BITSAT Biology Sample Paper-18

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

Instructions

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

Q1. An analytical chemist isolates a novel polysaccharide from a deep-sea extremophile. Complete hydrolysis reveals it is composed entirely of β-D-glucose units linked by β-(1→4) glycosidic bonds, but with an acetylated amino group at carbon-2 of each monomer. This macromolecule is structurally most analogous to which of the following?

(A) Cellulose

(B) Glycogen

(C) Chitin

(D) Inulin

Q2. A patient presents with chronic fatigue, low basal metabolic rate, and an elevated blood level of Thyroid Stimulating Hormone (TSH). A biopsy shows an accumulation of uniodinated thyroglobulin within the thyroid follicles. Which nutritional or physiological defect is most likely responsible?

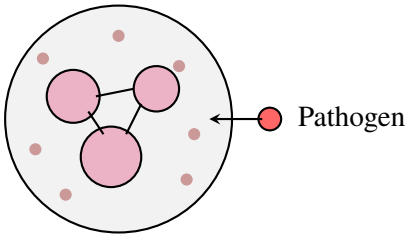
(A) Severe dietary iodine deficiency

(B) Primary autoimmune destruction of TSH receptors

(C) Hypersecretion of Thyrotropin-Releasing Hormone (TRH)

(D) Loss-of-function mutation in the sodium-iodide symporter (NIS)

Q3. A patient presents with a severe acute bacterial infection. Laboratory analysis reveals a massive increase in a specific class of circulating leukocytes characterized by a multi-lobed nucleus and prominent cytoplasmic granules that stain weakly with both acid and basic dyes. Which of the following represents the primary mechanism these cells use to destroy invading pathogens?



(A) Secretion of high-affinity IgG antibodies into plasma

(B) Degranulation and systemic release of histamine and heparin

(C) Phagocytosis followed by respiratory burst and enzymatic digestion

(D) Perforin-mediated pore formation and granzyme induction of apoptosis

Q4. During human oogenesis, the first meiotic division is completed in asymmetric fashion to produce a large secondary oocyte and a tiny first polar body. At which specific stage of human development does this asymmetrical cytokinesis occur?

(A) During embryonic development in the fetal ovary

(B) Immediately prior to ovulation in the mature Graafian follicle

(C) At the exact moment of sperm penetration in the fallopian tube

(D) During the luteal phase under the influence of progesterone

Q5. Phytochrome, a photomorphogenetic pigment in plants, exists in two interconvertible forms: Pr and Pfr. Which of the following physiological responses is correctly paired with the form of phytochrome that triggers it and the light spectrum responsible for that activation?

(A) Inhibition of flowering in short-day plants — Pfr form — Red light (660 nm)

(B) Stimulation of seed germination — Pr form — Far-red light (730 nm)

(C) De-etiolation of seedlings — Pr form — Red light (660 nm)

(D) Promotion of flowering in long-day plants — Pr form — Far-red light (730 nm)

Q6. A taxonomist discovers a unicellular, eukaryotic organism in a freshwater pond. The organism possesses a cellulosic cell wall organized into distinct plates, has two distinct flagella (one longitudinal and one transverse in a furrow), and exhibits a characteristic spinning movement. To which group under the kingdom Protista does this organism belong?

(A) Chrysophytes

(B) Dinoflagellates

(C) Euglenoids

(D) Slime moulds

Q7. In human immunology, the secondary immune response differs significantly from the primary immune response due to the presence of long-lived memory cells. Which of the following parameters describes the antibody profile of a secondary immune response compared to a primary response?

(A) Longer lag phase, lower peak titer, and predominantly IgM antibodies

(B) Shorter lag phase, higher peak titer, and predominantly IgG antibodies

(C) Shorter lag phase, lower peak titer, and predominantly IgA antibodies

(D) Identical lag phase, significantly higher peak titer, and predominantly IgM antibodies

Q8. In a terrestrial ecosystem, the Gross Primary Productivity (GPP) is measured at 2.4×10^4 kcal/m^2/yr. If the autotrophic respiratory loss (R) accounts for 40% of the GPP, what is the Net Primary Productivity (NPP) available to the primary consumers?

(A) 0.96×10^4 kcal/m^2/yr

(B) 1.44×10^4 kcal/m^2/yr

(C) 2.00×10^4 kcal/m^2/yr

(D) 3.36×10^4 kcal/m^2/yr

Q9. In a molecular biotechnology lab, a circular plasmid vector of size 6.0 kb has a single recognition site for the restriction endonuclease *EcoRI* and two recognition sites for *HindIII* spaced 1.5 kb apart. If the plasmid is completely digested simultaneously with both *EcoRI* and *HindIII*, assuming the *EcoRI* site lies exactly in the middle of the 1.5 kb *HindIII* fragment, what will be the sizes of the resulting DNA fragments visualized on an agarose gel?

(A) 4.5 kb and 1.5 kb

(B) 3.0 kb, 1.5 kb, and 1.5 kb

(C) 4.5 kb, 0.75 kb, and 0.75 kb

(D) 5.25 kb and 0.75 kb

Q10. Arrange the following events of a single skeletal muscle contraction cycle (sliding filament theory) in the correct chronological sequence from start to finish:

1. Binding of ATP to the myosin head causing detachment from actin.
2. Hydrolysis of ATP causing the myosin head to cock into a high-energy conformation.
3. Calcium binding to Troponin C, shifting tropomyosin to expose the active sites.
4. The power stroke wherein ADP and inorganic phosphate are released.
5. Binding of the energized myosin head to the exposed actin active site to form a cross-bridge.

(A) $3 \rightarrow 5 \rightarrow 4 \rightarrow 1 \rightarrow 2$

(B) $3 \rightarrow 2 \rightarrow 5 \rightarrow 4 \rightarrow 1$

(C) $2 \rightarrow 3 \rightarrow 5 \rightarrow 1 \rightarrow 4$

(D) $5 \rightarrow 4 \rightarrow 1 \rightarrow 2 \rightarrow 3$

Q11. In the human male reproductive system, the synthesis and secretion of testicular hormones called androgens is stimulated by _____ which acts directly on the _____ cells.

(A) Follicle Stimulating Hormone (FSH) ; Sertoli

(B) Luteinizing Hormone (LH) ; Leydig

(C) Gonadotropin-Releasing Hormone (GnRH) ; Spermatogonia

(D) Interstitial Cell Stimulating Hormone (ICSH) ; Sertoli

Q12. **Statement 1:** The codon AUG acts as the initiator codon during the translation process in both prokaryotes and eukaryotes, and it codes exclusively for the amino acid methionine or formyl-methionine.

Statement 2: The genetic code is described as degenerate because a single codon can code for more than one specific amino acid depending on the cellular context.

(A) Both Statement 1 and Statement 2 are correct.

(B) Both Statement 1 and Statement 2 are incorrect.

(C) Statement 1 is correct but Statement 2 is incorrect.

(D) Statement 1 is incorrect but Statement 2 is correct.

Q13. Assume an enzyme-catalyzed reaction follows standard Michaelis-Menten kinetics. If a competitive inhibitor is introduced into the reaction mixture, how will the kinetic parameters V_{max} (maximum velocity) and K_m (Michaelis constant) change?

(A) V_{max} decreases ; K_m remains unchanged

(B) V_{max} remains unchanged ; K_m increases

(C) V_{max} decreases ; K_m decreases

(D) V_{max} remains unchanged ; K_m decreases

Q14. The standard human electrocardiogram (ECG) is a graphical representation of the electrical activity of the heart during a cardiac cycle. Which of the following statements correctly interprets a specific component of the ECG wave?

(A) The P-wave represents the depolarization of the ventricles leading to atrial contraction.

(B) The QRS complex represents the depolarization of the ventricles, which initiates ventricular contraction.

(C) The T-wave represents the repolarization of the atria marking the end of atrial systole.

(D) The stretch from the end of the T-wave to the next P-wave represents the period of ventricular ejection.

Q15. An evolutionary biologist studies two species: a sweet potato (root modification) and a potato (stem modification). Both organs store starch and look superficially similar, yet they develop from completely different anatomical structures. This is an example of:

(A) Homologous organs resulting from divergent evolution

(B) Analogous organs resulting from convergent evolution

(C) Vestigial structures resulting from genetic drift

(D) Homologous organs resulting from adaptive radiation

Q16. During the development of a human embryo, the blastocyst implants into the endometrium of the uterus. Which specialized outer cellular layer of the blastocyst is directly responsible for invading the uterine wall and secreting Human Chorionic Gonadotropin (hCG)?

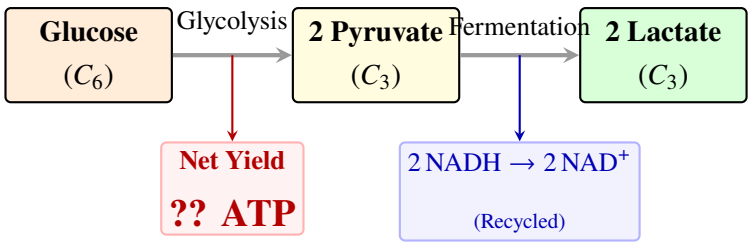
(A) Inner cell mass

(B) Epiblast

(C) Trophoblast

(D) Hypoblast

Q17. The complete anaerobic breakdown of one molecule of glucose through the homolactic fermentation pathway yields a net amount of energy captured in the form of ATP. Which of the following options correctly represents the net ATP yield per glucose molecule during this process?



(A) 2 ATP

(B) 4 ATP

(C) 36 ATP

(D) 38 ATP

Q18. Five different plant species are classified by a botanist. Species A and B belong to the same genus. Species C and D belong to different genera but the same family. Species E belongs to a completely different order. Which pair of species would be expected to share the highest number of common morphological and biochemical characters?

(A) Species C and D

(B) Species A and B

(C) Species B and C

(D) Species D and E

Q19. Proto-oncogenes are normal cellular genes found in all dividing cells. Which of the following mechanisms represents a way by which a proto-oncogene is converted into an active oncogene capable of inducing neoplastic transformation?

(A) Epigenetic silencing via heavy hypermethylation of its promoter region

(B) A reciprocal chromosomal translocation that places the gene under a highly active promoter

(C) A nonsense mutation that causes premature termination of the encoded protein

(D) Deletion of the entire gene locus during homologous recombination

Q20. In an aquatic ecosystem, a persistent organochlorine pesticide like DDT enters the food chain via agricultural runoff. If the concentration of DDT in water is measured at 0.003 ppb (parts per billion), which of the following represents the most likely concentration of DDT in the tissue of fish-eating birds at the top trophic level due to biomagnification?

(A) 0.003 ppb

(B) 0.5 ppm

(C) 25 ppm

(D) 0.04 ppm

Q21. To obtain virus-free healthy clones from a virus-infected valuable horticultural crop plant using tissue culture, which specific part of the explant must be excised and cultured?

(A) Fully expanded mature lamina

(B) Apical and axillary meristems

(C) Phloem companion cells

(D) Cortical parenchyma of the root

Q22. Fluid mosaic model dictates that the plasma membrane is a semi-fluid structure. The flip-flop movement (transverse diffusion) of lipids from one monolayer of the bilayer to the other occurs very rarely compared to lateral diffusion. What is the primary thermodynamic reason for this?

(A) Lateral diffusion requires specialized ATP-dependent flippase enzymes.

(B) The hydrophilic polar head group of the lipid must pass through the hydrophobic core of the membrane.

(C) Non-polar fatty acid tails are too tightly bound by hydrogen bonds to allow transverse movement.

(D) Peripheral membrane proteins block all pathways across the hydrophobic core.

Q23. A heavy meal rich in proteins enters the human stomach. Which of the following options correctly outlines the activation cascade of the proteolytic enzymes in the gastric lumen?

(A) Trypsinogen $\xrightarrow{\text{Enterokinase}}$ Trypsin $\rightarrow$ Cleaves proteins

(B) Pepsinogen $\xrightarrow{\text{Hydrochloric acid}}$ Pepsin $\rightarrow$ Converts proteins into peptones

(C) Chymotrypsinogen $\xrightarrow{\text{Pepsin}}$ Chymotrypsin $\rightarrow$ Hydrolyzes peptide bonds

(D) Procarboxypeptidase $\xrightarrow{\text{Bile salts}}$ Carboxypeptidase $\rightarrow$ Releases free amino acids

Q24. In a classic molecular genetics experiment, *Escherichia coli* cells fully labeled with heavy nitrogen (^{15}N) are transferred to a growth medium containing light nitrogen (^{14}N) as the sole nitrogen source. If these bacteria undergo exactly three generations of binary fission in the new medium, what will be the ratio of hybrid (^{15}N/^{14}N) DNA molecules to totally light (^{14}N/^{14}N) DNA molecules?

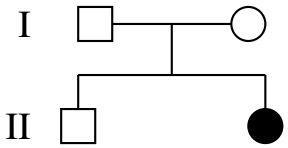
(A) 1 : 1

(B) 1 : 3

(C) 1 : 7

(D) 3 : 1

Q25. In human genetics, certain rare phenotypes skip generations and affect males and females with equal frequency. When an individual expresses the trait, their parents are typically normal carriers. Which of the following modes of inheritance matches the provided pedigree archetype?



(A) Autosomal dominant

(B) Autosomal recessive

(C) X-linked dominant

(D) Y-linked (Holandric)

Q26. During embryonic development in humans, the hollow ball of cells called the blastocyst differentiates into three primary germ layers during gastrulation. Which of the following tissue or organ systems is derived entirely from embryonic ectoderm?

(A) Muscular system and circulatory system

(B) Nervous system and epidermis of skin

(C) Liver, pancreas, and lining of gastrointestinal tract

(D) Dermis of skin, kidneys, and gonads

Q27. Order the following mechanical and cellular events of human wind-pollination or self-pollination checkpoints leading to double fertilization in a typical angiosperm plant:

1. Generative cell divides to form two male gametes inside the pollen tube.
2. Pollen grain lands on a compatible receptive stigma.
3. Pollen tube discharges its contents into one of the synergids.
4. Absorption of water and nutrients by the pollen grain leading to intine protrusion.
5. Chemotropic growth of the pollen tube through the style towards the micropyle.

(A) $2 \rightarrow 4 \rightarrow 1 \rightarrow 5 \rightarrow 3$

(B) $2 \rightarrow 1 \rightarrow 4 \rightarrow 5 \rightarrow 3$

(C) $4 \rightarrow 2 \rightarrow 5 \rightarrow 1 \rightarrow 3$

(D) $2 \rightarrow 4 \rightarrow 5 \rightarrow 1 \rightarrow 3$

Q28. In plant taxonomy, a clear distinction between Bryophytes and Pteridophytes lies in their life cycles and vascular architecture. Which statement correctly differentiates them?

(A) Bryophytes have a dominant sporophyte phase, while Pteridophytes have a dominant gametophyte phase.

(B) Bryophytes possess well-developed xylem with vessels, whereas Pteridophytes lack vascular tissues completely.

(C) Bryophytes have a dominant haploid gametophyte phase, whereas Pteridophytes have a dominant independent diploid sporophyte phase with vascular tissues.

(D) Both groups lack independent free-living gametophytes, but Pteridophytes produce seeds.

Q29. An epidemiological investigation during an outbreak reveals a pathogen that is a non-enveloped, single-stranded RNA virus transmitted via the fecal-oral route, causing acute inflammation of the liver, jaundice, and dark urine, but rarely progressing to chronic liver disease. The pathogen is most likely:

(A) Hepatitis B virus

(B) Hepatitis C virus

(C) Hepatitis A virus

(D) Human Immunodeficiency Virus (HIV)

Q30. Consider a population operating under the logistic growth model, described by the differential equation

$$\frac{dN}{dt} = rN\left(1 - \frac{N}{K}\right).$$

Under what specific condition will the absolute population growth rate $\left(\frac{dN}{dt}\right)$ reach its maximum value?

(A) When the population size N is approaching zero

(B) When the population size N is exactly equal to the carrying capacity K

(C) When the population size N is exactly equal to $K/2$

(D) When the intrinsic rate of natural increase r becomes negative

Q31. A molecular biologist constructs a cDNA library from human pancreatic β-cells to clone the insulin gene. Why is a cDNA library preferred over a genomic DNA library for expressing human proteins in a prokaryotic host like *E. coli*?

(A) Prokaryotes lack the machinery to replicate eukaryotic genomic DNA vectors.

(B) Eukaryotic genomic DNA contains introns which prokaryotic cells cannot splice out.

(C) The genetic code of prokaryotes differs significantly from the eukaryotic code in genomic DNA.

(D) cDNA contains highly active bacterial promoter regions already built-in.

Q32. In cell respiration, the link reaction which bridges glycolysis and the Krebs cycle occurs in the _____ and involves the conversion of pyruvate into _____ via oxidative decarboxylation.

(A) Cytoplasm ; Lactic acid

(B) Mitochondrial matrix ; Acetyl-CoA

(C) Inner mitochondrial membrane ; Oxaloacetate

(D) Peroxisome ; Succinyl-CoA

Q33. A patient undergoes blood analysis, and the laboratory technician notes an abnormally high count of eosinophils (eosinophilia). This clinical finding is most indicative of which underlying pathophysiological state?

(A) Acute bacterial infection of the urinary tract

(B) Allergic hypersensitivity reaction or parasitic helminthic infection

(C) Severe vitamin B_{12} deficiency anemia

(D) Chronic systemic hypoperfusion due to heart failure

Q34. In human genetics, hemophilia A is an X-linked recessive disorder. If a phenotypically normal woman whose father was a hemophiliac marries a normal healthy man, what is the probability that their first-born son will suffer from hemophilia?

(A) 0%

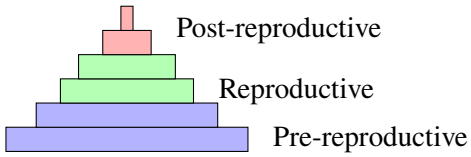
(B) 25%

(C) 50%

(D) 100%

Q35. The dynamic equilibrium of a population depends heavily on its age structure distribution. Consider an age pyramid characterized by a very broad base

representing a large proportion of prereproductive individuals, and a rapidly tapering top. What does this shape indicate about the future growth pattern of the population?



(A) The population is stable and stationary.

(B) The population is rapidly growing and expanding.

(C) The population is declining and facing extinction.

(D) The population has reached its absolute carrying capacity.

Q36. **Statement 1:** Periodic abstinence is a natural contraceptive method where couples avoid coitus from day 10 to 17 of the menstrual cycle when ovulation is highly expected.

Statement 2: Hormonal intra-uterine devices (IUDs) like LNG-20 prevent conception solely by acting as a mechanical barrier preventing sperm from entering the fallopian tubes.

(A) Both Statement 1 and Statement 2 are correct.

(B) Both Statement 1 and Statement 2 are incorrect.

(C) Statement 1 is correct but Statement 2 is incorrect.

(D) Statement 1 is incorrect but Statement 2 is correct.

Q37. An agricultural botanist treats a dwarf pea plant mutant with a specific plant growth regulator, resulting in dramatic stem elongation so that it matches the phenotype of wild-type tall plants. The hormone applied is also known for breaking seed dormancy and promoting bolting in rosette plants. Identify the hormone:

(A) Abscisic acid

(B) Gibberellin

(C) Cytokinin

(D) Ethylene

Q38. In a specific marine habitat, a keystone star-fish predator is experimentally removed from an enclosed intertidal community. Within a year, more than ten species of benthic invertebrates become locally extinct. What was the primary cause of this ecological collapse?

(A) Direct toxic chemical secretions from the decaying bodies of the starfish

(B) Intensive interspecific competition among the prey species for space, unchecked by predation

(C) Sharp drop in the gross primary productivity of the benthic microalgae

(D) Massive migration of prey species out of the enclosure to find alternative food sources

Q39. Transgenic 'Rosie' cow, produced in 1997, was a significant milestone in animal biotechnology. The milk produced by this transgenic cow was nutritionally superior to natural bovine milk because it contained a high concentration of which human protein?

(A) Human alpha-lactalbumin

(B) Human insulin-like growth factor

(C) Human tissue plasminogen activator

(D) Human alpha-1-antitrypsin

Q40. Cells of a mammalian tissue are treated with a metabolic drug that specifically blocks the activity of the signal peptidase enzyme inside the rough endoplasmic reticulum (RER). Which cellular process will be most directly disrupted by this drug?

(A) The transcription of ribosomal RNA genes in the nucleolus

(B) The modification and sorting of cytosolic proteins in the centrosome

(C) The translocation and proper processing of secretory and membrane-bound proteins

(D) The assembly of tubulin dimers into mitotic spindle fibers

Detailed Solutions

Q1.

Solution

Concept:

Polysaccharide architecture depends on the identity of the monosaccharide subunit, the carbons involved in the glycosidic bond, and the stereochemical orientation (α or β) of the linkage.

Solution:

(a) The description details a polymer consisting of β-D-glucose modified at carbon-2 with an acetylated amino group. This modified sugar is N-acetyl-D-glucosamine (GlcNAc).

(b) A homopolymer composed entirely of N-acetyl-D-glucosamine units linked by β-(1→4) glycosidic bonds is the exact chemical definition of chitin. Chitin is a major structural component in fungal cell walls and arthropod exoskeletons.

(c) Cellulose is composed of unmodified β-D-glucose units linked by β-(1→4) glycosidic bonds. It lacks the acetylated amino modification at the carbon-2 position.

(d) Glycogen consists of α-D-glucose units with α-(1→4) linkages and α-(1→6) branches, making it structurally distinct from the linear β-linked macromolecule described.

(e) Inulin is a polymer of fructose subunits, functioning primarily as a storage carbohydrate in various plant species, which is completely unrelated to modified glucose chains.

Final Answer: The macromolecule is structurally most analogous to Chitin.

Answer: (C)

Go Back to Question 1

Q2.

Solution

Concept:

Thyroid hormone synthesis requires the uptake of systemic iodide, its transport into follicles, and the subsequent iodination of tyrosine residues on the scaffold protein thyroglobulin.

Solution:

(a) The clinical presentation includes symptoms of hypothyroidism (low metabolic rate, chronic fatigue) alongside elevated Thyroid Stimulating Hormone (TSH) caused by the absence of negative feedback from active thyroid hormones.

(b) The accumulation of uniodinated thyroglobulin within the follicles indicates that the protein scaffold is being synthesized normally, but the chemical addition of iodine is failing.

(c) Severe dietary iodine deficiency fits this profile perfectly because thyroglobulin cannot be iodinated without a source of iodine, halting the synthesis of active T3 and T4 hormones.

(d) A mutation in the sodium-iodide symporter (NIS) could also mimic this, but severe dietary iodine deficiency is the classic primary nutritional defect responsible for endemic goiter and uniodinated thyroglobulin accumulation.

(e) Autoimmune destruction of TSH receptors would cause follicle atrophy and prevent high thyroglobulin synthesis, while TRH hypersecretion would not selectively yield uniodinated thyroglobulin.

Final Answer: The responsible condition is severe dietary iodine deficiency.

Answer: (A)

Go Back to Question 2

Q3.

Solution

Concept:

Genetic mapping estimates the physical distance between distinct gene loci on a chromosome based on the frequency of meiotic crossover events observed in a testcross.

Solution:

(a) A dihybrid testcross involves crossing a double heterozygous individual with a homozygous recessive tester. The offspring display parental and recombinant phenotypes.

(b) The provided offspring counts show parental types as wild-type ($AB = 442$) and double mutant ($ab = 458$). The recombinant types are Recombinant 1 ($Ab = 52$) and Recombinant 2 ($aB = 48$).

(c) The total number of offspring produced across all classes is calculated by finding the sum of all individuals: $442 + 458 + 52 + 48 = 1000$.

(d) The total number of recombinant individuals resulting from crossover events is calculated as: $52 + 48 = 100$.

(e) Recombination frequency is computed by dividing the number of recombinants by the total progeny: $\frac{100}{1000} \times 100 = 10\%$. Since 1% recombination frequency corresponds to 1.0 centimorgan (cM), the map distance is 10.0 cM.

Final Answer: The map distance between the two loci is 10.0 centimorgans.

Answer: (B)

Go Back to Question 3

Q4.

Solution

Concept:

Human oogenesis features specialized developmental pauses, with the first and second meiotic divisions completing at precise chronological intervals during a female's life.

Solution:

(a) Primary oocytes form during embryonic development in the fetal ovary and remain arrested in prophase I of meiosis until the individual reaches puberty.

(b) Each month following puberty, a select cohort of primordial follicles begins maturing under cyclical hormonal influences, progressing toward a mature Graafian follicle.

(c) Just prior to ovulation, the surge of Luteinizing Hormone (LH) induces the primary oocyte within the dominant follicle to complete its first meiotic division.

(d) This division features highly asymmetric cytokinesis, allocating the cytoplasm to a single large secondary oocyte while forming a small, non-functional first polar body.

(e) The second meiotic division begins immediately after but arrests at metaphase II, completing only if fertilization by a sperm occurs within the fallopian tube.

Final Answer: Asymmetrical cytokinesis occurs immediately prior to ovulation in the mature Graafian follicle.

Answer: (B)

Go Back to Question 4

Q5.

Solution

Concept:

Phytochrome pigments modulate plant photomorphogenesis via light-induced interconversion between an inactive red-absorbing form (Pr) and an active far-red-absorbing form (Pfr).

Solution:

(a) Exposure to red light (660 nm) converts the inactive Pr form into the biologically active Pfr form. Far-red light (730 nm) drives the reverse reaction, changing Pfr back to Pr.

(b) In short-day plants, flowering is triggered by long nights. The presence of the active Pfr form during the night inhibits flowering. Red light exposure converts Pr to Pfr, thereby suppressing flowering.

(c) Seed germination and seedling de-etiolation are positively regulated by the active Pfr form following activation by red light, not by the Pr form.

(d) Long-day plants require the Pfr form to promote flowering, which accumulates during extended periods of daylight or via artificial red light pulses during dark intervals.

Final Answer: The correctly paired response is inhibition of flowering in short-day plants — Pfr form — Red light (660 nm).

Answer: (A)

Go Back to Question 5

Q6.

Solution

Concept:

Diagnostic morphological markers, including cell wall architecture and flagellar orientation, serve to distinguish the diverse phyla organized within the kingdom Protista.

Solution:

(a) The organism exhibits a unicellular eukaryotic structure with a specialized cell wall divided into distinct, rigid cellulosic armor plates.

(b) It features a unique flagellar configuration consisting of two flagella: one oriented longitudinally and another arranged transversely within a structural furrow or cingulum.

(c) This asymmetrical flagellar beating generates a characteristic whirling or spinning rotational movement through aquatic environments.

(d) These structural and behavioral attributes are classic diagnostic hallmarks characterizing the dinoflagellates, which function as major marine and freshwater planktonic producers.

(e) Chrysophytes lack this flagellar arrangement, euglenoids lack rigid cell walls, and slime moulds exist as wall-less amoeboid structures or multinucleated plasmodial masses during vegetative growth phases.

Final Answer: The organism belongs to the group Dinoflagellates.

Answer: (B)

Go Back to Question 6

Q7.

Solution

Concept:

Immunological memory alters the kinetics and composition of humoral immunity, ensuring enhanced performance upon re-exposure to a previously encountered antigen.

Solution:

(a) A primary immune response occurs when naive B cells encounter a novel antigen. It features a prolonged lag phase, a modest peak antibody titer, and a predominance of IgM antibodies.

(b) During this initial phase, antigen-selected B cells differentiate into plasma cells and long-lived memory B cells configured for rapid clonal expansion.

(c) Re-exposure to the same antigen triggers the secondary immune response. Memory cells respond immediately, dramatically shortening the initial lag phase.

(d) The secondary response yields a significantly higher peak antibody titer and produces antibodies with increased binding affinity via affinity maturation.

(e) Class-switch recombination shifts production so that IgG becomes the predominant antibody isotype circulating in the blood, replacing the initial IgM pool.

Final Answer: The secondary response features a shorter lag phase, higher peak titer, and predominantly IgG antibodies.

Answer: (B)

Go Back to Question 7

Q8.

Solution

Concept:

Ecosystem energetics balances primary energy capture against metabolic consumption, regulating the total biomass available for transfer across trophic levels.

Solution:

(a) Gross Primary Productivity (GPP) represents the absolute rate at which autotrophic producers capture solar energy and fix it into organic chemical bonds.

(b) Net Primary Productivity (NPP) represents the remaining organic energy stored by producers after accounting for their own metabolic maintenance via cellular respiration (R).

(c) The thermodynamic relationship between these values is represented by the linear algebraic equation: $NPP = GPP - R$.

(d) The problem states that autotrophic respiratory loss accounts for 40% of the GPP value. This means the NPP available corresponds to 60% of the total GPP.

(e) Calculating this fractional value yields: $0.60 \times (2.4 \times 10^4 \text{ kcal/m}^2/\text{yr}) = 1.44 \times 10^4 \text{ kcal/m}^2/\text{yr}$.

Final Answer: The Net Primary Productivity available is 1.44×10^4 kcal/m^2/yr.

Answer: (B)

Go Back to Question 8

Q9.

Solution

Concept:

Restriction mapping requires calculating the lengths of linear DNA fragments generated by executing single or simultaneous multiple endonucleolytic digestions on circular plasmids.

Solution:

(a) The circular plasmid template has a total length of 6.0 kb. It contains two target recognition sites for HindIII and one target recognition site for EcoRI.

(b) Digestion with HindIII alone cuts the circular molecule at two distinct loci, dividing the plasmid into two fragments: a minor 1.5 kb piece and a remaining 4.5 kb piece.

(c) The single EcoRI cleavage site is located exactly in the center of the 1.5 kb HindIII region. This placement splits the 1.5 kb segment into two equal portions of 0.75 kb each.

(d) Performing a complete simultaneous digestion with both enzymes cleaves all three positions, converting the circular plasmid into three separate linear segments.

(e) These resulting fragments measure 4.5 kb, 0.75 kb, and 0.75 kb. They can be separated and visualized as distinct bands using standard agarose gel electrophoresis.

Final Answer: The sizes of the resulting DNA fragments are 4.5 kb, 0.75 kb, and 0.75 kb.

Answer: (C)

Go Back to Question 9

Q10.

Solution

Concept:

Skeletal muscle contraction operates via a highly regulated biochemical cascade described by the sliding filament theory, driven by calcium ions and cyclic ATP hydrolysis.

Solution:

(a) The cycle initiates when intracellular calcium binds to Troponin C. This induces a conformational shift in tropomyosin, uncovering the myosin-binding active sites on actin filaments (Event 3).

(b) Once exposed, the energized myosin head, which already holds bound ADP and inorganic phosphate, binds to the actin active site to establish a cross-bridge (Event 5).

(c) The release of ADP and inorganic phosphate triggers the power stroke, causing the myosin head to pivot and pull the actin filament toward the center of the sarcomere (Event 4).

(d) Following the power stroke, a new molecule of ATP binds to the empty nucleotide slot on the myosin head, breaking the cross-bridge and inducing detachment from actin (Event 1).

(e) Myosin-associated ATPase then hydrolyzes the bound ATP, converting it to ADP and Pi. This energy re-cocks the myosin head into its high-energy conformation, preparing it for another cycle (Event 2).

Final Answer: The correct chronological sequence of events is $3 \rightarrow 5 \rightarrow 4 \rightarrow 1 \rightarrow 2$.

Answer: (A)

Go Back to Question 10

Q11.

Solution

Concept:

The endocrine regulation of the human male reproductive system relies on gonadotropins secreted by the anterior pituitary gland to modulate spermatogenesis and steroidogenesis.

Solution:

(a) Gonadotropin-Releasing Hormone (GnRH) from the hypothalamus stimulates the anterior pituitary gland to secrete two primary gonadotropins: Follicle Stimulating Hormone (FSH) and Luteinizing Hormone (LH).

(b) Luteinizing Hormone (LH) travels through the bloodstream to the testes, where it binds to specific receptors located on the surface of the interstitial cells, also known as Leydig cells.

(c) This binding triggers an intracellular signaling cascade that stimulates the Leydig cells to synthesize and secrete androgens, primarily testosterone, which is vital for maintaining spermatogenesis and secondary male characteristics.

(d) Because of its specific role in stimulating interstitial tissue, LH is historically referred to as Interstitial Cell Stimulating Hormone (ICSH) in males.

(e) FSH acts independently on the Sertoli cells located within the seminiferous tubules to stimulate the secretion of androgen-binding protein (ABP) and factors essential for spermiogenesis.

Final Answer: Androgens are stimulated by Luteinizing Hormone (LH) which acts directly on the Leydig cells.

Answer: (B)

Go Back to Question 11

Q12.

Solution

Concept:

The genetic code exhibits unique properties such as universality, specificity, and degeneracy, which ensure accurate translation of mRNA transcripts into functional proteins.

Solution:

(a) Statement 1 is fully accurate. The triplet codon AUG serves as the universal initiation codon for protein synthesis in both prokaryotic and eukaryotic organisms. It codes exclusively for methionine in eukaryotes and formyl-methionine in prokaryotes.

(b) Statement 2 is incorrect regarding the definition of degeneracy. The genetic code is described as degenerate because multiple distinct codons can code for the same single amino acid. For example, six different codons all code for leucine.

(c) A single codon mapping to multiple different amino acids would violate the unambiguous nature of the genetic code, as each specific codon must code for only one amino acid.

(d) While exceptional recoding events exist, such as UGA coding for selenocysteine under tight structural contexts, the baseline definition of degeneracy given in the statement is inverted and biochemically incorrect.

Final Answer: Statement 1 is correct but Statement 2 is incorrect.

Answer: (C)

Go Back to Question 12

Q13.

Solution

Concept:

Enzyme kinetics can be altered by inhibitors, which are classified based on whether they bind to the free enzyme, the enzyme-substrate complex, or both.

Solution:

(a) Competitive inhibitors possess a chemical structure that closely mimics the natural substrate of the enzyme, allowing them to bind reversibly to the active site.

(b) Because the inhibitor and substrate compete directly for the same physical pocket, increasing the substrate concentration can completely displace the inhibitor from the active site.

(c) At infinitely high substrate concentrations, the enzyme can still reach its maximum potential velocity. Therefore, the maximum velocity (V_{max}) of the reaction remains entirely unchanged.

(d) The apparent Michaelis constant (K_m), which reflects the substrate concentration needed to reach half of V_{max}, increases because a higher amount of substrate is required to overcome the competitive inhibition.

(e) This characteristic signature helps distinguish competitive inhibition from non-competitive and uncompetitive mechanisms using a Lineweaver-Burk double-reciprocal plot.

Final Answer: V_{max} remains unchanged ; K_m increases.

Answer: (B)

Go Back to Question 13

Q14.

Solution

Concept:

An electrocardiogram (ECG) translates the spatial and temporal summation of cardiac electrical vectors into distinct waves that correspond to specific mechanical events.

Solution:

(a) The P-wave corresponds to atrial depolarization, which spreads from the sinoatrial node across the atria and precedes actual atrial contraction.

(b) The QRS complex represents the rapid depolarization of both the left and right ventricles. This electrical activation is the direct physiological trigger that initiates ventricular contraction or systole.

(c) The T-wave represents ventricular repolarization, which allows the ventricular muscle fibers to relax, marking the onset of ventricular diastole. Atrial repolarization is buried within the larger QRS complex.

(d) The period from the end of the T-wave to the next P-wave represents the quiescent phase of late ventricular diastole, during which passive ventricular filling occurs, not ventricular ejection.

Final Answer: The QRS complex represents the depolarization of the ventricles, which initiates ventricular contraction.

Answer: (B)

Go Back to Question 14

Q15.

Solution

Concept:

Comparative anatomy categorizes structural adaptations as either homologous or analogous based on their underlying evolutionary origin and ancestral relationships.

Solution:

(a) A sweet potato represents an underground root modification, whereas a regular potato represents an underground stem modification known as a tuber.

(b) Although both organs look superficially similar and fulfill identical physiological roles by storing starch, they develop from completely different anatomical structures and embryonic lineages.

(c) Structures that perform similar functions but lack a common anatomical or ancestral origin are defined as analogous organs.

(d) Analogous organs arise due to convergent evolution, where distinct lineages adapt to similar environmental pressures or ecological niches over geological time.

(e) Homologous organs, by contrast, share a common structural plan and ancestral origin but may deviate in function due to divergent evolution, such as the flipper of a whale and the wing of a bat.

Final Answer: This is an example of analogous organs resulting from convergent evolution.

Answer: (B)

Go Back to Question 15

Q16.

Solution

Concept:

Early human embryogenesis transitions a fertilized zygote into a specialized blastocyst consisting of distinct cell lineages dedicated to embryonic or placental development.

Solution:

(a) Following fertilization, cleavage divisions create a blastocyst containing an inner cell mass and an outer epithelial monolayer.

(b) This outer cellular monolayer is called the trophoblast, which is specifically tasked with mediating attachment and invasion into the maternal endometrium.

(c) Upon contact with the uterine wall, the trophoblast proliferates and differentiates into an inner cytotrophoblast and an outer invasive syncytiotrophoblast.

(d) The syncytiotrophoblast extends proteolytic projections into the endometrium to establish the early maternal-fetal connection.

(e) The trophoblast cells also synthesize and secrete Human Chorionic Gonadotropin (hCG), a hormone that maintains the corpus luteum and prevents the onset of menstruation.

Final Answer: The specialized outer layer responsible is the Trophoblast.

Answer: (C)

Go Back to Question 16

Q17.

Solution

Concept:

Angiosperm reproduction features a double fertilization event that alters the ploidy levels of different structural tissues within the developing seed.

Solution:

(a) The somatic chromosome number is given as $2n = 24$, meaning the haploid gametic number (n) for this specific plant species is 12.

(b) The aleurone layer forms the outermost cellular boundary of the endosperm. Because endosperm is produced via triple fusion ($2n$ central cell + n male gamete), it is triploid ($3n$). Thus, $3 \times 12 = 36$ chromosomes.

(c) The pollen mother cell is a specialized microsporocyte belonging to the sporophytic generation. It is diploid ($2n$) and undergoes meiosis later, so it contains 24 chromosomes.

(d) Synergids are components of the female gametophyte (egg apparatus) generated via mitotic divisions of the haploid megaspore. They are haploid (n) and contain 12 chromosomes.

Final Answer: The respective chromosome numbers are 36, 24, and 12.

Answer: (A)

Go Back to Question 17

Q18.

Solution

Concept:

The biological taxonomic hierarchy is arranged in a specific nested order, where lower categories share a greater number of homologies than higher categories.

Solution:

(a) The taxonomic hierarchy progresses from kingdom down through division, class, order, family, genus, and finally species.

(b) As you move down from highest to lowest categories, the organisms grouped together display an increasing degree of shared morphological, physiological, and biochemical traits.

(c) Species A and B are grouped within the exact same genus, representing the closest taxonomic proximity among all the pairs described.

(d) Species C and D share a family but belong to different genera, meaning they are less closely related than species sharing a genus.

(e) Species E is separated at the level of order, making it the most phylogenetically distant from all other options provided.

Final Answer: Species A and B are expected to share the highest number of common characters.

Answer: (B)

Go Back to Question 18

Q19.

Solution

Concept:

Oncogenesis involves the conversion of tightly regulated proto-oncogenes into constitutively active oncogenes via specific activating mutations or structural rearrangements.

Solution:

(a) Proto-oncogenes code for normal cellular proteins that promote controlled growth, survival, and cell cycle progression.

(b) Activating these genes into oncogenes requires gain-of-function modifications rather than inactivating or silencing mutations.

(c) A reciprocal chromosomal translocation can relocate a proto-oncogene adjacent to an exceptionally strong promoter or enhancer sequence, leading to massive overproduction of the normal protein.

(d) A classic example is the t(8;14) translocation in Burkitt lymphoma, which places the MYC proto-oncogene under the highly active immunoglobulin heavy chain promoter.

(e) Epigenetic silencing, nonsense mutations, or deletions represent loss-of-function changes, which are typical mechanisms for inactivating tumor suppressor genes rather than activating proto-oncogenes.

Final Answer: The mechanism is a reciprocal chromosomal translocation placing the gene under a highly active promoter.

Answer: (B)

Go Back to Question 19

Q20.

Solution

Concept:

Biomagnification describes the progressive increase in the tissue concentration of lipophilic, non-biodegradable toxins at higher trophic levels within a food chain.

Solution:

(a) DDT is a highly persistent organochlorine pesticide that is insoluble in water but highly soluble in lipids, causing it to accumulate inside animal fatty tissues.

(b) Because organisms at higher trophic levels must consume vast quantities of biomass from lower levels, the toxin concentration amplifies exponentially at each step.

(c) In a typical aquatic food web, DDT concentrations scale up from water to phytoplankton, zooplankton, small fish, large fish, and finally apex fish-eating birds.

(d) Given an initial water concentration of 0.003 ppb, biomagnification regularly elevates the concentration by several million-fold by the time it reaches top predators.

(e) Among the choices provided, 25 ppm (parts per million) represents the classic, verified concentration level found in apex avian predators, which interferes with calcium deposition and causes eggshell thinning.

Final Answer: The most likely concentration found in fish-eating birds is 25 ppm.

Answer: (C)

Go Back to Question 20

Q21.

Solution

Concept:

Plant tissue culture exploits cellular totipotency to regenerate intact plants from isolated pieces of tissue, known as explants, within a sterile environment.

Solution:

(a) When a valuable plant variety becomes systematically infected with viral pathogens, the virus usually spreads through vascular channels like the phloem to colonize most vegetative tissues.

(b) However, the rapidly dividing cells at the growing tips, specifically the apical and axillary meristems, remain completely free of virus particles.

(c) This virus-free status exists because the rate of rapid cell division outpaces viral replication, and the absence of fully differentiated vascular connections limits viral entry into the meristematic zone.

(d) To obtain virus-free healthy clones from an infected specimen, an analytical micro-dissection is performed to isolate the apical or axillary meristem dome under a stereomicroscope.

(e) Culturing this virus-free meristem explant on an optimal nutrient medium containing balanced ratios of auxin and cytokinin induces shoot multiplication and root development, successfully producing healthy, virus-free progeny.

Final Answer: The specific part that must be excised is the apical and axillary meristems.

Answer: (B)

Go Back to Question 21

Q22.

Solution

Concept:

The fluid mosaic model defines cellular membranes as dynamic, two-dimensional fluids where individual lipids undergo different modes of diffusion based on thermodynamic barriers.

Solution:

(a) Phospholipid bilayers exhibit structural asymmetry, containing a central hydrophobic core formed by non-polar fatty acid chains and outer surfaces formed by hydrophilic polar head groups.

(b) Lateral diffusion involves lipids moving sideways within the same monolayer leaflet. This type of motion faces minimal resistance and occurs rapidly because it preserves favorable electrostatic and hydrophobic interactions.

(c) Flip-flop movement, or transverse diffusion, requires an individual lipid molecule to migrate from one monolayer leaflet across to the opposing leaflet.

(d) For a flip-flop to occur, the highly hydrophilic polar head group must detach from its aqueous environment and pass directly through the non-polar, hydrophobic core of the membrane bilayer.

(e) This translocation presents a massive thermodynamic energy barrier, making spontaneous flip-flop events extremely rare unless actively accelerated by specialized, ATP-dependent transporter enzymes known as flippases or floppases.

Final Answer: The primary reason is that the hydrophilic polar head group of the lipid must pass through the hydrophobic core of the membrane.

Answer: (B)

Go Back to Question 22

Q23.

Solution

Concept:

The human digestive system uses sequential biochemical cascades to activate inactive proenzymes, protecting secretory tissues from self-digestion.

Solution:

(a) Protein digestion initiates within the gastric lumen of the stomach upon the entry of a meal, which triggers the secretion of gastric juice.

(b) Chief cells in the gastric glands secrete the inactive zymogen precursor pepsinogen into the lumen to prevent damage to cellular structures.

(c) Parietal cells simultaneously secrete hydrochloric acid (HCl), which lowers the gastric pH to a highly acidic range of 1.5 to 2.5.

(d) This acidic environment causes a conformational shift in pepsinogen, inducing auto-cleavage to yield the active proteolytic enzyme pepsin.

(e) Once activated, pepsin acts endopeptidolytically to hydrolyze internal peptide bonds within complex dietary proteins, converting them into smaller, soluble peptide fragments called proteoses and peptones.

(f) The options containing tryptic, chymotryptic, or carboxypeptidase cascades occur exclusively within the alkaline environment of the small intestine, driven by pancreatic secretions.

Final Answer: The correct gastric activation cascade is Pepsinogen $\xrightarrow{\text{Hydrochloric acid}}$ Pepsin $\rightarrow$ Converts proteins into peptones.

Answer: (B)

Go Back to Question 23

Q24.

Solution

Concept:

The Meselson-Stahl experiment provided definitive physical evidence for the semi-conservative model of DNA replication using heavy nitrogen isotopes and density-gradient centrifugation.

Solution:

(a) Initial bacterial cells contain double-stranded DNA molecules where both strands are fully integrated with heavy nitrogen, represented as $^{15}N/^{15}N$.

(b) When transferred to a light nitrogen (^{14}N) medium, each original heavy strand acts as a permanent template for synthesizing a new, light complementary strand.

(c) After generation one, replication yields two DNA molecules, both of which are hybrid ($^{15}N/^{14}N$). The absolute number of these hybrid molecules remains fixed at two in all subsequent generations.

(d) After generation two, the two hybrid molecules replicate to form four total DNA molecules: two hybrid ($^{15}N/^{14}N$) and two entirely light ($^{14}N/^{14}N$).

(e) After generation three, binary fission doubles the total to eight DNA molecules. Two remain hybrid ($^{15}N/^{14}N$), while the remaining six are light ($^{14}N/^{14}N$).

(f) Calculating the final ratio of hybrid molecules to entirely light molecules yields $2 : 6$, which simplifies directly to $1 : 3$.

Final Answer: The ratio of hybrid to light DNA molecules is $1 : 3$.

Answer: (B)

Go Back to Question 24

Q25.

Solution

Concept:

The countercurrent multiplier system in mammalian kidneys establishes a high osmotic gradient within the medullary interstitium through regional variations in water and solute permeability.

Solution:

(a) The loop of Henle features a specialized U-shaped anatomy with distinct descending and ascending limbs that exhibit opposite permeability profiles.

(b) The descending limb of Henle's loop contains dense aquaporin-1 channels, making it highly permeable to water but entirely passive to the movement of NaCl and other electrolytes.

(c) The ascending limb of Henle's loop exhibits a complete structural absence of aquaporin water channels, making its entire epithelial lining completely impermeable to water.

(d) The thick portion of this ascending segment contains specialized Na-K-2Cl cotransporters that actively pump sodium, potassium, and chloride ions out of the tubular fluid.

(e) This active solute extrusion into the medullary interstitium, unaccompanied by water, dilutes the tubular fluid while raising the interstitial osmolarity to drive water reabsorption from the descending limb and collecting duct.

Final Answer: The segment that is impermeable to water but transports electrolytes is the ascending limb of Henle's loop.

Answer: (C)

Go Back to Question 25

Q26.

Solution

Concept:

Gastrulation reorganizes the early blastoderm into three distinct primary embryonic germ layers, each programmed to generate specific organ systems.

Solution:

(a) The embryonic ectoderm forms the outermost layer during gastrulation and is committed to generating the external boundaries and communication networks of the body.

(b) The entire central and peripheral nervous systems, including the brain, spinal cord, nerves, and ganglia, develop directly from the ectodermal layer via neurulation.

(c) The epidermis of the skin, along with cutaneous appendages like hair, nails, and specific secretory glands, is derived entirely from the ectoderm.

(d) The muscular, circulatory, and skeletal systems, along with internal organs like the kidneys, dermis, and gonads, develop from the middle embryonic layer, known as the mesoderm.

(e) The epithelial linings of the gastrointestinal tract, respiratory tract, and associated digestive glands like the liver and pancreas develop from the inner embryonic layer, known as the endoderm.

Final Answer: The tissue system derived entirely from embryonic ectoderm is the nervous system and epidermis of skin.

Answer: (B)

Go Back to Question 26

Q27.

Solution

Concept:

Angiosperm fertilization follows a regulated sequence of physical, cellular, and chemotropic events that guide male gametes to the female gametophyte.

Solution:

(a) The process begins when a pollen grain lands on a compatible, receptive stigmatic surface via a pollination vector (Event 2).

(b) Following hydration, the pollen grain absorbs water and nutrients from the stigma, causing the internal pressure to rise and forcing the intine to protrude through a germ pore to initiate a pollen tube (Event 4).

(c) As the pollen tube elongates, it exhibits chemotropic growth, responding to calcium and boron gradients to navigate through the transmitting tissue of the style toward the micropyle (Event 5).

(d) During its descent through the style, the generative cell undergoes a mitotic division to form two distinct, non-motile male gametes inside the pollen tube (Event 1).

(e) The pollen tube enters the ovule via the micropyle and discharges its contents into one of the synergids, which then guides double fertilization (Event 3).

Final Answer: The correct chronological sequence of events is $2 \rightarrow 4 \rightarrow 5 \rightarrow 1 \rightarrow 3$.

Answer: (D)

Go Back to Question 27

Q28.

Solution

Concept:

Plant evolutionary history tracks transitions in generation dominance and the development of specialized vascular bundles for terrestrial adaptations.

Solution:

(a) Bryophytes represent a primitive lineage of non-vascular embryophytes. Their life cycle is dominated by a free-living, photosynthetic, haploid gametophyte generation, while the diploid sporophyte remains structurally dependent on the gametophyte.

(b) Bryophytes lack specialized vascular tissues like xylem and phloem, which limits their physical size and confines them to damp microhabitats.

(c) Pteridophytes represent the earliest lineage of vascular cryptogams. They exhibit an evolutionary shift where the diploid sporophyte becomes the dominant, independent, and physically complex generation.

(d) The sporophyte of pteridophytes possesses well-differentiated vascular tissues containing tracheids and sieve cells to transport water and nutrients efficiently.

(e) Both groups require external liquid water to facilitate the migration of motile, flagellated antherozoids to the archegonia for fertilization, and neither group produces seeds.

Final Answer: Bryophytes have a dominant haploid gametophyte phase, whereas Pteridophytes have a dominant independent diploid sporophyte phase with vascular tissues.

Answer: (C)

Go Back to Question 28

Q29.

Solution

Concept:

Viral hepatitis strains are categorized into distinct taxonomic families based on their structural characteristics, genomic configurations, and modes of transmission.

Solution:

(a) The epidemiological data describes an acute infectious illness targeting liver tissue, presenting with classic signs of hepatic inflammation, jaundice, and dark urine.

(b) Transmission occurs via the fecal-oral route, which is typically associated with consuming contaminated water or food supplies during localized outbreaks.

(c) The pathogen is described as a non-enveloped, single-stranded RNA virus. It causes acute infections but does not establish chronic liver disease, carrier states, or cirrhosis.

(d) These biological and clinical criteria match Hepatitis A virus (HAV), a member of the Picornaviridae family.

(e) Hepatitis B virus is an enveloped, double-stranded DNA virus transmitted through blood or sexual contact. Hepatitis C virus is an enveloped, single-stranded RNA virus that is also blood-borne and regularly progresses to chronic infection.

Final Answer: The pathogen is most likely Hepatitis A virus.

Answer: (C)

Go Back to Question 29

Q30.

Solution

Concept:

The logistic growth model incorporates environmental resistance, showing how a population's absolute growth rate varies as its density approaches the carrying capacity.

Solution:

(a) The math underlying logistic population growth is expressed by the differential equation: $\frac{dN}{dt} = rN\left(1 - \frac{N}{K}\right)$.

(b) The absolute growth rate ($\frac{dN}{dt}$) is a function of both the current population size (N) and the remaining available resources, represented by the modifier term $\left(1 - \frac{N}{K}\right)$.

(c) When the population size (N) is very low and approaching zero, the resource term is near one, but the small number of breeding individuals keeps the absolute growth rate low.

(d) When the population size (N) equals the carrying capacity (K), the resource term becomes zero, causing the absolute growth rate to drop to zero as the population stabilizes.

(e) Maximizing the mathematical function reveals that the highest absolute growth rate occurs at the inflection point of the sigmoidal growth curve, which is exactly when the population size (N) reaches half of the carrying capacity, or $K/2$.

Final Answer: The population growth rate reaches its maximum value when the population size N is exactly equal to $K/2$.

Answer: (C)

Go Back to Question 30

Q31.

Solution

Concept:

Recombinant DNA technology requires selecting expression vectors and insert libraries that are compatible with the transcription and translation machinery of the host organism.

Solution:

(a) Eukaryotic genomic DNA contains coding segments called exons interspersed with non-coding regulatory or structural segments called introns.

(b) Eukaryotic cells transcribe genomic DNA into pre-mRNA and use specialized nuclear machinery, including spliceosomes, to remove introns and splice exons together into mature mRNA.

(c) Prokaryotic organisms, such as Escherichia coli, lack introns in their genes and do not possess the structural spliceosomal machinery required to remove eukaryotic introns.

(d) If an unedited human genomic DNA fragment containing introns is introduced into a bacterial host, the bacterium transcribes the entire sequence directly, resulting in a non-functional protein.

(e) A complementary DNA (cDNA) library is synthesized by reverse-transcribing mature, pre-spliced mRNA isolated from a target tissue. Because the introns have already been removed by the host cell, the resulting cDNA inserts can be translated accurately into the correct protein by the bacterial host.

Final Answer: A cDNA library is preferred because eukaryotic genomic DNA contains introns which prokaryotic cells cannot splice out.

Answer: (B)

Go Back to Question 31

Q32.

Solution

Concept:

Cellular respiration links the anaerobic pathway of glycolysis to the aerobic citric acid cycle through a dedicated transport and decarboxylation phase.

Solution:

(a) Glycolysis occurs entirely within the aqueous environment of the cytoplasm, breaking down one molecule of glucose into two molecules of the three-carbon compound pyruvate.

(b) Under aerobic conditions, specialized transport proteins move pyruvate across the outer and inner mitochondrial membranes into the mitochondrial matrix.

(c) Once inside the matrix, pyruvate undergoes the link reaction, which is catalyzed by a large multi-enzyme complex known as the pyruvate dehydrogenase complex.

(d) This complex drives oxidative decarboxylation, removing a carboxyl group as carbon dioxide, reducing NAD+ to NADH, and attaching the remaining two-carbon acetyl group to Coenzyme A.

(e) This reaction converts pyruvate into acetyl-coenzyme A (Acetyl-CoA). Acetyl-CoA then enters the Krebs cycle by condensing with oxaloacetate to form citrate, continuing aerobic ATP production.

Final Answer: The link reaction occurs in the mitochondrial matrix and converts pyruvate into Acetyl-CoA.

Answer: (B)

Go Back to Question 32

Q33.

Solution

Concept:

Leukocyte differentials serve as key clinical diagnostic indicators, since distinct subpopulations of white blood cells proliferate in response to specific pathophysiological cues.

Solution:

(a) Eosinophils are specialized granulocytic leukocytes characterized by a bilobed nucleus and cytoplasmic granules that stain intensely with acidic dyes like eosin.

(b) The primary physiological roles of eosinophils involve defending against large, non-phagocytosable pathogens and modulating immediate hypersensitivity immune responses.

(c) During a parasitic helminthic infection, such as an infection by tapeworms or flukes, eosinophils degranulate to release cytotoxic proteins that damage the parasite's tegument.

(d) Eosinophils also accumulate at sites of allergic inflammation, such as asthma or allergic rhinitis, where they interact with mast cells and release histaminase to limit the reaction.

(e) An abnormally high eosinophil count, known as eosinophilia, is a clinical indicator of an underlying allergic hypersensitivity reaction or a parasitic infection, whereas bacterial infections typically trigger neutrophil proliferation.

Final Answer: Eosinophilia is most indicative of an allergic hypersensitivity reaction or parasitic helminthic infection.

Answer: (B)

Go Back to Question 33

Q34.

Solution

Concept:

X-linked recessive traits exhibit unique inheritance patterns, displaying a skewed phenotypic distribution between male and female offspring due to hemizygosity.

Solution:

(a) Hemophilia A is an X-linked recessive disorder. Let the mutant allele be represented by Xh and the normal dominant allele be represented by X.

(b) The phenotypically normal woman has a father who was a hemophiliac (XhY). Because a father must pass his single X chromosome to his daughter, she is a mandatory heterozygous carrier (XXh).

(c) The woman marries a normal healthy man, whose genotype is XY. They cross a carrier female (XXh) with a normal male (XY).

(d) The potential genetic combinations for their offspring are normal females (XX), carrier females (XXh), normal males (XY), and affected hemophiliac males (XhY).

(e) The question asks for the probability that their first-born son will suffer from the condition. Looking specifically at the male offspring options (XY and XhY), there is a 50% chance the son inherits the Xh chromosome and develops hemophilia.

Final Answer: The probability that their first-born son will suffer from hemophilia is 50%.

Answer: (C)

Go Back to Question 34

Q35.

Solution

Concept:

Non-cyclic photophosphorylation relies on a continuous flow of electrons extracted from water molecules by a specialized catalytic center embedded within the thylakoid membrane.

Solution:

(a) During the light-dependent reactions of photosynthesis, Photosystem II (PSII) absorbs photons, exciting its reaction center chlorophyll, P680, and causing it to eject electrons.

(b) To reset the system and continue light absorption, the oxidized P680+ must replace its missing electrons by oxidizing water molecules via photolysis.

(c) This photolysis reaction is carried out by a specialized multi-protein subunit located on the luminal side of Photosystem II, known as the Oxygen-Evolving Complex (OEC).

(d) The Oxygen-Evolving Complex contains a catalytic cluster of inorganic metal cofactors, consisting of four manganese ions, one calcium ion, and associated chloride ions.

(e) These manganese ions transition through multiple oxidation states to strip electrons from water molecules, producing molecular oxygen and releasing protons into the thylakoid lumen to drive ATP synthesis.

Final Answer: The multi-protein complex and cofactors are Photosystem II ; Mn^{2+}, Cl^{-}, and Ca^{2+}.

Answer: (B)

Go Back to Question 35

Q36.

Solution

Concept:

Contraceptive methodologies are classified based on whether they operate via behavioral modifications, physical barriers, or biochemical alterations to prevent fertilization.

Solution:

(a) Statement 1 is correct. Periodic abstinence, or the rhythm method, is a natural family planning approach where couples avoid intercourse during the fertile window of the menstrual cycle. In a standard 28-day cycle, this window spans from day 10 to day 17, when ovulation is most likely to occur.

(b) Statement 2 is incorrect regarding the mechanism of hormonal intra-uterine devices (IUDs) like LNG-20. Hormonal IUDs do not function as simple physical or mechanical barriers.

(c) Instead, devices like LNG-20 release a steady dose of levonorgestrel, a synthetic progestin, directly into the uterine cavity.

(d) This hormone thickens the cervical mucus to block sperm migration, suppresses endometrial development to prevent implantation, and can inhibit ovulation entirely.

(e) Physical barrier functions are typical of condoms, diaphragms, or cervical caps, rather than medicated intra-uterine delivery systems.

Final Answer: Statement 1 is correct but Statement 2 is incorrect.

Answer: (C)

Go Back to Question 36

Q37.

Solution

Concept:

Plant growth regulators act as chemical signals that coordinate development, cell elongation, and adaptive responses to environmental stimuli.

Solution:

(a) The classic dwarf pea plant mutant lacks the active metabolic pathways required to synthesize endogenous gibberellins, limiting its internodal stem elongation.

(b) Exogenous application of gibberellins bypassing this genetic block triggers cell division and rapid elongation of the internodal cells, causing the dwarf plant to grow to a normal height.

(c) Beyond stem elongation, gibberellins play a key role in breaking seed and bud dormancy by stimulating the transcription of hydrolytic enzymes like alpha-amylase to mobilize nutrient reserves.

(d) Gibberellins also induce bolting, which is the rapid elongation of internodes and subsequent flowering in rosette plants, often triggered by changes in photoperiod.

(e) Abscisic acid acts as a growth inhibitor, cytokinins primarily promote cytokinesis, and ethylene coordinates fruit ripening and abscission, making gibberellin the correct hormone.

Final Answer: The hormone applied is Gibberellin.

Answer: (B)

Go Back to Question 37

Q38.

Solution

Concept:

Keystone species exert strong top-down regulatory control over community structure, maintaining species diversity by preventing dominant competitors from monopolizing resources.

Solution:

(a) Robert Paine conducted a classic ecological experiment by removing the predatory starfish Pisaster ochraceus from an intertidal ecosystem.

(b) In this community, several benthic invertebrate species, including various mussels and barnacles, compete intensely for a limited amount of physical attachment space on the rocks.

(c) The predatory starfish preys preferentially on the dominant competitor, the blue mussel, which keeps the mussel population in check and opens up space for other species.

(d) When the starfish predator was removed, the prey species no longer faced predation pressure, allowing the blue mussels to outcompete and exclude other invertebrates.

(e) This unchecked interspecific competition led to a rapid drop in biodiversity, causing the local extinction of more than ten benthic species and demonstrating the importance of keystone predators.

Final Answer: The primary cause was intensive interspecific competition among the prey species for space, unchecked by predation.

Answer: (B)

Go Back to Question 38

Q39.

Solution

Concept:

Animal biotechnology uses transgenesis to turn livestock into bioreactors that produce therapeutic human proteins or enhanced nutritional compounds in their milk.

Solution:

(a) In 1997, scientists successfully generated the first transgenic cow, named 'Rosie', by introducing a specific human gene construct into bovine embryos.

(b) This genetic modification was designed to express a valuable human whey protein, alpha-lactalbumin, specifically within the secretory epithelial cells of the mammary glands.

(c) Natural bovine milk contains lower levels of alpha-lactalbumin and higher levels of beta-lactoglobulin compared to human breast milk, making it harder for human infants to digest.

(d) Transgenic Rosie cow produced milk containing approximately 2.4 grams of recombinant human alpha-lactalbumin per liter, significantly improving its nutritional profile.

(e) This protein enrichment made the transgenic milk more balanced and highly suitable for human infants, marking a major milestone in molecular farming.

Final Answer: The milk contained a high concentration of human alpha-lactalbumin.

Answer: (A)

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Q40.

Solution

Concept:

Co-translational translocation routes nascent polypeptides containing hydrophobic signal sequences into the rough endoplasmic reticulum for processing and sorting.

Solution:

(a) Secretory proteins, lysosomal enzymes, and transmembrane proteins are synthesized by ribosomes bound to the membrane of the rough endoplasmic reticulum (RER).

(b) These proteins are initially translated with an N-terminal signal peptide that acts as an address tag, directing the ribosome-nascent chain complex to the RER membrane.

(c) As the polypeptide chain is threaded through a protein channel called the translocon into the RER lumen, it encounters an integral membrane enzyme known as signal peptidase.

(d) Signal peptidase cleaves the signal peptide from the growing polypeptide chain, a step that is required for the protein to fold correctly into its native shape.

(e) Inhibiting signal peptidase activity prevents this cleavage, trapping the protein in an immature state and disrupting its proper folding, trafficking, and secretion.

Final Answer: The drug will directly disrupt the translocation and proper processing of secretory and membrane-bound proteins.

Answer: (C)

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Answer Key

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