Rajasthan JET Biology Sample Paper-2

Duration: 40 Minutes **Maximum Marks: 160**

Instructions

- This paper contains **40** Multiple Choice Questions (Single Correct).
- Each correct answer carries **+4 marks**.
- Each incorrect answer carries: **−1 marks**.
- Use of mobile phones, smartwatches, calculators, or any electronic gadgets is strictly prohibited.

Q1. Which of the following families is characterized by the presence of a bicarpellary, syncarpous ovary with superior positioning, swollen placenta with many ovules, and an oblique septum?

(A) Fabaceae

(B) Solanaceae

(C) Liliaceae

(D) Brassicaceae

Q2. A plant anatomy specimen shows a concentric vascular bundle where phloem completely surrounds xylem. This specific arrangement is termed as:

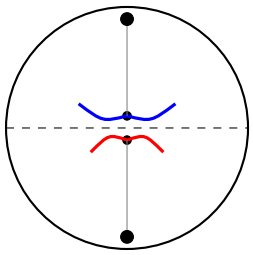
(A) Amphivasal (Leptocentric)

(B) Amphicribral (Hadrocentric)

(C) Collateral closed

(D) Bicollateral open

Q3. Consider the following diagram representing a specific stage of cell division observed under a microscope:



Identify the stage shown in the diagram and choose the option that describes its correct hallmark event.

(A) Metaphase I; alignment of homologous pairs on the equatorial plate

(B) Anaphase; splitting of centromeres and migration of sister chromatids

(C) Metaphase II; alignment of univalent chromosomes on the equator

(D) Prophase; condensation of chromatin networks

Q4. During megasporogenesis in a typical angiosperm, a single functional megaspore undergoes sequential mitotic divisions to form a mature embryo sac. What is the correct order of nuclear divisions and the structural organization of this embryo sac?

(A) 2 mitotic divisions; 8-celled, 7-nucleate structure

(B) 3 mitotic divisions; 7-celled, 8-nucleate structure

(C) 3 mitotic divisions; 8-celled, 8-nucleate structure

(D) 2 mitotic divisions; 7-celled, 7-nucleate structure

Q5. If a plant heterozygous for three independently assorting traits ($AaBbCc$) is self-pollinated, what is the theoretical probability of obtaining an offspring with the exact genotype $AABbcc$?

(A) $1/64$

(B) $1/32$

(C) $1/16$

(D) $1/8$

Q6. A chromosome map shows that the recombination frequency between gene loci

X and Y is 8%, between Y and Z is 12%, and between X and Z is 4%. What is the absolute linear sequence of these genes along the chromosome?

(A) $Y - X - Z$

(B) $X - Y - Z$

(C) $X - Z - Y$

(D) $Z - Y - X$

Q7. During the light reactions of photosynthesis, the movement of electrons through the electron transport chain sets up a proton gradient across the thylakoid membrane. Which of the following correctly describes the accumulation site and the direct driving force for ATP synthesis?

(A) Protons accumulate in the stroma; ATP is generated when protons return to the lumen via $CF_0 - CF_1$ complexes.

(B) Protons accumulate in the thylakoid lumen; ATP is generated when protons flow down their gradient into the stroma through $CF_0 - CF_1$ complexes.

(C) Protons accumulate in the intermembrane space; ATP is generated across the outer membrane.

(D) Protons accumulate in the lumen; ATP synthesis occurs inside the lumen via simple diffusion.

Q8. In C4 plants, the primary carboxylation reaction takes place in the cytoplasm of mesophyll cells, while the final Calvin cycle occurs within the bundle sheath cells. Which enzyme complex initiates the primary fixation, and what is the first stable intermediate compound?

(A) RuBisCO; 3-phosphoglyceric acid (3-PGA)

(B) PEP carboxylase; Oxaloacetic acid (OAA)

(C) RuBisCO; Oxaloacetic acid (OAA)

(D) PEP carboxylase; Malic acid

Q9. When one molecule of acetyl-CoA enters a single turn of the Tricarboxylic Acid (TCA) cycle within the mitochondrial matrix, what is the net yield of metabolic

energy equivalents produced via substrate-level phosphorylation and coenzyme reduction?

(A) 3 NADH + 1 $FADH_2$ + 1 GTP

(B) 2 NADH + 2 $FADH_2$ + 2 ATP

(C) 4 NADH + 1 $FADH_2$ + 1 GTP

(D) 1 NADH + 1 $FADH_2$ + 0 ATP

Q10. The mechanism of active loading of sucrose into sieve tube elements during phloem translocation is fundamentally driven by which cellular process?

(A) Co-transport with protons (H^+) driven by an electrochemical gradient generated by a plasma membrane H^+-ATPase pump

(B) Simple passive diffusion down a chemical concentration gradient

(C) Facilitated antiport diffusion coupled with calcium ions

(D) Hydrostatic pressure differences between source and sink tissues alone

Q11. An enzyme-catalyzed reaction exhibits a specific rate dependency. Which option correctly identifies the structural region where competitive inhibitors bind, and how they alter the kinetic constants (K_m and V_{max}) of the enzyme?

(A) Allosteric site; increases K_m without changing V_{max}

(B) Active site; increases K_m without changing V_{max}

(C) Active site; decreases V_{max} without changing K_m

(D) Regulatory site; decreases both K_m and V_{max}

Q12. In a stable terrestrial ecosystem, the concentration of certain non-biodegradable chemical pollutants increases significantly at each successive higher trophic level. This ecological phenomenon is scientifically termed as:

(A) Eutrophication

(B) Bioaccumulation

(C) Biomagnification

(D) Bioremediation

Q13. Which specific type of ecological pyramid can never occur in an inverted state under any natural field conditions, owing to the fundamental thermodynamic laws governing energy transfer between trophic tiers?

(A) Pyramid of numbers in a parasitic food chain

(B) Pyramid of biomass in a marine ecosystem

(C) Pyramid of energy in a forest ecosystem

(D) Pyramid of numbers in an agro-ecosystem

Q14. The dense, evergreen tropical rainforests containing global hot-spots of unique flora and fauna are characterized by exceptionally high biodiversity index scores. Which ecological region in India represents a prominent example of this biome type?

(A) The Aravalli Range of Rajasthan

(B) The Western Ghats

(C) The Indo-Gangetic Plains

(D) The Thar Desert Basin

Q15. Under the National Forest Policy of India, what is the legally targeted minimum percentage of geographical area that should ideally be maintained under dense forest and tree cover across plains and mountainous regions respectively?

(A) 20% in plains and 50% in hills

(B) 33% in plains and 67% in hills

(C) 15% in plains and 33% in hills

(D) 40% in plains and 60% in hills

Q16. The major carbohydrate-rich cereal crop *Triticum aestivum* (Bread Wheat) globally cultivated across Rabi seasons exhibits a specific genetic ploidy status. What is its ploidy level and standard chromosome number ($2n$)?

(A) Tetraploid; $2n = 28$

(B) Hexaploid; $2n = 42$

(C) Diploid; $2n = 14$

(D) Octaploid; $2n = 56$

Q17. Which oilseed crop, prominently grown across the arid zones of Rajasthan, belongs to the family Brassicaceae and yields an oil high in erucic acid?

(A) *Glycine max* (Soybean)

(B) *Brassica juncea* (Indian Mustard)

(C) *Ricinus communis* (Castor bean)

(D) *Arachis hypogaea* (Groundnut)

Q18. The valuable medicinal plant commonly known as ”Ashwagandha,” widely utilized in traditional systems to enhance immunity and combat physiological stress, belongs to which botanical family?

(A) Solanaceae

(B) Fabaceae

(C) Apiaceae

(D) Liliaceae

Q19. Which option correctly matches a primary commercial spice crop cultivated in northern Rajasthan with its correct botanical name and economical plant part harvested?

(A) Coriander – *Coriandrum sativum* – Leaves only

(B) Cumin – *Cuminum cyminum* – Dried Schizocarpic Fruit

(C) Fenugreek – *Trigonella foenum-graecum* – Root tubers

(D) Fennel – *Foeniculum vulgare* – Fleshy rhizome

Q20. In recombinant DNA technology, a cloning vector must contain an origin of replication (ori), a selectable marker, and unique restriction endonuclease cloning sites. What is the fundamental utility of the selectable marker gene?

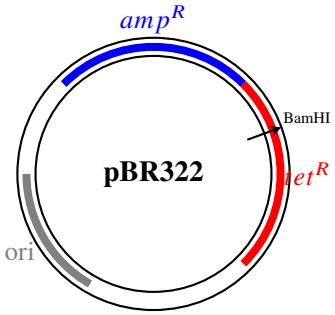
(A) It allows the selective identification and survival of transformant host cells while eliminating non-transformants.

(B) It initiates the unwinding of the double-stranded DNA template during polymerase amplification.

(C) It acts as a target sequence where the restriction enzyme cleaves the phosphodiester backbone.

(D) It expresses the foreign therapeutic protein inside eukaryotic expression systems.

Q21. Consider the given structural representation of a widely utilized cloning vector plasmid:



If a foreign gene of interest is successfully ligated at the unique *BamHI* restriction site within this plasmid, what will be the resulting phenotypic expression of the recombinant host cell?

(A) It will become resistant to both ampicillin and tetracycline antibiotics.

(B) It will lose ampicillin resistance but retain tetracycline resistance.

(C) It will retain ampicillin resistance but lose tetracycline resistance due to insertional inactivation.

(D) It will become completely susceptible to all bacterial screening agents.

Q22. The inherent biological capacity of an isolated single plant somatic cell or tissue explant to differentiate and regenerate into a complete, fully functional whole plant organism when provided with optimal nutrient media under sterile in-vitro environments is defined as:

(A) Pluripotency

(B) Somatic Embryogenesis

(C) Cellular Totipotency

(D) Organogenesis

Q23. A farmer in Western Rajasthan observes a distinct chalky, white powdery growth on the upper leaf surfaces and stems of his cumin and mustard crops during cold winter weeks, leading to severe defoliation and yield collapse. Which phytopathogenic fungal group causes this disease?

(A) *Albugo candida* (White rust)

(B) *Erysiphe polygoni* (Powdery mildew)

(C) *Puccinia graminis* (Black stem rust)

(D) *Ustilago nuda* (Loose smut)

Q24. Green Ear disease (Downy Mildew) is a catastrophic phytopathological condition affecting Pearl Millet (*Pennisetum glaucum*, Bajra) across Rajasthan. Which oomycete pathogen is responsible for transforming fertile floral spikes into leafy structures?

(A) *Sclerospora graminicola*

(B) *Alternaria solani*

(C) *Xanthomonas citri*

(D) *Claviceps purpurea*

Q25. Citrus Canker is a highly contagious disease affecting lemon and lime orchards across Rajasthan, producing characteristic corky, necrotic lesions on leaves, twigs, and fruits. What type of pathogen induces this disease, and how is it primarily disseminated?

(A) Fungal pathogen (*Deuteromycetes*); waterborne spores

(B) Bacterial pathogen (*Xanthomonas citri*); wind-driven rain and mechanical pruning tools

(C) Viral agent (Citrus Tristeza); insect aphid vectors

(D) Phytoplasma organism; leafhopper vectors

Q26. Which of the following phyla is characterized by a pseudocoelomate body plan, a complete digestive tract with a muscular pharynx, a syncytial epidermis covered by a tough cuticle, and lacks any circulatory or respiratory organs?

(A) Aschelminthes (Nematoda)

(B) Platyhelminthes

(C) Annelida

(D) Arthropoda

Q27. The structural tissue lining the inner lumen of fallopian tubes (oviducts) and respiratory bronchioles is specialized to move mucus or particles in a specific directional vector across the surface. This specialized epithelial class is named:

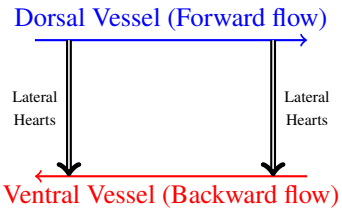
(A) Simple squamous epithelium

(B) Keratinized stratified squamous epithelium

(C) Ciliated columnar/cuboidal epithelium

(D) Transitional epithelium (Urothelium)

Q28. Consider the following schematic diagram displaying the internal vascular/circulatory loops of a specific invertebrate organ system:



Which organism possesses this true closed circulatory setup featuring pulsating lateral pairs of hearts linking a dorsal contractile vessel to a ventral vessel?

(A) *Amoeba proteus*

(B) *Periplaneta americana* (Cockroach)

(C) *Pheretima posthuma* (Earthworm)

(D) *Pila globosa* (Apple Snail)

Q29. In the anatomical organization of a male cockroach (*Periplaneta americana*), the characteristic mushroom-shaped gland (utricular gland) functioning as an accessory reproductive structure is structurally localized within which specific abdominal segments?

(A) 2nd to 4th abdominal segments

(B) 6th to 7th abdominal segments

(C) 9th to 10th abdominal segments

(D) 5th thoracic segment

Q30. The specialized excretory units embedded within the coelomic cavity of an earthworm that open internally via a ciliated funnel to collect waste fluids and discharge them through body pores are classified as:

(A) Protonephridia with flame cells

(B) Malpighian tubules

(C) Metanephridia (Nephrostome and Nephridiophore)

(D) Green glands (Antennal glands)

Q31. The devastating subterranean crop pest known as ”White Grub” (*Holotrichia consanguinea*) poses a severe economic threat to groundnut and pearl millet fields across Rajasthan. During which specific lifecycle stage does this insect cause maximum root destruction?

(A) Adult beetle stage during nocturnal feeding

(B) Grub (larval) stage in subsurface soil

(C) Quiescent pupal stage

(D) Egg stage inside soil cracks

Q32. Which stored grain insect pest is uniquely adapted to thrive under exceptionally low moisture parameters, with its small larvae causing serious structural damage to wheat grain heaps by feeding exclusively inside the kernel endosperm?

(A) *Trogoderma granarium* (Khapra Beetle)

(B) *Sitophilus oryzae* (Rice Weevil)

(C) *Tribolium castaneum* (Red Flour Beetle)

(D) *Callosobruchus maculatus* (Pulse Beetle)

Q33. The integration of cultural practices (deep summer ploughing), biological agents (*Trichogramma* wasps), pheromone mass-trapping, and minimal selective chemical applications to suppress pest populations below the Economic Injury Level (EIL) forms the foundation of:

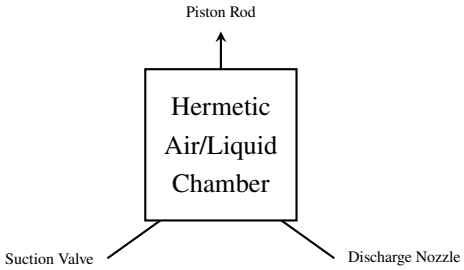
(A) Total Chemical Eradication Program

(B) Integrated Pest Management (IPM)

(C) Quarantine Exclusion Protocol

(D) Biological Monoculture Control

Q34. Consider the provided functional diagram outlining the mechanical pressure assemblies found within agricultural field sprayers:



Which sprayer type operates on this precise continuous manual piston pressurization mechanism, making it highly suitable for targeted chemical applications across small-scale vegetable and crop plots in Rajasthan?

(A) Ultra-Low Volume (ULV) motorized mist blower

(B) Hand-operated Knapsack Hydraulic Sprayer

(C) Tractor-mounted boom sprayer

(D) Electrostatic dusting unit

Q35. The beneficial insect *Laccifer lacca* (Lac insect) secretes a commercially valuable resinous matrix used in traditional industries. Which anatomical structure of this tiny insect produces and extrudes this raw substance?

(A) Salivary glands during feeding

(B) Dermal cuticular glands distributed across the body surface

(C) Malpighian tubules along with excretory residues

(D) Specialized silk glands located near the mouthparts

Q36. Which biochemical vitamin acts as an essential precursor coenzyme required by the hepatic enzyme gamma-glutamyl carboxylase to synthesize functional blood clotting factors like prothrombin (Factor II), VII, IX, and X?

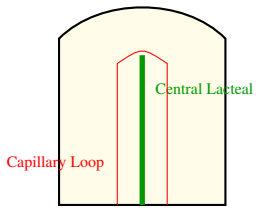
(A) Vitamin A (Retinol)

(B) Vitamin E (Tocopherol)

(C) Vitamin K (Phylloquinone)

(D) Vitamin C (Ascorbic Acid)

Q37. Consider the following schematic structural diagram of a single microvillus functional unit present within the small intestinal mucosal boundary:



Which nutrient class is too large and hydrophobic to pass directly into the blood capillary network shown, requiring repackaging into chylomicrons for absorption into the central lacteal?

(A) Monosaccharides like glucose and galactose

(B) Water-soluble amino acids

(C) Long-chain fatty acids and monoglycerides

(D) Water-soluble vitamins like B-complex

Q38. During prolonged fasting or intense physiological exertion, the liver activates a highly regulated metabolic pathway to synthesize fresh glucose molecules from non-carbohydrate precursors such as glycerol, lactate, and glucogenic amino acids. This metabolic sequence is termed:

(A) Glycogenolysis

(B) Glycolysis

(C) Gluconeogenesis

(D) Glycogenesis

Q39. A severe deficiency of dietary proteins in infants and young children, characterized by profound muscle wasting, extreme emaciation, thinning of limbs, and the complete absence of subcutaneous fat reserves without presenting edema, leads to which specific nutritional disorder?

(A) Kwashiorkor

(B) Marasmus

(C) Pellagra

(D) Osteomalacia

Q40. Which specific hormonal pair, secreted by endocrine cells within the duodenal mucosa, acts in synergy to stimulate the exocrine pancreas to release large quantities of digestive enzymes and bicarbonate ions, while simultaneously triggering gallbladder contractions to eject bile?

(A) Insulin and Glucagon

(B) Cholecystokinin (CCK) and Secretin

(C) Gastrin and Somatostatin

(D) Erythropoietin and Renin

Detailed Solutions

Q1.

Solution

Concept: The family Solanaceae, colloquially known as the nightshade family, comprises ecologically and economically significant herbs, shrubs, and small trees. In plant taxonomy, floral characteristics serve as the primary diagnostic criteria for family identification. The structural architecture of the gynoecium—specifically the number of carpels, their fusion state, orientation, and placental morphology—provides definitive taxonomic markers.

Solution:

(a) The gynoecium of the Solanaceae family is characteristically bicarpellary (composed of two distinct carpels) and syncarpous, meaning these carpels are completely fused to form a single compound pistil structure.

(b) The ovary occupies a superior position relative to the attachment points of the perianth segments and androecium, which means the flower is functionally hypogynous.

(c) A defining anatomical trait of this family is that the ovary is positioned obliquely at an angle of roughly 45 degrees relative to the median plane of the flower. This causes the internal septum dividing the locules to appear characteristically tilted or oblique.

(d) The central placenta is remarkably swollen, fleshy, and adnate to the septum. It breaks into two main locules (bilocular) and bears numerous amphitropous or anatropous ovules arranged via axile placentation.

(e) In contrast, Fabaceae features a monocarpellary unilocular ovary, Liliaceae presents a tricarpellary trilocular ovary, and Brassicaceae is distinguished by a replum (false septum). Thus, Solanaceae is the matching family.

Final Answer: Solanaceae.

Answer: (B)

Go Back to Question 1

Q2.

Solution

Concept: Vascular bundles in angiosperms are categorized into distinct structural configurations based on the relative spatial arrangement, orientation, and cellular distribution of xylem and phloem tissues within the stele. While collateral and bicollateral layouts represent standard parallel configurations, concentric vascular bundles describe systems where one vascular tissue type entirely envelopes the other.

Solution:

(a) Concentric vascular bundles are fundamentally closed, meaning they completely lack an internal vascular cambium zone between the primary xylem and primary phloem cells, preventing secondary growth.

(b) When the central core is occupied entirely by xylem vessels, and this core is surrounded by a continuous outer ring of phloem sieve elements, the bundle is termed amphicribral or hadrocentric. This configuration is widely seen in many pteridophytes, such as ferns, as well as the floral organs of specific angiosperms.

(c) Conversely, if the phloem forms the central core and is enclosed by an outer cylinder of xylem tissue, the vascular bundle is classified as amphivasal or leptocentric, which is typically found in the stems of monocots like Acorus and Dracaena.

(d) Collateral bundles feature phloem located only on the outer side of the internal xylem, whereas bicollateral bundles possess both outer and inner strands of phloem flanking a central xylem mass.

(e) Since the prompt describes an arrangement where phloem completely surrounds a central xylem core, it represents a classic amphicribral or hadrocentric concentric bundle.

Final Answer: Amphicribral (Hadrocentric).

Answer: (B)

Go Back to Question 2

Q3.

Solution

Concept: Mitosis and meiosis are coordinated nuclear division processes that ensure the precise partition of genetic material into daughter cells. Metaphase is generally defined by the maximum condensation of chromosomes and their subsequent orientation along the equatorial region of the cell. However, a critical distinction exists between the structural configurations of chromosomes in metaphase I of meiosis versus metaphase II of meiosis or standard mitotic metaphase.

Solution:

(a) The attached TikZ illustration shows a single cell with univalent chromosomes—each consisting of two distinct sister chromatids attached at a single centromere—aligned individually along the equatorial (metaphase) plate.

(b) In metaphase I of meiosis, homologous chromosomes pair up to form bivalents or tetrads, and it is these pairs that line up in two parallel rows along the equator, with spindle fibers attaching to homologous centromeres.

(c) The diagram clearly shows single, individual chromosomes aligned along the central axis rather than pairs. This isolated arrangement demonstrates that the homologous partners have already separated during the preceding anaphase I.

(d) The presence of a single, univalent row of chromosomes at the equator matches the key structural event of metaphase II of meiosis. During this phase, chromosomes align so that kinetochores of sister chromatids face opposite poles.

(e) Anaphase would show active migration toward the poles, while prophase would show a disorganized chromatin network. Thus, the diagram captures the metaphase II stage of cell division.

Final Answer: Metaphase II; alignment of univalent chromosomes on the equator.

Answer: (C)

Go Back to Question 3

Q4.

Solution

Concept: Megasporogenesis and megagametogenesis are successive developmental stages in female plant gametophyte evolution. In most angiosperms, these processes follow the monosporic, Polygonum-type pattern. This process traces the transformation of a diploid megaspore mother cell into a functional haploid megaspore, which then develops into a mature embryo sac.

Solution:

(a) Megasporogenesis concludes when a diploid cell undergoes meiotic division to produce a linear tetrad of four haploid megaspores. In monosporic development, the three micropylar megaspores degenerate, leaving a single functional chalazal megaspore.

(b) This functional megaspore expands and initiates megagametogenesis. The single haploid nucleus undergoes three successive, free-nuclear mitotic divisions without immediate cytokinesis.

(c) The first mitosis produces two nuclei that move to opposite poles. The second division creates four nuclei, and the third creates eight free nuclei, evenly split with four at each pole.

(d) Cellular organization then occurs through wall formation. Three nuclei at the micropylar pole form the egg apparatus (one egg cell and two synergids). Three nuclei at the chalazal pole become antipodal cells.

(e) The remaining two nuclei, one from each pole, migrate to the center to form polar nuclei within a massive central cell. This results in a mature female gametophyte structured as a 7-celled, 8-nucleate embryo sac.

Final Answer: 3 mitotic divisions; 7-celled, 8-nucleate structure.

Answer: (B)

Go Back to Question 4

Q5.

Solution

Concept: Mendelian genetics dictates that when tracking multiple independent traits, the laws of segregation and independent assortment operate concurrently. For genes residing on non-homologous chromosomes, the probability of inheriting specific alleles at one locus is completely independent of the other loci. The overall probability of a multi-locus genotype can therefore be calculated using the product rule.

Solution:

(a) The parental plant is trihybrid with the genotype $AaBbCc$. Self-pollination means crossing $AaBbCc \times AaBbCc$. Because the three pairs of alleles assort independently, we can evaluate each gene locus as an isolated monohybrid cross.

(b) For the A locus, the cross $Aa \times Aa$ yields a genotypic ratio of $1/4$ AA, $2/4$ Aa, and $1/4$ aa. The probability of obtaining the homozygous dominant genotype AA is exactly $1/4$.

(c) For the B locus, the cross $Bb \times Bb$ gives a genotypic ratio of $1/4$ BB, $2/4$ Bb, and $1/4$ bb. The probability of getting the heterozygous genotype Bb is $2/4$, which simplifies to $1/2$.

(d) For the C locus, the cross $Cc \times Cc$ yields $1/4$ CC, $2/4$ Cc, and $1/4$ cc. The probability of obtaining the homozygous recessive genotype cc is exactly $1/4$.

(e) To find the probability of the combined genotype $AABbcc$, we multiply the independent probabilities of each locus together: $1/4$ (for AA) $\times$ $1/2$ (for Bb) $\times$ $1/4$ (for cc) $= 1/32$.

Final Answer: $1/32$.

Answer: (B)

Go Back to Question 5

Q6.

Solution

Concept: Linkage mapping and chromosome construction are based on the principle that the recombination frequency between two linked genes is directly proportional to the physical distance separating them on a chromosome. One percent recombination frequency is defined as one map unit (mu) or centimorgan (cM). By analyzing these additive linear distances, the relative order of gene loci can be deduced.

Solution:

(a) The given values state that the recombination frequency between gene X and gene Y is 8%, which equates to a map distance of 8 cM.

(b) The recombination frequency between gene Y and gene Z is 12%, establishing a map distance of 12 cM between them.

(c) The recombination frequency between gene X and gene Z is 4%, corresponding to a map distance of 4 cM.

(d) To find the correct linear arrangement, identify the two genes separated by the maximum map distance. Here, Y and Z are furthest apart at 12 cM, meaning they form the outer boundaries of this gene cluster.

(e) Gene X must reside between Y and Z. We can verify this position by checking the distances: the distance from Y to X (8 cM) plus the distance from X to Z (4 cM) equals the total distance from Y to Z (12 cM). This confirms the absolute linear order along the chromosome is $Y - X - Z$.

Final Answer: $Y - X - Z$.

Answer: (A)

Go Back to Question 6

Q7.

Solution

Concept: The chemiosmotic hypothesis, formulated by Peter Mitchell, explains the precise mechanism of ATP synthesis within chloroplasts during the light-dependent reactions of photosynthesis. This process relies on an electrochemical proton gradient established across the hydrophobic thylakoid membrane, which couples electron transport to photophosphorylation.

Solution:

(a) During the light-driven operations of Photosystem II and Photosystem I, protons (H^+ ions) are actively translocated across the thylakoid membrane. This occurs through the photolysis of water molecules on the inner face of the membrane and via the plastoquinone shuttle loop.

(b) This directional transport leads to a high concentration of protons within the internal thylakoid lumen, causing a corresponding drop in lumen pH relative to the surrounding stroma.

(c) The hydrophobic thylakoid membrane is impermeable to protons, preventing them from diffusing directly back into the stroma. This creates a strong proton-motive force across the membrane.

(d) The only pathway available for protons to flow down their electrochemical gradient is through the specialized transmembrane channels of the CF_0 subunit of the ATP synthase complex.

(e) As protons pass through CF_0 into the stroma, the derived potential energy drives conformational changes in the catalytic CF_1 headpiece. This allows the enzyme to synthesize ATP from ADP and inorganic phosphate on the stromal side.

Final Answer: Protons accumulate in the thylakoid lumen; ATP is generated when protons flow down their gradient into the stroma through $CF_0 - CF_1$ complexes.

Answer: (B)

Go Back to Question 7

Q8.

Solution

Concept: Plants utilizing the C4 photosynthetic pathway feature a specialized structural adaptation known as Kranz anatomy, which physically segregates the initial capture of carbon dioxide from the primary reducing reactions of the Calvin cycle. This spatial separation minimizes photorespiration by maintaining a high concentration of carbon dioxide around the RuBisCO enzyme.

Solution:

(a) In C4 plants, atmospheric carbon dioxide enters the mesophyll cells, where it dissolves to form bicarbonate ions (HCO_3^-).

(b) The primary carboxylation enzyme in the mesophyll cytoplasm is Phosphoenolpyruvate carboxylase (PEP carboxylase). Unlike RuBisCO, PEP carboxylase has a high affinity for bicarbonate and completely lacks oxygenase activity.

(c) PEP carboxylase catalyzes the condensation of carbon dioxide with the three-carbon substrate phosphoenolpyruvate (PEP). This reaction produces oxaloacetic acid (OAA), a four-carbon dicarboxylic acid, which is the first stable intermediate compound of the C4 pathway.

(d) OAA is quickly converted into malate or aspartate, which is then transported through plasmodesmata into the adjacent bundle sheath cells.

(e) Once inside the bundle sheath cells, these organic acids undergo decarboxylation to release carbon dioxide. This localized release creates a high-CO2 environment where RuBisCO can efficiently fix carbon via the standard Calvin cycle.

Final Answer: PEP carboxylase; Oxaloacetic acid (OAA).

Answer: (B)

Go Back to Question 8

Q9.

Solution

Concept: The Tricarboxylic Acid (TCA) cycle, or Krebs cycle, is a key series of mitochondrial matrix reactions central to aerobic cellular respiration. The cycle oxidizes acetyl groups derived from carbohydrates, proteins, and lipids into carbon dioxide. This oxidation releases high-energy electrons, which are captured by coenzymes to power ATP production via oxidative phosphorylation.

Solution:

(a) A single turn of the TCA cycle begins when a two-carbon acetyl-CoA molecule condenses with a four-carbon oxaloacetate molecule to form a six-carbon citrate molecule.

(b) During the subsequent series of enzymatic steps, two decarboxylation reactions occur, releasing two molecules of carbon dioxide and restoring the four-carbon oxaloacetate scaffold.

(c) There are three specific oxidation steps where NAD^+ acts as the electron acceptor: the conversions of isocitrate to alpha-ketoglutarate, alpha-ketoglutarate to succinyl-CoA, and malate to oxaloacetate. These steps generate a net yield of three molecules of reduced Nicotinamide Adenine Dinucleotide (NADH).

(d) During the conversion of succinate to fumarate, electrons are transferred to FAD, yielding one molecule of reduced Flavin Adenine Dinucleotide ($FADH_2$).

(e) Substrate-level phosphorylation occurs when succinyl-CoA is converted to succinate. This reaction couples the cleavage of a high-energy thioester bond to the synthesis of one molecule of Guanosine Triphosphate (GTP) or Adenosine Triphosphate (ATP). Therefore, each turn of the cycle yields 3 NADH + 1 $FADH_2$ + 1 GTP.

Final Answer: 3 NADH + 1 $FADH_2$ + 1 GTP.

Answer: (A)

Go Back to Question 9

Q10.

Solution

Concept: Phloem translocation operates according to the pressure-flow (mass-flow) hypothesis, which states that sap moves through sieve tube elements driven by a hydrostatically generated turgor pressure gradient between source and sink tissues. Establishing this pressure gradient requires the active loading of photosynthates from mesophyll source cells into the sieve tube-companion cell complexes.

Solution:

(a) Sucrose synthesized in source leaves moves toward the minor veins through the apoplast or symplast. Phloem loading into the sieve tube-companion cell complex occurs against a steep concentration gradient, requiring active metabolic transport.

(b) This active loading mechanism is driven by plasma membrane H^+-ATPase pumps located in the membranes of companion cells and sieve elements. These pumps hydrolyze ATP to actively translocate protons (H^+ ions) out into the cell wall space (apoplast).

(c) This asymmetric proton extrusion establishes a significant electrochemical gradient, characterized by a lower pH and a more positive electrical potential in the apoplast relative to the cell interior.

(d) The potential energy stored in this proton gradient drives the entry of sucrose. Protons re-enter the cytoplasm by flowing down their gradient through specialized sucrose-H^+ symporter proteins.

(e) This symporter couples the energetically favorable inward movement of protons with the simultaneous transport of sucrose molecules into the phloem against their concentration gradient.

Final Answer: Co-transport with protons (H^+) driven by an electrochemical gradient generated by a plasma membrane H^+-ATPase pump.

Answer: (A)

Go Back to Question 10

Q11.

Solution

Concept: Enzyme kinetics describe the catalytic rates of biochemical reactions and how various inhibitory molecules influence these velocity profiles. Competitive inhibition represents a classic scenario where an inhibitor structurally resembles the natural substrate of an enzyme, leading to direct competition for binding.

Solution:

(a) A competitive inhibitor possesses a three-dimensional conformation that closely mimics the geometric configuration of the authentic substrate molecule. This structural mimicry allows the inhibitor to specifically target and bind to the catalytic active site of the free enzyme.

(b) Because the inhibitor physically occupies the active site, it blocks access to the actual substrate, effectively preventing the formation of productive enzyme-substrate complexes.

(c) This reduction in active site availability requires a much higher concentration of substrate to reach the same rate of reaction, which reflects a decrease in binding affinity. Consequently, the Michaelis constant (K_m) increases.

(d) At infinitely high substrate concentrations, the substrate molecules completely outnumber and displace the competitive inhibitor from the active sites.

(e) Under these saturating conditions, the catalytic system still reaches its maximum theoretical velocity. Thus, the maximum reaction velocity (V_{max}) remains completely unchanged, differentiating competitive inhibition from non-competitive inhibition.

Final Answer: Active site; increases K_m without changing V_{max}.

Answer: (B)

Go Back to Question 11

Q12.

Solution

Concept: Ecosystem dynamics involve the continuous cycling of nutrients and the unidirectional flow of energy through successive feeding positions known as trophic levels. When considering the movement of chemical substances, their properties dictate whether they follow metabolic breakdown pathways or accumulate within living tissues.

Solution:

(a) Certain chemical synthetic agents, heavy metals, and persistent organic pollutants enter aquatic or terrestrial food webs through environmental contamination. These compounds are hydrophobic and chemically stable.

(b) Because these xenobiotic substances cannot be metabolized, broken down by enzymes, or efficiently excreted by organisms, they remain stored within fatty adipose tissues.

(c) As energy is lost as heat at each trophic step, a consumer must eat many times its own body weight in biomass from the lower trophic level to survive and grow.

(d) Consequently, the non-biodegradable toxins present in lower-level organisms are gathered and concentrated within the bodies of higher-level consumers.

(e) This progressive increase in the tissue concentration of toxic chemical residues at each successive stage of a food chain is defined as biomagnification, a process distinct from localized bioaccumulation.

Final Answer: Biomagnification.

Answer: (C)

Go Back to Question 12

Q13.

Solution

Concept: Ecological pyramids provide a graphical representation of trophic structures and functional relationships across natural communities. These structural models can be constructed to visualize total individual numbers, accumulated biomass, or total productivity within each successive trophic tier.

Solution:

(a) The shape of pyramids of numbers and biomass depends on the size and life cycles of the organisms involved, meaning they can appear upright, inverted, or spindle-shaped depending on the specific ecosystem.

(b) For instance, a pyramid of numbers becomes inverted in a parasitic food chain centered on a single tree host, while a pyramid of biomass is inverted in marine ecosystems due to rapid phytoplankton turnover.

(c) In contrast, the pyramid of energy reflects the total productivity and rate of energy flow through each trophic tier over a given period.

(d) Energy transfer between trophic levels is governed by the Second Law of Thermodynamics and Lindeman's ten percent law. Only about 10% of the energy fixed at one tier is stored as organic matter for the next.

(e) Because the remaining 90% of available energy is lost as metabolic heat or decomposer food, the energy pool shrinks at each step. This ensures the pyramid of energy is always upright.

Final Answer: Pyramid of energy in a forest ecosystem.

Answer: (C)

Go Back to Question 13

Q14.

Solution

Concept: Biodiversity hot-spots are geographic regions that harbor exceptionally high levels of species richness and endemism, while facing severe threats from habitat destruction. India contains several globally recognized ecological zones characterized by these unique floral and faunal assemblages.

Solution:

(a) Tropical rainforest biomes thrive in regions with high annual rainfall and stable warm temperatures. This climate supports layered tree canopies and complex niches for diverse organisms.

(b) In India, these dense rainforest biomes are primarily located in the northeastern states and along the narrow coastal strip of the Western Ghats mountain range.

(c) The Western Ghats intercept moisture-laden monsoon winds from the Arabian Sea, creating a humid climate that supports evergreen forests and unique species found nowhere else.

(d) This high level of unique biodiversity makes the Western Ghats a vital reservoir of genetic resources and a critical conservation priority in South Asia.

(e) Other options, like the Aravalli Range or the Thar Desert, represent arid or semi-arid ecosystems. These habitats have lower species richness compared to the Western Ghats rainforests.

Final Answer: The Western Ghats.

Answer: (B)

Go Back to Question 14

Q15.

Solution

Concept: Forest conservation policies establish regulatory frameworks to protect forest resources, preserve ecological stability, and maintain the balance of atmospheric gases. The National Forest Policy outlines targeted land-use goals to achieve these environmental objectives across diverse terrains.

Solution:

(a) The revised National Forest Policy of India emphasizes maintaining ecological balance and environmental stability through the expansion of forest and tree cover.

(b) To prevent soil erosion, flash floods, and land degradation, the policy recommends maintaining specific levels of forest cover based on regional topography.

(c) For the lowlands and plains, where human infrastructure and agriculture are concentrated, the statutory guideline sets a minimum threshold of 33% forest cover.

(d) In mountainous regions and hills, the steep slopes are more vulnerable to landslides, watershed degradation, and soil loss.

(e) To stabilize these fragile highland landscapes, the policy mandates a higher target of 67% forest cover. This brings the national target to an average of one-third of the total geographical area.

Final Answer: 33% in plains and 67% in hills.

Answer: (B)

Go Back to Question 15

Q16.

Solution

Concept: Economic botany deals with cultivated plant species that support human survival and industrial production. Bread wheat (*Triticum aestivum*) serves as a primary staple cereal worldwide, and its evolutionary history provides an example of polyploid speciation in crops.

Solution:

(a) Modern bread wheat is not a simple diploid organism; rather, its genome formed through a series of natural hybridization events involving three distinct ancestral diploid grass species.

(b) This interspecific hybridization coupled with spontaneous chromosome doubling led to an allopolyploid genetic configuration containing three distinct sets of chromosomes (designated as genomes A, B, and D).

(c) Since each ancestral genome contributes a diploid set of 14 chromosomes ($2n = 14$), the combination of these three sets results in a hexaploid organism ($6n$).

(d) Multiplying the basic monoploid chromosome number ($x = 7$) by the hexaploid factor ($6x$) gives a total somatic chromosome count of 42 ($2n = 42$).

(e) This hexaploid genetic structure contributes to the crop's broad environmental adaptability and high protein content, supporting its widespread cultivation during the Rabi season.

Final Answer: Hexaploid; $2n = 42$.

Answer: (B)

Go Back to Question 16

Q17.

Solution

Concept: Agricultural practice in arid regions relies on cultivating crop species adapted to low water availability and high thermal conditions. The family Brassicaceae includes several oilseed crops that are central to the agricultural economy of northern and western India.

Solution:

(a) Arid zones in Rajasthan require crops with deep root systems and efficient water use to withstand dry periods during the winter growing season.

(b) Indian Mustard, botanically classified as *Brassica juncea* and locally called Rai, is a major crop in these dry farming systems.

(c) As a member of the Brassicaceae family, it has floral features like tetradynamous stamens and a specialized siliqua fruit containing oil-rich seeds.

(d) The extracted seed oil has a sharp, pungent aroma due to glucosinolates, and features a high concentration of erucic acid, a long-chain fatty acid.

(e) While crops like soybeans, castor beans, and groundnuts also produce commercial oils, they belong to different plant families, leaving Indian Mustard as the representative oilseed crop for this region.

Final Answer: *Brassica juncea* (Indian Mustard).

Answer: (B)

Go Back to Question 17

Q18.

Solution

Concept: Medicinal plants synthesize secondary metabolites that have therapeutic effects on human physiology. Plant taxonomy classifies these species into families based on shared structural, floral, and genetic characteristics.

Solution:

(a) Ashwagandha, known botanically as *Withania somnifera* and often called Indian ginseng, is used in traditional Ayurvedic medicine as an adaptogen to reduce stress and boost immunity.

(b) The active medicinal properties are derived from secondary metabolites called withanolides, which are concentrated in the roots and leaves of the plant.

(c) Examining its floral features reveals five fused petals, alternate leaves, and a superior ovary that develops into a berry enclosed by an enlarged calyx.

(d) These structural traits place *Withania somnifera* in the Solanaceae family, alongside other economically important crops like potatoes, tomatoes, and chili peppers.

(e) While families like Fabaceae and Apiaceae also contain medicinal species, Ashwagandha belongs to Solanaceae.

Final Answer: Solanaceae.

Answer: (A)

Go Back to Question 18

Q19.

Solution

Concept: Spice cultivation forms a major sector of cash-crop farming in arid and semi-arid regions. Successful production requires matching crop choices with regional soil types, seasonal weather patterns, and proper botanical identification.

Solution:

(a) Cumin, locally called Jeera, is a major spice crop grown during the Rabi season in western and northern Rajasthan due to its low water requirements.

(b) The plant is an annual herb known botanically as *Cuminum cyminum*, a member of the Apiaceae (Umbelliferae) family characterized by its umbrella-like umbel inflorescences.

(c) The commercially valuable part of the plant is the small, ridged seed-like structure harvested at maturity.

(d) Anatomically, this structure is not a true seed but a dried schizocarpic fruit that splits into two single-seeded mericarps containing essential oils like cuminaldehyde.

(e) Other options mix up the harvested parts; for example, coriander is grown primarily for both its foliage and fruits, whereas fenugreek produces pods with angular seeds rather than root tubers.

Final Answer: Cumin – *Cuminum cyminum* – Dried Schizocarpic Fruit.

Answer: (B)

Go Back to Question 19

Q20.

Solution

Concept: Genetic engineering relies on vector molecules to transfer foreign DNA fragments into host cells for replication and expression. A functional cloning vector requires a group of specialized sequence domains to manage this molecular process.

Solution:

(a) During transformation, host cells are exposed to a vector solution, but only a small percentage take up the foreign plasmid DNA. This leaves a mixture of transformed and non-transformed cells.

(b) To isolate the modified cells, researchers use selectable marker genes included in the vector design, which usually confer resistance to specific antibiotics like ampicillin or tetracycline.

(c) When the host cells are cultured on a selective agar medium containing these antibiotics, cells without the plasmid cannot survive and die.

(d) Cells that successfully integrated the vector express the resistance enzymes, allowing them to grow into visible colonies.

(e) Selectable markers thus serve as a screening tool to identify and select transformants while eliminating non-transformed background cells.

Final Answer: It allows the selective identification and survival of transformant host cells while eliminating non-transformants.

Answer: (A)

Go Back to Question 20

Q21.

Solution

Concept: Recombinant DNA technology relies on selection strategies to distinguish between recombinant and non-recombinant cells. Insertional inactivation is a classic screening method where cloning a foreign DNA fragment directly inside the coding region of a selectable marker gene permanently disrupts its operational framework.

Solution:

(a) The pBR322 plasmid serves as a standard cloning vehicle containing two distinct antibiotic resistance marker genes: ampicillin resistance (amp^R) and tetracycline resistance (tet^R).

(b) The unique restriction endonuclease cleavage site for the enzyme *BamHI* is located inside the regulatory coding sequence of the tetracycline resistance gene (tet^R).

(c) When a foreign gene fragment of interest is successfully ligated at this *BamHI* restriction site, it breaks the open reading frame of the tet^R gene, preventing the expression of the functional enzyme.

(d) This structural disruption leaves the resulting recombinant plasmid unable to confer tetracycline immunity to its host bacterium, a phenomenon termed insertional inactivation.

(e) Since the ampicillin resistance gene (amp^R) remains fully intact on the opposite side of the circular plasmid, the host cell retains full resistance to ampicillin, allowing it to survive on ampicillin-supplemented plates while perishing on tetracycline-supplemented media.

Final Answer: It will retain ampicillin resistance but lose tetracycline resistance due to insertional inactivation.

Answer: (C)

Go Back to Question 21

Q22.

Solution

Concept: Plant tissue culture and micropropagation are founded on specific developmental rules governing the regeneration of differentiated somatic cells. Unlike specialized animal tissues, many mature somatic plant cells retain their full genetic potential and can reorganize their developmental programming when given appropriate biochemical signals.

Solution:

(a) The biological property that allows an isolated, non-reproductive somatic cell or tissue explant to revert to an undifferentiated state and generate an entire, functional individual is called cellular totipotency.

(b) Gottlieb Haberlandt first proposed this concept in 1902, predicting that isolated plant vegetative cells could be grown in artificial nutrient solutions to regenerate complete plants.

(c) When an explant is placed on a sterile agar medium with balanced ratios of auxins and cytokinins, it undergoes dedifferentiation to form a mass of dividing cells called a callus.

(d) Subsequent changes in hormone concentrations trigger redifferentiation, inducing organogenesis (forming roots and shoots) or somatic embryogenesis to build a whole plantlet.

(e) This totipotent capacity differentiates plant cells from pluripotent animal stem cells, which can form various tissue lineages but cannot regenerate a complete, independent organism on their own.

Final Answer: Cellular Totipotency.

Answer: (C)

Go Back to Question 22

Q23.

Solution

Concept: Plant pathology studies the interactions between host plants and specialized pathogens that cause visible disease symptoms. Fungal pathogens are classified into specific taxonomic groups based on their mycelial structures, reproductive stages, and how their spores present on host surfaces.

Solution:

(a) The appearance of a powdery, chalk-like white dusting on the upper leaf blades, petioles, and stems of agricultural crops points to the widespread fungal disease known as powdery mildew.

(b) For spice crops like cumin and various cruciferous hosts, this specific disease is caused by the ascomycete fungus *Erysiphe polygoni*, an obligate biotrophic parasite.

(c) The white powdery coating consists of a network of superficial fungal hyphae growing over the host epidermis, along with vertical chains of asexual spores called conidia.

(d) These conidia are easily detached and carried by wind currents, spreading the infection across neighboring fields during cool, humid winter periods.

(e) In contrast, the oomycete *Albugo candida* causes white rust, which appears as distinct, smooth white blisters on the lower leaf surfaces rather than a dusty, continuous powdery layer across the upper foliage.

Final Answer: *Erysiphe polygoni* (Powdery mildew).

Answer: (B)

Go Back to Question 23

Q24.

Solution

Concept: Crop protection in semi-arid zones requires identifying endemic plant pathogens that target major staple food crops. Specific oomycete pathogens cause downy mildew infections that trigger severe developmental deformities in the reproductive structures of cereal grasses.

Solution:

(a) Green Ear disease, or downy mildew, is a destructive infection affecting Pearl Millet (*Pennisetum glaucum*, locally called Bajra) across the sandy soils of Rajasthan.

(b) This disease is caused by the obligate oomycete pathogen *Sclerospora graminicola*, which survives as dormant oospores in contaminated soil or seed coats.

(c) The pathogen invades host tissues early in development, leading to systemic infections that produce a soft, downy growth of sporangiophores on the undersides of leaves.

(d) The diagnostic symptom appears during the flowering stage, where the pathogen disrupts normal floral development in the emerging ear head.

(e) This hormonal disruption causes phyllody, transforming fertile floral organs into twisted, green leafy structures. This completely prevents grain formation and gives the inflorescence its characteristic green ear appearance.

Final Answer: *Sclerospora graminicola*.

Answer: (A)

Go Back to Question 24

Q25.

Solution

Concept: Bacterial plant pathogens invade host tissues through natural openings or mechanical wounds, disrupting internal cellular systems. Managing these highly contagious diseases requires understanding their transmission pathways and environmental triggers.

Solution:

(a) Citrus Canker is a severe disease affecting acid lime and lemon orchards throughout Rajasthan, causing raised, corky, brown necrotic spots surrounded by yellow halos on leaves, twigs, and fruits.

(b) This disease is caused by the rod-shaped, Gram-negative bacterium *Xanthomonas citri* subsp. *citri*, which multiplies inside the host's intercellular leaf spaces.

(c) The bacteria ooze out from active lesions when moisture is present, making water the primary agent for short-distance spread.

(d) Wind-driven rain droplets carry the bacterial cells through the air, depositing them onto healthy citrus trees where they enter through stomata or wounds caused by thorns.

(e) Human activities also spread the pathogen; contaminated pruning tools, clothing, and moving infected nursery stock can quickly introduce the bacteria into clean orchards.

Final Answer: Bacterial pathogen (*Xanthomonas citri*); wind-driven rain and mechanical pruning tools.

Answer: (B)

Go Back to Question 25

Q26.

Solution

Concept: Animal taxonomy classifies invertebrates into phyla based on fundamental body plans, embryonic tissue layers, coelom configurations, and the complexity of internal organ systems.
Solution:

(a) The presence of a pseudocoelom—a body cavity left unlined by mesodermal tissue layers—is the defining embryonic trait of the phylum Aschelminthes, also known as Nematoda.

(b) These roundworms have a complete, straight digestive tract running from the mouth to the anus, supported by a specialized muscular pharynx that pumps food into the gut.

(c) Their outer boundary consists of a non-cellular, collagenous cuticle secreted by an underlying syncytial epidermis, which contains multiple nuclei without individual cell walls.

(d) Lacking specialized circulatory or respiratory systems, roundworms rely on the fluid in the pseudocoelom to transport nutrients and dissolved gases throughout the body.

(e) In contrast, Platyhelminthes are acoelomate flatworms, while Annelida and Arthropoda are true coelomates with segmented bodies, leaving Aschelminthes as the matching group.

Final Answer: Aschelminthes (Nematoda).

Answer: (A)

Go Back to Question 26

Q27.

Solution

Concept: Animal histology categorizes epithelial tissues based on cell shape, layer density, and specialized surface modifications that support specific physiological roles within organ systems.

Solution:

(a) Epithelial linings that require surface transport mechanisms feature specialized apical modifications known as cilia, which are hair-like, microtubule-based projections capable of synchronized movement.

(b) In the respiratory bronchioles, this ciliated epithelium is interspersed with mucus-secreting goblet cells, forming a transport loop that sweeps trapped dust particles up toward the pharynx.

(c) In the female fallopian tubes, ciliated columnar cells line the lumen, generating directional fluid currents that help transport the ovum or zygote toward the uterus.

(d) Simple squamous epithelium forms thin barriers optimized for passive diffusion, whereas stratified squamous layers are built to withstand mechanical wear and tear.

(e) The need for active, directed transport in both the respiratory tract and reproductive oviducts requires a ciliated columnar or cuboidal epithelial lining.

Final Answer: Ciliated columnar/cuboidal epithelium.

Answer: (C)

Go Back to Question 27

Q28.

Solution

Concept: Annelid anatomy features a complex, closed circulatory system where blood remains confined within continuous vascular channels. This vascular network relies on specific contractile vessels and lateral pumps to maintain directional blood flow through the body segments.

Solution:

(a) The Indian earthworm, *Pheretima posthuma*, possesses a true closed circulatory system where hemoglobin is dissolved directly in the liquid plasma rather than carried in red blood cells.

(b) In this circulatory layout, the dorsal vessel is the primary contractile channel, using peristaltic waves to drive blood forward along the animal's back.

(c) The ventral vessel runs beneath the digestive tract, carrying blood backward toward the posterior segments without independent contractions.

(d) In segments 7, 9, 12, and 13, the dorsal and ventral vessels are linked by four pairs of muscular, pulsating channels called lateral and lateral-esophageal hearts.

(e) These lateral hearts contain one-way internal valves that pump blood downward from the dorsal channel into the ventral network, matching the setup shown in the TikZ schematic. Cockroaches, by contrast, have an open circulatory system with a open hemocoel cavity.

Final Answer: *Pheretima posthuma* (Earthworm).

Answer: (C)

Go Back to Question 28

Q29.

Solution

Concept: Arthropod morphology relies on precise structural layout, where specific reproductive organs and accessory glands are positioned within designated segments of the abdomen or thorax.
Solution:

(a) The reproductive system of a male cockroach (*Periplaneta americana*) includes a large, mushroom-shaped accessory structure known as the utricular gland.

(b) This gland consists of an organized cluster of small tubules (utriculi majores and utriculi minores) that secrete fluids to coat and nourish sperm cells.

(c) Anatomically, this mushroom gland sits in the anterior region of the male abdomen, specifically occupying the 6th and 7th abdominal segments.

(d) The secretions from these tubules help package sperm into a multi-layered capsule called a spermatophore, which is transferred to the female during mating.

(e) The pair of testes resides further forward in the 4th to 6th segments, while the 9th and 10th segments house external genitalia like phallomeres and anal cerci, placing the mushroom gland in segments 6 and 7.

Final Answer: 6th to 7th abdominal segments.

Answer: (B)

Go Back to Question 29

Q30.

Solution

Concept: Invertebrate physiology uses specialized excretory structures to manage osmoregulation and remove nitrogenous wastes from coelomic fluid or hemolymph, with designs varying significantly across phyla.

Solution:

(a) Earthworms use an organized network of paired metanephridia distributed throughout their body segments to process metabolic wastes and regulate fluid balance.

(b) A typical metanephridium opens into the coelomic cavity via a ciliated, funnel-shaped structure called the nephrostome.

(c) This ciliated funnel draws in coelomic fluid, driving it through a long, coiled glandular tubule wrapped in blood capillaries.

(d) As the fluid flows through the tubule, useful ions, water, and nutrients are reabsorbed into the bloodstream, concentrating the nitrogenous waste products.

(e) The remaining waste fluid is then carried to the body wall and discharged outside through small pores called nephridiophores.

(f) Other structures listed belong to different groups; flame cells are found in flatworms, Malpighian tubules in insects, and green glands in crustaceans, leaving metanephridia as the correct answer for annelids.

Final Answer: Metanephridia (Nephrostome and Nephridiophore).

Answer: (C)

Go Back to Question 30

Q31.

Solution

Concept: Economic zoology and agricultural entomology study the lifecycle stages of prominent insect pests to identify when they cause the most severe structural damage to crops. Subterranean root-feeding pests often exhibit specialized larval phases that are adapted to live and feed entirely within soil horizons.

Solution:

(a) The white grub beetle species *Holotrichia consanguinea* undergoes complete holometabolous metamorphosis involving four separate developmental stages: egg, larva (grub), pupa, and adult.

(b) While the adult beetles emerge from the subsurface soil following early monsoon rains to feed nocturnally on the leaves of nearby trees, their feeding has a minimal impact on major field crops.

(c) The female beetles return to lay their eggs deep inside warm soil cracks, where the emerging young larvae develop through three distinct instars.

(d) These subterranean C-shaped larvae possess strong, chitinous biting-and-chewing mandibles specifically adapted for underground feeding.

(e) The second and third instar grubs feed aggressively on the fibrous root systems of groundnut and pearl millet plants, cutting off water and nutrient transport, which causes extensive patch-drying and field collapse.

Final Answer: Grub (larval) stage in subsurface soil.

Answer: (B)

Go Back to Question 31

Q32.

Solution

Concept: Post-harvest food security relies on monitoring stored grain insect pests, which are classified as primary or secondary pests depending on their ability to breach intact seed coats. Internal grain feeders possess unique physiological adaptations that allow them to live in dry environments.

Solution:

(a) The Khapra beetle, known scientifically as *Trogoderma granarium*, is a highly destructive primary pest that targets stored wheat, barley, and oilseeds across dry regions.

(b) This insect is adapted to thrive in low moisture levels and high storage temperatures, allowing it to survive in grain heaps with a moisture content of less than 2%.

(c) The adult beetles are short-lived and do not feed on the stored grains, meaning they do not directly reduce the weight of the crop.

(d) Instead, the damage is caused entirely by the hairy, yellowish-brown larval stage, which uses specialized chewing mouthparts to penetrate intact grain kernels.

(e) The larvae feed on the nutrient-rich inner endosperm and germ, leaving behind empty grain shells, shed larval skins, and fine frass that ruins the commercial quality of the wheat.

Final Answer: *Trogoderma granarium* (Khapra Beetle).

Answer: (A)

Go Back to Question 32

Q33.

Solution

Concept: Applied entomology uses multi-tiered control strategies to suppress insect pest populations while minimizing ecological damage. This approach avoids total chemical eradication, focusing instead on keeping pest densities below established economic thresholds.

Solution:

(a) Relying solely on synthetic chemical pesticides can lead to pest resistance, secondary pest outbreaks, and toxic residues in food webs.

(b) To address these issues, Integrated Pest Management (IPM) combines cultural, physical, biological, and chemical control methods into a unified strategy.

(c) Cultural practices, such as deep summer plowing, expose buried pest pupae to birds and solar heat, lowering initial pest numbers.

(d) Biological control relies on natural predators and parasitoids, such as releasing *Trichogramma* wasps to target and destroy lepidopteran pest eggs.

(e) Pheromone traps use synthetic insect sex attractants to disrupt mating cycles and monitor pest density. Chemical treatments are used only as a last resort when pest levels cross the Economic Injury Level (EIL).

Final Answer: Integrated Pest Management (IPM).

Answer: (B)

Go Back to Question 33

Q34.

Solution

Concept: Agricultural engineering focuses on designing and operating fluid-application equipment to distribute crop protection chemicals. Choosing the right machinery depends on farm size, target crop type, and the mechanical drive system of the sprayer pump.

Solution:

(a) Small vegetable plots and patch-cropped fields require portable, hand-operated spray equipment that provides reliable pressure without needing motorized fuel or tractor attachments.

(b) The hand-operated hydraulic knapsack sprayer features a molded spray tank worn on the operator's back, fitted with a manual lever assembly.

(c) Operating this lever drives a internal piston or diaphragm inside a sealed pressure chamber, creating a manual hydraulic head.

(d) This continuous pressure forces the liquid pesticide out through a delivery hose and a directional nozzle, breaking the fluid into a fine spray pattern.

(e) Motorized mist blowers use engine-driven fans to break up spray droplets, while tractor-mounted boom sprayers are designed for large fields, leaving the manual hydraulic knapsack sprayer as the best option for small plots.

Final Answer: Hand-operated Knapsack Hydraulic Sprayer.

Answer: (B)

Go Back to Question 34

Q35.

Solution

Concept: Commercial sericulture and lac culture study the physiological secretions of beneficial insects. Specialized glands within the insect integument produce complex resinous or fibrous matrices that serve protective functions during development.

Solution:

(a) The lac insect, *Laccifer lacca* (also classified as *Kerria lacca*), is a small phytophagous scale insect that inserts its long proboscis into host plant tissues to feed on sap.

(b) After settling on a twig, the insect begins secreting a complex resinous substance to build a protective shield around its soft body.

(c) This natural resin is produced by specialized dermal cuticular glands distributed across the insect's body surface.

(d) The liquid secretion hardens upon contact with the air, forming a solid, encrusted matrix known as raw lac around the growing insect.

(e) In contrast, silk insects produce their fibers from modified labial salivary glands, while lac insects rely entirely on these dermal cuticular glands to extrude their resinous shell.

Final Answer: Dermal cuticular glands distributed across the body surface.

Answer: (B)

Go Back to Question 35

Q36.

Solution

Concept: Nutritional biochemistry examines how vitamins act as coenzymes or structural precursors in essential human metabolic pathways. The synthesis of blood coagulation proteins in the liver requires specific fat-soluble vitamins to complete post-translational modifications.

Solution:

(a) Hemostasis relies on a cascade of plasma clotting factors that convert soluble fibrinogen into an insoluble fibrin mesh to seal vascular injuries.

(b) The liver synthesizes several core clotting factors, including Prothrombin (Factor II), Factor VII, Factor IX, and Factor X, as inactive zymogen precursors.

(c) Activating these proteins requires adding carboxyl groups to specific glutamic acid residues, a reaction catalyzed by the microsomal enzyme gamma-glutamyl carboxylase.

(d) This carboxylase enzyme requires the fat-soluble Vitamin K (phylloquinone) as an essential electron donor and coenzyme to complete the modification.

(e) Without sufficient Vitamin K, the clotting factors remain uncarboxylated and cannot bind calcium ions or attach to platelet membranes, disrupting the coagulation cascade and increasing bleeding risks.

Final Answer: Vitamin K (Phylloquinone).

Answer: (C)

Go Back to Question 36

Q37.

Solution

Concept: Gastrointestinal physiology studies how distinct structural layouts match specific nutrient transport systems across the intestinal brush border. Water-soluble and fat-soluble molecules follow separate absorption pathways based on their chemical properties.

Solution:

(a) Digesting dietary lipids breaks down large triglycerides into individual long-chain fatty acids and 2-monoglycerides within the intestinal lumen.

(b) These hydrophobic lipid components combine with bile salts to form water-soluble aggregates called micelles, which ferry the lipids to the microvillus brush border.

(c) Once inside the enterocytes, the long-chain fatty acids are transported to the smooth endoplasmic reticulum, where they are re-esterified into triglycerides.

(d) These hydrophobic triglycerides are then packaged with cholesterol and phospholipids, and coated with apolipoproteins to form water-soluble spheres called chylomicrons.

(e) Because chylomicrons are too large to pass through the tight basement membranes of blood capillaries, they exit via exocytosis and enter the larger pores of the central lacteal, traveling through the lymphatic system instead.

Final Answer: Long-chain fatty acids and monoglycerides.

Answer: (C)

Go Back to Question 37

Q38.

Solution

Concept: Metabolic integration adjusts biochemistry during fasting, exercise, or carbohydrate restriction to maintain stable blood glucose levels. The body switches between breaking down stored glycogen and synthesizing glucose from scratch depending on nutrient availability.

Solution:

(a) During the early hours of fasting, the liver maintains blood glucose levels by breaking down stored glycogen reserves through glycogenolysis.

(b) Once liver glycogen stores are depleted after prolonged fasting, the body activates an alternate pathway to synthesize glucose from non-carbohydrate precursors.

(c) This biochemical pathway is called gluconeogenesis, and it takes place primarily within the cytosol and mitochondria of hepatocytes and renal cortical cells.

(d) The primary substrates for this pathway include lactate from anaerobic glycolysis, glycerol from adipose tissue lipolysis, and glucogenic amino acids from muscle protein breakdown.

(e) This process reverses most steps of glycolysis using specialized bypass enzymes, ensuring a steady supply of glucose for glucose-dependent tissues like the brain and red blood cells.

Final Answer: Gluconeogenesis.

Answer: (C)

Go Back to Question 38

Q39.

Solution

Concept: Pediatric clinical nutrition classifies protein-energy malnutrition (PEM) into distinct types based on dietary deficiencies, body mass indices, and physical symptoms. Nutritional deficits can present as generalized starvation or selective macronutrient deficiencies.

Solution:

(a) Marasmus is a form of severe protein-energy malnutrition caused by a balanced deficiency of both total dietary calories and protein.

(b) It typically occurs in infants under one year of age when breast milk is replaced too early by diluted, nutrient-poor supplements.

(c) This severe calorie restriction forces the body to break down skeletal muscle and adipose tissue reserves for energy, leading to extreme emaciation and a wrinkled skin appearance.

(d) In contrast, Kwashiorkor is caused by a selective protein deficiency despite adequate total calorie intake, which often happens in older children transitioned to high-starch diets.

(e) Kwashiorkor preserves some subcutaneous fat but causes hypoalbuminemia, leading to systemic fluid retention and edema, which helps differentiate it from the unswollen, wasted appearance of Marasmus.

Final Answer: Marasmus.

Answer: (B)

Go Back to Question 39

Q40.

Solution

Concept: Endocrine regulation of digestion coordinates the release of pancreatic enzymes, buffering agents, and bile salts in response to food entering the digestive tract. Specialized duodenal mucosal cells monitor acidity and nutrient composition to trigger appropriate hormonal signals.

Solution:

(a) When acidic chyme containing partially digested lipids and proteins moves from the stomach into the duodenum, it triggers the release of local digestive hormones.

(b) In response to the presence of fats and amino acids, duodenal I-cells secrete cholecystokinin (CCK) into the bloodstream.

(c) CCK travels to the gallbladder, stimulating it to contract and release bile salts, while also prompting pancreatic acinar cells to secrete digestive enzymes.

(d) Simultaneously, the low pH of the incoming chyme stimulates duodenal S-cells to release secretin.

(e) Secretin acts mainly on pancreatic duct cells, prompting them to secrete water and bicarbonate ions to neutralize gastric acid, working alongside CCK to optimize conditions for intestinal digestion.

Final Answer: Cholecystokinin (CCK) and Secretin.

Answer: (B)

Go Back to Question 40

Answer Key

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