a complex temporary organ that forms during mammalian pregnancy, serving as the structural and functional interface between the developing embryo and the maternal uterus. Beyond its critical roles in facilitating nutrient absorption, gas exchange, and waste elimination, the human placenta functions as a major temporary endocrine gland. It synthesizes and secretes several hormones necessary to maintain pregnancy, modify maternal metabolism, and prepare the body for parturition and lactation.

Solution:

Step 1: Identify the hormones synthesized and secreted directly by the syncytiotrophoblast cells of the human placenta.

Step 2: Evaluate human chorionic gonadotropin (hCG). hCG is produced early by the chorionic villi of the placenta to maintain the corpus luteum, ensuring continuous progesterone production during the first trimester. Thus, it is a placental hormone.

Step 3: Evaluate human placental lactogen (hPL). hPL is a placental hormone that alters maternal carbohydrate and lipid metabolism to ensure a steady supply of glucose reaches the fetus. Thus, it is a placental hormone.

Step 4: Evaluate Progesterone. During the second and third trimesters, the placenta takes over the bulk synthesis of progesterone from the corpus luteum to maintain the structural integrity of the uterine endometrium. Thus, it is a placental hormone.

Step 5: Evaluate Luteinizing Hormone (LH). LH is a glycoprotein gonadotropin synthesized and secreted by gonadotrope cells in the anterior pituitary gland, not the placenta. High levels of placental steroids during pregnancy exert strong negative feedback that suppresses maternal LH secretion. Therefore, LH is the correct answer because it is not produced by the placenta.

Final Answer: Luteinizing hormone (LH)

Answer: (C) Go Back to Question 40

Answer Key

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