UPCATET Agriculture Zoology Sample Paper-7

Duration: 20 Minutes **Maximum Marks: 100**

Instructions

- This paper contains **25** Multiple Choice Questions.
- Each correct answer carries **+4** mark. Incorrect answer: **−1** marks. Only **one** correct option.
- Unattempted questions carry **0** marks.
- Use of mobile phones, smartwatches, or any electronic gadgets is strictly prohibited.

Q1. The hepatopancreas of Carcinus maenas (edible crab) differs fundamentally from the hepatic tissue of vertebrates in its embryological origin and functional complexity. Which of the following statements best describes this organ's structural organization and physiological roles?

(A) A compound endoderm-derived gland exclusively responsible for glycogen synthesis and lipid mobilization only

(B) A mesodermal structure that functions solely in hemolymph filtration and urine concentration

(C) A hepatopancreatic structure combining both digestive enzyme secretion and metabolic storage, derived from midgut endoderm, functioning in concurrent lipase, amylase, and protease synthesis

(D) An ectodermal invagination purely dedicated to cholesterol regulation in hemocytes

Q2. The brown planthopper (Nilaparvata lugens) causes massive yield losses in rice through its piercing-sucking feeding activity. Under high population pressure conditions, a morphological shift occurs from macropter to brachypter morphs. Which neurobiological and endocrinological factors primarily trigger this dimorphic transition?

(A) Increased juvenile hormone (JH) titers combined with serotonergic signaling from chemoreceptors detecting plant alkaloid accumulation

(B) Mechanical stimulation via decreased antennal mechanoreceptor activation due to lower crowding density

(C) Elevated ecdysone pulses triggered by visual photoreception of shortened photoperiod alone

(D) Thermal stress-induced hypothermia causing direct suppression of flight muscle development

Q3. During the histological sectioning of an insect tracheal system, a researcher observes that the tracheal walls contain a continuous spiral thickening called taenidia derived from ectodermal invagination. What is the fundamental advantage of this structure in the context of gas exchange efficiency and mechanical integrity?

(A) Increases surface area for water vapor absorption while maintaining rigid structural support

(B) Prevents tracheal collapse during high-speed flight while maintaining patency for unobstructed gaseous diffusion

(C) Actively pumps oxygen molecules through molecular channels using ATP-dependent mechanisms

(D) Selectively filters out harmful nitrogen compounds before they reach tracheoles

Q4. The armyworm pest complex (Spodoptera litura, Spodoptera frugiperda) shows differential susceptibility to baculovirus infections based on larval midgut pH, peritrophic matrix composition, and virus-specific binding protein expression. What is the cellular mechanism by which the peritrophic matrix regulates pathogen entry?

(A) It acts as a semipermeable physical barrier controlling molecular size exclusion while maintaining pH gradient for enzyme activity optimization

(B) It secretes systemic antimicrobial peptides that directly lyse viral envelopes through complement-like cascades

(C) It actively transports viral particles via endocytosis into epithelial cells for rapid immune processing

(D) It inhibits water reabsorption entirely, flushing pathogens before they can establish infection foci

Q5. Comparative examination of the cellular ultrastructure reveals that Meloidogyne arenaria (root-knot nematode) possesses highly specialized esophageal glands with cytoplasmic densities rich in rough endoplasmic reticulum and Golgi complexes arranged in extensive cisternae. This structural organization supports synthesis and secretion of which molecular category of pathogenic substances?

(A) Chitin-binding lectin-type proteins that interfere with host cell wall integrity alone

(B) Cell wall-degrading pectinases, cellulases, and hemicellulases; phytohormone-mimicking peptides; and cell-cycle modulating effector proteins

(C) Purely protease inhibitors that block all host protease function irreversibly

(D) Simple inorganic calcium salts that mineralize root tissues into brittle structures

Q6. The tobacco armyworm (Manduca sexta) demonstrates temporal resource allocation polymorphism during its larval phase, shifting feeding intensity and metabolic rate in response to photoperiod and nutritional status. How does the neuroendocrine axis regulate this behavioral plasticity through insulin-like peptide signaling?

(A) Insulin-like peptides directly inhibit juvenile hormone synthesis, triggering immediate dispersal behavior and reduced feeding

(B) Insulin-like peptides integrate nutritional state information from nutrient-sensing neurons to regulate lipid storage metabolism, growth rate, and reproductive maturation timing

(C) Insulin-like peptides exclusively regulate hemolymph glucose levels without affecting behavioral phenotypes

(D) Insulin-like peptides competitively inhibit ecdysone binding to its nuclear receptor, delaying metamorphosis indefinitely

Q7. A parasitic nematode (Strongylus equinus) infesting equine hosts displays a complex life cycle involving free-living larval stages in soil and parasitic stages within the equine gastrointestinal tract. Which of the following statements accurately characterizes the physiological and biochemical adaptations enabling parasitic competence?

(A) Development of a chitinous exoskeleton capable of withstanding 100C temperatures indefinitely

(B) Expression of anticoagulant peptides, immunosuppressive compounds, and metabolic adaptation to low-oxygen microenvironments within host tissues

(C) Complete loss of nervous system function, relying entirely on diffusion-based sensory perception

(D) Synthesis of plant-derived photosynthetic pigments enabling heterotrophic nutrition independent of host resources

Q8. The German cockroach (Blattella germanica) exhibits remarkable pesticide resistance evolution through upregulation of cytochrome P450 monooxygenase isozymes (particularly CYP6A family) and altered target-site mutations in acetylcholinesterase. Which of the following mechanisms best explains the selective advantage under pesticide pressure?

(A) Increased detoxification enzyme expression through constitutive promoter activation in resistant populations combined with modified enzyme active sites reducing pesticide binding affinity

(B) Random mutation accumulation with no functional basis for enhanced resistance

(C) Enhanced cuticle thickness alone preventing all pesticide penetration

(D) Upregulation of excretory systems exclusively through increased nephridial activity without metabolic involvement

Q9. The larval development of the diamond-back moth (Plutella xylostella) involves five distinct instars before pupation. High-resolution histological analysis reveals progressive enlargement of the silk gland acini and increased cellular special-

ization for fibroin and sericin protein synthesis. What epigenetic regulatory mechanism coordinates this tissue-specific gene expression cascade?

(A) Random heterochromatin formation without specific regulatory elements or transcription factor involvement

(B) Stage-specific chromatin remodeling at silk protein gene promoters coupled with selective histone acetylation/deacetylation cycles and stage-specific transcription factor binding

(C) Permanent DNA methylation silencing all genes except silk proteins in an irreversible manner

(D) Constitutive expression of all genes uniformly throughout development without differential regulation

Q10. During systemic infection by Heterorhabditis bacteriophora (entomopathogenic nematode), the nematode's bacterial symbiont (Photorhabdus luminescens) secretes multiple virulence factors including photobacterone and Tc toxins. What is the primary mechanism by which these toxins subvert host insect immune homeostasis?

(A) Direct inhibition of melanin synthesis through tyrosinase inactivation, combined with suppression of hemocyte phagocytic capability and phenoloxidase cascade activation

(B) Purely mechanical obstruction of tracheal system without involving immune pathways

(C) Stimulation of excessive immune response leading to rapid encapsulation and walling-off of pathogens

(D) Conversion of insect hemolymph into plant tissue through de novo cellular differentiation

Q11. The whitefly (Bemisia tabaci) vector complex exhibits distinct host plant specialization (Q biotype preferring cotton; B biotype preferring cassava) based on differential expression of detoxification genes and chemosensory receptor repertoires. How does this reproductive isolation mechanism function at the molecular level?

(A) Complete inability to process any plant chemistry, relying on random dispersal

(B) Identical detoxification machinery across all biotypes with no host preference mechanisms

(C) Mechanical mandibular incompatibility preventing mating between biotypes regardless of chemical communication

(D) Different olfactory receptor neuron populations detect host-specific volatile organic compounds, triggering differential xenobiotic enzyme expression and reproductive maturation only on preferred host plants through pheromone-mediated mate recognition

Q12. The apple maggot fly (Rhagoletis pomonella) displays rapid host-race formation within historic timeframes, with distinct populations specializing on apple versus hawthorn fruits through allochronic reproductive isolation (earlier fruiting synchrony in apple trees). Which neurobiological mechanism enables this reproductive temporal shift?

(A) Complete reversal of circadian clock periodicity without any underlying molecular basis

(B) Random variation in development time with no adaptive significance

(C) Photoperiod-independent circadian rhythm entrainment coupled with fruit volatile-mediated acceleration of larval development and adult eclosion timing through temperature-responsive transcription factors

(D) Fixed genetic determination with no environmental responsiveness whatsoever

Q13. Microscopic examination of the silk producing region in Bombyx mori reveals unique posterior silk gland (PSG) cells organized into a syncytium rather than individual cells. What functional advantage does this syncytial organization provide during fibroin protein secretion?

(A) Prevents any protein synthesis entirely through nuclear material dispersion

(B) Allows coordinated, massive protein synthesis and secretion through shared cytoplasmic pools with synchronized ER-Golgi trafficking without cellular

bottlenecks

(C) Enables aerobic respiration at rates 100 times higher than normal cells without mitochondrial involvement

(D) Directly photosynthesizes glucose from light radiation independent of carbohydrate metabolism

Q14. The red cotton bug (Dysdercus cingulatus) undergoes diapause in response to shortening photoperiod, involving suppression of gonadotropin-releasing hormone (GnRH)-equivalent neuropeptide release from neurosecretory cells. Which neural afferent pathway processes photoperiodic information for diapause induction?

(A) Optic lobe photoreceptors (simple ocelli and compound eye lamina) signal through lateral neurons and clock neurons to the pars intercerebralis, modulating juvenile hormone III synthesis rhythmically

(B) Direct chemoreceptive detection of seasonal carbon dioxide concentrations without visual involvement

(C) Thermal sensing alone through cuticular thermoreceptors triggering diapause regardless of light conditions

(D) Random internal oscillations producing diapause without any external environmental stimulus

Q15. The structural organization of the mouthparts in blood-feeding dipterans (Aedes aegypti, Anopheles stephensi) includes a sophisticated piercing-sucking apparatus with sensory hair-like chemoreceptors concentrated on labial palps. How does this morphological configuration enhance host-seeking and feeding efficiency?

(A) Inability to detect any chemical signals, relying purely on visual cues for host location

(B) Taste receptors exclusively respond to plant nectar without recognizing animal-derived compounds

(C) Random wandering behavior without any directional host-seeking mechanism

(D) Chemoreceptors detect host kairomones (lactic acid, CO2, body odors) with sensitivity thresholds in the parts-per-billion range, enabling directed upwind anemotaxis to hosts combined with gustatory discrimination of blood meal suitability during insertion

Q16. During the process of egg-to-adult development in Drosophila melanogaster, the larval fat body undergoes massive cellular remodeling during metamorphosis, with programmed autophagy degrading obsolete structures while selective protein synthesis provides amino acids for adult tissue development. What molecular mechanism triggers this selective degradation?

(A) Ecdysone-mediated rapid induction of autophagy-related genes through direct transcriptional activation of atg gene family members; coupled with miRNA-mediated suppression of mTOR signaling pathway, enabling selective autophagic degradation of larval-specific proteins

(B) Complete cessation of all cellular processes without any molecular signaling

(C) Indefinite retention of larval structures through blocking autophagy entirely

(D) Random protein degradation without any specificity or regulatory mechanism

Q17. The soil nematode (Caenorhabditis elegans) possesses bilateral sensory neurons capable of detecting extremely minute chemical gradients (concentration differences as small as 1% per cell body diameter). What specialized adaptations in ion channel composition and neural signaling enable this extraordinary chemotactic sensitivity?

(A) Utilization of voltage-gated calcium channels with modified pore selectivity combined with G-protein-coupled receptor activation of phospholipase C-mediated IP3/diacylglycerol cascades enabling amplification of minute concentration differences into robust neural responses

(B) Loss of all ion channel function relying purely on osmotic pressure differences

(C) Inability to detect any chemical gradients without external amplification devices

(D) Random neural firing patterns without stimulus-response coupling

Q18. The parasitic flatworm (Fasciola hepatica) possesses a complex acetabular sucking apparatus with muscular layers arranged in both circular and radial orientations. Which biomechanical principle underlies the generation of adhesive force sufficient to withstand hepatic bile flow?

(A) Pure adhesive glue synthesis without mechanical force generation

(B) Electromagnetic force generation independent of muscle physiology

(C) Coordinated contraction of circular muscles creating negative pressure within the acetabulum combined with radial muscle tension stabilizing the acetabular margin against tissue deformation from external hydraulic forces

(D) Passive sinking into host tissue without active gripping mechanisms

Q19. The cotton leafworm (Spodoptera littoralis) synthesizes polyhydroxyalkanoate (PHA) polymer-like compounds in its hemolymph during starvation, enabling survival under resource-limited field conditions. Which metabolic pathway enables this unusual polymer synthesis in an insect system?

(A) Enhanced beta-oxidation of triglycerides combined with activation of acetyl-CoA carboxylase and fatty acid synthase generating polyunsaturated fatty acids subsequently polymerized through non-ribosomal peptide synthetase-like enzymes in hemocytes

(B) Direct photosynthesis of sugar polymers from atmospheric carbon dioxide

(C) Synthesis of cellulose identical to plant cell walls through expression of plant genes

(D) Conversion of hemolymph into solid rock-like structures through mineralization

Q20. In Periplaneta americana, the dorsal vessel (heart) exhibits myogenic autorhythmicity driven by calcium-dependent action potentials in isolated cardiac muscle tissue preparations, completely independent of neural input. Which ion channel properties enable this autonomous pacemaking activity?

(A) Complete dependence on external neural stimulation with no intrinsic cellular mechanism for rhythm generation

(B) Absence of any ion channels with uniform membrane potential throughout

(C) L-type calcium channels with slow activation kinetics coupled with delayed potassium channel activation creating oscillatory membrane potential changes in the absence of nervous input; combined with sarcoplasmic reticulum calcium release amplifying depolarization

(D) Exclusively sodium channel-dependent firing identical to vertebrate neural tissue

Q21. The cereal cyst nematode (Heteroderm avenae) produces complex carbohydrate-rich secretions from its esophageal glands that dissolve host plant cell walls and remodel cell structures into feeding cells (syncytia). What is the chemical nature of the cellulolytic enzyme complex secreted by this parasitic nematode?

(A) Purely protease enzymes capable of degrading only proteins without affecting cellulose

(B) Combination of endopectinase, endocellulase, and exocellulase enzymes derived from horizontal gene transfer from bacterial ancestors; coupled with pectin methylesterase enabling complete degradation of primary cell wall components

(C) Simple inorganic acid secretion (hydrochloric acid) without enzymatic involvement

(D) Synthetic pesticide compounds manufactured through unknown biosynthetic pathways

Q22. The migratory locust (Locusta migratoria) exhibits gregarious phase polyphenism involving dramatic morphological, physiological, and behavioral changes triggered by serotonergic neural circuits. Which population-level phenomenon drives this phase transformation under natural field conditions?

(A) Crowding-induced tactile stimulation of hind leg mechanoreceptors combined with visual stimuli from aggregate patterns triggering serotonin release

in the central complex and antennal lobes, driving behavioral aggregation and sustained flight musculature hypertrophy

(B) Complete isolation in solitary conditions with no crowding effects whatsoever

(C) Random morphological changes with no environmental trigger

(D) Purely genetic determination with zero environmental plasticity

Q23. The Mediterranean fruit fly (Ceratitis capitata) employs a sophisticated sterile insect technique (SIT) control strategy. What is the biological basis for the sterility induced by X-ray irradiation of males, and how does this affect reproductive potential?

(A) Elimination of male sexual interest and mating behavior entirely through neural destruction

(B) X-ray-induced dominant lethal mutations in the spermatogonial stem cells causing chromosome aberrations in sperm without affecting male mating competence; fertilized eggs from irradiated males fail to develop past embryonic stages due to recessive lethal allele homozygosity

(C) Conversion of males into females through sex reversal

(D) Development of permanent immunity to all future X-ray exposure in unexposed male offspring

Q24. The silkworm (Bombyx mori) exhibits sexual dimorphism in pheromone production, with exclusively female production of bombykol (sex pheromone) in specialized abdominal glands. What regulatory mechanism ensures sex-specific pheromone synthesis only in females?

(A) Sex-lethal (Sxl) transcription factor-mediated female-specific splicing of pheromonogen biosynthetic enzyme transcripts combined with developmental exposure to ecdysone and juvenile hormone regulating gland differentiation exclusively in females

(B) Complete inability of males to produce any pheromones through presence of Y chromosome-linked male determination factors

(C) Identical pheromone production in both sexes with female-specific sequestration preventing male release

(D) Random pheromone production with 50% chance in either sex independently

Q25. The parasitic copepod (Argulus japonicus) infecting fish hosts secretes anticoagulant compounds (bradykinins, leukotriene analogs) directly into the host blood during feeding. What is the molecular mechanism enabling these arthropod-derived compounds to interfere with vertebrate coagulation cascades?

(A) Structural mimicry of vertebrate prostaglandins enabling binding to G-protein-coupled receptors on platelets and endothelial cells, blocking thrombin formation and fibrin polymerization through competitive inhibition of tissue factor pathway signaling

(B) Complete inability to affect vertebrate physiology due to phylogenetic distance

(C) Random molecular effects with no specific receptor interaction

(D) Conversion of vertebrate blood into plant sap through metabolic transformation

Detailed Solutions

Q1.

Solution

Concept: The hepatopancreas in crustaceans is a multi-functional organ fundamentally distinct from vertebrate liver. It represents a fusion of hepatic and pancreatic tissues derived from the midgut endoderm, performing simultaneous digestive and storage functions without spatial segregation.

Solution:

(a) The hepatopancreas consists of blind-ended tubules arranged in branching systems lined with columnar epithelial cells.

(b) Three main cell types operate: B-cells (basophilic) synthesizing and secreting digestive enzymes; R-cells (acidophilic/resorptive) absorbing nutrients; and F-cells storing lipid and glycogen reserves.

(c) Functionally, it simultaneously secretes digestive enzymes (lipase, amylase, protease) into the midgut while absorbing and storing nutrients.

(d) This concurrent digestive-absorptive-storage function distinguishes it from vertebrate liver (purely storage/metabolic) and pancreas (purely secretory).

(e) The endodermal origin via midgut invagination confirms its embryological distinctiveness from mesodermal vertebrate liver.

Final Answer: A hepatopancreatic structure combining both digestive enzyme secretion and metabolic storage, derived from midgut endoderm, functioning in concurrent lipase, amylase, and protease synthesis

Answer: (C)

Go Back to Question 1

Q2.

Solution

Concept: The brown planthopper undergoes phase polymorphism involving dramatic wing reduction and body size changes under crowding stress. This morphological transition involves complex neuroendocrine circuits integrating sensory inputs with hormone synthesis.

Solution:

(a) Macropters possess fully developed wings enabling dispersal under low-density conditions.

(b) High crowding pressure triggers mechanoreceptor activation on antennae and legs through continuous tactile stimulation.

(c) This sensory input increases serotonin release in the central nervous system, particularly in the pars intercerebralis.

(d) Elevated serotonin suppresses juvenile hormone (JH) synthesis while potentiating ecdysone signaling pathways.

(e) Low JH titers combined with high ecdysone result in development of brachypter morphs with rudimentary wing structures.

(f) Brachypters show enlarged gonads (indicating reproductive focus) and reduced flight capability, maintaining population aggregation.

Final Answer: Increased juvenile hormone (JH) titers combined with serotonergic signaling from chemoreceptors detecting plant alkaloid accumulation

Answer: (A)

Go Back to Question 2

Q3.

Solution

Concept: Insect tracheal systems face competing mechanical and physiological demands. Taenidia represent an elegant structural solution providing rigidity without compromising gas diffusion across tracheal walls.

Solution:

(a) Taenidia are continuous spiral thickenings of the tracheal wall, derived from ectodermal chitin secretion.

(b) These spiral rings prevent radial collapse of the tracheal lumen during flight-induced pressure fluctuations and muscular compression.

(c) The spiral arrangement (rather than complete rings) leaves portions of the tracheal wall unthickened, maintaining permeability for oxygen diffusion.

(d) During high-speed flight, muscular compression could otherwise obliterate tracheal patency, but taenidia resist this inward collapse.

(e) This allows sustained oxygen delivery during intense metabolic activity while maintaining structural integrity.

(f) The mechanical advantage is analogous to reinforced tubing in engineering applications.

Final Answer: Prevents tracheal collapse during high-speed flight while maintaining patency for unobstructed gaseous diffusion

Answer: (B)

Go Back to Question 3

Q4.

Solution

Concept: The peritrophic matrix represents a specialized compartmentalization system in the insect gut. Beyond providing physical separation, it regulates molecular entry through size-selective permeability and pH maintenance critical for enzyme function.

Solution:

(a) The peritrophic matrix is a semi-permeable chitinous/proteinaceous structure secreted by the anterior midgut epithelium.

(b) It forms a tubular membrane surrounding ingested food, isolating it from direct epithelial contact.

(c) Functionally, it excludes macromolecular pathogens while permitting passage of digestion products.

(d) The matrix maintains an acidic pH gradient essential for optimal enzyme function in the enclosed food bolus.

(e) Viruses entering via oral route encounter this physical barrier, reducing infection probability.

(f) The chitinous composition also binds some viral particles, preventing direct epithelial contact.

(g) Additionally, it mechanically transports digestive waste toward the hindgut while protecting the epithelium from abrasive particles.

Final Answer: It acts as a semipermeable physical barrier controlling molecular size exclusion while maintaining pH gradient for enzyme activity optimization

Answer: (A)

Go Back to Question 4

Q5.

Solution

Concept: Root-knot nematodes are obligate endoparasites that remodel host plant cell morphology and function through molecular secretions. The ultrastructural specialization of esophageal glands reflects the synthesis of sophisticated effector molecules.

Solution:

(a) The esophageal glands of *Meloidogyne* species show exceptional ultrastructural development with extensive rough ER and Golgi cisternae.

(b) This organization indicates synthesis of complex protein products requiring extensive post-translational modification.

(c) Cell wall-degrading enzymes (pectinases, cellulases) are secreted to dissolve host cell walls during initial penetration.

(d) Phytohormone mimics (auxin/cytokinin-like peptides) remodel gene expression in target cells, triggering cell enlargement and dedifferentiation.

(e) Cell-cycle modulating effectors (like CLAVATA3-like peptides) alter plant developmental programs.

(f) These proteins collectively transform root cells into nutrient-absorptive syncytia supporting nematode development.

(g) The extensive endomembrane systems reflect the high protein synthesis demand for these secretory proteins.

Final Answer: Cell wall-degrading pectinases, cellulases, and hemicellulases; phytohormone-mimicking peptides; and cell-cycle modulating effector proteins

Answer: (B)

Go Back to Question 5

Q6.

Solution

Concept: Insect growth and reproduction are tightly coupled to nutritional status through neuroendocrine pathways. Insulin-like peptides serve as nutrient sensors integrating metabolic state information with developmental decisions.

Solution:

(a) Insulin-like peptides (ILPs) in insects functionally analogous to mammalian insulin are synthesized in neurosecretory cells.

(b) These peptides are released in response to elevated hemolymph amino acid and sugar concentrations signaling nutrient abundance.

(c) ILP binding to insect insulin receptors activates phosphatidylinositol 3-kinase (PI3K) signaling cascades in target tissues.

(d) PI3K signaling upregulates mTOR complex 1 (mTORC1), promoting ribosomal biogenesis, translation initiation, and anabolic metabolism.

(e) Simultaneously, mTORC1 inhibits autophagy, preventing catabolism and ensuring net biosynthesis during nutrient-rich periods.

(f) ILPs also promote juvenile hormone synthesis in the corpus allatum, accelerating reproductive maturation.

(g) Low nutritional conditions suppress ILP release, reducing growth rate and delaying reproductive maturation until resources improve.

Final Answer: Insulin-like peptides integrate nutritional state information from nutrient-sensing neurons to regulate lipid storage metabolism, growth rate, and reproductive maturation timing

Answer: (B)

Go Back to Question 6

Q7.

Solution

Concept: Parasitic helminths surviving within host tissues must overcome multiple hostile barriers: digestive enzymes, antimicrobial peptides, immune responses, and low-oxygen environments. Successful parasites display coordinated biochemical and morphological adaptations.

Solution:

(a) The strongyle nematode survives in the equine intestinal lumen, an acidic, enzyme-rich, oxidatively stressful environment.

(b) It synthesizes anticoagulant peptides preventing platelet aggregation and thrombin formation at the feeding site.

(c) It secretes immunosuppressive compounds (TGF-beta homologs, IL-10-like cytokines) modulating host immune responses away from parasites.

(d) It expresses enhanced antioxidant defenses (superoxide dismutase, catalase, glutathione S-transferases) protecting against reactive oxygen species.

(e) It develops anaerobic metabolic pathways (lactate fermentation, succinate production) functioning in the low-oxygen intestinal lumen.

(f) These adaptations enable long-term parasitism without being eliminated by host immunity.

Final Answer: Expression of anticoagulant peptides, immunosuppressive compounds, and metabolic adaptation to low-oxygen microenvironments within host tissues

Answer: (B)

Go Back to Question 7

Q8.

Solution

Concept: Pesticide resistance in insects evolves through multiple mechanisms: metabolic detoxification and target-site modification. Understanding these mechanisms is critical for resistance management strategies.

Solution:

(a) Resistant German cockroaches upregulate cytochrome P450 monooxygenases, particularly CYP6A subfamily members.

(b) These enzymes catalyze oxidative metabolism of organophosphate and pyrethroid insecticides, converting them into inactive metabolites.

(c) Constitutive (continuous) overexpression of P450 genes occurs through promoter mutations increasing transcription rates in resistant strains.

(d) Simultaneously, target-site mutations in acetylcholinesterase (point mutations in the esterase domain) reduce insecticide binding affinity.

(e) These mutations maintain sufficient catalytic activity for normal nervous system function while preventing inhibition by insecticides.

(f) The combination of both mechanisms (metabolic + target-site) creates multi-tiered resistance more difficult to overcome through pesticide chemistry changes alone.

(g) Under continued pesticide selection pressure, resistant alleles increase in frequency, replacing susceptible genotypes.

Final Answer: Increased detoxification enzyme expression through constitutive promoter activation in resistant populations combined with modified enzyme active sites reducing pesticide binding affinity

Answer: (A)

Go Back to Question 8

Q9.

Solution

Concept: Insect metamorphosis involves dramatic tissue remodeling requiring precise coordination of gene expression. The silk gland exemplifies tissue-specific developmental specialization where particular genes are activated while others are silenced.

Solution:

(a) The silk glands undergo massive hypertrophy during larval development, increasing from microscopic to macroscopic structures.

(b) Histologically, the acini (secretory units) enlarge dramatically with increased rough endoplasmic reticulum density.

(c) This correlates with massive synthesis of fibroin (the major silk protein) and sericin (glue-like coating protein).

(d) Epigenetic regulation occurs through stage-specific chromatin remodeling: histone acetyltransferase activity increases at silk gene promoters during critical instars.

(e) Conversely, histone deacetylases are recruited to non-silk genes, compacting chromatin and silencing them.

(f) Ecdysone-responsive transcription factors bind to ecdysone response elements in silk gene promoters, activating transcription.

(g) Simultaneously, juvenile hormone titers decline instar-to-instar, removing JH-mediated suppression of silk genes.

(h) This creates an instar-specific transcriptional landscape where silk genes become increasingly accessible and actively transcribed.

Final Answer: Stage-specific chromatin remodeling at silk protein gene promoters coupled with selective histone acetylation/deacetylation cycles and stage-specific transcription factor binding

Answer: (B)

Go Back to Question 9

Q10.

Solution

Concept: Entomopathogenic nematodes carry bacterial symbionts producing specialized toxins targeting insect immunity. These toxins exploit specific molecular vulnerabilities in the arthropod immune system.

Solution:

(a) *Photorhabdus luminescens* synthesizes toxins including photobacterone (a polyketide metabolite) and Tc toxins (three-component toxins derived from insecticidal proteins).

(b) Photobacterone inhibits melanin synthesis by blocking tyrosinase enzyme activity.

(c) Melanin is produced during the encapsulation response, where hemocytes wall off foreign pathogens in melanized nodules.

(d) Tyrosinase inhibition prevents melanin production, disabling this critical immune defense.

(e) Simultaneously, Tc toxins oligomerize in hemocyte membranes forming pores, disrupting cellular integrity and hemocyte lysis.

(f) The bacteria also suppress phenoloxidase cascade activation through additional secreted compounds, preventing both melanization and complement-like coagulation responses.

(g) Additionally, immunosuppressive compounds like photobacterone suppress hemocyte differentiation and proliferation, reducing overall immune cell numbers.

(h) This multi-layered attack on distinct immune pathways overwhelms the insect's immune response, allowing bacterial proliferation.

Final Answer: Direct inhibition of melanin synthesis through tyrosinase inactivation, combined with suppression of hemocyte phagocytic capability and phenoloxidase cascade activation

Answer: (A)

Go Back to Question 10

Q11.

Solution

Concept: Whitefly biotypes maintain reproductive isolation despite overlapping geographic distributions through host fidelity. This reproductive isolation requires integrated sensory, neuroendocrine, and metabolic specialization.

Solution:

(a) Different whitefly biotypes show differential expression of olfactory receptor (OR) gene families.

(b) Host-plant volatile organic compounds (VOCs) are detected by specialized sensory receptor neurons expressing biotype-specific OR combinations.

(c) Q biotype antennae express receptors for compounds prevalent in cotton volatiles; B biotype antennae express receptors for cassava-specific compounds.

(d) This olfactory specialization enables biotype-specific host plant recognition and preferential landing/feeding.

(e) Once on the host plant, biotype-specific detoxification enzyme expression is induced, allowing metabolism of plant defensive chemicals specific to that host.

(f) Q biotype upregulates cytochrome P450s and carboxylesterases effective against cotton toxins; B biotype expresses different enzyme complements.

(g) Reproductive maturation proceeds only on the preferred host where both sensory recognition and detoxification are optimal.

(h) Pheromone-mediated mate recognition also involves biotype-specific pheromone composition and receptor expression.

(i) Mating occurs primarily between same-biotype individuals due to these chemosensory and reproductive barriers, maintaining reproductive isolation.

Final Answer: Different olfactory receptor neuron populations detect host-specific volatile organic compounds, triggering differential xenobiotic enzyme expression and reproductive maturation only on preferred host plants through pheromone-mediated mate recognition

Answer: (D)

Go Back to Question 11

Q12.

Solution

Concept: Host-race formation in *Rhagoletis pomonella* represents rapid evolution of reproductive isolation. This process requires altered developmental timing coupled with sensory specialization for novel host fruits.

Solution:

(a) Apple trees fruit 3-4 weeks earlier than native hawthorn trees.

(b) Flies developing on apples encounter ripe fruits when hawthorn fruits remain immature.

(c) A circadian clock gene mutation or epigenetic modification advances developmental timing in apple-associated populations.

(d) This timing advancement is not fixed genetically but shows environmental plasticity through temperature-responsive transcription factor expression.

(e) Warmer microclimates associated with earlier-fruiting apples accelerate larval development, advancing eclosion timing.

(f) Simultaneously, olfactory specialization increases: apple-associated populations show enhanced preference for apple-derived volatiles (e.g., codlure, apple ester blend) through differential OR expression.

(g) Mating occurs on host fruits immediately post-eclosion when flies are most receptive.

(h) Reproductive timing alignment with host fruiting creates reproductive isolation: apple flies mate on apples while hawthorn flies mate on hawthorn fruits.

(i) This allochronic reproductive isolation prevents gene flow between populations despite overlapping geographic ranges.

Final Answer: Photoperiod-independent circadian rhythm entrainment coupled with fruit volatile-mediated acceleration of larval development and adult eclosion timing through temperature-responsive transcription factors

Answer: (C)

Go Back to Question 12

Q13.

Solution

Concept: The silk gland of *Bombyx mori* represents one of the most secretory-specialized tissues in biology. Its syncytial organization (multiple nuclei sharing cytoplasm) enables exceptional protein synthesis rates unachievable by individual cells.

Solution:

(a) The posterior silk gland (PSG) consists of a syncytium: many cell nuclei embedded in a shared cytoplasmic continuum.

(b) This syncytial arrangement arose through incomplete cytokinesis, creating a structure with 100-1000 times more nuclei than typical single-cell glands.

(c) Each nucleus directs transcription of massive quantities of fibroin and sericin mRNA.

(d) The shared cytoplasm contains equivalent quantities of rough endoplasmic reticulum (rER), allowing simultaneous translation of mRNA from all nuclei.

(e) Synthesized fibroin and sericin enter rER-studded tubules for transport to Golgi complexes processing these proteins.

(f) The shared cytoplasm eliminates transport delays between nuclei and protein synthesis sites versus packaging apparatus.

(g) Fibroin protein is 60-70% of total PSG protein by mass, requiring unprecedented synthesis rates.

(h) The syncytial organization allows coordinated secretion from the entire structure into the single spinneret opening.

(i) This enables extrusion of continuous silk filaments up to 1500 meters in length during the final larval instar.

Final Answer: Allows coordinated, massive protein synthesis and secretion through shared cytoplasmic pools with synchronized ER-Golgi trafficking without cellular bottlenecks

Answer: (B)

Go Back to Question 13

Q14.

Solution

Concept: Insects possess circadian timing systems sensitive to photoperiod changes. These light-sensing systems drive seasonal physiological adjustments including diapause induction during shortened autumnal days.

Solution:

(a) The red cotton bug possesses two types of photoreceptive organs: compound eyes and simple ocelli.

(b) Photoreceptor neurons in the compound eye lamina detect light intensity and spectral composition.

(c) Light information is processed through the optic lobes via specific neural pathways connecting to lateral neurons and clock neurons.

(d) Clock neurons (expressing period and timeless genes) integrate light signals with endogenous circadian rhythm generators.

(e) These circadian pathways converge on the pars intercerebralis, a neurosecretory region containing dopaminergic and GABAergic neurons.

(f) Photoperiod length (ratio of light to dark hours) determines whether pars intercerebralis neurons suppress juvenile hormone (JH) synthesis.

(g) Short photoperiods (shortened light hours) trigger neurons reducing JH release from the corpus allatum.

(h) Low JH titers permit ecdysone signaling to induce reproductive diapause: ovarian development arrests and metabolic rate decreases.

(i) The timing is precise: insects measure photoperiod through clock gene expression cycles comparing internal oscillation to external light cycles.

Final Answer: Optic lobe photoreceptors (simple ocelli and compound eye lamina) signal through lateral neurons and clock neurons to the pars intercerebralis, modulating juvenile hormone III synthesis rhythmically

Answer: (A)

Go Back to Question 14

Q15.

Solution

Concept: Blood-feeding insects face unique challenges: detecting hosts from distances, piercing skin/cuticle, preventing clotting, and consuming rapid meals. Their sensory-motor apparatus reflects evolutionary specialization for these challenges.

Solution:

(a) The piercing-sucking apparatus consists of paired maxillary stylets forming a central food canal surrounded by labial sheath.

(b) Chemoreceptor hairs (sensilla placodea) on the labial palps detect host-derived semiochemicals with extraordinary sensitivity.

(c) Lactic acid (a host metabolite) is detected at concentrations as low as 0.01 parts per million.

(d) CO2 (exhaled breath) triggers upwind anemotaxis through detection in the maxillary palps and antennae.

(e) Body odor compounds including human sweat volatiles and skin-derived aldehydes/ketones activate olfactory pathways.

(f) These chemical cues guide the mosquito upwind toward the host from distances up to 50 meters.

(g) Upon landing, labial palp chemoreceptors sample skin chemistry, discriminating suitable blood meals from unsuitable ones.

(h) Gustatory receptors evaluate blood suitability: presence of appropriate osmolarity, ionic composition, and absence of deterrents.

(i) During stylet insertion, the mosquito monitors tissue penetration through mechanoreceptors on maxillary stylets.

(j) Simultaneous saliva secretion injects anticoagulants (apyrase, serine proteases) preventing platelet aggregation and thrombin formation.

(k) This sensorimotor integration enables efficient host location, feeding, and escape before immune responses develop.

Final Answer: Chemoreceptors detect host kairomones (lactic acid, CO2, body odors) with sensitivity thresholds in the parts-per-billion range, enabling directed upwind anemotaxis to hosts combined with gustatory discrimination of blood meal suitability during insertion

Answer: (D)

Go Back to Question 15

Q16.

Solution

Concept: Insect metamorphosis requires disposal of larval tissues no longer needed in adults. Programmed autophagy (selective degradation) accomplishes this while recycling nutrients for adult development.

Solution:

(a) During pupation, larval tissues undergo massive remodeling initiated by ecdysone surge and juvenile hormone depletion.

(b) The fat body is a primary larval storage organ accumulating lipid and carbohydrate reserves through larval feeding.

(c) Ecdysone binds to ecdysone receptors (EcR/Ultraspiracle) in fat body nuclei, activating transcription of autophagy-related genes.

(d) Particular target genes include atg1, atg2, atg4, atg5, atg8, and others encoding the molecular machinery for autophagic degradation.

(e) Simultaneously, juvenile hormone depletion removes JH-mediated suppression of autophagy genes, permitting rapid transcription.

(f) Autophagy-related proteins oligomerize into the isolation membrane (phagophore), engulfing larval-specific proteins and obsolete organelles.

(g) The completed autophagosome fuses with lysosomes, exposing contents to degradative proteases and lipases.

(h) Amino acids released from protein degradation are transported to developing adult tissues (thoracic flight muscles, compound eyes, imaginal wing discs).

(i) Fat storage lipids are mobilized via hormone-sensitive lipases producing glycerol and fatty acids supporting adult metabolic demands.

(j) miRNA molecules (particularly miR-14) suppress mTOR signaling pathways, further promoting autophagy induction during metamorphosis.

Final Answer: Ecdysone-mediated rapid induction of autophagy-related genes through direct transcriptional activation of atg gene family members; coupled with miRNA-mediated suppression of mTOR signaling pathway, enabling selective autophagic degradation of larval-specific proteins

Answer: (A)

Go Back to Question 16

Q17.

Solution

Concept: Nematodes navigate extremely steep chemical gradients with minimal sensory organs. This extraordinary sensitivity requires specialized ion channel properties and signal amplification mechanisms.

Solution:

(a) *C. elegans* chemosensory neurons detect concentration differences as small as 1% per cell body diameter.

(b) These sensory neurons express voltage-gated calcium channels with unique pore selectivity: they preferentially pass calcium over monovalent cations.

(c) Chemoattractant molecules (ascarole, diacetyl) bind to G-protein-coupled receptors on sensory neuron membranes.

(d) Activated receptors couple to heterotrimeric G-proteins (Go/Gi family) activating phospholipase C (PLC).

(e) PLC catalyzes phosphatidylinositol 4,5-bisphosphate hydrolysis, generating inositol 1,4,5-trisphosphate (IP3) and diacylglycerol (DAG).

(f) IP3 diffuses to the endoplasmic reticulum, binding IP3 receptors and triggering calcium release into the cytoplasm.

(g) This ER calcium release further activates plasma membrane voltage-gated calcium channels, amplifying the initial signal.

(h) DAG activates protein kinase C, which phosphorylates and modulates ion channel properties, further sensitizing the neuron.

(i) The calcium influx depolarizes the sensory neuron, generating action potentials transmitted to interneurons.

(j) The combination of IP3/calcium signaling amplification coupled with unusual calcium channel selectivity enables detection of minute concentration differences.

(k) Bilateral sensory neurons comparing signals from left and right sides enable gradient computation: left-side signal stronger indicates chemotaxis leftward.

Final Answer: Utilization of voltage-gated calcium channels with modified pore selectivity combined with G-protein-coupled receptor activation of phospholipase C-mediated IP3/diacylglycerol cascades enabling amplification of minute concentration differences into robust neural responses

Answer: (A)

Go Back to Question 17

Q18.

Solution

Concept: The acetabulum of parasitic flatworms operates as a powerful sucker resisting substantial external forces from blood and bile flow. Its biomechanical design exemplifies evolutionary optimization.

Solution:

(a) The acetabulum is a muscular sucker disc containing concentric circular and radial muscle layers.

(b) Circular muscles (oriented circumferentially) contract, flattening the central acetabular vault and creating negative pressure.

(c) This negative pressure (partial vacuum) pulls the surrounding tissue into intimate contact with the acetabular rim.

(d) Radial muscles (oriented centripetally) contract simultaneously, actively pulling the margin inward while stabilizing the muscular wall against deformation.

(e) The combined contraction pattern generates adhesive forces exceeding 100 millimeters of mercury of negative pressure.

(f) External hydraulic forces from hepatic bile flow and blood movement attempt to dislodge the parasite.

(g) Radial muscle tension resists this external pressure, preventing radial expansion and acetabular rupture.

(h) The circular muscle maintains negative pressure differential between the acetabular interior and surrounding tissue.

(i) This coordinated circular-radial muscular antagonism creates a powerful, stable adhesion capable of withstanding vascular forces throughout the parasite's tenure in the host.

(j) The design represents a hydraulic-mechanical system where muscle contraction patterns optimize force generation and stability.

Final Answer: Coordinated contraction of circular muscles creating negative pressure within the acetabulum combined with radial muscle tension stabilizing the acetabular margin against tissue deformation from external hydraulic forces

Answer: (C)

Go Back to Question 18

Q19.

Solution

Concept: The synthesis of polymer compounds in insects during starvation represents an extraordinary metabolic adaptation. This requires recruitment of existing biosynthetic pathways in novel combinations.

Solution:

(a) PHA-like compounds are long-chain polyester polymers normally synthesized by bacteria (polyhydroxybutyrate, polyhydroxyvalerate).

(b) *Spodoptera* insects synthesize analogous compounds under starvation conditions, enabling survival during resource scarcity.

(c) The biosynthetic pathway begins with enhanced beta-oxidation of stored triglyceride lipids.

(d) Beta-oxidation generates acetyl-CoA, which normally enters the citric acid cycle for energy production.

(e) During starvation, acetyl-CoA instead is diverted to acetyl-CoA carboxylase, which produces malonyl-CoA.

(f) Fatty acid synthase uses malonyl-CoA to synthesize novel polyunsaturated fatty acid chains.

(g) These polyunsaturated fatty acids (with unusual branching patterns) are likely polymerized by non-ribosomal peptide synthetase-like enzymes.

(h) These enzymes normally function in natural product biosynthesis (insecticides, pheromones) but are repurposed during starvation.

(i) The resulting polymer is synthesized in hemocytes (insect blood cells) and circulated in hemolymph.

(j) This polymer serves as an inert energy storage compound mobilizable when feeding resumes.

(k) The adaptation permits survival through extended starvation periods common in field conditions.

Final Answer: Enhanced beta-oxidation of triglycerides combined with activation of acetyl-CoA carboxylase and fatty acid synthase generating polyunsaturated fatty acids subsequently polymerized through non-ribosomal peptide synthetase-like enzymes in hemocytes

Answer: (A)

Go Back to Question 19

Q20.

Solution

Concept: The cockroach heart generates its own contractions without nervous system input, a phenomenon termed myogenic autorhythmicity. This intrinsic contractility requires special ion channel properties enabling autonomous pacemaking.

Solution:

(a) The dorsal vessel cardiac muscle can contract rhythmically in isolated tissue preparations without any neural connections.

(b) This myogenic pacemaking arises from L-type calcium channels with unusually slow activation kinetics.

(c) L-type calcium channels normally activate rapidly; in cockroach cardiac muscle, they activate slowly over 200-300 milliseconds.

(d) Delayed activation permits potassium channels (with faster activation kinetics) to activate and repolarize the membrane before calcium channels fully open.

(e) This produces oscillatory behavior: calcium influx drives depolarization; potassium efflux drives repolarization; the cycle repeats automatically.

(f) Additionally, sarcoplasmic reticulum calcium release through ryanodine receptors amplifies the initial calcium influx.

(g) Released ER calcium further activates L-type channels, creating positive feedback amplifying the depolarization phase.

(h) Simultaneously, calcium-dependent potassium channel activation is triggered, permitting repolarization and diastolic rest.

(i) Calmodulin acts as the calcium sensor coupling ER calcium release to potassium channel activation, maintaining rhythmicity.

(j) The frequency of autonomous beating depends on calcium channel kinetics, ER calcium load, and potassium channel expression levels.

(k) Neuromodulators can adjust beating rate by altering calcium and potassium channel properties, but the fundamental rhythm is neurally independent.

Final Answer: L-type calcium channels with slow activation kinetics coupled with delayed potassium channel activation creating oscillatory membrane potential changes in the absence of nervous input; combined with sarcoplasmic reticulum calcium release amplifying depolarization

Answer: (C)

Go Back to Question 20

Q21.

Solution

Concept: Cyst nematodes remodel plant root tissues through secretion of complex enzymes and proteins. Understanding the enzymatic toolkit is essential for comprehending host-parasite interactions.

Solution:

(a) *Heterodera avenae* esophageal glands synthesize a diverse arsenal of plant cell wall-degrading enzymes.

(b) Cellulases (endocellulases, exocellulases) cleave cellulose polymer chains, the primary structural component of primary cell walls.

(c) Pectinases (pectate lyases, polygalacturonases) degrade pectin polysaccharides, which cement cellulose fibrils together in plant cell walls.

(d) Hemicellulases (xylanases, arabinosidases) degrade hemicellulose polysaccharides associated with cellulose in the cell wall matrix.

(e) Pectin methylesterase removes methyl ester groups from pectin, exposing carboxyl groups for enzymatic attack by pectinases.

(f) Additionally, expansin-like proteins are secreted that disrupt hydrogen bonding between cell wall polymers, weakening structural integrity.

(g) These enzyme genes were likely acquired through horizontal gene transfer from soil bacteria or fungi, integrated into the nematode genome.

(h) The enzyme complex enables nematodes to penetrate root cortex tissue and create feeding sites.

(i) Secretion occurs through the stylet (needle-like feeding apparatus) directly into plant tissue ahead of parasite migration.

(j) This localized enzymatic attack dissolves cell walls, permitting nematode penetration while minimizing distant plant tissue damage.

Final Answer: Combination of endopectinase, endocellulase, and exocellulase enzymes derived from horizontal gene transfer from bacterial ancestors; coupled with pectin methylesterase enabling complete degradation of primary cell wall components

Answer: (B)

Go Back to Question 21

Q22.

Solution

Concept: Gregarization (phase shift) in locusts is a complex phenomenon converting solitary, sedentary individuals into synchronized, aggregated swarms. This transformation depends on sensory inputs processed through neural circuits.

Solution:

(a) Under low-density conditions, locusts are solitary with cryptic coloration (pale brown) and dispersed spatial distribution.

(b) When population density increases, locusts contact neighbors with increasing frequency through crowding.

(c) Mechanical stimulation occurs primarily through hind leg compression against adjacent locusts and antennal contact.

(d) Specialized mechanoreceptor neurons in the legs and antennae detect this tactile stimulation.

(e) Mechanoreceptor signals are transmitted through neural ganglia toward the central complex and antennal lobes.

(f) Central complex neurons integrating mechanosensory signals release serotonin (a biogenic amine neuromodulator).

(g) Elevated serotonin levels in the antennal lobes and central brain regions shift neural processing patterns.

(h) Serotonin promotes visual interneurons that enhance responsiveness to moving objects (critical for collective motion).

(i) Simultaneously, serotonin suppresses juvenile hormone synthesis in the corpus allatum.

(j) Low juvenile hormone permits ecdysone-mediated development of gregarious morphology: darker pigmentation, body size reduction, wing relative enlargement.

(k) Behaviorally, elevated serotonin increases activity levels, attraction to conspecifics, and sustained flight capability.

(l) Flight muscles undergo hypertrophy, enabling prolonged migration capability supporting gregarious swarms.

Final Answer: Crowding-induced tactile stimulation of hind leg mechanoreceptors combined with visual stimuli from aggregate patterns triggering serotonin release in the central complex and antennal lobes, driving behavioral aggregation and sustained flight musculature hypertrophy

Answer: (A)

Go Back to Question 22

Q23.

Solution

Concept: The sterile insect technique (SIT) exploits X-ray-induced chromosomal aberrations in sperm, causing lethality in offspring. This represents a population-level genetic strategy for pest suppression.

Solution:

(a) X-rays cause double-strand breaks in DNA, generating chromosomal aberrations including deletions, duplications, and inversions.

(b) In dividing spermatogonia (sperm-producing cells), these aberrations remain fixed in the genome.

(c) Affected spermatozoa carry complex, heterozygous chromosomal rearrangements that reduce viability.

(d) When irradiated males mate with wild females, sperm carrying aberrations fertilize eggs.

(e) Fertilized embryos become heterozygous for the chromosomal aberrations, inheriting abnormal chromosome sets.

(f) Zygotic development proceeds initially, but as cell divisions multiply the aberrant genome copies, chromosomal imbalances become severe.

(g) Aneuploidy (incorrect chromosome numbers) results from unbalanced crossing over during early embryonic cell divisions.

(h) Embryos become lethally aneuploid and die during embryogenesis, preventing adult emergence.

(i) The key advantage: irradiated males remain fully competent for mating and insemination; only their offspring die.

(j) Male mating behavior is unaffected by irradiation; they seek and inseminate wild females with normal vigor.

(k) Released irradiated males rapidly mate with wild females, reducing population growth as fertilized eggs fail to develop.

(l) This "genetic control" approach avoids insecticide resistance and environmental contamination.

Final Answer: X-ray-induced dominant lethal mutations in the spermatogonial stem cells causing chromosome aberrations in sperm without affecting male mating competence; fertilized eggs from irradiated males fail to develop past embryonic stages due to recessive lethal allele homozygosity

Answer: (B)

Go Back to Question 23

Q24.

Solution

Concept: Sex determination in insects involves diverse mechanisms; in *Bombyx mori*, the XX-XY system controls sex. Sexual dimorphism in pheromone production requires female-specific gene expression of biosynthetic enzymes.

Solution:

(a) The silkworm employs an XX (female) / XY (male) sex determination system similar to mammals.

(b) The sex-lethal (Sxl) gene encodes a splicing factor that undergoes sex-specific alternative splicing.

(c) In females (XX genotype), Sxl protein is expressed in functional form, acting as a splicing regulator.

(d) In males (XY genotype), Sxl transcripts undergo non-functional splicing lacking critical exons, producing non-functional protein.

(e) Sxl protein in females directs female-specific splicing of the doublesex (dsx) gene, producing female-specific Dsx protein.

(f) Female Dsx protein is a transcription factor that activates pheromone biosynthetic gene expression.

(g) These genes encode fatty acyl-CoA desaturases, acetyltransferases, and other enzymes synthesizing bombykol.

(h) Simultaneously, Dsx suppresses male-specific genes required for male reproductive structures.

(i) Developmental exposure to ecdysone during critical larval instars interacts with Dsx to specify female abdominal gland morphology.

(j) Juvenile hormone (present in higher titers in females during late larvae) permits gland tissue development.

(k) The combination of Sxl/Dsx signaling plus hormonal environment results in functional pheromone gland development exclusively in females.

(l) Males either lack these glands entirely or develop non-functional rudimentary structures incapable of pheromone synthesis.

Final Answer: Sex-lethal (Sxl) transcription factor-mediated female-specific splicing of pheromonogen biosynthetic enzyme transcripts combined with developmental exposure to ecdysone and juvenile hormone regulating gland differentiation exclusively in females

Answer: (A)

Go Back to Question 24

Q25.

Solution

Concept: Parasitic arthropods feeding on vertebrate blood face the challenge of preventing blood clotting. They secrete molecules mimicking vertebrate signaling compounds, exploiting fundamental coagulation biochemistry.

Solution:

(a) The parasitic copepod secretes anticoagulant compounds including prostaglandin analogs and leukotriene-like molecules.

(b) These compounds structurally mimic vertebrate eicosanoids (prostaglandins, leukotrienes) derived from arachidonic acid metabolism.

(c) Vertebrate bradykinins (a family of inflammatory peptides) are also secreted by the copepod with high structural specificity.

(d) Prostaglandin analogs bind to vertebrate G-protein-coupled prostaglandin receptors on platelet and endothelial cell surfaces.

(e) Receptor activation couples to heterotrimeric G-proteins, increasing intracellular cyclic AMP through adenylyl cyclase activation.

(f) Elevated cAMP activates protein kinase A, which phosphorylates platelet calcium channels and other signaling molecules.

(g) This phosphorylation reduces platelet activation and aggregation responses to collagen and thrombin.

(h) Separately, leukotriene analogs interfere with 5-lipoxygenase signaling, suppressing inflammatory cell recruitment.

(i) Bradykinin analogs competitively antagonize vertebrate bradykinin receptor signaling, reducing vascular permeability and hemostatic responses.

(j) Combined, these secreted factors prevent platelet aggregation, fibrin polymerization, and tissue factor pathway activation.

(k) The anticoagulant effect maintains blood fluidity for sustained feeding while preventing clot formation.

Final Answer: Structural mimicry of vertebrate prostaglandins enabling binding to G-protein-coupled receptors on platelets and endothelial cells, blocking thrombin formation and fibrin polymerization through competitive inhibition of tissue factor pathway signaling

Answer: (A)

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Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	C	2	A	3	B	4	A	5	B
6	B	7	B	8	A	9	B	10	A
11	D	12	C	13	B	14	A	15	D
16	A	17	A	18	C	19	A	20	C
21	B	22	A	23	B	24	A	25	A