UPCATET Biology Sample Paper-2

Duration: 80 Minutes **Maximum Marks: 320**

Instructions

- This paper contains **80** 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. During non-cyclic photophosphorylation, the primary electron acceptor from the excited reaction center chlorophyll P_{680} is transferred to which of the following molecules?

(A) Plastoquinone

(B) Pheophytin

(C) Plastocyanin

(D) Ferredoxin

Q2. A man with blood group A marries a woman with blood group B. They have a child with blood group O. What is the probability that their next child will also have blood group O?

(A) 25%

(B) 50%

(C) 75%

(D) 0%

Q3. In which stage of the cell cycle do the centrioles begin to move towards opposite poles of the animal cell?

(A) Interphase

(B) Prophase

(C) Metaphase

(D) Anaphase

Q4. Which of the following cells in the gastric glands secrete pepsinogen under the influence of vagal stimulation?

(A) Parietal cells

(B) Chief cells

(C) Oxyntic cells

(D) Goblet cells

Q5. Which of the following interactions is correctly exemplified by the relationship between a cuckoo bird laying eggs in a crow's nest?

(A) Amensalism

(B) Commensalism

(C) Brood parasitism

(D) Ectoparasitism

Q6. Persistent calyx, swollen placenta with oblique septa, and epipetalous stamens are the characteristic floral features of which family?

(A) Cruciferae

(B) Solanaceae

(C) Leguminosae

(D) Liliaceae

Q7. What is the correct sequence of development of a human embryo during the first trimester?

(A) Zygote → Morula → Blastocyst → Gastrula

(B) Zygote → Blastocyst → Morula → Gastrula

(C) Zygote → Morula → Gastrula → Blastocyst

(D) Zygote → Gastrula → Morula → Blastocyst

Q8. Which of the following vector systems is most appropriate for introducing a large gene fragment exceeding 40 kb into a bacterial host cell?

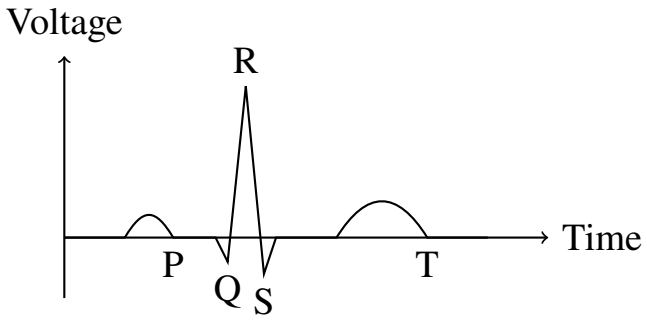
(A) pBR322

(B) PUC19

(C) Cosmid

(D) Ti-plasmid

Q9. In a standard ECG record, the T-wave represents which of the following cardiac events?



(A) Depolarisation of atria

(B) Depolarisation of ventricles

(C) Repolarisation of ventricles

(D) Repolarisation of atria

Q10. How many turns of the Calvin cycle are required to generate one molecule of sucrose?

(A) 3

(B) 6

(C) 12

(D) 24

Q11. The conversion of a purine to a pyrimidine or vice versa in a DNA segment is a type of point mutation termed as:

(A) Transition

(B) Transversion

(C) Frame-shift

(D) Nonsense mutation

Q12. If a double-stranded DNA molecule contains 30% Adenine, what will be the percentage of Cytosine in this DNA sequence according to Chargaff's rule?

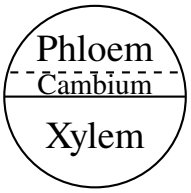
(A) 20%

(B) 30%

(C) 40%

(D) 70%

Q13. In which type of vascular bundle is the cambium present between the xylem and phloem tissues?



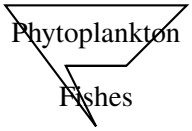
(A) Radial open

(B) Conjoint closed

(C) Conjoint open

(D) Bicollateral closed

Q14. The Pyramid of Biomass in a deep aquatic ecosystem like an ocean is generally:



(A) Always upright

(B) Inverted

(C) Spindle-shaped

(D) Bell-shaped

Q15. Diadelphous stamens along with vexillary aestivation are diagnostic features found in the members of which family?

(A) Fabaceae

(B) Solanaceae

(C) Brassicaceae

(D) Poaceae

Q16. The specific DNA sequence sequence recognized by a restriction endonuclease that reads the same in both $5' \rightarrow 3'$ and $3' \rightarrow 5'$ directions is called a:

(A) Satellite sequence

(B) Palindromic sequence

(C) Promoter sequence

(D) Operon sequence

Q17. Which of the following hormones is derived from the amino acid tyrosine and acts through an intracellular nuclear receptor?

(A) Epinephrine

(B) Insulin

(C) Thyroxine

(D) Glucagon

Q18. The primary site of gaseous exchange in human lungs is lined by which type of epithelium?

(A) Simple cuboidal epithelium

(B) Simple squamous epithelium

(C) Ciliated columnar epithelium

(D) Stratified squamous epithelium

Q19. During intense exercise, the accumulation of lactic acid in muscles is a direct result of the reduction of pyruvic acid by NADH. This reaction is catalyzed by:

(A) Pyruvate dehydrogenase

(B) Lactate dehydrogenase

(C) Succinate dehydrogenase

(D) Malate dehydrogenase

Q20. Which element is essential for the photolysis of water during the light reaction of photosynthesis?

(A) Magnesium

(B) Manganese

(C) Zinc

(D) Copper

Q21. The chromosomal constitution of an individual with Turner's syndrome is represented as:

(A) 44 + XXY

(B) 44 + XO

(C) 44 + XYY

(D) 45 + XX

Q22. Which cell organelle is directly responsible for the synthesis of steroidal lipids and phospholipids in eukaryotic cells?

(A) Rough Endoplasmic Reticulum

(B) Golgi Apparatus

(C) Smooth Endoplasmic Reticulum

(D) Peroxisomes

Q23. The secondary productivity in an ecosystem refers to the rate of resynthesis of organic matter by:

(A) Producers

(B) Consumers

(C) Decomposers

(D) Herbivores only

Q24. In a five-kingdom classification system, where would you place an organism that is unicellular, eukaryotic, photosynthetic, and possesses a cell wall?

(A) Monera

(B) Protista

(C) Fungi

(D) Plantae

Q25. Tapetum, the innermost layer of the microsporangial wall, performs which of the following primary functions?

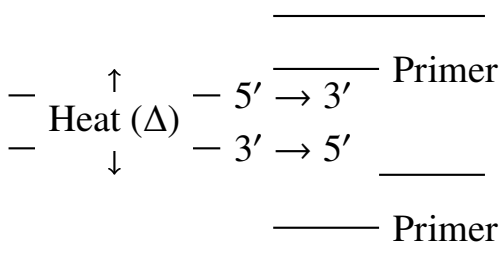
(A) Protection of the anther wall

(B) Dehiscence of the anther

(C) Nourishment of developing pollen grains

(D) Formation of microspores

Q26. Which of the following techniques is commonly used to amplify specific segments of DNA in vitro for diagnostic purposes?



(A) Gel Electrophoresis

(B) Polymerase Chain Reaction

(C) Western Blotting

(D) ELISA

Q27. A hormone that stimulates the secretion of pancreatic juice rich in water and bicarbonate ions is:

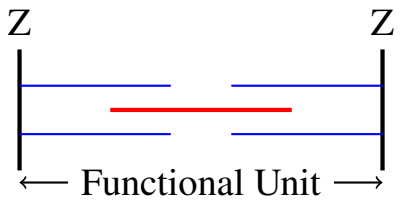
(A) Cholecystokinin

(B) Secretin

(C) Gastrin

(D) Enterocrinin

Q28. The functional unit of a skeletal muscle myofibril lying between two successive Z-lines is called a:



(A) Sarcolemma

(B) Sarcoplasm

(C) Sarcomere

(D) Fascia

Q29. During which stage of Prophase-I of meiosis does the process of crossing over between non-sister chromatids take place?

(A) Leptotene

(B) Zygotene

(C) Pachytene

(D) Diplotene

Q30. Abscisic acid (ABA) acts as an antagonist to which of the following plant growth regulators?

(A) Auxin

(B) Gibberellin

(C) Cytokinin

(D) Ethylene

Q31. The structural monomer of a chitin molecule which forms the cell wall of fungi is:

(A) N-acetylglucosamine

(B) Glucose-6-phosphate

(C) N-acetylmuramic acid

(D) D-Galactose

Q32. In an operon model, the structural genes are switched off when the repressor protein binds to the:

(A) Promoter site

(B) Operator site

(C) Regulator gene

(D) Structural gene

Q33. Which layer of the atmosphere contains the protective ozone layer that absorbs harmful ultraviolet radiations?

(A) Troposphere

(B) Stratosphere

(C) Mesosphere

(D) Thermosphere

Q34. Heterocyst is a specialized structure found in certain cyanobacteria. Its primary function is:

(A) Reproduction

(B) Carbon dioxide fixation

(C) Nitrogen fixation

(D) Respiration

Q35. The method of birth control that prevents ovulation and implantation by altering the hormonal balance of the female body is:

(A) Intrauterine Devices (IUDs)

(B) Oral contraceptive pills

(C) Tubectomy

(D) Condoms

Q36. Transgenic "Golden Rice" has been genetically engineered to synthesize high amounts of which nutrient precursor?

(A) Vitamin C

(B) Beta-carotene

(C) Iron

(D) Lysine

Q37. The action potential along an unmyelinated nerve fiber is propagated via:

(A) Saltatory conduction

(B) Continuous conduction

(C) Synaptic transmission

(D) Active transport only

Q38. Kranz anatomy is a characteristic anatomical feature found in the leaves of:

(A) C3 plants

(B) C4 plants

(C) CAM plants

(D) Hydrophytes

Q39. If the sequence of bases in the template strand of DNA is 5′ – ATGCGAT – 3′, what will be the sequence of bases in the transcribed mRNA?

(A) 5′ – UACGCUA – 3′

(B) 5′ – AUCGCAU – 3′

(C) 5′ – ATCGCAT – 3′

(D) 5′ – AUCGCAU – 3′

Q40. The structural level of a protein that is absolutely necessary for its biological activity and features a three-dimensional folding stabilized by disulfide bonds and hydrophobic interactions is the:

(A) Primary structure

(B) Secondary structure

(C) Tertiary structure

(D) Quaternary structure

Q41. Which of the following regions of the brain regulates body temperature, hunger, and thirst?

(A) Cerebrum

(B) Cerebellum

(C) Hypothalamus

(D) Medulla oblongata

Q42. The process of decomposition of detritus by bacterial and fungal enzymes into simpler inorganic substances is called:

(A) Fragmentation

(B) Leaching

(C) Catabolism

(D) Humification

Q43. Which plant family is characterized by the presence of a cruciform corolla, tetradynamous stamens, and a siliqua fruit?

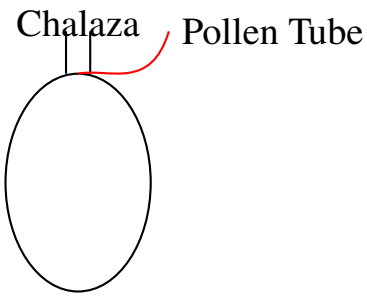
(A) Malvaceae

(B) Brassicaceae

(C) Solanaceae

(D) Liliaceae

Q44. The entry of pollen tube into the ovule through the chalazal end is called:



(A) Porogamy

(B) Chalazogamy

(C) Mesogamy

(D) Syngamy

Q45. The Bt toxin protein produced by *Bacillus thuringiensis* exists as an inactive protoxin in the bacterium. It becomes active inside the target insect gut due to:

(A) Acidic pH of the gut

(B) Alkaline pH of the gut

(C) Mechanical rupture of cells

(D) Action of salivary amylase

Q46. The reabsorption of water from the distal convoluted tubule and collecting duct of the nephron is principalmente regulated by which hormone?

(A) Aldosterone

(B) Atrial Natriuretic Peptide

(C) Antidiuretic Hormone

(D) Renin

Q47. The atmospheric component that acts as the terminal electron acceptor during aerobic respiration is:

(A) Carbon dioxide

(B) Nitrogen

(C) Oxygen

(D) Water vapor

Q48. In DNA replication, the discontinuous synthesis of the lagging strand creates short fragments known as Okazaki fragments. These fragments are joined together by the enzyme:

(A) DNA Polymerase I

(B) Helicase

(C) Topoisomerase

(D) DNA Ligase

Q49. Which of the following cell organelles is bounded by a single unit membrane and contains hydrolytic enzymes that function optimal at an acidic pH?

(A) Lysosome

(B) Peroxisome

(C) Mitochondrion

(D) Chloroplast

Q50. Biomagnification refers to an increase in the concentration of a non-biodegradable toxicant at successive trophic levels. Which pollutant is classically known to cause this in aquatic food chains?

(A) Sulphur dioxide

(B) DDT

(C) Carbon monoxide

(D) Phosphates

Q51. Naked seeds lacking an enclosing ovary wall are found in members of which group?

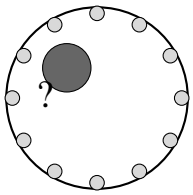
(A) Pteridophytes

(B) Bryophytes

(C) Gymnosperms

(D) Angiosperms

Q52. The inner cellular layer of the blastocyst that gives rise to the proper tissues of the embryo is called the:



(A) Trophoblast

(B) Inner cell mass

(C) Blastocoel

(D) Chorion

Q53. Humulin, the first genetically engineered human insulin, was successfully produced by a biotechnological firm in 1983 using which host organism?

(A) *Saccharomyces cerevisiae*

(B) *Escherichia coli*

(C) *Bacillus subtilis*

(D) *Agrobacterium tumefaciens*

Q54. During the transmission of a nerve impulse across a chemical synapse, the influx of which ions triggers the exocytosis of neurotransmitters from the synaptic vesicles?

(A) Sodium ions

(B) Potassium ions

(C) Calcium ions

(D) Magnesium ions

Q55. The respiratory quotient (RQ) value for a pure lipid or tripalmitin substrate oxidized during cellular respiration is approximately:

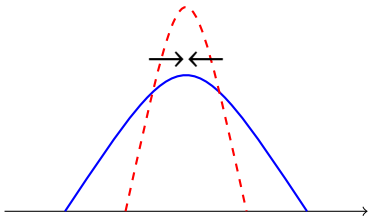
(A) 1.0

(B) 0.9

(C) 0.7

(D) 1.3

Q56. What type of selection operates in a population when individuals with intermediate phenotypes are favored over individuals with extreme phenotypes?



(A) Directional selection

(B) Disruptive selection

(C) Stabilizing selection

(D) Artificial selection

Q57. Competitive inhibition of an enzyme can be overcome by which of the following modifications in the reaction system?

(A) Increasing the substrate concentration

(B) Decreasing the enzyme concentration

(C) Adding an allosteric modulator

(D) Increasing the temperature

Q58. Minamata disease is a severe neurological syndrome caused by eating fish contaminated with which environmental pollutant?

(A) Cadmium

(B) Lead

(C) Methylmercury

(D) Arsenic

Q59. The dynamic property of plasma membranes described as the "Fluid Mosaic Model" was proposed by Singer and Nicolson. The fluidity of the membrane is primarily determined by:

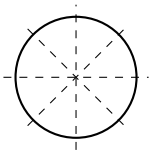
(A) Integral proteins

(B) Peripheral proteins

(C) Lateral movement of lipids and proteins

(D) Cell wall matrix

Q60. A condition of floral symmetry where a flower can be divided into two equal halves by any vertical radial plane passing through the center is known as:



(A) Actinomorphic

(B) Zygomorphic

(C) Asymmetric

(D) Epigynous

Q61. The process of triple fusion in double fertilization of angiosperms involves the fusion of:

(A) One male gamete with the egg cell

(B) One male gamete with two polar nuclei

(C) Two male gametes with one polar nucleus

(D) Synergids with antipodal cells

Q62. The first clinical gene therapy trial was conducted in 1990 on a four-year-old girl suffering from a severe deficiency of which enzyme?

(A) Adenosine deaminase

(B) Phenylalanine hydroxylase

(C) Tyrosinase

(D) Alkaline phosphatase

Q63. Which part of the human nephron is completely impermeable to water but allows the active or passive transport of electrolytes?

(A) Proximal Convoluted Tubule

(B) Descending limb of Henle's loop

(C) Ascending limb of Henle's loop

(D) Collecting duct

Q64. In a plant tissue, when cells lose their protoplasm, become elongated, lignified, and possess tapering ends with pitted walls without any perforations, they are termed:

(A) Vessels

(B) Tracheids

(C) Sieve tubes

(D) Parenchyma

Q65. The technique of DNA fingerprinting relies on identifying variations in specific regions of DNA called:

(A) Coding sequences

(B) Mini-satellites or VNTRs

(C) Single-copy functional genes

(D) Intronic structural sequences

Q66. The competitive exclusion principle, which states that two closely related species competing for the same limiting resources cannot coexist indefinitely, was formulated by:

(A) G.F. Gause

(B) Robert May

(C) E.P. Odum

(D) Paul Ehrlich

Q67. A cell with an osmotic potential of -10 bars and a turgor pressure of $+4$ bars is placed in a solution with a water potential of -8 bars. In which direction will the net movement of water take place?

(A) Water will move out of the cell

(B) Water will move into the cell

(C) There will be no net movement of water

(D) The cell will burst immediately

Q68. The specialized cells present in the interstitial spaces of the human testes that secrete androgenic hormones like testosterone are:

(A) Sertoli cells

(B) Leydig cells

(C) Spermatogonia

(D) Macrophages

Q69. In a monohybrid cross, the F2 generation exhibits a phenotypic ratio of 1:2:1 instead of 3:1. This condition is a hallmark of:

(A) Complete Dominance

(B) Codominance

(C) Incomplete Dominance

(D) Pleiotropy

Q70. Which stage of mitosis is characterized by the alignment of chromosomes along the equatorial plate of the spindle apparatus?

(A) Prophase

(B) Metaphase

(C) Anaphase

(D) Telophase

Q71. The standard method used for the conservation of threatened plant and animal species outside their natural habitats, such as in botanical gardens or cryopreservation centers, is called:

(A) In-situ conservation

(B) Ex-situ conservation

(C) Sacred groves technique

(D) Biosphere reservation

Q72. In a standard five-kingdom classification, multicellular decomposers with chitinous cell walls and heterotrophic absorptive nutrition belong to which kingdom?

(A) Monera

(B) Protista

(C) Fungi

(D) Plantae

Q73. The primary functional role of the hormone progesterone secreted by the corpus luteum is to:

(A) Stimulate the growth of ovarian follicles

(B) Maintain the vascular endometrium for implantation

(C) Trigger ovulation from the Graafian follicle

(D) Promote lactation in mammary glands

Q74. Which of the following plant hormones is primarily responsible for inducing apical dominance in vascular plants?

(A) Auxin

(B) Cytokinin

(C) Gibberellin

(D) Ethylene

Q75. The mechanism where the end-product of a metabolic pathway acts as an allosteric inhibitor for the first enzyme of that pathway is called:

(A) Feedback inhibition

(B) Competitive inhibition

(C) Non-competitive activation

(D) Denaturation

Q76. The genetic material of the Human Immunodeficiency Virus (HIV) consists of:

(A) Double-stranded DNA

(B) Single-stranded DNA

(C) Two identical molecules of single-stranded RNA

(D) Double-stranded RNA

Q77. A localized ecosystem boundary where two distinct ecological communities meet and integrate is called a/an:

(A) Ecotone

(B) Ecotype

(C) Niche

(D) Biome

Q78. The floral formula symbol $\oplus$ represents which type of structural organization in a flower?

(A) Zygomorphic nature

(B) Actinomorphic nature

(C) Epigynous position

(D) Unisexual structure

Q79. During the process of translation in protein synthesis, the peptide bond formation between two successive amino acids is catalyzed by:

(A) Aminoacyl tRNA synthetase

(B) Peptidyl transferase

(C) RNA Polymerase II

(D) DNA Ligase

Q80. The hormone that triggers the ejection of milk from mammary glands and causes powerful contractions of the uterine smooth muscle during childbirth is:

(A) Prolactin

(B) Oxytocin

(C) Estrogen

(D) Progesterone

Detailed Solutions

Q1.

Solution

Concept:

The light-dependent reactions of photosynthesis involve the transfer of electrons through a series of electron carriers organized as Z-scheme. Photolysis of water occurs at Photosystem II (PSII), where the reaction center chlorophyll P_{680} gets photo-excited. The primary electron acceptor is responsible for capturing this high-energy electron before passing it down to the subsequent mobile electron carriers in the thylakoid membrane.

Solution:

Step 1: When light photons strike the antenna complex of Photosystem II, the energy is transferred to the reaction center molecule P_{680}, causing it to reach an excited state, designated as P^*_{680}.

Step 2: The excited reaction center P^*_{680} immediately expels an electron, becoming oxidized to P^+_{680}. This rapid photo-induced charge separation transfers the expelled electron to the primary electron acceptor.

Step 3: The primary electron acceptor of Photosystem II is pheophytin, which is a modified chlorophyll molecule lacking a central magnesium ion.

Step 4: From pheophytin, the electron is subsequently transferred to plastoquinone (Q_A and then Q_B), followed by the cytochrome b_6f complex, plastocyanin, and eventually Photosystem I.

Step 5: Therefore, the molecule that directly and primarily captures the electron from the excited P_{680} is pheophytin, making option B the correct choice.

Final Answer: Pheophytin

Answer: (B)

Go Back to Question 1

Q2.

Solution

Concept:

ABO blood grouping in humans is governed by the I gene, which exhibits multiple allelism and codominance. The alleles I^A and I^B are completely dominant over the recessive allele i. By analyzing the phenotypes of the parents and their child, we can deduce the exact parental genotypes using Mendelian principles, which allows us to determine the statistical probability for any subsequent offspring.

Solution:

Step 1: The child has blood group O, which corresponds to the homozygous recessive genotype ii. The child must inherit one recessive allele i from each biological parent.

Step 2: The father has blood group A. Since he must possess at least one i allele to pass to the child, his genotype is uniquely determined to be heterozygous, represented as I^Ai.

Step 3: The mother has blood group B. Because she must also carry and pass on the recessive i allele, her genotype is determined to be heterozygous, represented as I^Bi.

Step 4: We construct a Punnett square for the cross between I^Ai and I^Bi. The resulting offspring genotypes are I^AI^B (blood group AB), I^Ai (blood group A), I^Bi (blood group B), and ii (blood group O).

Step 5: Each genetic combination has an equal probability of occurrence. Therefore, the probability of producing a child with genotype ii (blood group O) is exactly 1 out of 4, which equates to 25%.

Final Answer: 25%

Answer: (A)

Go Back to Question 2

Q3.

Solution

Concept:

Mitosis is a highly coordinated process divided into distinct morphological stages: prophase, metaphase, anaphase, and telophase. Centrioles serve as the main microtubule-organizing centers in animal cells. Understanding the precise chronological events of the cytoskeleton and centrosome cycle during early mitotic entry is essential for identifying when spindle morphogenesis initiates.

Solution:

Step 1: During the S phase of interphase, the centrosome duplicates, resulting in two pairs of centrioles contained within a single cellular region outside the nucleus.

Step 2: As the cell enters prophase, the first true stage of mitosis, chromatin begins to condense into distinct chromosomes, and the nuclear envelope starts to disintegrate.

Step 3: Concurrently in prophase, the duplicated centrosomes (each containing a pair of centrioles) begin to synthesize mitotic spindle microtubules and actively migrate away from each other toward the opposite poles of the animal cell.

Step 4: By metaphase, these centrioles have already reached the opposite poles, and the chromosomes align along the equatorial plate. Anaphase involves the separation of sister chromatids.

Step 5: Since the initial movement and migration of centrioles toward opposite poles begins during prophase, option B is the correct physiological stage.

Final Answer: Prophase

Answer: (B)

Go Back to Question 3

Q4.

Solution

Concept:

The gastric mucosa contains specialized tubular glands composed of distinct secretory cell types. These cells function in coordination to produce gastric juice under neural and hormonal regulation. Identifying the specific cellular sources of enzymes, hydrochloric acid, and protective mucus is crucial for understanding the biochemical breakdown of dietary nutrients in the stomach.

Solution:

Step 1: Gastric glands are composed of several cell types, including mucous neck cells, peptic or chief cells, and parietal or oxyntic cells, each secreting unique components.

Step 2: Parietal cells, also known as oxyntic cells, are responsible for secreting hydrochloric acid (HCl) and intrinsic factor, which is necessary for vitamin B_{12} absorption.

Step 3: Chief cells, also termed peptic cells or zymogenic cells, synthesize and secrete the inactive proenzyme pepsinogen into the gastric lumen.

Step 4: Upon stimulation by the vagus nerve (parasympathetic neural input), chief cells are signaled to release pepsinogen via exocytosis. This proenzyme is then cleaved by gastric acid into active pepsin.

Step 5: Goblet cells secrete mucus to protect the stomach lining. Therefore, the specific cells that secrete pepsinogen are the chief cells, corresponding to option B.

Final Answer: Chief cells

Answer: (B)

Go Back to Question 4

Q5.

Solution

Concept:

Biotic interactions in an ecosystem dictate the evolutionary dynamics between species. Parasitism is a heterospecific interaction where one organism benefits at the direct expense of the host. Certain avian species have evolved a specific behavioral manipulation known as social or reproductive parasitism, avoiding the energetic costs associated with nest construction and parental care.

Solution:

Step 1: Parasitism is broadly classified based on the nature of the interaction. Ectoparasites live on the outer surface of hosts, while endoparasites reside inside the host's body.

Step 2: Brood parasitism is a highly specialized form of parasitic behavior found predominantly among birds, where the parasite relies on a host species to rear its offspring.

Step 3: The European cuckoo bird does not build its own nest. Instead, it lays its eggs within the nest of a host species, such as a crow.

Step 4: The cuckoo eggs have evolved to closely mimic the size, color, and patterning of the host's eggs, reducing the likelihood that the crow will detect and eject the foreign eggs.

Step 5: The host crow unknowingly spends metabolic energy incubating the cuckoo's eggs and feeding the parasite's chicks. This phenomenon is termed brood parasitism, matching option C.

Final Answer: Brood parasitism

Answer: (C)

Go Back to Question 5

Q6.

Solution

Concept:

Angiosperm taxonomy relies heavily on floral and vegetative characteristics to distinguish between plant families. The organization of the calyx, corolla, androecium, and gynoecium provides definitive diagnostic traits. Analyzing specific features such as the orientation of the locules, placentation type, and stamen attachment allows for precise family identification.

Solution:

Step 1: The family Solanaceae, commonly known as the potato family, exhibits distinct floral patterns that distinguish it from Brassicaceae, Fabaceae, or Liliaceae.

Step 2: In Solanaceae, the flowers are typically actinomorphic and bisexual. The calyx consists of five united sepals that are persistent, meaning they remain attached and grow along with the developing fruit.

Step 3: The androecium features five stamens that are epipetalous, meaning the filaments are physically fused to the inner face of the corolla petals.

Step 4: The gynoecium is bicarpellary and syncarpous with a superior ovary. A primary diagnostic trait is the swollen placenta bearing numerous ovules, separated by an obliquely oriented septum.

Step 5: Comparing these specified traits to the provided options confirms that persistent calyx, epipetalous stamens, and an oblique swollen placenta are uniquely characteristic of Solanaceae.

Final Answer: Solanaceae

Answer: (B)

Go Back to Question 6

Q7.

Solution

Concept:

Human embryogenesis is a highly synchronized developmental sequence that begins at fertilization. The single-celled zygote undergoes a series of rapid mitotic divisions called cleavage. These cleavages increase cell number without changing the overall volume of the embryo, transitioning through specific morphological landmarks prior to implantation and germ layer differentiation.

Solution:

Step 1: Fertilization of the secondary oocyte by a spermatozoon in the ampulla of the fallopian tube produces the diploid, single-celled zygote.

Step 2: The zygote undergoes rapid holoblastic cleavage as it moves down the oviduct. At the 8 to 16-cell stage, it forms a solid, mulberry-like ball of cells called the morula.

Step 3: As cleavage continues, fluid enters the morula, creating a central cavity called the blastocoel. This transforms the embryo into a hollow sphere of cells known as the blastocyst.

Step 4: The blastocyst implants into the uterine endometrium. Following implantation, the inner cell mass undergoes gastrulation, a morphogenetic movement of cells that establishes the three primary germ layers, forming the gastrula.

Step 5: The correct chronological sequence of these early embryonic stages is: Zygote → Morula → Blastocyst → Gastrula, which corresponds directly to option A.

Final Answer: Zygote → Morula → Blastocyst → Gastrula

Answer: (A)

Go Back to Question 7

Q8.

Solution

Concept:

Cloning vectors are specialized DNA molecules used to carry foreign genetic material into a host cell for replication or expression. Different vectors have distinct insert size capacities based on their structural configuration. Selecting an appropriate vector requires matching the size of the target gene with the maximum carrying capacity of the vector system.

Solution:

Step 1: Plasmids like pBR322 and pUC19 are small, circular, extrachromosomal DNA molecules widely used in molecular biology. Their optimal insert size capacity is generally limited to less than 10 kilobases (kb). Larger inserts render plasmids unstable and difficult to transform.

Step 2: The Ti-plasmid of *Agrobacterium tumefaciens* is utilized primarily for transferring genes into plant genomes, rather than routinely hosting fragments exceeding 40 kb in bacterial vectors.

Step 3: Cosmids are hybrid vectors constructed by combining features of plasmids and the lambda (λ) bacteriophage. Specifically, they contain a plasmid origin of replication, selectable markers, and phage cos sites.

Step 4: Because of the packaging constraints of the λ phage head mechanism, cosmids require a large DNA insert to be efficiently packaged into viral capsids. They are optimized to carry large genomic fragments ranging between 30 and 45 kb.

Step 5: For an insert fragment exceeding 40 kb destined for a bacterial host, a cosmid is the most structurally efficient choice among the given options.

Final Answer: Cosmid

Answer: (C)

Go Back to Question 8

Q9.

Solution

Concept:

Electrocardiography (ECG) is a diagnostic technique that records the electrical activity of the myocardium over time using surface electrodes. A standard normal ECG tracing consists of a series of characteristic waves designated as P, QRS, and T. Each component corresponds to a specific phase of atrial or ventricular electrical activation or recovery.

Solution:

Step 1: The P-wave is the first small upward deflection, representing the depolarization of the atria, which triggers atrial contraction.

Step 2: The QRS complex consists of a downward deflection (Q), a tall upward wave (R), and a final downward deflection (S). This complex represents the rapid depolarization of the ventricles, which precedes ventricular systole.

Step 3: The T-wave is a smooth, upward deflection following the QRS complex. It reflects the electrical recovery or repolarization of the ventricular muscle fibers.

Step 4: Atrial repolarization occurs simultaneously during ventricular depolarization and is structurally masked by the larger QRS complex on a standard tracing.

Step 5: Thus, the T-wave specifically correlates with the repolarization of the ventricles, which matches option C.

Final Answer: Repolarisation of ventricles

Answer: (C)

Go Back to Question 9

Q10.

Solution

Concept:

The Calvin cycle (C3 pathway) is the light-independent phase of photosynthesis where carbon dioxide (CO_2) is fixed into carbohydrates. This process takes place within the stroma of chloroplasts. To understand the stoichiometry of carbohydrate synthesis, one must calculate the total number of carbon atoms fixed relative to the molecular composition of the final sugar product.

Solution:

Step 1: Each individual turn of the Calvin cycle fixes one single molecule of inorganic carbon dioxide (CO_2), thereby adding one carbon atom into the metabolic pool.

Step 2: The primary direct product of the Calvin cycle is a three-carbon sugar phosphate called glyceraldehyde-3-phosphate (G3P). It takes three turns of the cycle to produce one net molecule of G3P for export.

Step 3: Glucose is a six-carbon monosaccharide ($C_6H_{12}O_6$). To synthesize one molecule of glucose, six molecules of CO_2 must be fixed, requiring exactly six complete turns of the Calvin cycle.

Step 4: Sucrose ($C_{12}H_{22}O_{11}$) is a disaccharide composed of one glucose molecule and one fructose molecule covalently linked. It contains a total of twelve carbon atoms.

Step 5: Because sucrose contains twelve carbon atoms, the plant requires twelve individual molecules of CO_2 to be fixed. This necessitates exactly 12 turns of the Calvin cycle, corresponding to option C.

Final Answer: 12

Answer: (C)

Go Back to Question 10

Q11.

Solution

Concept:

Point mutations involve the substitution of a single nucleotide base pair within a DNA molecule. These substitutions are classified into distinct biochemical categories based on the structural properties of the nitrogenous bases involved. Nitrogenous bases are structurally categorized into double-ringed purines (Adenine and Guanine) and single-ringed pyrimidines (Cytosine, Thymine, and Uracil).

Solution:

Step 1: A substitution mutation can either maintain the structural class of the base or alter it.

Step 2: A transition mutation occurs when a purine is replaced by another purine ($A \leftrightarrow G$) or a pyrimidine is replaced by another pyrimidine ($C \leftrightarrow T$).

Step 3: A transversion mutation occurs when a purine is replaced by a pyrimidine, or a pyrimidine is replaced by a purine ($A/G \leftrightarrow C/T$).

Step 4: Frame-shift mutations involve the insertion or deletion of nucleotides, altering the reading frame, while nonsense mutations introduce a premature stop codon.

Step 5: Because the question specifies the conversion of a purine to a pyrimidine or vice versa, this explicitly defines a transversion mutation, which corresponds to option B.

Final Answer: Transversion

Answer: (B)

Go Back to Question 11

Q12.

Solution

Concept:

Erwin Chargaff's rules outline the stoichiometric relationships between nitrogenous bases in double-stranded DNA molecules. The rules state that DNA from any cell of any organism should have a 1:1 ratio of pyrimidine and purine bases. Specifically, the amount of Adenine is equal to Thymine, and the amount of Guanine is equal to Cytosine.

Solution:

Step 1: According to Chargaff's rules, in any double-stranded DNA molecule, Adenine (A) base-pairs exclusively with Thymine (T). Therefore, the percentage of Adenine must equal the percentage of Thymine:

$$\%A = \%T$$

Given that $\%A = 30\%$, it follows that $\%T = 30\%$.

Step 2: The combined percentage of Adenine and Thymine in this specific DNA molecule is:

$$\%A + \%T = 30\% + 30\% = 60\%$$

Step 3: The remaining portion of the DNA molecule consists of Guanine (G) and Cytosine (C). The total percentage for all four bases combined must equal 100%:

$$\%G + \%C = 100\% - 60\% = 40\%$$

Step 4: Since Guanine base-pairs exclusively with Cytosine, their amounts must be equal ($\%G = \%C$). We divide the remaining percentage equally between them:

$$\%C = \frac{40\%}{2} = 20\%$$

Step 5: Therefore, the percentage of Cytosine in the DNA sequence is 20%, which corresponds to option A.

Final Answer: 20%

Answer: (A)

Go Back to Question 12

Q13.

Solution

Concept:

Plant anatomy categorizes vascular bundles based on the relative spatial arrangement of xylem and phloem, and the presence or absence of meristematic tissue. The presence of cambium determines whether a vascular bundle can undergo secondary growth. Understanding these structural configurations is essential for differentiating between monocotyledonous and dicotyledonous plant organs.

Solution:

Step 1: Vascular bundles where xylem and phloem lie on the same radius are termed conjoint. If they lie on alternating radii, they are termed radial (typically found in roots).

Step 2: Within conjoint vascular bundles, if there is no cambium present between the xylem and phloem, the bundle is structurally incapable of secondary growth and is termed closed. This is characteristic of monocot stems.

Step 3: If a strip of intrafascicular cambium is physically present between the primary xylem and primary phloem, the bundle is capable of secondary growth and is classified as open. This configuration is characteristic of dicotyledonous stems.

Step 4: Bicollateral closed bundles are rare; bicollateral bundles generally possess phloem on both outer and inner sides of the xylem and are open.

Step 5: Since the question describes a bundle where xylem and phloem are conjoint and a cambium layer is present between them, it is classified as a conjoint open vascular bundle, matching option C.

Final Answer: Conjoint open

Answer: (C)

Go Back to Question 13

Q14.

Solution

Concept:

Ecological pyramids graphically represent the trophic structure and function of an ecosystem across successive levels. The pyramid of biomass depicts the total dry weight of living organic matter per unit area. While terrestrial ecosystems typically display an upright pyramid, certain aquatic environments exhibit structural variations due to differences in organism lifespan and turnover rates.

Solution:

Step 1: In a deep aquatic ecosystem like an open ocean, the primary producers are microscopic phytoplankton. Though numerous, their individual biomass is extremely small, and they exhibit a very rapid turnover rate due to intense grazing.

Step 2: The standing crop biomass of the phytoplankton at any single point in time is relatively low compared to the biomass of the organisms that feed upon them.

Step 3: The primary consumers are zooplankton, which have a larger individual biomass and longer lifespans than phytoplankton.

Step 4: The secondary and tertiary consumers are small and large predatory fishes. These organisms accumulate a substantial amount of biomass over their prolonged lifespans, supported by the highly productive lower trophic levels.

Step 5: When plotted graphically, the biomass increases at higher trophic levels, resulting in a narrow base and a wide top. This configuration describes an inverted pyramid, which matches option B.

Final Answer: Inverted

Answer: (B)

Go Back to Question 14

Q15.

Solution

Concept:

The family Fabaceae (formerly Papilionaceae) is a major group of flowering plants distinguished by specific morphological adaptations of the flower. Identifying the characteristic configuration of the corolla petals (aestivation) and the arrangement of the male reproductive organs (androecium) provides unambiguous diagnostic criteria for taxonomy.

Solution:

Step 1: Vexillary aestivation is a unique arrangement of the corolla found in the family Fabaceae. It consists of five petals: one large posterior petal called the vexillum or standard, which overlaps two lateral petals called alae or wings. These wings, in turn, overlap two anterior, fused petals called the carina or keel.

Step 2: The androecium of Fabaceae typically consists of ten stamens. In most members, these stamens are diadelphous, meaning they are fused by their filaments into two distinct bundles.

Step 3: The standard arrangement is a (9) + 1 configuration, where nine filaments are fused to form a sheath around the pistil, while the tenth posterior stamen remains completely free.

Step 4: Solanaceae possesses five epipetalous stamens, Brassicaceae features six tetradynamous stamens, and Poaceae typically has three stamens with versatile anthers.

Step 5: Therefore, diadelphous stamens paired with vexillary aestivation are definitive hallmarks of the family Fabaceae, corresponding to option A.

Final Answer: Fabaceae

Answer: (A)

Go Back to Question 15

Q16.

Solution

Concept:

Restriction endonucleases, often referred to as molecular scissors, are bacterial enzymes that cleave double-stranded DNA at specific internal nucleotide sequences. These enzymes are essential tools in recombinant DNA technology. Their target sites possess a distinct structural symmetry that allows the enzyme to recognize and bind to the substrate symmetrically on both strands.

Solution:

Step 1: Restriction enzymes scan DNA molecules for highly specific sequences, typically ranging from 4 to 8 base pairs in length.

Step 2: A sequence that reads exactly the same on both complementary strands when the direction of orientation is kept identical (e.g., $5' \rightarrow 3'$ on the top strand and $5' \rightarrow 3'$ on the bottom strand) exhibits rotational symmetry.

Step 3: This type of sequence is defined as a palindromic sequence. An example is the EcoRI recognition site: $5'-GAATTC-3'$, which pairs with $3'-CTTAAG-5'$ (reading $5'-GAATTC-3'$ in reverse).

Step 4: Satellite DNA consists of highly repetitive non-coding sequences, promoters are binding sites for RNA polymerase, and operons are clusters of coregulated genes.

Step 5: Thus, the sequence described by the user is a palindromic sequence, making option B the correct response.

Final Answer: Palindromic sequence

Answer: (B)

Go Back to Question 16

Q17.

Solution

Concept:

Hormones are biochemical messengers categorized into distinct structural classes: peptides, steroids, and amino acid derivatives. Their mechanism of action is determined by their chemical solubility. Hydrophilic hormones bind to extracellular surface receptors, whereas lipophilic hormones can cross the lipid bilayer to interact with intracellular or nuclear receptors, directly altering gene transcription.

Solution:

Step 1: Epinephrine and thyroxine are both chemical derivatives of the amino acid tyrosine. However, they exhibit fundamentally different solubility properties and mechanisms of action.

Step 2: Epinephrine (adrenaline) is a hydrophilic catecholamine. It cannot cross the plasma membrane and instead binds to cell-surface β-adrenergic or α-adrenergic receptors, utilizing secondary messengers like cyclic AMP.

Step 3: Insulin and glucagon are large, water-soluble peptide hormones synthesized by the pancreas, and they bind exclusively to transmembrane receptors on target cells.

Step 4: Thyroxine (T_4) is an iodinated tyrosine derivative. Despite being an amino acid derivative, it is highly lipophilic. It enters target cells via specific transporters and binds to intracellular thyroid hormone receptors located directly within the cell nucleus.

Step 5: Because thyroxine is derived from tyrosine and functions specifically through an intracellular nuclear receptor, it satisfies all criteria outlined in the question, corresponding to option C.

Final Answer: Thyroxine

Answer: (C)

Go Back to Question 17

Q18.

Solution

Concept:

The respiratory membrane is optimized to facilitate the rapid passive diffusion of respiratory gases (O_2 and CO_2) between the external atmosphere and the pulmonary capillaries. According to Fick's law of diffusion, the rate of gas transfer is inversely proportional to the thickness of the structural barrier. The tissue lining the primary exchange sites must therefore be minimized in structural thickness.

Solution:

Step 1: The primary sites where gaseous exchange occurs within the human lung are the alveoli. The wall of each alveolus must be thin to maximize diffusion efficiency.

Step 2: Simple squamous epithelium consists of a single layer of flattened, scale-like cells with irregular boundaries. This morphology provides the thinnest cellular barrier possible in vertebrate anatomy.

Step 3: Simple cuboidal epithelium is found in regions specialized for secretion and absorption, such as kidney tubules, while ciliated columnar epithelium lines the upper respiratory tract to sweep mucus.

Step 4: Stratified squamous epithelium is multi-layered and serves a protective role against mechanical abrasion, which would severely impede gas diffusion if present in the alveoli.

Step 5: The alveolar wall is composed of a single layer of simple squamous epithelium (Type I pneumocytes), which minimizes the diffusion distance for gases. This matches option B.

Final Answer: Simple squamous epithelium

Answer: (B)

Go Back to Question 18

Q19.

Solution

Concept:

Under anaerobic conditions or high metabolic demands that exceed oxygen supply, skeletal muscle cells shift from aerobic oxidative phosphorylation to lactic acid fermentation. This alternate metabolic pathway allows for the continuous regeneration of NAD^+ from NADH, ensuring that glycolysis can proceed uninterrupted to generate ATP for muscle contraction.

Solution:

Step 1: Glycolysis converts glucose into two molecules of pyruvic acid, generating a net yield of two ATP and two molecules of reduced NADH.

Step 2: During strenuous exercise, oxygen levels within the sarcoplasm drop significantly, preventing pyruvic acid from entering the mitochondrial matrix for decarboxylation by pyruvate dehydrogenase.

Step 3: To maintain a continuous supply of oxidized NAD^+ required by glyceraldehyde-3-phosphate dehydrogenase in glycolysis, pyruvic acid acts as an alternate electron acceptor.

Step 4: Pyruvic acid is reduced into lactic acid. This specific biochemical step involves the transfer of electrons from NADH, producing NAD^+ and lactic acid.

Step 5: This reversible redox reaction is catalyzed by the cytosolic enzyme lactate dehydrogenase (LDH). Succinate and malate dehydrogenases are components of the citric acid cycle. This confirms option B.

Final Answer: Lactate dehydrogenase

Answer: (B)

Go Back to Question 19

Q20.

Solution

Concept:

The light-dependent phase of photosynthesis involves the absorption of light by Photosystem II, driving the photolysis or splitting of water molecules ($2H_2O \rightarrow 4H^+ + 4e^- + O_2$). This reaction takes place on the luminal side of the thylakoid membrane and is catalyzed by an oxygen-evolving complex (OEC) that requires specific inorganic cofactor ions to maintain structural integrity.

Solution:

Step 1: The photolysis of water serves as the ultimate electron source to replace the electrons lost by the oxidized reaction center chlorophyll P_{680} in Photosystem II.

Step 2: The water-splitting complex, or oxygen-evolving complex, contains a specialized catalytic cluster of metal ions that facilitate the abstraction of electrons from water.

Step 3: Biochemical and structural studies demonstrate that this catalytic center contains four manganese ions (Mn) and one calcium ion (Ca), along with chloride ions (Cl^-) as essential cofactors.

Step 4: Magnesium (Mg) is the central structural component of the porphyrin ring of chlorophyll molecules, zinc (Zn) activates carbonic anhydrase, and copper (Cu) is found in plastocyanin.

Step 5: Among the given options, manganese (Mn) is the element directly required for the water-splitting mechanism, matching option B.

Final Answer: Manganese

Answer: (B)

Go Back to Question 20

Q21.

Solution

Concept:

Chromosomal aberrations result from errors during meiosis, primarily due to the non-disjunction of homologous chromosomes or sister chromatids during anaphase. This leads to aneuploidy, where an individual inherits an abnormal number of chromosomes. Turner's syndrome is a classic human genetic disorder caused by sex chromosome monosomy.

Solution:

Step 1: A normal human somatic cell contains a diploid complement of 46 chromosomes, structurally organized into 22 pairs of autosomes (44) and one pair of sex chromosomes (XX in females or XY in males).

Step 2: Turner's syndrome occurs when a female is born with only one functional sex chromosome instead of the normal pair. This condition represents a type of monosomy.

Step 3: Due to the loss of one X chromosome, the total number of chromosomes in the somatic cells drops from 46 to 45.

Step 4: Genetically, the individual possesses the normal 44 autosomes but has only a single X chromosome, with no second sex chromosome present. This is written as 44 + XO or 45, X.

Step 5: Option A (44 + XXY) represents Klinefelter's syndrome, while option B (44 + XO) correctly depicts the karyotype of Turner's syndrome.

Final Answer: 44 + XO

Answer: (B)

Go Back to Question 21

Q22.

Solution

Concept:

The endoplasmic reticulum (ER) is an extensive interconnected network of membrane-bound tubules and sacs that is continuous with the outer nuclear membrane. The ER is structurally and functionally segregated into two regions based on the presence or absence of surface ribosomes, which dictates the biochemical biosynthetic capacity of each domain.

Solution:

Step 1: The Rough Endoplasmic Reticulum (RER) is studded with ribosomes on its outer cytosolic surface. Its primary function is the synthesis, folding, and post-translational modification of membrane-bound or secreted proteins.

Step 2: The Smooth Endoplasmic Reticulum (SER) lacks attached ribosomes. Consequently, its membrane contains distinct sets of enzymes specialized for lipid metabolism rather than protein synthesis.

Step 3: The SER is the major site for the synthesis of fatty acids, phospholipids, and cholesterol. In animal cells, it is specifically responsible for producing steroidal hormones such as estrogen, progesterone, and testosterone.

Step 4: The Golgi apparatus modifies and packages proteins, while peroxisomes are involved in long-chain fatty acid oxidation and hydrogen peroxide detoxification.

Step 5: Because the question asks for the organelle responsible for synthesizing steroidal lipids and phospholipids, the answer is the Smooth Endoplasmic Reticulum, matching option C.

Final Answer: Smooth Endoplasmic Reticulum

Answer: (C)

Go Back to Question 22

Q23.

Solution

Concept:

Energy flow within an ecosystem follows thermodynamic laws, moving across consecutive trophic levels starting from autotrophic primary producers. Ecosystem productivity is defined as the rate at which biomass or organic matter is accumulated per unit area. This productivity is categorized into primary and secondary forms based on the trophic level where the synthesis occurs.

Solution:

Step 1: Primary productivity refers to the rate at which radiant solar energy is captured and converted into organic compounds by photosynthetic autotrophs (producers).

Step 2: Gross primary productivity is the total energy fixed, while net primary productivity is the remaining energy after accounting for autotrophic respiratory losses (R).

Step 3: Secondary productivity is defined as the rate at which organic matter is re-synthesized and assimilated into new biomass by heterotrophic organisms.

Step 4: Heterotrophs include all consumers—herbivores, carnivores, and omnivores—that ingest organic compounds synthesized by other organisms, converting them into their own cellular components.

Step 5: Since secondary productivity refers broadly to the accumulation of energy by consumers rather than just herbivores or decomposers alone, option B is the correct choice.

Final Answer: Consumers

Answer: (B)

Go Back to Question 23

Q24.

Solution

Concept:

The Five-Kingdom Classification system, proposed by Robert H. Whittaker in 1969, categorizes organisms based on structural criteria: cell type, thallus organization, mode of nutrition, reproduction, and phylogenetic relationships. Understanding the precise cellular boundaries and structural criteria of each kingdom is necessary for correct taxonomic classification.

Solution:

Step 1: Kingdom Monera is uniquely characterized by prokaryotic cellular organization. Any organism possessing a true nucleus enclosed by a nuclear envelope is excluded from Monera.

Step 2: Kingdoms Fungi, Plantae, and Animalia are fundamentally reserved for organisms that exhibit multicellular or tissue-level structural organization.

Step 3: Kingdom Protista was specifically established by Ernst Haeckel and adapted by Whittaker to serve as a taxonomic repository for all unicellular eukaryotic organisms.

Step 4: The description specifies an organism that is unicellular and eukaryotic. Even though it is photosynthetic and possesses a cell wall (traits shared with multi-cellular plants), its unicellular nature places it within Protista.

Step 5: Examples of such organisms include unicellular green algae like *Chlamydomonas* and diatoms. Thus, the organism belongs to Kingdom Protista, matching option B.

Final Answer: Protista

Answer: (B)

Go Back to Question 24

Q25.

Solution

Concept:

The microsporangium, or pollen sac, of an angiosperm anther is enclosed by a specialized multi-layered wall. From the outside inward, these layers are the epidermis, endothecium, middle layers, and tapetum. Each layer has specific structural and physiological adaptations that support the development and dispersal of male gametophytes.

Solution:

Step 1: The outer three layers (epidermis, endothecium, and middle layers) provide mechanical protection to the young anther. The endothecium develops fibrous bands that assist in the hygroscopic dehiscence of the mature anther.

Step 2: The tapetum is the innermost layer surrounding the sporogenous tissue. The cells of the tapetum are typically larger, possess dense cytoplasm, and frequently become multinucleate due to endomitosis.

Step 3: As microspore mother cells undergo meiosis to form microspore tetrads, the tapetal cells break down to release nutrients, hormones, and structural proteins into the locule.

Step 4: The tapetum synthesizes sporopollenin, a highly resistant organic polymer that forms the outer exine layer of the pollen grain wall, along with pollenkit proteins.

Step 5: Therefore, the primary physiological function of the tapetum is providing nourishment to the developing microspores, which corresponds to option C.

Final Answer: Nourishment of developing pollen grains

Answer: (C)

Go Back to Question 25

Q26.

Solution

Concept:

Molecular diagnostics and genetic engineering often require working with small or degraded samples of DNA. To perform structural analysis or cloning, researchers utilize specific enzymatic techniques capable of rapidly generating millions of identical copies of a target sequence *in vitro* without using a living host organism.

Solution:

Step 1: Gel electrophoresis is a physical separation technique used to sort DNA fragments based on their molecular size and electrical charge, but it does not synthesize or amplify DNA.

Step 2: Western blotting is used for protein detection, and ELISA (Enzyme-Linked Immunosorbent Assay) is an immunochemical technique utilized to detect antigens or antibodies.

Step 3: The Polymerase Chain Reaction (PCR), developed by Kary Mullis in 1983, is an enzymatic technique designed for the rapid *in vitro* amplification of specific DNA sequences.

Step 4: PCR relies on thermal cycling, which exposes the reaction mixture to repeating phases of denaturation (at high temperatures), primer annealing, and enzymatic extension catalyzed by a thermostable DNA polymerase (such as *Taq* polymerase).

Step 5: Because the prompt specifies an *in vitro* technique designed to amplify specific DNA fragments, the answer is Polymerase Chain Reaction, matching option B.

Final Answer: Polymerase Chain Reaction

Answer: (B)

Go Back to Question 26

Q27.

Solution

Concept:

The digestive tract synthesizes localized gastrointestinal hormones that regulate the timing and composition of digestive secretions. These hormones are produced by enteroendocrine cells in response to the entry of acidic chyme into the duodenum. Understanding the functional differences between these messengers is key to analyzing exocrine pancreatic regulation.

Solution:

Step 1: Gastrin is produced by G-cells in the stomach mucosa and primarily stimulates parietal cells to secrete hydrochloric acid.

Step 2: Cholecystokinin (CCK) is secreted by the duodenal mucosa in response to the presence of fats and proteins. CCK stimulates the gallbladder to contract and induces the pancreas to secrete an enzyme-rich pancreatic juice.

Step 3: Secretin was the first hormone discovered, isolated from the duodenal mucosa. It is triggered by the high acidity of gastric chyme entering the small intestine.

Step 4: Secretin acts on the exocrine pancreatic ductal cells, stimulating them to secrete a watery fluid high in bicarbonate ions (HCO_3^-). This alkaline fluid neutralizes gastric acid and establishes an optimal pH for duodenal enzymes.

Step 5: Since the question specifies a hormone that induces a pancreatic secretion rich in water and bicarbonate ions, secretin is the correct choice, matching option B.

Final Answer: Secretin

Answer: (B)

Go Back to Question 27

Q28.

Solution

Concept:

Skeletal muscle fibers contain thousands of rod-like myofibrils that exhibit a characteristic striated appearance under microscopic examination. These striations are formed by the alternating arrangement of thin actin filaments and thick myosin filaments. The structural and functional unit of contraction is defined by repeating segments along the length of the myofibril.

Solution:

Step 1: The thin actin filaments are anchored at their midpoints to a dense protein disc called the Z-line (or Z-disc).

Step 2: The region containing thick filaments forms the dark A-band, while the region containing only thin filaments forms the light I-band.

Step 3: A sarcomere is defined as the structural segment of a myofibril that extends from one Z-line to the next consecutive Z-line.

Step 4: During muscle contraction, the sliding filament mechanism causes the Z-lines to move closer together, shortening the individual sarcomere units along the length of the muscle fiber.

Step 5: The sarcolemma refers to the plasma membrane of the muscle cell, and the sarcoplasm is its cytoplasm. Therefore, the structural unit bounded by two successive Z-lines is the sarcomere, matching option C.

Final Answer: Sarcomere

Answer: (C)

Go Back to Question 28

Q29.

Solution

Concept:

Meiosis I features a prolonged and complex Prophase I, during which homologous chromosomes pair and exchange genetic material. Prophase I is subdivided into five sequential stages: leptotene, zygotene, pachytene, diplotene, and diakinesis. Each stage is characterized by distinct chromosomal behaviors that can be observed cytologically.

Solution:

Step 1: During leptotene, chromatin condenses, and chromosomes become visible as thin threads. In zygotene, homologous chromosomes begin to pair up in a highly specific alignment called synapsis, mediated by the synaptonemal complex.

Step 2: The paired homologous chromosomes form bivalents or tetrads. This stage marks the transition into pachytene.

Step 3: During pachytene, large recombination nodules appear along the synaptonemal complex. These nodules are the sites where crossing over occurs—the physical exchange of genetic fragments between non-sister chromatids of homologous chromosomes.

Step 4: This process is mediated by the enzyme recombinase and results in genetic recombination.

Step 5: In the subsequent diplotene stage, the synaptonemal complex dissolves, and the homologous chromosomes remain held together only at the points of crossing over, called chiasmata. Thus, crossing over occurs during pachytene, corresponding to option C.

Final Answer: Pachytene

Answer: (C)

Go Back to Question 29

Q30.

Solution

Concept:

Plant growth and development are regulated by five major classes of phytohormones: auxins, gibberellins, cytokinins, ethylene, and abscisic acid. These phytohormones often interact synergistically or antagonistically to modulate physiological responses. Identifying these hormonal interactions is key to understanding how plants adapt to environmental stresses and regulate dormancy.

Solution:

Step 1: Abscisic acid (ABA) is a sesquiterpenoid phytohormone that primarily functions as a growth inhibitor and a stress signaling molecule, inducing stomatal closure and seed dormancy.

Step 2: Gibberellins (gibberellic acid, GA) are diterpenoid hormones that promote stem elongation, break seed and bud dormancy, and induce hydrolytic enzymes during seed germination.

Step 3: Because ABA promotes seed dormancy and prevents germination, while GA breaks dormancy and triggers seed germination, these two hormones act as direct physiological antagonists in seed development.

Step 4: ABA also counteracts the elongation effects induced by gibberellins in vegetative tissues. Auxins and cytokinins interact primarily in regulating apical dominance and organogenesis.

Step 5: Therefore, abscisic acid functions as a direct physiological antagonist to gibberellins, which matches option B.

Final Answer: Gibberellin

Answer: (B)

Go Back to Question 30

Q31.

Solution

Concept:

Biomolecules include complex carbohydrates structured as long chains of repeating monosaccharide subunits. Polysaccharides are classified as homopolysaccharides or heteropolysaccharides based on their monomeric composition. Understanding the specific chemical linkages and monomers of structural polysaccharides provides insight into the composition of fungal cell walls and arthropod exoskeletons.

Solution:

Step 1: Cellulose is a plant structural homopolysaccharide composed of repeating glucose monomers linked by $\beta - 1,4 -$ glycosidic bonds.

Step 2: Chitin is the primary structural component found in the cell walls of fungi and the rigid exoskeletons of insects and crustaceans. It is a tough, nitrogen-containing polysaccharide.

Step 3: The structural monomer of chitin is N-acetylglucosamine (NAG), which is an amino sugar derivative of glucose. These NAG monomers are joined together by $\beta - 1,4 -$ glycosidic linkages.

Step 4: N-acetylmuramic acid (NAM) is an essential component found in the peptidoglycan cell walls of eubacteria, but it is not present in fungal chitin.

Step 5: Since chitin is a homopolymer entirely composed of linked N-acetylglucosamine subunits, option A is the correct answer.

Final Answer: N-acetylglucosamine

Answer: (A)

Go Back to Question 31

Q32.

Solution

Concept:

The operon model, proposed by François Jacob and Jacques Monod in 1961, describes a mechanism for coordinated gene regulation in prokaryotes. An operon is a functional genetic unit consisting of structural genes, a promoter site, and an operator site, which is regulated by a specific repressor protein. Understanding these interactions is essential for analyzing transcription initiation.

Solution:

Step 1: The regulator gene synthesizes a repressor protein that can bind to a specific regulatory sequence within the operon.

Step 2: The promoter site is the sequence recognized and bound by RNA polymerase to initiate the transcription of structural genes.

Step 3: The operator site is a segment of DNA positioned between the promoter and the structural genes. It acts as a physical traffic control switch for transcription.

Step 4: When the repressor protein binds to the operator site, it sterically blocks RNA polymerase from moving forward along the template strand. This prevents transcription of the structural genes, turning the operon off.

Step 5: Thus, the repressor protein exerts negative control by binding directly to the operator site, corresponding to option B.

Final Answer: Operator site

Answer: (B)

Go Back to Question 32

Q33.

Solution

Concept:

The Earth's atmosphere is stratified into distinct thermal layers based on temperature gradients and altitude. From the surface upward, these layers are the troposphere, stratosphere, mesosphere, and thermosphere. Each layer contains a unique composition of gases that play roles in meteorological phenomena and filtering solar radiation.

Solution:

Step 1: The troposphere is the lowest atmospheric layer, extending from the surface up to about 12 kilometers. It contains most of the atmosphere's water vapor and is where weather events occur.

Step 2: The stratosphere extends above the troposphere up to approximately 50 kilometers. This layer is highly stable and dry.

Step 3: The stratosphere contains a high concentration of ozone (O_3) molecules, forming the ozone layer. This layer absorbs high-energy ultraviolet radiation (UV-B and UV-C) emitted by the sun.

Step 4: Mesosphere and thermosphere are higher layers with very low gas densities that do not contain the primary protective ozone layer.

Step 5: Because the ozone layer is located within the stratosphere, option B is the correct choice.

Final Answer: Stratosphere

Answer: (B)

Go Back to Question 33

Q34.

Solution

Concept:

Cyanobacteria, or blue-green algae, are photosynthetic prokaryotes capable of autotrophic carbon fixation. Certain genera, such as *Anabaena* and *Nostoc*, can also fix atmospheric nitrogen into bioavailable forms. Because the enzyme nitrogenase is highly sensitive to oxygen, these organisms develop specialized cells to isolate this biochemical process.

Solution:

Step 1: The fixation of atmospheric nitrogen ($N_2 \rightarrow NH_3$) is catalyzed by the enzyme complex nitrogenase. This enzyme is irreversibly inactivated by molecular oxygen (O_2).

Step 2: Since cyanobacteria perform oxygenic photosynthesis, oxygen is continuously generated within normal vegetative cells, which would inhibit nitrogenase activity.

Step 3: To resolve this, certain cyanobacteria differentiate specialized, thick-walled cells called heterocysts under nitrogen-limiting conditions.

Step 4: Heterocysts lack Photosystem II, meaning they do not produce oxygen through photosynthesis. They also possess a thick cell wall that restricts the entry of atmospheric oxygen, creating an anaerobic internal environment optimized for nitrogenase activity.

Step 5: Therefore, the primary physiological function of a heterocyst is nitrogen fixation, matching option C.

Final Answer: Nitrogen fixation

Answer: (C)

Go Back to Question 34

Q35.

Solution

Concept:

Contraceptive methods are categorized based on their mechanism of action: barrier methods, chemical methods, mechanical devices, or surgical interventions. Hormonal contraceptives utilize synthetic analogs of female sex steroids to modify endocrine feedback loops, regulating reproductive physiology to prevent conception.

Solution:

Step 1: Intrauterine Devices (IUDs) function primarily by altering the uterine microenvironment, increasing phagocytosis of sperm, or releasing copper ions to suppress sperm motility.

Step 2: Tubectomy is a surgical sterilization method where the fallopian tubes are cut and tied, physically preventing the ova from meeting sperm cells. Barrier methods like condoms physically block sperm entry.

Step 3: Oral contraceptive pills contain combinations of synthetic progesterone (progestogens) or a combination of estrogen and progesterone.

Step 4: These exogenous hormones exert negative feedback on the hypothalamus and anterior pituitary gland, suppressing the secretion of Follicle-Stimulating Hormone (FSH) and Luteinizing Hormone (LH). This lack of gonadotropins prevents follicular development and ovulation, while also altering the endometrium to prevent implantation.

Step 5: Thus, oral contraceptive pills prevent ovulation and implantation by altering hormonal balance, corresponding to option B.

Final Answer: Oral contraceptive pills

Answer: (B)

Go Back to Question 35

Q36.

Solution

Concept:

Biofortification uses genetic engineering technologies to increase the nutritional value of crop plants. This approach aims to address micronutrient deficiencies, known as hidden hunger, in populations that rely on staple crops. Understanding the specific biosynthetic pathways engineered into these transgenic varieties is essential for identifying their nutritional benefits.

Solution:

Step 1: Golden Rice (*Oryza sativa*) is a classic transgenic crop variety developed by Ingo Potrykus and Peter Beyer to address nutritional deficiencies in regions where rice is a staple food.

Step 2: Normal rice plants naturally synthesize beta-carotene in green tissues for photosynthesis, but the biosynthetic pathway is inactive in the edible endosperm tissue of the seed.

Step 3: Scientists inserted two foreign genes into the rice genome: the *psy* (phytoene synthase) gene from daffodils and the *crtI* (phytoene desaturase) gene from the bacterium *Erwinia uredovora*.

Step 4: These introduced genes complete the biosynthetic pathway in the grain, enabling the endosperm to synthesize and accumulate beta-carotene, which gives the rice its characteristic golden hue.

Step 5: Beta-carotene is a precursor that the human body converts into active Vitamin A. Thus, Golden Rice is engineered to synthesize beta-carotene, matching option B.

Final Answer: Beta-carotene

Answer: (B)

Go Back to Question 36

Q37.

Solution

Concept:

Nerve impulses travel along axons via the propagation of action potentials, which are driven by the sequential opening and closing of voltage-gated sodium and potassium channels. The architectural structure of the axonal membrane—specifically the presence or absence of a myelin sheath—determines the path and speed of the electrical signal.

Solution:

Step 1: Myelinated nerve fibers are insulated by a lipid-rich myelin sheath produced by Schwann cells, which is interrupted at regular intervals by uninsulated regions called the nodes of Ranvier.

Step 2: In myelinated axons, action potentials skip from one node of Ranvier to the next. This rapid, hopping mode of transmission is termed saltatory conduction.

Step 3: Unmyelinated nerve fibers lack this insulating sheath. Consequently, voltage-gated channels are distributed continuously along the entire length of the axolemma.

Step 4: When an action potential occurs at one point, it generates local currents that depolarize the immediately adjacent segment of the membrane. This process repeats sequentially along the entire length of the axon, a mechanism known as continuous conduction.

Step 5: Because the question specifies propagation along an unmyelinated nerve fiber, it occurs via continuous conduction, which matches option B.

Final Answer: Continuous conduction

Answer: (B)

Go Back to Question 37

Q38.

Solution

Concept:

Plants have evolved alternate photosynthetic pathways to minimize photorespiration under conditions of high temperature, drought, and low carbon dioxide levels. These physiological adaptations are supported by distinct anatomical changes in the leaf tissue, which spatially separate initial carbon fixation from the Calvin cycle.

Solution:

Step 1: In standard C3 plants, initial carbon fixation is mediated by RuBisCO in the mesophyll cells, where it is vulnerable to the oxygenase activity of the enzyme under high temperatures.

Step 2: C4 plants have evolved a dual-cell system to concentrate CO_2 around RuBisCO, minimizing photorespiratory losses.

Step 3: The leaves of C4 plants exhibit a specialized internal arrangement known as Kranz anatomy (from the German word for wreath).

Step 4: In Kranz anatomy, large bundle sheath cells form a tightly packed ring or wreath around the vascular bundles. These cells are surrounded by an outer layer of mesophyll cells. The bundle sheath cells typically contain large chloroplasts that lack grana, whereas the mesophyll chloroplasts are granal.

Step 5: This diagnostic anatomical structure is uniquely found in C4 plants, such as maize, sugarcane, and sorghum, which corresponds to option B.

Final Answer: C4 plants

Answer: (B)

Go Back to Question 38

Q39.

Solution

Concept:

Transcription is the biological process where RNA polymerase synthesizes a complementary RNA strand using a DNA template strand. The synthesis proceeds in a strict directionality from 5′ to 3′. Understanding base-pairing rules and the antiparallel nature of nucleic acids is essential for determining the sequence of the resulting mRNA transcript.

Solution:

Step 1: The template strand of DNA runs antiparallel to the newly synthesized RNA strand. RNA polymerase reads the template strand in the 3′ → 5′ direction and assembles the RNA molecule from 5′ to 3′.

Step 2: The given template strand is oriented as: 5′ – ATGCGAT – 3′. To simplify base pairing, we can re-write this sequence in the 3′ → 5′ direction: 3′ – TAGCGTA – 5′.

Step 3: We apply complementary base-pairing rules to determine the RNA nucleotides. In RNA, Adenine (A) pairs with Uracil (U), Thymine (T) pairs with Adenine (A), Cytosine (C) pairs with Guanine (G), and Guanine (G) pairs with Cytosine (C).

Step 4: Pairing with the template strand 3′ – TAGCGTA – 5′ gives the complementary RNA sequence: 5′ – AUGCGCAU – 3′? No, let us carefully derive it base by base from the template:

Given template: 5′ – A-T-G-C-G-A-T – 3′

The RNA strand must be antiparallel, so its 3′ end matches the DNA 5′ end:

DNA template 5′ – A pairs with RNA 3′ – U

DNA template 3′ – T (at the end) pairs with RNA 5′ – A

Let's pair step-by-step from left to right keeping orientation flipped:

DNA 5′ – A → RNA 3′ – U

DNA T → RNA A

DNA G → RNA C

DNA C → RNA G

DNA G → RNA C

DNA A → RNA U

DNA 3′ – T → RNA 5′ – A

Step 5: Writing the resulting RNA strand from 5′ to 3′ gives 5′ – AUCGCAU – 3′, which matches option B.

Final Answer: 5′ – AUCGCAU – 3′

Answer: (B)

Go Back to Question 39

Q40.

Solution

Concept:

Proteins exhibit four sequential levels of structural organization: primary, secondary, tertiary, and quaternary. The spatial configuration of a polypeptide chain determines its chemical properties and biological functionality. Analyzing the stabilizing forces at each level explains how proteins maintain their active conformations.

Solution:

Step 1: The primary structure refers to the linear sequence of amino acids linked together by covalent peptide bonds.

Step 2: The secondary structure involves local folding into patterns like α-helices or β-pleated sheets, stabilized by hydrogen bonding along the polypeptide backbone.

Step 3: The tertiary structure represents the overall three-dimensional folding of a single polypeptide chain. This conformation is stabilized by complex intramolecular interactions between amino acid side chains (R groups).

Step 4: These stabilizing forces include hydrophobic interactions, hydrogen bonds, ionic bonds (salt bridges), and covalent disulfide bonds between cysteine residues. This three-dimensional folding forms active sites, rendering the protein biologically functional.

Step 5: Quaternary structure only occurs in multi-subunit proteins. Thus, the level described—stabilized by disulfide bonds and hydrophobic interactions to form a functional 3D shape—is the tertiary structure, matching option C.

Final Answer: Tertiary structure

Answer: (C)

Go Back to Question 40

Q41.

Solution

Concept:

The human brain is a highly specialized organ divided into the forebrain, midbrain, and hindbrain. The diencephalon, located in the forebrain, contains critical regulatory centers. These centers act as the master integration zones for homeostatic control mechanisms, connecting the nervous system to the endocrine system.

Solution:

Step 1: The cerebrum is responsible for complex cognitive functions, memory, sensory perception, and voluntary motor control.

Step 2: The cerebellum, part of the hindbrain, regulates muscle coordination, posture, and balance. The medulla oblongata controls autonomic cardiovascular reflexes and respiration.

Step 3: The hypothalamus is a small but vital region located at the base of the diencephalon, directly below the thalamus. It contains specialized nuclei that monitor physiological parameters in the blood.

Step 4: The hypothalamus acts as the primary thermostat of the body, regulating heat production and loss. It also contains the osmoreceptors and satiety centers that control thirst, fluid balance, and hunger.

Step 5: Therefore, the region of the brain that coordinates body temperature, hunger, and thirst is the hypothalamus, matching option C.

Final Answer: Hypothalamus

Answer: (C)

Go Back to Question 41

Q42.

Solution

Concept:

Decomposition is a critical ecological process through which dead organic matter (detritus) is broken down into simpler inorganic nutrients. This process is essential for nutrient cycling within ecosystems and proceeds through five distinct, overlapping stages: fragmentation, leaching, catabolism, humification, and mineralization.

Solution:

Step 1: Fragmentation involves the physical breakdown of large detritus into smaller particles by detritivores like earthworms.

Step 2: Leaching is the physical process where water-soluble inorganic nutrients sink into the soil profile and precipitate as unavailable salts.

Step 3: Catabolism is the chemical process driven by extracellular enzymes secreted by saprophytic decomposers, such as bacteria and fungi.

Step 4: These microbial enzymes chemically digest complex organic compounds within the detritus, converting them into simpler, low-molecular-weight inorganic substances.

Step 5: Humification leads to the accumulation of dark-colored amorphous humus, while the enzymatic breakdown described in the prompt is specifically defined as catabolism, corresponding to option C.

Final Answer: Catabolism

Answer: (C)

Go Back to Question 42

Q43.

Solution

Concept:

Plant taxonomy utilizes specific floral traits to identify and categorize plant families. The arrangement of the perianth, the number and relative lengths of the stamens, and the structure of the fruit provide essential diagnostic criteria that distinguish different angiosperm lineages.

Solution:

Step 1: The family Brassicaceae (formerly Cruciferae), commonly known as the mustard family, possesses a distinctive set of floral modifications.

Step 2: The corolla features four free petals arranged diagonally in the shape of a cross, a configuration known as a cruciform corolla.

Step 3: The androecium consists of six stamens that exhibit a tetradynamous arrangement: four inner stamens have long filaments, while the two outer stamens have short filaments.

Step 4: The gynoecium develops a syncarpous, superior ovary with a false septum called the replum. The characteristic dry, dehiscent fruit that develops from this structure is a siliqua.

Step 5: Matching these unique morphological hallmarks to the provided choices confirms that they are diagnostic traits of the Brassicaceae family, corresponding to option B.

Final Answer: Brassicaceae

Answer: (B)

Go Back to Question 43

Q44.

Solution

Concept:

Following pollination, the pollen grain germinates on the stigma, producing a pollen tube that grows down through the style toward the ovary. The entry point of the pollen tube into the ovule determines the embryological classification of the fertilization process, depending on which anatomical region it penetrates.

Solution:

Step 1: An ovule consists of the central nucellus protected by integuments, with a small opening at one end called the micropyle, and an opposite basal region where the integuments originate, called the chalaza.

Step 2: Porogamy is the most common route of entry, where the pollen tube penetrates the ovule directly through the micropylar opening.

Step 3: Mesogamy occurs when the pollen tube penetrates through the central integuments or the funiculus of the ovule.

Step 4: Chalazogamy is a specialized entry pathway where the pollen tube enters the ovule from the basal region, penetrating through the tissues of the chalaza. This phenomenon is observed in plants like *Casuarina* and *Betula*.

Step 5: Because the question specifies entry through the chalazal end of the ovule, the process is classified as chalazogamy, matching option B.

Final Answer: Chalazogamy

Answer: (B)

Go Back to Question 44

Q45.

Solution

Concept:

Biopesticides utilize biological agents or toxins to control agricultural pests. *Bacillus thuringiensis* synthesizes crystalline (Cry) proteins during its sporulation phase. These proteins are highly specific endotoxins. Understanding the biochemical activation mechanism of these proteins explains their selective toxicity toward target insects.

Solution:

Step 1: The Cry proteins are synthesized by the bacterium as crystalline inclusions. In this form, they exist as inactive protoxins, which prevents them from damaging the bacterial cell itself.

Step 2: When an insect ingests the transgenic plant tissue containing the protoxin, the crystals enter the digestive tract.

Step 3: The midgut of specific target insects (such as lepidopterans, coleopterans, and dipterans) maintains a highly alkaline pH environment.

Step 4: This alkaline pH solubilizes the protein crystals. Midgut proteases then cleave the solubilized protein, converting the inactive protoxin into its active, toxic form.

Step 5: The active toxin binds to cadherin-like receptors on the epithelial cells of the midgut, creating pores that cause osmotic lysis and eventual death of the insect. This process matches option B.

Final Answer: Alkaline pH of the gut

Answer: (B)

Go Back to Question 45

Q46.

Solution

Concept:

The mammalian kidney regulates blood pressure, osmolarity, and fluid balance by adjusting the reabsorption of water and electrolytes along the nephron. While the proximal convoluted tubule performs obligatory water reabsorption, the distal segments of the nephron carry out facultative water reabsorption under precise endocrine control.

Solution:

Step 1: When hypothalamic osmoreceptors detect an increase in blood osmolarity or a decrease in blood volume, they signal the posterior pituitary gland to release stored hormones.

Step 2: The posterior pituitary releases Antidiuretic Hormone (ADH), also known as vasopressin, into the bloodstream.

Step 3: ADH travels to the kidneys and binds to V_2 receptors on the basolateral membrane of principal cells in the distal convoluted tubule (DCT) and collecting duct.

Step 4: This binding triggers an intracellular signaling cascade that induces the exocytosis of vesicles containing aquaporin-2 water channels into the apical membrane, increasing the water permeability of these segments.

Step 5: Aldosterone regulates sodium reabsorption, while ADH is primarily responsible for facultative water reabsorption in the distal tubule and collecting duct, matching option C.

Final Answer: Antidiuretic Hormone

Answer: (C)

Go Back to Question 46

Q47.

Solution

Concept:

Aerobic cellular respiration couples the oxidation of organic substrates with the generation of an electrochemical proton gradient across the inner mitochondrial membrane, driving ATP synthesis. The electron transport chain (ETC) consists of a series of protein complexes that transfer electrons derived from reduced coenzymes to a final electron acceptor.

Solution:

Step 1: Electrons from NADH and $FADH_2$ enter the electron transport chain through Complex I and Complex II, respectively, and flow through ubiquinone, Complex III, cytochrome c, and Complex IV.

Step 2: As electrons pass through these complexes, protons are actively pumped from the mitochondrial matrix into the intermembrane space, creating a proton-motive force.

Step 3: At the end of the electron transport chain, Cytochrome c Oxidase (Complex IV) transfers the low-energy electrons to their final destination.

Step 4: Molecular oxygen (O_2) serves as the terminal electron acceptor in aerobic respiration. It binds these electrons along with free protons from the matrix to form water:

$$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$$

Step 5: Without oxygen, the electron transport chain backs up, stopping ATP production via oxidative phosphorylation. This matches option C.

Final Answer: Oxygen

Answer: (C)

Go Back to Question 47

Q48.

Solution

Concept:

DNA replication is a semi-conservative, bidirectional process that occurs during the S phase of the cell cycle. Because DNA polymerases can only synthesize new strands in the $5' \rightarrow 3'$ direction, the antiparallel orientation of the parental strands requires two distinct replication mechanisms at the replication fork.

Solution:

Step 1: The leading strand is synthesized continuously in the same direction as the unwinding replication fork ($5' \rightarrow 3'$).

Step 2: The lagging strand template is oriented in the opposite direction, requiring discontinuous synthesis away from the fork. This produces short segments of DNA known as Okazaki fragments, each initiated by an RNA primer.

Step 3: DNA Polymerase I removes the RNA primers and fills the resulting gaps with DNA nucleotides, leaving a missing phosphodiester bond between adjacent fragments.

Step 4: The enzyme DNA ligase catalyzes the formation of a covalent phosphodiester bond between the $3' - OH$ group of one fragment and the $5' -$ phosphate group of the adjacent fragment.

Step 5: This biochemical joining seals the nick in the sugar-phosphate backbone, creating a continuous lagging strand. This matches option D.

Final Answer: DNA Ligase

Answer: (D)

Go Back to Question 48

Q49.

Solution

Concept:

Eukaryotic cells contain specialized compartments called membrane-bound organelles that isolate distinct biochemical microenvironments. The internal pH and enzymatic composition of an organelle determine its specific physiological role within the cell.

Solution:

Step 1: Mitochondria and chloroplasts are double-membrane-bound organelles containing their own genetic material, specialized for metabolic energy conversion.

Step 2: Peroxisomes are single-membrane-bound organelles that contain oxidative enzymes like catalase, primarily functioning in fatty acid breakdown and hydrogen peroxide detoxification.

Step 3: Lysosomes are spherical, single-membrane-bound vesicles formed by budding from the trans-Golgi network.

Step 4: The lumen of a lysosome contains more than 40 different types of hydrolytic enzymes (including acid phosphatases, nucleases, proteases, and lipases).

Step 5: These enzymes are specialized to function optimally within an acidic microenvironment (pH around 4.5 to 5.0), which is maintained by active V-type H^+-ATPase proton pumps in the lysosomal membrane. This matches option A.

Final Answer: Lysosome

Answer: (A)

Go Back to Question 49

Q50.

Solution

Concept:

Biomagnification, or bioaccumulation, describes the progressive increase in the concentration of a chemical substance within the tissues of organisms at higher trophic levels in a food chain. For a pollutant to undergo biomagnification, it must be long-lived, lipophilic, and resistant to metabolic breakdown or excretion by living organisms.

Solution:

Step 1: Gaseous or soluble pollutants like sulfur dioxide, carbon monoxide, and dissolved inorganic phosphates do not accumulate in fat tissues as they move up the food chain.

Step 2: Dichlorodiphenyltrichloroethane (DDT) is a synthetic organochlorine insecticide that is highly persistent in the environment and insoluble in water, but highly soluble in lipids.

Step 3: When aquatic producers absorb trace amounts of DDT from runoff, they cannot metabolize or excrete it. Consequently, the chemical concentrates within their lipid structures.

Step 4: As primary consumers ingest large volumes of these producers, the accumulated DDT is transferred and concentrated within their own fat deposits. This compounding effect continues up through predatory fish to apex avian predators.

Step 5: At the highest trophic levels, elevated DDT concentrations interfere with calcium metabolism, causing eggshell thinning and population declines. This matches option B.

Final Answer: DDT

Answer: (B)

Go Back to Question 50

Q51.

Solution

Concept:

The plant kingdom is categorized into major evolutionary lineages based on the presence of vascular tissue and structural adaptations for reproduction. Seed-producing plants, known as spermatophytes, are divided into two main groups based on whether their ovules are enclosed within protective maternal tissues.

Solution:

Step 1: Bryophytes and pteridophytes are seedless spore-producing plants that rely on water for the motility of flagellated male gametes.

Step 2: Angiosperms are flowering plants where the ovules are completely enclosed inside a specialized structure called the ovary. Following fertilization, the ovary matures into a fruit, and the enclosed ovules develop into covered seeds.

Step 3: Gymnosperms (derived from the Greek words for naked seeds) are vascular plants that produce seeds without developing flowers.

Step 4: In gymnosperms, the ovules are borne exposed on the surfaces of modified scale-like structures called megasporophylls, which are typically arranged into cones. Because they lack an enclosing ovary wall, the seeds develop uncovered or naked.

Step 5: Thus, naked seeds lacking an ovary wall are the defining characteristic of gymnosperms, matching option C.

Final Answer: Gymnosperms

Answer: (C)

Go Back to Question 51

Q52.

Solution

Concept:

During early mammalian development, cleavage divisions transform the single-celled zygote into a hollow ball of cells called the blastocyst. The blastocyst undergoes structural differentiation, segregating into distinct cellular lineages that play specific roles in implantation and the formation of the embryo.

Solution:

Step 1: The blastocyst is bounded by an outer single layer of flattened epithelial cells called the trophoblast. The trophoblast functions in uterine attachment and gives rise to the fetal portion of the placenta (the chorion).

Step 2: Located internally at one pole of the blastocyst is a dense cluster of rounded cells known as the inner cell mass (ICM), or embryoblast.

Step 3: The inner cell mass consists of pluripotent stem cells that retain the capacity to differentiate into all the specialized cell types of the body.

Step 4: During gastrulation, the inner cell mass reorganizes into the three primary embryonic germ layers (ectoderm, mesoderm, and endoderm), which form the tissues of the embryo proper.

Step 5: The fluid-filled internal cavity is called the blastocoel. Therefore, the specific layer that gives rise to the proper tissues of the embryo is the inner cell mass, matching option B.

Final Answer: Inner cell mass

Answer: (B)

Go Back to Question 52

Q53.

Solution

Concept:

Recombinant DNA technology enables the production of therapeutic human proteins in heterologous host systems. Human insulin consists of two polypeptide chains, designated as chain A and chain B, which are covalently linked by disulfide bonds. Synthesizing this hormone requires selecting a compatible host organism and establishing an effective expression system.

Solution:

Step 1: Prior to the advent of biotechnology, therapeutic insulin was extracted from the pancreas of slaughtered pigs and cattle, which occasionally triggered allergic reactions in patients due to minor structural differences.

Step 2: In 1983, the American pharmaceutical company Eli Lilly successfully engineered and produced Humulin, the first genetically engineered human insulin.

Step 3: Scientists synthesized distinct DNA sequences corresponding to individual human insulin A and B chains.

Step 4: These synthetic DNA sequences were inserted into plasmids next to the β-galactosidase gene and transformed into the common laboratory bacterium *Escherichia coli*.

Step 5: The host *E. coli* cells expressed the separate polypeptide chains, which were subsequently extracted, purified, and chemically bonded *in vitro* via disulfide linkages to form functional human insulin. This matches option B.

Final Answer: *Escherichia coli*

Answer: (B)

Go Back to Question 53

Q54.

Solution

Concept:

Synaptic transmission is the physiological process by which a neural signal is passed from a presynaptic neuron to a postsynaptic cell across a chemical synapse. This mechanism converts an electrical action potential into a chemical signal through the regulated release of neurotransmitters.

Solution:

Step 1: An action potential propagates along the axon of the presynaptic neuron via the sequential opening of voltage-gated sodium channels, eventually reaching the axon terminal.

Step 2: The depolarization of the axon terminal triggers the opening of localized voltage-gated calcium channels.

Step 3: Because the extracellular concentration of calcium is significantly higher than the intracellular concentration, calcium ions (Ca^{2+}) rapidly rush into the presynaptic terminal.

Step 4: This localized influx of calcium ions activates intracellular motor proteins and synaptotagmin, driving the migration and fusion of neurotransmitter-filled synaptic vesicles with the presynaptic active zone membrane.

Step 5: The vesicles release their neurotransmitters into the synaptic cleft via exocytosis. Thus, calcium ions act as the direct signal for vesicle fusion, matching option C.

Final Answer: Calcium ions

Answer: (C)

Go Back to Question 54

Q55.

Solution

Concept:

The Respiratory Quotient (RQ) is a dimensionless physiological ratio used to determine the primary metabolic substrate being oxidized during cellular respiration. The RQ is defined as the volume of carbon dioxide (CO_2) produced divided by the volume of oxygen (O_2) consumed over a given period:

$$\text{RQ} = \frac{\text{Volume of } CO_2 \text{ evolved}}{\text{Volume of } O_2 \text{ consumed}}$$

Solution:

Step 1: The stoichiometric equation for the complete aerobic oxidation of a standard carbohydrate like glucose ($C_6H_{12}O_6$) yields an equal ratio of gases:

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$$

$$\text{RQ} = \frac{6}{6} = 1.0$$

Step 2: Lipids, such as fats and fatty acids, contain a lower proportion of oxygen relative to carbon and hydrogen atoms in their molecular structure. Consequently, they require more external oxygen for complete combustion.

Step 3: The balanced metabolic equation for the oxidation of tripalmitin ($C_{51}H_{98}O_6$), a typical lipid substrate, is written as:

$$2C_{51}H_{98}O_6 + 145O_2 \rightarrow 102CO_2 + 98H_2O$$

Step 4: Calculating the specific gas ratio for this lipid substrate yields:

$$\text{RQ} = \frac{102}{145} \approx 0.7$$

Step 5: Protein substrates exhibit an average RQ value of approximately 0.9. Thus, the specific RQ value for lipids is 0.7, matching option C.

Final Answer: 0.7

Answer: (C)

Go Back to Question 55

Q56.

Solution

Concept:

Natural selection changes allele frequencies within a population based on the relative fitness of different phenotypes under specific environmental conditions. Selection pressures alter the phenotypic distribution of a continuous trait over generations, operating through three primary modes: directional, disruptive, or stabilizing selection.

Solution:

Step 1: Directional selection occurs when environmental changes favor individuals at one phenotypic extreme, shifting the population mean over time.

Step 2: Disruptive selection takes place when environmental conditions favor individuals at both phenotypic extremes over intermediate individuals, splitting the population phenotypic curve into two distinct peaks.

Step 3: Stabilizing selection operates when a stable environment favors individuals with intermediate or average phenotypes.

Step 4: Under stabilizing selection, individuals expressing extreme traits at either end of the phenotypic spectrum experience reduced fitness and are selected against. This mechanism narrows the phenotypic distribution curve around the mean value without changing the average phenotype of the population.

Step 5: A classic example is human birth weight. Because intermediate phenotypes are favored over extreme ones, this represents stabilizing selection, matching option C.

Final Answer: Stabilizing selection

Answer: (C)

Go Back to Question 56

Q57.

Solution

Concept:

Enzyme inhibitors reduce the catalytic activity of enzymes by disrupting substrate binding or the catalytic mechanism. Inhibitors are categorized as competitive, non-competitive, or uncompetitive based on their binding kinetics and interaction sites. Analyzing these kinetics under varying substrate conditions reveals how competitive inhibition can be reversed.

Solution:

Step 1: A competitive inhibitor possesses a three-dimensional molecular structure that closely mimics the shape of the natural substrate.

Step 2: Because of this structural similarity, the inhibitor competes directly with the substrate for binding to the free enzyme's active site. It forms an inactive enzyme-inhibitor (EI) complex.

Step 3: The binding of a competitive inhibitor is a fully reversible equilibrium process. The likelihood of an active site binding a molecule depends on the relative concentrations of the substrate and the inhibitor.

Step 4: If the substrate concentration is significantly increased while the inhibitor concentration remains constant, the substrate molecules outnumber the inhibitor molecules. This increases the probability that a substrate molecule will occupy the active site.

Step 5: At high substrate concentrations, the enzyme active sites become saturated with substrate, allowing the reaction to reach its maximum velocity (V_{max}). Thus, competitive inhibition is overcome by increasing substrate concentration, matching option A.

Final Answer: Increasing the substrate concentration

Answer: (A)

Go Back to Question 57

Q58.

Solution

Concept:

Industrial pollution can release heavy metals and toxic chemicals into aquatic ecosystems, posing significant environmental and public health risks. Certain stable contaminants undergo biomagnification, accumulating in food webs and causing severe health syndromes in humans who ingest contaminated marine organisms.

Solution:

Step 1: Cadmium contamination causes chronic toxicity known as Itai-Itai disease, which is characterized by painful bone softening and kidney failure. Lead poisoning results in plumbism, damaging the central nervous system.

Step 2: Minamata disease was discovered in 1956 around Minamata Bay in Japan. An industrial plant discharged wastewater containing high levels of inorganic mercury into the bay.

Step 3: Anaerobic aquatic bacteria converted the inorganic mercury into methylmercury (CH_3Hg^+), a highly toxic organic form.

Step 4: Methylmercury entered the aquatic food chain and biomagnified within fish and shellfish. Local populations that consumed these marine organisms ingested high doses of the toxin.

Step 5: Methylmercury is a potent neurotoxin that crosses the blood-brain barrier, causing neurological symptoms such as ataxia, numbness, loss of peripheral vision, and paralysis. This matches option C.

Final Answer: Methylmercury

Answer: (C)

Go Back to Question 58

Q59.

Solution

Concept:

The Fluid Mosaic Model, proposed by S. Jonathan Singer and Garth L. Nicolson in 1972, describes the structure of biological membranes. The model presents the plasma membrane as a dynamic, two-dimensional liquid mosaic where amphipathic lipid molecules and various proteins are organized in a fluid arrangement.

Solution:

Step 1: The structural backbone of the plasma membrane is a bimolecular sheet of phospholipids. These lipid molecules are amphipathic, possessing hydrophilic heads facing the aqueous environments and hydrophobic fatty acid tails sequestered inside.

Step 2: The weak van der Waals interactions holding the hydrophobic tails together allow individual lipid molecules to move freely.

Step 3: Lipids and embedded integral proteins continuously rotate and move sideways within their respective layers. This lateral movement of lipids and proteins is what determines the fluidity of the membrane.

Step 4: Membrane fluidity is regulated by temperature and lipid composition, such as the saturation level of fatty acid tails and cholesterol content, which acts as a fluidity buffer.

Step 5: Among the options, membrane fluidity is defined by the lateral movement of lipids and proteins within the bilayer, matching option C.

Final Answer: Lateral movement of lipids and proteins

Answer: (C)

Go Back to Question 59

Q60.

Solution

Concept:

Floral symmetry is an important morphological trait used in angiosperm taxonomy to classify flowers based on their geometric properties. Symmetry describes how a flower can be divided into identical mirror-image halves across different planes passing through its central axis.

Solution:

Step 1: Flowers that lack a defined plane of symmetry and cannot be divided into equal halves along any plane are classified as asymmetric or irregular (e.g., *Canna*).

Step 2: Flowers that can be divided into two equal, mirroring halves along only one single vertical plane exhibit bilateral symmetry. These are termed zygomorphic flowers (e.g., peas, orchids).

Step 3: Flowers that can be divided into two equal halves by any vertical radial plane passing directly through the central axis exhibit radial symmetry.

Step 4: This radial symmetry is termed actinomorphic. Examples of actinomorphic flowers include mustard, *Datura*, and chili.

Step 5: Since the prompt describes a flower that can be divided into equal halves along any vertical plane passing through the center, it is actinomorphic, matching option A.

Final Answer: Actinomorphic

Answer: (A)

Go Back to Question 60

Q61.

Solution

Concept:

Angiosperms undergo double fertilization, a specialized reproductive mechanism that takes place within the female gametophyte (embryo sac). This process involves two distinct fusion events between male gametes and the cells of the embryo sac, leading to the formation of both embryonic and nutritive tissues.

Solution:

Step 1: A pollen grain germinates and delivers two haploid male gametes into the embryo sac through the pollen tube.

Step 2: The first male gamete (n) fuses with the haploid egg cell (n) to form a diploid zygote ($2n$). This fusion event is called syngamy and gives rise to the embryo.

Step 3: The second male gamete (n) migrates toward the center of the embryo sac, where it encounters the large central cell containing two haploid polar nuclei.

Step 4: This male gamete fuses with the two polar nuclei (or the fused diploid secondary nucleus). Because this event involves the fusion of three haploid nuclei, it is called triple fusion.

Step 5: Triple fusion results in the formation of a triploid ($3n$) primary endosperm nucleus (PEN), which develops into the endosperm tissue to nourish the embryo. This matches option B.

Final Answer: One male gamete with two polar nuclei

Answer: (B)

Go Back to Question 61

Q62.

Solution

Concept:

Gene therapy is a medical approach focused on treating genetic disorders by introducing functional copies of a gene into a patient's cells to replace a defective or missing counterpart. Understanding historical milestones in gene therapy highlights how recombinant DNA technology is applied to manage human monogenic diseases.

Solution:

Step 1: In September 1990, the first clinical gene therapy trial was conducted by William French Anderson and his colleagues on a four-year-old girl named Ashanti DeSilva.

Step 2: The patient suffered from Severe Combined Immunodeficiency (SCID), a rare genetic disorder that disrupts immune system function, leaving individuals vulnerable to opportunistic infections.

Step 3: This form of SCID is caused by a mutation in the gene encoding the enzyme adenosine deaminase (ADA), which is essential for the breakdown of metabolic byproducts in T-lymphocytes.

Step 4: Doctors extracted T-lymphocytes from the patient's blood, inserted a functional human ADA gene into these cells *in vitro* using a retroviral vector, and infused the corrected cells back into her body.

Step 5: Thus, the first clinical trial targeted a deficiency of the enzyme adenosine deaminase, matching option A.

Final Answer: Adenosine deaminase

Answer: (A)

Go Back to Question 62

Q63.

Solution

Concept:

The loop of Henle is a specialized, U-shaped segment of the nephron that generates an osmotic gradient within the renal medulla via a countercurrent multiplier system. The loop consists of a descending limb and an ascending limb, each possessing distinct structural characteristics and transport permeabilities.

Solution:

Step 1: The proximal convoluted tubule performs non-selective reabsorption of water, ions, and organic nutrients.

Step 2: The thin descending limb of Henle's loop has a membrane that is highly permeable to water molecules due to a high density of aquaporin-1 channels, but it is almost completely impermeable to electrolytes like sodium and chloride ions.

Step 3: As tubular fluid flows down the descending limb into the concentrated renal medulla, water leaves the tubule osmotically, concentrating the urine inside.

Step 4: The ascending limb of Henle's loop exhibits the opposite permeability profile. This segment is completely impermeable to water molecules because it lacks water channels. However, it actively or passively transports electrolytes (Na^+, Cl^-, and K^+) out of the tubule into the surrounding medullary interstitium.

Step 5: This selective transport dilutes the tubular fluid as it ascends. Thus, the segment impermeable to water but permeable to electrolytes is the ascending limb, matching option C.

Final Answer: Ascending limb of Henle's loop

Answer: (C)

Go Back to Question 63

Q64.

Solution

Concept:

Xylem is a complex permanent tissue in vascular plants responsible for the conduction of water and dissolved mineral nutrients from the roots to the aerial organs. It is composed of four cell types: tracheids, vessels, xylem fibers, and xylem parenchyma. Understanding the structural differences between these components is key to identifying wood elements.

Solution:

Step 1: Xylem parenchyma cells remain alive at maturity, retaining their protoplasm, and function primarily in short-distance storage and transport.

Step 2: Vessels are long, tube-like structures formed from rows of cells joined end-to-end. Their end walls develop perforation plates, creating a continuous pipeline for efficient water flow.

Step 3: Tracheids are elongated, single cells with tapering ends. During differentiation, they undergo programmed cell death, completely losing their protoplasm to leave a hollow lumen.

Step 4: The cell walls of tracheids become heavily thickened with lignin, providing mechanical support. Unlike vessels, tracheids do not have open perforation plates; their walls remain intact but feature specialized thin areas called pits that allow water to pass between adjacent cells.

Step 5: The description—elongated, lignified cells with tapering ends and pitted walls lacking perforations—defines a tracheid, matching option B.

Final Answer: Tracheids

Answer: (B)

Go Back to Question 64

Q65.

Solution

Concept:

The human genome contains non-coding regional segments that exhibit high degrees of polymorphism among individuals. These variations serve as distinct genetic markers. DNA fingerprinting, developed by Sir Alec Jeffreys in 1984, relies on identifying variations within these specific genomic regions for forensic analysis, paternity testing, and mapping studies.

Solution:

Step 1: The coding sequences of functional genes are highly conserved among human populations to preserve protein structure and function.

Step 2: A large portion of non-coding DNA contains repetitive sequences where a short nucleotide pattern is repeated head-to-tail multiple times. These are termed tandem repeats.

Step 3: Variable Number Tandem Repeats (VNTRs), or mini-satellites, are hypervariable sequences ranging from 10 to 100 base pairs long, repeated varying numbers of times across individuals.

Step 4: Because the exact number of repeat units at any given locus varies significantly between unrelated humans due to mutation, an individual's combination of VNTR lengths forms a unique genetic profile.

Step 5: DNA fingerprinting uses restriction enzymes to cleave DNA, followed by Southern blotting with radioactive VNTR probes to visualize this unique banding pattern. This matches option B.

Final Answer: Mini-satellites or VNTRs

Answer: (B)

Go Back to Question 65

Q66.

Solution

Concept:

In community ecology, competitive interactions occur when multiple organisms or species rely on the same shared, resource-limited environmental factors. Mathematical and laboratory models help analyze how niche overlap influences the long-term coexistence of competing populations.

Solution:

Step 1: Robert May is known for his work on global biodiversity estimations, Paul Ehrlich proposed the rivet popper hypothesis for ecosystem stability, and E.P. Odum is recognized for foundational concepts in general ecology.

Step 2: The Competitive Exclusion Principle was formulated by Russian biologist G.F. Gause in 1934 based on controlled laboratory experiments with ciliates like *Paramecium*.

Step 3: Gause's principle states that two separate species competing for the exact same limiting resource cannot coexist indefinitely if all other ecological factors remain constant.

Step 4: The species that possesses even a minor competitive advantage will outcompete the other, leading to the localized extinction or displacement of the less efficient competitor.

Step 5: Thus, the competitive exclusion principle was developed by G.F. Gause, matching option A.

Final Answer: G.F. Gause

Answer: (A)

Go Back to Question 66

Q67.

Solution

Concept:

Water potential (ψ_w) determines the direction of passive water movement in plant systems, with water always flowing from a region of higher water potential to one of lower water potential. The water potential of a plant cell is calculated as the sum of its osmotic or solute potential (ψ_s) and its turgor or pressure potential (ψ_p):

$$\psi_w = \psi_s + \psi_p$$

Solution:

Step 1: First, we calculate the internal water potential of the plant cell using the provided parameters. Given that the osmotic potential $\psi_s = -10$ bars and the turgor pressure $\psi_p = +4$ bars:

$$\psi_{w(\text{cell})} = -10 \text{ bars} + 4 \text{ bars} = -6 \text{ bars}$$

Step 2: The cell is placed in an external solution. The water potential of this external solution is given as:

$$\psi_{w(\text{solution})} = -8 \text{ bars}$$

Step 3: We compare the water potentials of the cell and the solution. The cell has a water potential of -6 bars, while the solution has a water potential of -8 bars.

Step 4: Since -6 is a higher value than -8, the cell has a higher water potential than the surrounding solution ($\psi_{w(\text{cell})} > \psi_{w(\text{solution})}$).

Step 5: Because water moves down its potential gradient from higher to lower values, water will leave the cell and move into the solution, causing plasmolysis. This matches option A.

Final Answer: Water will move out of the cell

Answer: (A)

Go Back to Question 67

Q68.

Solution

Concept:

The human testes perform both exocrine and endocrine functions, producing male gametes and synthesizing steroidal sex hormones. The seminiferous tubules contain cells that support spermatogenesis, while the vascularized connective tissue surrounding these tubules hosts cells responsible for endocrine regulation.

Solution:

Step 1: Spermatogonia are the diploid germ cells that undergo mitotic and meiotic divisions within the seminiferous tubules to differentiate into mature spermatozoa.

Step 2: Sertoli cells are large nurse cells located within the tubule walls that support, protect, and nourish developing germ cells, while also secreting androgen-binding protein.

Step 3: The interstitial connective tissue spaces between adjacent seminiferous tubules contain small groups of endocrine cells known as Leydig cells, or interstitial cells.

Step 4: In response to Luteinizing Hormone (LH) secreted by the anterior pituitary gland, Leydig cells synthesize and secrete androgenic hormones, primarily testosterone.

Step 5: Testosterone regulates spermatogenesis and maintains male secondary sexual characteristics.

Therefore, the cells that secrete testosterone are the Leydig cells, matching option B.

Final Answer: Leydig cells

Answer: (B)

Go Back to Question 68

Q69.

Solution

Concept:

Mendelian inheritance patterns assume complete dominance, where a dominant allele fully masks a recessive allele in heterozygous individuals. Consequently, a standard monohybrid cross between homozygous parents produces an F2 generation with a 3 : 1 phenotypic ratio. Deviations from this ratio occur when the heterozygous phenotype is distinct from both homozygous parents.

Solution:

Step 1: In complete dominance, the heterozygous individual (Rr) looks identical to the homozygous dominant parent (RR), yielding a 3 : 1 ratio in the F2 generation.

Step 2: Codominance occurs when both alleles are fully and independently expressed in the heterozygote, as seen in AB blood grouping.

Step 3: Incomplete dominance describes a genetic scenario where neither allele is completely dominant over the other.

Step 4: The heterozygous individual displays an intermediate, blended phenotype that falls between the two homozygous parental types. A classic example is flower color in *Antirrhinum majus* (snapdragon), where crossing red (RR) and white (rr) flowers produces pink (Rr) offspring.

Step 5: Selfing these pink F1 heterozygotes produces an F2 generation with a phenotypic ratio of 1 Red : 2 Pink : 1 White (1 : 2 : 1). This matches the genotypic ratio, making option C the correct answer.

Final Answer: Incomplete Dominance

Answer: (C)

Go Back to Question 69

Q70.

Solution

Concept:

Mitosis is a continuous process divided into prophase, metaphase, anaphase, and telophase. Each stage is characterized by distinct morphological arrangements of the chromosomes and the mitotic spindle. Identifying these structural arrangements helps differentiate the phases of nuclear division.

Solution:

Step 1: During prophase, chromatin condenses into distinct chromosomes, the nuclear envelope breaks down, and the mitotic spindle begins to form.

Step 2: As the cell enters metaphase, the spindle fibers attach to the kinetochores on the centromere of each chromosome.

Step 3: The mitotic spindle exerts opposing pulling forces, moving all chromosomes until they align along a single plane in the center of the cell, known as the metaphase plate or equatorial plate.

Step 4: During anaphase, sister chromatids are pulled apart toward opposite poles. Telophase involves the uncoiling of chromosomes and the re-formation of nuclear envelopes.

Step 5: Because the alignment of chromosomes along the equatorial plate is the defining hallmark of metaphase, option B is the correct choice.

Final Answer: Metaphase

Answer: (B)

Go Back to Question 70

Q71.

Solution

Concept:

Biodiversity conservation strategies protect threatened or endangered species from extinction using two primary approaches based on the location of management. Selecting an appropriate conservation method depends on whether the species can be adequately protected within its natural environment.

Solution:

Step 1: In-situ conservation involves protecting endangered species within their natural habitats by preserving entire ecosystems. Examples include national parks, wildlife sanctuaries, biosphere reserves, and sacred groves.

Step 2: Ex-situ conservation is the strategy of removing threatened or endangered plants or animals from their vulnerable natural habitats and placing them under human care in managed settings.

Step 3: Ex-situ facilities include botanical gardens, zoological parks, wildlife safari parks, and gene banks.

Step 4: This approach also utilizes advanced technologies like cryopreservation, where gametes or tissues are stored at ultra-low temperatures ($-196^{\circ}C$ in liquid nitrogen) to preserve genetic material long-term.

Step 5: Since the prompt specifies conservation outside natural habitats, such as in botanical gardens or cryopreservation centers, it defines ex-situ conservation, matching option B.

Final Answer: Ex-situ conservation

Answer: (B)

Go Back to Question 71

Q72.

Solution

Concept:

Whittaker's Five-Kingdom Classification system groups organisms based on cellular structure, body organization, and mode of nutrition. Comparing these key traits helps distinguish between fungi, plants, and other eukaryotic lineages.

Solution:

Step 1: Kingdom Monera comprises all unicellular prokaryotes, and Kingdom Protista includes all unicellular eukaryotes. Both are excluded because the organism is multicellular.

Step 2: Kingdom Plantae includes multicellular, autotrophic organisms that produce their own food via photosynthesis and possess cell walls composed primarily of cellulose.

Step 3: Kingdom Fungi is composed of eukaryotic, predominantly multicellular organisms.

Step 4: Fungi are heterotrophic and utilize an absorptive mode of nutrition, secreting extracellular enzymes to digest dead organic matter before absorbing the simpler nutrients. A defining structural characteristic of fungi is their cell wall, which is composed of chitin rather than cellulose.

Step 5: Thus, multicellular decomposers with chitinous cell walls and absorptive nutrition belong to Kingdom Fungi, matching option C.

Final Answer: Fungi

Answer: (C)

Go Back to Question 72

Q73.

Solution

Concept:

The female menstrual cycle is regulated by complex hormonal feedback loops involving the hypothalamus, anterior pituitary, and ovaries. Following ovulation, the remnants of the ruptured Graafian follicle reorganize into a temporary endocrine structure called the corpus luteum, which secretes hormones to prepare the uterus for pregnancy.

Solution:

Step 1: Follicle-Stimulating Hormone (FSH) stimulates the growth of ovarian follicles, while a surge in Luteinizing Hormone (LH) triggers ovulation from the mature Graafian follicle.

Step 2: Following ovulation, the corpus luteum develops and secretes high levels of the steroid hormone progesterone.

Step 3: Progesterone stimulates the uterine endometrium to become highly vascularized, glandular, and secretory.

Step 4: This physiological state is necessary to maintain the endometrium, ensuring it can support the implantation of a fertilized blastocyst and maintain early pregnancy.

Step 5: If fertilization does not occur, the corpus luteum degenerates, progesterone levels drop, and the endometrium sloughs off during menstruation. Thus, progesterone's primary role is maintaining the endometrium, matching option B.

Final Answer: Maintain the vascular endometrium for implantation

Answer: (B)

Go Back to Question 73

Q74.

Solution

Concept:

Apical dominance is a developmental phenomenon in vascular plants where the central shoot tip grows more vigorously than the lateral side branches. This growth pattern is regulated by the production and transport of specific phytohormones, which coordinate plant architecture.

Solution:

Step 1: Apical dominance occurs because the growing apical bud synthesizes high concentrations of the plant hormone auxin (primarily indole-3-acetic acid, IAA).

Step 2: Auxin is transported downward through the stem via polar transport, where it suppresses the growth and elongation of axillary buds located lower down.

Step 3: If the apical bud is physically removed (decapitation), the source of auxin is eliminated, allowing lateral axillary buds to grow and form branches. Gardeners use this technique to promote bushier growth in hedges and tea plantations.

Step 4: Cytokinins act antagonistically to auxins; applying cytokinins directly to lateral buds can overcome apical dominance and promote branching.

Step 5: Since the question asks for the hormone primarily responsible for inducing apical dominance, the answer is auxin, matching option A.

Final Answer: Auxin

Answer: (A)

Go Back to Question 74

Q75.

Solution

Concept:

Metabolic pathways consist of series of connected, enzyme-catalyzed chemical reactions. To maintain cellular efficiency and prevent the overproduction of specific metabolites, these pathways are regulated by complex enzyme inhibition mechanisms.

Solution:

Step 1: Competitive inhibition occurs when an inhibitor competes with the substrate directly at the active site, while denaturation involves the structural unfolding of the enzyme protein.

Step 2: Feedback inhibition, or end-product inhibition, is a common regulatory mechanism where the final product of a metabolic pathway accumulates within the cell.

Step 3: When the concentration of this end-product exceeds a specific threshold, it binds to a regulatory site on the first enzyme of the pathway. This regulatory site is separate from the catalytic active site and is called an allosteric site.

Step 4: Binding to the allosteric site induces a conformational change in the enzyme's structure, reducing its affinity for the initial substrate and shutting down the entire biochemical pathway.

Step 5: This feedback mechanism matches the scenario described in the prompt, corresponding to option A.

Final Answer: Feedback inhibition

Answer: (A)

Go Back to Question 75

Q76.

Solution

Concept:

Viruses are non-cellular infectious agents consisting of a core of nucleic acid genetic material enclosed within a protective protein coat called a capsid. The genetic material of a virus can vary significantly across families, occurring as either DNA or RNA in single-stranded or double-stranded configurations.

Solution:

Step 1: The Human Immunodeficiency Virus (HIV) is an enveloped animal virus that belongs to the Retroviridae family and is the causative agent of AIDS.

Step 2: Retroviruses possess an RNA genome but replicate through a DNA intermediate using a specialized viral enzyme called reverse transcriptase.

Step 3: The core of the HIV virion contains its genetic material, which is structurally organized as two identical, non-segmented molecules of single-stranded RNA ($2 \times$ ssRNA).

Step 4: This configuration makes the virus diploid, carrying two copies of its genetic template. During infection, reverse transcriptase copies these single strands of RNA into double-stranded DNA, which integrates into the host cell's genome.

Step 5: Comparing this structure to the options confirms that the HIV genome consists of two identical molecules of single-stranded RNA, matching option C.

Final Answer: Two identical molecules of single-stranded RNA

Answer: (C)

Go Back to Question 76

Q77.

Solution

Concept:

Ecosystems are dynamically organized across spatial boundaries rather than being isolated by sharp, rigid lines. The transition zones where different ecological communities meet contain unique physical conditions and distinct species assemblages, reflecting the ecological properties of both adjacent systems.

Solution:

Step 1: A biome is a large regional or global biotic community characterized by distinct climate and vegetation patterns, such as a desert or tundra. An ecotype is a genetically distinct geographic variety within a single species.

Step 2: A niche describes the specific functional role and physical space that an organism occupies within its environment.

Step 3: An ecotone is defined as the localized boundary or transition zone where two distinct ecological communities meet and integrate. Examples of ecotones include estuaries (the transition between a river and the sea), marshes (between land and water), and forest edges (between woodland and grassland).

Step 4: Ecotones frequently display higher species richness and population densities than either surrounding community, an ecological phenomenon known as the edge effect.

Step 5: Therefore, the transition zone described in the prompt is an ecotone, matching option A.

Final Answer: Ecotone

Answer: (A)

Go Back to Question 77

Q78.

Solution

Concept:

A floral formula uses standardized typographic symbols and numbers to represent the structural organization, symmetry, and arrangement of parts in a flower. Understanding these taxonomic symbols is essential for reading and interpreting botanical descriptions of angiosperm families.

Solution:

Step 1: The symbol % or $\downarrow$ is used in floral formulas to represent a zygomorphic flower, which exhibits bilateral symmetry and can be cut into equal halves along only one plane.

Step 2: The symbol $\oplus$ is used to designate an actinomorphic flower. This denotes radial symmetry, meaning the flower can be divided into identical mirror-image halves by any vertical plane passing through its center.

Step 3: Other symbols include **K** for calyx, **C** for corolla, **A** for androecium, and **G** for gynoecium. A line below the **G** ($\underline{\mathbf{G}}$) indicates a superior ovary, while a line above ($\overline{\mathbf{G}}$) indicates an inferior ovary.

Step 4: Unisexual structures are designated using standard sex symbols ($\sigma^{\nearrow}$ for male or $\odot$ for female).

Step 5: Since the symbol $\oplus$ explicitly represents radial symmetry, it denotes an actinomorphic flower, matching option B.

Final Answer: Actinomorphic nature

Answer: (B)

Go Back to Question 78

Q79.

Solution

Concept:

Translation is the biochemical process where the genetic code carried by an mRNA molecule is translated into a sequence of amino acids, forming a polypeptide chain. This process takes place on the ribosome and requires specific catalytic activity to join amino acids via covalent peptide bonds.

Solution:

Step 1: Aminoacyl tRNA synthetase is responsible for attaching the correct amino acid to its corresponding tRNA molecule during the tRNA charging phase.

Step 2: During the elongation phase of translation, an aminoacyl-tRNA binds to the A-site of the ribosome, positioning its amino acid adjacent to the growing polypeptide chain attached to the tRNA in the P-site.

Step 3: The formation of a peptide bond between the amino group of the amino acid in the A-site and the carboxyl group of the polypeptide in the P-site is catalyzed by the enzyme peptidyl transferase.

Step 4: In structural terms, this catalytic activity is driven by a ribozyme within the large ribosomal subunit—specifically the 23S rRNA in prokaryotes or the 28S rRNA in eukaryotes.

Step 5: Thus, the enzyme responsible for catalyzing peptide bond formation during translation is peptidyl transferase, matching option B.

Final Answer: Peptidyl transferase

Answer: (B)

Go Back to Question 79

Q80.

Solution

Concept:

The endocrine system coordinates complex reproductive processes like childbirth (parturition) and lactation using neuroendocrine reflexes. These processes involve hormones synthesized by the hypothalamus and released by the pituitary gland, which act on specific target tissues to drive muscular contractions and glandular responses.

Solution:

Step 1: Prolactin is synthesized and secreted by the anterior pituitary gland, and its primary role is stimulating the development of mammary glands and driving milk production.

Step 2: Oxytocin is a peptide hormone synthesized by paraventricular and supraoptic nuclei in the hypothalamus and stored in the posterior pituitary gland.

Step 3: During labor, stretching of the cervix triggers a neuroendocrine reflex that signals the release of oxytocin into the bloodstream. Oxytocin binds to receptors on uterine smooth muscle cells, stimulating powerful contractions that help expel the fetus.

Step 4: Following childbirth, suckling by the infant triggers another neuroendocrine reflex that drives oxytocin release. The hormone causes the contraction of myoepithelial cells surrounding the alveoli of the mammary glands, forcing milk into the ducts for ejection.

Step 5: Thus, oxytocin is responsible for both milk ejection and uterine contractions during labor, matching option B.

Final Answer: Oxytocin

Answer: (B)

Go Back to Question 80

Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	B	2	A	3	B	4	B	5	C
6	B	7	A	8	C	9	C	10	C
11	B	12	A	13	C	14	B	15	A
16	B	17	C	18	B	19	B	20	B
21	B	22	C	23	B	24	B	25	C
26	B	27	B	28	C	29	C	30	B
31	A	32	B	33	B	34	C	35	B
36	B	37	B	38	B	39	B	40	C
41	C	42	C	43	B	44	B	45	B
46	C	47	C	48	D	49	A	50	B
51	C	52	B	53	B	54	C	55	C
56	C	57	A	58	C	59	C	60	A
61	B	62	A	63	C	64	B	65	B
66	A	67	A	68	B	69	C	70	B
71	B	72	C	73	B	74	A	75	A
76	C	77	A	78	B	79	B	80	B