NIOS Class 12 Biology Sample Paper-3

Duration: 180 Minutes **Maximum Marks: 80**

Instructions

- This paper contains **43** Questions. The paper is divided into two sections: **Section A – 40** marks, **Section B – 40** marks.
- **Section A** consists of
  - **Q.No. 1 to 16** – Multiple Choice type questions (MCQs) carrying 1 mark each. Select and write the most appropriate option out of the four options given in each of these questions. An internal choice has been provided in some of these questions. You have to attempt only one of the given choices in such questions.
  - **Q. No. 17 to 28**– Objective-type questions. Q. No. 17 to 28 carry 02 marks each (with 2 sub- parts of 1 mark each). Attempt these questions as per the instructions given for each of the questions 17 –28.
- **Section B** consists of
  - **Q.No. 29 to 37** – Very Short questions carrying 02 marks each to be answered in the range of 30 to 50 words.
  - **Q.No. 38 to 41** – Short Answer type questions carrying 03 marks each to be answered in the range of 50 to 80 words.
  - **Q.No. 42 and 43** – Long Answer type questions carrying 05 marks each to be answered in the range of 80 to 120 words.
- There is **No Negative marking**.
- Use of mobile phones, smartwatches, calculators, or any electronic gadgets is strictly prohibited.

Section: A

Q1. A bacterial cell is kept in a medium containing an antibiotic that specifically blocks peptidoglycan synthesis. Which structure is most directly affected? **(1)**

(A) Nuclear membrane

(B) Cell wall

(C) Chloroplast

(D) Contractile vacuole

Q2. A mushroom body seen above soil is mainly the reproductive structure. The thread-like feeding body inside the soil is called: **(1)**

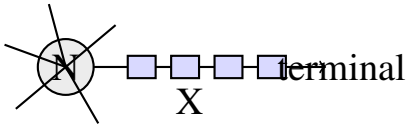
(A) Mycelium

(B) Prothallus

(C) Protonema

(D) Sporangium

Q3. The diagram shows a neuron. The part that usually carries nerve impulse away from the cell body is: **(1)**



(A) Dendrite

(B) Axon

(C) Nissl granule

(D) Synaptic vesicle

Q4. In a flowering plant, removal of the shoot tip is often followed by growth of lateral buds. This is because removal of the tip reduces: **(1)**

(A) Apical dominance by auxin

(B) Phototropism by gibberellin

(C) Root pressure by cytokinin

(D) Transpiration pull by ABA

Q5. During nitrogen metabolism in plants, nitrate is first reduced to nitrite mainly by the enzyme: **(1)**

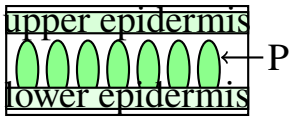
(A) Nitrogenase

(B) Nitrate reductase

(C) Rubisco

(D) Pepsim

Q6. A leaf cross-section is shown. The tissue marked P is rich in chloroplasts and is the chief site of photosynthesis. P is: **(1)**



(A) Cuticle

(B) Palisade mesophyll

(C) Xylem vessel

(D) Sieve tube

Q7. In aerobic respiration, the final electron acceptor in the electron transport chain is: **(1)**

(A) Carbon dioxide

(B) Oxygen

(C) NADH

(D) Glucose

Q8. The component of human blood that helps in clotting at an injury site is mainly: **(1)**

(A) Erythrocytes

(B) Platelets

(C) Plasma albumin

(D) Lymphocytes only

Q9. A homozygous tall pea plant is crossed with a dwarf pea plant. All F_1 plants are tall. This observation supports: **(1)**

(A) Blending inheritance

(B) Dominance of tall allele

(C) Codominance of dwarf allele

(D) Linkage only

Q10. In DNA, adenine pairs specifically with thymine because they form: **(1)**

(A) Two hydrogen bonds

(B) Three hydrogen bonds

(C) One peptide bond

(D) One phosphodiester bond

Q11. A simple Punnett square for a monohybrid cross $Tt \times Tt$ is shown. The expected phenotype ratio, if T is completely dominant, is: **(1)**

TT	Tt
Tt	tt

(A) 1 tall : 3 dwarf

(B) 2 tall : 2 dwarf

(C) 3 tall : 1 dwarf

(D) 1 tall : 1 dwarf

Q12. The immediate product of transcription in a protein-coding gene is: **(1)**

(A) mRNA

(B) Cellulose

(C) Amino acid

(D) Glycogen

Q13. A balanced diet deficient in vitamin C for a long period may lead to: **(1)**

(A) Rickets

(B) Scurvy

(C) Night blindness

(D) Beri-beri

Q14. In the ecological pyramid shown, which level usually contains the maximum total energy? **(1)**

(A) Top carnivores

(B) Carnivores

(C) Herbivores

(D) Producers

Q15. A vaccine primarily protects by stimulating the body to produce memory cells and: **(1)**

(A) Antibodies

(B) Bile salts

(C) Digestive enzymes

(D) Insulin only

Q16. In recombinant DNA technology, the enzyme used to cut DNA at specific recognition sequences is: **(1)**

(A) DNA ligase

(B) Restriction endonuclease

(C) Amylase

(D) Cellulase

Note: Q. No. 17 to 28 are the objective type questions of 2 marks each.

Q17. Read the passage given below and answer the following questions:
A pond ecosystem contains phytoplankton, small fish, large fish, decomposer bacteria and aquatic plants. Sunlight is trapped by producers. Energy is then transferred through feeding relationships, but only a small fraction is passed to the next trophic level. Decomposers return mineral nutrients to the water and soil.

1. Name the producers mentioned in the passage.
2. Why is less energy available at higher trophic levels?

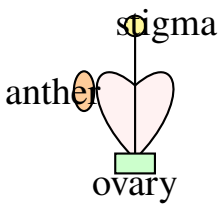
(2)

Q18. Complete the following by using the options given below:
(xylem, phloem, insulin, adrenaline, chlorophyll)

1. Food prepared in leaves is transported mainly through .....
2. The green pigment essential for trapping light energy is .....

(2)

Q19. Read the passage and answer the questions that follow it.
A bisexual flower has anthers and stigma. Pollen grains reach the stigma during pollination. After germination, a pollen tube grows through the style and carries male gametes to the ovule for fertilization.



1. What is pollination?
2. Name the structure that carries male gametes to the ovule.

(2)

Q20. Fill in the blanks:

1. The enzyme nitrogenase is associated with biological . . . . . fixation.
2. The oxygen released during photosynthesis comes from splitting of . . . . . .

(2)

Q21. Match the items in Column I with the most appropriate items in Column II:

Column I	**Column II**
(a) Parenchyma	(i) Conducts water in plants
(b) Xylem	(ii) Living storage tissue
(c) Epithelial tissue	(iii) Covers body surfaces and organs
(d) Muscle tissue	(iv) Shows contraction and movement

(2)

Q22. Fill in the blanks:

1. The physical and functional unit of heredity is called a . . . . . .
2. The codon AUG usually codes for . . . . . and acts as a start codon.

(2)

Q23. Write TRUE (T) for the correct statement and FALSE (F) for the incorrect statement:

1. Vaccination can produce immunological memory.
2. Antibiotics are effective against viral infections such as measles.

(2)

Q24. Match the items in Column I with the most appropriate items in Column II:

Column I	Column II
(a) Pituitary	(i) Thyroxine
(b) Thyroid	(ii) Master endocrine gland
(c) Pancreas	(iii) Adrenaline
(d) Adrenal medulla	(iv) Insulin

(2)

Q25. Fill in the blanks:

1. The place where an organism lives is called its .....
2. Deficiency of iodine in diet may cause .....

(2)

Q26. Match the items in Column I with the most appropriate items in Column II:

Column I	Column II
(a) Restriction enzyme	(i) Joins DNA fragments
(b) DNA ligase	(ii) Cuts DNA at specific sites
(c) Plasmid	(iii) Small circular bacterial DNA vector
(d) Bt cotton	(iv) Genetically modified insect-resistant crop

(2)

Q27. Write TRUE (T) for the correct statement and FALSE (F) for the incorrect statement:

1. Cyanobacteria are prokaryotic organisms.
2. Fungi prepare their own food by photosynthesis.

(2)

Q28. Match the items in Column I with the most appropriate items in Column II:

Column I	Column II
(a) Auxin	(i) Closing of stomata under water stress
(b) Gibberellin	(ii) Cell elongation and apical dominance
(c) Abscisic acid	(iii) Stem elongation and seed germination
(d) Cytokinin	(iv) Cell division

(2)

Section: B

Q29. Define binomial nomenclature. Write one advantage of using scientific names in biology. **(2)**

Q30. Differentiate between tap root and fibrous root on the basis of origin and one example of each. **(2)**

Q31. (i) State Mendel's law of segregation with one example.

OR

(ii) Give two characteristic features of fungi and mention one useful fungus.

(2)

Q32. (i) Write the overall equation of photosynthesis and mention the role of chlorophyll.

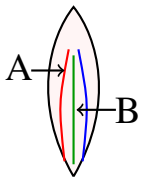
OR

(ii) What is anaerobic respiration? Give one example in living organisms.

(2)

Q33. In a monohybrid cross between two heterozygous tall pea plants, 160 offspring are produced. If tallness is dominant over dwarfness, calculate the expected number of tall and dwarf plants. **(2)**

Q34. The diagram shows a human digestive villus. Identify parts A and B and state one function of villi. **(2)**



Q35. (i) Mention two temporary methods of contraception.

OR

(ii) What are antibodies? Name the cells that produce them.

(2)

Q36. Explain the 10 percent law of energy transfer in an ecosystem using a simple food chain. **(2)**

Q37. Write two differences between arteries and veins. **(2)**

Q38. Define the following terms with one example each:

A. Population

B. Vaccine

C. Recombinant DNA

(3)

Q39. (i) Explain the feedback control of blood glucose by insulin and glucagon.

OR

(ii) Describe any three steps of nitrogen cycle involving microorganisms.

(3)

Q40. Explain the basic steps used to produce a genetically modified bacterium carrying a human gene. Draw a simple flow diagram. **(3)**

Q41. (i) A red-flowered plant with genotype Rr is self-pollinated, where R is dominant over r. Show the genotype and phenotype ratio of progeny.

OR

(ii) Describe the main events of menstrual cycle in brief and mention the role of hormones.

(3)

Q42. (i) (a) Describe the light reaction and dark reaction of photosynthesis.

(b) Explain how root nodules help in nitrogen fixation.

OR

(ii) (a) Explain semi-conservative replication of DNA with a labelled sketch.

(b) What is the genetic code? Mention two features of it.

(5)

Q43. (i) (a) Describe double circulation in humans with reference to pulmonary and systemic circulation.

(b) Explain why balanced diet is necessary for adolescents.

OR

(ii) (a) Explain the structure of a food chain and food web with examples.

(b) Mention three practices that help maintain personal and community health.

(5)

Detailed Solutions

Q1.

Solution

Concept: Microscopic structural biochemistry separates biological domains based on their specific cell wall compositions. Members of the domain Bacteria are categorized as unicellular prokaryotes lacking membrane-bound organelles. A defining feature of most bacterial cells is an external protective cell wall composed of a unique polymeric mesh known as peptidoglycan or murein, which contains repeating disaccharide units cross-linked by short amino acid chains. This structure maintains cell shape and prevents osmotic lysis, differing from plant cell walls containing cellulose or fungal cell walls containing chitin.

Solution: Step 1: The biochemical mode of action for this specific therapeutic antibiotic agent is the targeted disruption of late-stage peptidoglycan biosynthesis during cellular replication.
Step 2: Peptidoglycan serves as the primary structural polymer within the multi-layered envelope framework of the bacterial cell wall, providing structural integrity.
Step 3: Because prokaryotic cells lack a nuclear membrane and internal chloroplasts, and do not rely on contractile vacuoles for managing internal osmotic balance, these structures are completely unaffected by the antibiotic. Therefore, the direct cellular target of this drug must be the structural envelope surrounding the cytoplasm.
Final Answer: Cell wall.

Answer: (B)

Go Back to Question 1

Q2.

Solution

Concept: The kingdom Fungi contains heterotrophic eukaryotic organisms characterized by a specialized vegetative growth structure optimized for absorptive nutrition. The vegetative body of a filamentous fungus consists of a vast, spreading network of microscopic, elongated, thread-like cellular filaments termed hyphae. This highly branched collection of interconnected hyphal tubes forms a collective network known as the mycelium. While the macroscopic fruiting body, or mushroom, is transient and specialized for spore dispersal, the subterranean vegetative network handles active metabolic feeding.

Solution: Step 1: The true vegetative feeding body of a filamentous fungus expands and branches through its nutritional substratum, maximizing its functional surface area.
Step 2: This extensive underground structural network releases extracellular hydrolytic enzymes into the surrounding environment to break down complex organic polymers, then absorbs the liberated nutrients through its semipermeable walls.
Step 3: In mycology, this specific network of absorptive filaments is called the mycelium. It is structurally distinct from the haploid prothallus seen in pteridophytes or the filamentous protonema stage that appears during early moss development.
Final Answer: Mycelium.

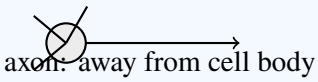
Answer: (A)

Go Back to Question 2

Q3.

Solution

Concept: A highly differentiated neuron is the foundational functional unit of the nervous system, structurally adapted for the rapid propagation of electro-chemical signals. The standard anatomy of a multipolar neuron includes an expansive somatic cell body, multiple short branching dendrites that receive incoming inputs, and a single elongated projection called the axon. Dendrites gather local signals from adjacent synapses and carry them inward, whereas the singular axon is specialized for conducting action potentials away from the soma toward target tissues.



Solution: Step 1: Structural analysis of the provided neurological diagram shows that the long, uniform cytoplasmic fiber labeled X emerges from the central somatic cell body.
Step 2: The directional arrow running parallel to this elongated fiber indicates that the electro-chemical action potential is conducted outward, away from the soma.
Step 3: In neuroanatomy, the specific cellular projection dedicated to carrying action potentials away from the cell body toward terminal synaptic regions is defined as the axon.
Final Answer: Axon.

Answer: (B)

Go Back to Question 3

Q4.

Solution

Concept: Plant developmental architecture is regulated by hormone gradients that manage localized tissue growth. The primary phytohormone indole-3-acetic acid, or auxin, is synthesized at high levels within the actively dividing cells of the terminal shoot apex. This apical pool of auxin moves downward through polar transport, directly suppressing the development of lateral axillary buds situated further down the stem. This physiological phenomenon is known as apical dominance and prioritizes upward vertical growth over lateral branching.

Solution: Step 1: The growing terminal shoot tip functions as the dominant center for auxin synthesis, maintaining high local hormone concentrations along the primary stem axis.
Step 2: Surgically removing or damaging this terminal apical bud eliminates the main source of auxin, dropping hormone levels near the lower, inactive axillary buds.
Step 3: Relieved from this hormone-mediated suppression, the lateral axillary buds exit dormancy and begin active cell division. They expand into side branches, transforming the plant's overall shape from vertical to bushy. This proves that apical dominance was actively repressing them.
Final Answer: Apical dominance by auxin.

Answer: (A)

Go Back to Question 4

Q5.

Solution

Concept: Higher plants incorporate inorganic environmental nitrogen by converting oxidized soil ions into organic molecules like amino acids. This multi-step assimilatory pathway begins by absorbing nitrate from the soil and converting it into more reactive nitrogen species through sequential reduction steps. The first step involves converting nitrate into nitrite within the cell cytoplasm, a process driven by a specialized metalloenzyme. This enzyme is distinct from nitrogenase, which breaks down atmospheric nitrogen gas in prokaryotes.

Solution: Step 1: The metabolic reaction requires converting oxidized nitrate ions (NO_3^-) into reduced nitrite ions (NO_2^-) within the plant tissue.
Step 2: This chemical transformation involves a two-electron reduction step, which forms the entry point for nitrogen assimilation in autotrophic plants.
Step 3: The specific enzyme that catalyzes this step is nitrate reductase, a highly regulated homodimeric protein. It should not be confused with nitrogenase, which is restricted to nitrogen-fixing bacteria, or nitrite reductase, which performs the next reduction step down to ammonium.
Final Answer: Nitrate reductase.

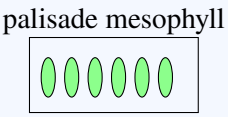
Answer: (B)

Go Back to Question 5

Q6.

Solution

Concept: The structural layout of a typical bifacial dicot leaves is optimized to maximize light capture for photosynthesis. Located directly beneath the protective upper epidermis is the mesophyll layer, which is divided into two distinct regions. The upper region contains the palisade mesophyll, made of tightly packed, elongated column-shaped parenchymal cells. These cells are rich in chloroplasts and positioned vertically to capture maximum sunlight, making this layer the primary site for carbon fixation.



Solution: Step 1: The structural marker labeled P identifies a row of vertically elongated cells located directly underneath the non-photosynthetic upper epidermis.
Step 2: These cells are packed tightly together and contain a high density of light-absorbing chloroplasts, making them ideal for harvesting photons from sunlight.
Step 3: Based on this anatomical layout, layer P is identified as the palisade mesophyll. It is easily distinguished from the lower, loosely arranged spongy mesophyll layer, which is adapted for gas exchange.
Final Answer: Palisade mesophyll.

Answer: (B)

Go Back to Question 6

Q7.

Solution

Concept: Aerobic cellular respiration breaks down organic molecules and stores their energy as ATP through a process linked to electron transport. High-energy electrons extracted during glycolysis and the citric acid cycle are carried by cofactor molecules like NADH and $FADH_2$ to the inner mitochondrial membrane. These electrons move through a series of membrane-bound protein complexes, losing energy along the way to pump protons. To maintain this flow, a final electron acceptor must clear electrons from the end of the chain.

Solution: Step 1: The mitochondrial electron transport chain requires a final chemical acceptor with high electronegativity to pull electrons through the terminal complex.
Step 2: In aerobic organisms, molecular oxygen (O_2) acts as this terminal electron acceptor. It binds electrons and free protons to form metabolic water (H_2O).
Step 3: While carbon dioxide (CO_2) is produced during prior decarboxylation steps in the matrix, it cannot accept electrons. Without oxygen to clear the pathway, electron transport stops, halting oxidative phosphorylation.
Final Answer: Oxygen.

Answer: (B)

Go Back to Question 7

Q8.

Solution

Concept: Mammalian blood contains specialized cellular elements that maintain vascular integrity and stop bleeding after an injury. Blood platelets, or thrombocytes, are small, disc-shaped cell fragments produced from large megakaryocytes in the bone marrow. When a blood vessel wall is damaged, platelets adhere to the exposed subendothelial matrix. They trigger coagulation by releasing biochemical factors that activate a cascade of proteins, forming a stable fibrin clot.

Solution: Step 1: When a blood vessel is injured, the body must quickly seal the breach to minimize blood loss and maintain blood pressure.
Step 2: Platelets quickly home in on the injury site, adhering to the broken surface and clumping together to form a temporary primary platelet plug.
Step 3: These activated platelets then release clotting factors that accelerate the coagulation cascade. This converts soluble fibrinogen into insoluble strands of fibrin, creating a mesh that traps red blood cells and forms a secure clot.
Final Answer: Platelets.

Answer: (B)

Go Back to Question 8

Q9.

Solution

Concept: Classical Mendelian genetics demonstrates how inheritance works through contrasting allele pairs that determine traits. Under complete dominance, one allele in a heterozygous pair completely masks the expression of the other. The allele that dictates the organism's visible trait is dominant, while the masked allele is recessive. This means a heterozygote carrying both alleles will look identical to an organism that is homozygous for the dominant trait.

Solution: Step 1: Crossing a homozygous tall plant (TT) with a homozygous dwarf plant (tt) produces an F_1 generation where every offspring inherits a heterozygous genotype (Tt).
Step 2: Phenotypic analysis shows that all of these heterozygous F_1 offspring grow tall, with no intermediate or dwarf versions appearing in the group.
Step 3: Because the tall trait is fully expressed in the heterozygote while the dwarf trait is completely hidden, the allele for tallness is dominant. This cross demonstrates Mendelian dominance over the recessive dwarf allele.
Final Answer: Dominance of tall allele.

Answer: (B)

Go Back to Question 9

Q10.

Solution

Concept: The structural integrity of the DNA double helix relies on precise complementary base pairing across its strands. According to Chargaff's rules and the Watson-Crick model, purine bases pair exclusively with pyrimidine bases via localized hydrogen bonds. This specific pairing keeps the helix width uniform. Adenine pairs with thymine, while guanine pairs with cytosine. The stability of these pairs depends on how many hydrogen bonds form between the bases.

Solution: Step 1: This question focuses on the specific chemical interaction that connects adenine (A) to thymine (T) across the two strands of a DNA molecule.
Step 2: Based on their molecular structures, the partial charges on adenine and thymine line up to form exactly two hydrogen bonds between them.
Step 3: In contrast, guanine and cytosine form three hydrogen bonds. These weak hydrogen bonds hold the strands together securely but allow them to separate for replication, unlike the strong covalent phosphodiester bonds that form the DNA backbone.
Final Answer: Two hydrogen bonds.

Answer: (A)

Go Back to Question 10

Q11.

Solution

Concept: In classical Mendelian genetics, a monohybrid cross tracks the inheritance pattern of a single gene locus with two contrasting alleles. When two heterozygous parent organisms (Tt) expressing a completely dominant phenotype are self-crossed, their alleles segregate independently during gamete formation. The random fusion of these haploid gametes is standardly evaluated using a Punnett square. This mathematical grid shows that the resulting offspring cohort will display a predictable genotypic ratio of 1 TT : 2 Tt : 1 tt and a distinct phenotypic ratio of 3 dominant individuals to 1 recessive individual.

Solution: Step 1: Constructing a two-by-two Punnett square for the cross Tt × Tt shows that out of four possible combinations, exactly three boxes receive at least one dominant allele (T). These boxes contain the genotypes TT and Tt.
Step 2: The remaining fourth box receives a recessive allele from both parents, resulting in the homozygous recessive genotype tt.
Step 3: Because the T allele shows complete dominance over the recessive t allele, both the TT and Tt variations express the tall trait. Only the tt variation grows into a dwarf plant, which establishes a clear physical distribution of three tall plants for every one dwarf plant.
Final Answer: 3 tall : 1 dwarf.

Answer: (C)
Go Back to Question 11

Q12.

Solution

Concept: The central dogma of molecular biology outlines the precise directional flow of genetic information inside a living cell, tracking its path from storage to expression. The first major phase of this expression mechanism is transcription, a highly regulated enzymatic process where a specific segment of genomic deoxyribonucleic acid (DNA) is copied into a complementary strand of ribonucleic acid (RNA). For structural genes that contain codes for building functional proteins, this single-stranded RNA transcript undergoes specialized processing to serve as a mobile copy of the genetic blueprint.

Solution: Step 1: During transcription, RNA polymerase binds to a gene's promoter region and opens the double helix, using one strand of the genomic DNA as a temporary template.
Step 2: RNA polymerase then reads this DNA template strand and connects complementary ribonucleotide monomers together, assembling a new single-stranded RNA molecule.
Step 3: For protein-coding sequences, this newly synthesized strand carries the essential genetic message from the protected cell nucleus out into the cytoplasm. It travels directly to the ribosomes to guide protein synthesis, functioning explicitly as messenger RNA or mRNA.
Final Answer: mRNA.

Answer: (A)
Go Back to Question 12

Q13.

Solution

Concept: Nutritional biochemistry classifies vitamins as essential organic micronutrients that an organism must obtain in small amounts from its diet to support vital metabolic processes. These molecules function mainly as key coenzymes or structural cofactors across diverse biochemical pathways. A chronic dietary deficiency in any specific vitamin disrupts these internal systems, triggering distinct deficiency diseases. For instance, water-soluble Vitamin C, or ascorbic acid, is an essential cofactor for the enzymatic hydroxylation of collagen fibers, a structural protein that supports connective tissues throughout the body.

Solution: Step 1: Evaluating common nutritional diseases shows that a chronic deficiency in fat-soluble Vitamin A causes night blindness, while an extreme deficiency in Vitamin D disrupts calcium absorption and causes rickets.
Step 2: Looking at water-soluble options, a severe shortage of Vitamin B_1 (thiamine) disrupts glucose metabolism and leads to the neurological disorder known as beri-beri.
Step 3: In contrast, a lack of Vitamin C prevents the proper cross-linking of collagen fibers. This weakens capillary walls and connective tissues, triggering the classic symptoms of scurvy, which include bleeding gums and poor wound healing.
Final Answer: Scurvy.

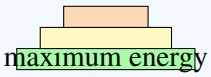
Answer: (B)

Go Back to Question 13

Q14.

Solution

Concept: Ecosystem dynamics are governed by fundamental thermodynamic principles that dictate how energy flows through living communities. Unlike chemical nutrients, which cycle continuously through an environment, the flow of energy across successive trophic levels is strictly unidirectional. According to Lindeman's ten percent rule, only a small fraction of net energy is successfully transferred up to the next feeding level; the vast majority is lost as metabolic heat or remains unconsumed. Consequently, a graphical pyramid of energy always tapers upward, featuring its broadest foundation at the base.



Solution: Step 1: Primary producers, such as green plants and algae, occupy the lowest trophic level. They use photosynthesis to capture raw solar energy and convert it into stable chemical energy.

Step 2: Because primary consumers and higher predators lose significant amounts of energy to respiration and heat at each step, they only inherit a small fraction of the energy captured before them.

Step 3: Because energy continuously diminishes as it moves up the food web, the lowest level must hold the largest total energy reserve. This confirms that primary producers contain the maximum amount of energy in an ecosystem.

Final Answer: Producers.

Answer: (D)

Go Back to Question 14

Q15.

Solution

Concept: Immunology utilizes specialized medical interventions to trigger protective immune responses without causing actual disease. Vaccination involves introducing a harmless preparation into an organism, such as inactivated pathogens, weakened live strains, or isolated microbial surface proteins. These components act as safe antigens that expose the host's immune system to the pathogen's structural markers. This exposure triggers clonal expansion among matching B-lymphocytes, establishing lasting immunity against future infections.

Solution: Step 1: When a vaccine enters the body, specialized antigen-presenting cells detect the foreign structural markers and present them to matching helper cells.
Step 2: This interaction activates specific B-lymphocytes, causing them to multiply and differentiate into active plasma cells. These specialized plasma cells then manufacture and release highly targeted protective proteins called antibodies.
Step 3: Along with these active cells, the process generates long-lived memory lymphocytes. If the real pathogen invades later, these memory cells recognize it instantly and launch a faster, stronger defense to neutralize the threat.
Final Answer: Antibodies.

Answer: (A)
Go Back to Question 15

Q16.

Solution

Concept: Modern recombinant DNA technology relies on a specialized molecular toolkit to alter and engineer genetic sequences. Creating functional recombinant vectors requires precise biochemical tools that can cut and join DNA fragments from different sources. Genetic engineering uses two primary groups of enzymes to perform these operations: molecular scissors that slice through DNA strands, and molecular glues that weld them back together by reforming broken phosphodiester bonds.

Solution: Step 1: Creating a viable recombinant DNA molecule requires cutting open a host plasmid vector and isolating a target gene of interest from an external donor source.
Step 2: While the structural joining of these loose DNA fragments is performed by the enzyme DNA ligase, a different type of specialized enzyme is required to make the initial precise cuts.
Step 3: These precise molecular cuts are made by restriction endonucleases. These specialized bacterial enzymes scan DNA strands to find specific nucleotide sequences, then cleanly slice through the sugar-phosphate backbone at those exact locations.
Final Answer: Restriction endonuclease.

Answer: (B)
Go Back to Question 16

Q17.

Solution

Concept: Trophic ecology analyzes how biomass and chemical energy move through communities, mapping the feeding relationships between different organisms. Every ecosystem relies on primary autotrophs to introduce usable energy into the food web by using chlorophyll to capture raw sunlight. As this stored energy moves up through successive consumer levels, much of it is lost due to metabolic activities like cellular respiration, physical movement, tissue growth, and standard heat loss.

Solution: Step 1: According to the provided passage, microscopic phytoplankton and larger aquatic plants function as the primary autotrophs in this environment, using photosynthesis to convert solar energy into organic biomass.
Step 2: The transfer of energy between feeding levels is highly inefficient because organisms consume most of their stored energy to power daily survival processes like respiration, movement, and growth.
Step 3: Because a massive amount of energy is lost as metabolic heat at each step, the total energy available drops sharply as you move up the food chain. This leaves top predators with only a fraction of the energy originally captured by the producers.
Final Answer: Producers: phytoplankton and aquatic plants; energy decreases due to metabolic loss and heat loss.

Answer: (See above)
Go Back to Question 17

Q18.

Solution

Concept: Plant anatomy uses specialized vascular tissues and biochemical pigments to manage food production and internal nutrient transport. Photosynthesis relies on specialized light-absorbing pigments inside chloroplasts to capture incoming solar energy. Once these green leaf tissues synthesize simple sugars, the plant uses an interconnected network of living vascular cells to distribute these nutrients, ensuring that non-photosynthetic structures like roots and stems receive adequate food.

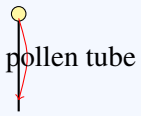
Solution: Step 1: The long-distance transport of manufactured organic nutrients, such as sucrose, from source leaves to sink tissues is called translocation. This process occurs through the living sieve-tube elements of the phloem tissue.
Step 2: In contrast, the initial absorption of light energy inside a leaf is managed by chlorophyll, a specialized pigment that absorbs red and blue light wavelengths while reflecting green light.
Step 3: These two systems work together to sustain the plant: chlorophyll captures solar energy to manufacture sugars, and the phloem network distributes those sugars to power growth and metabolism throughout the entire plant.
Final Answer: phloem; chlorophyll.

Answer: (See above)
Go Back to Question 18

Q19.

Solution

Concept: The reproductive cycle of angiosperms relies on sequential events to achieve successful fertilization inside a flower. Before fertilization can occur, pollen grains must be transferred from the pollen-producing anther to the receptive surface of the stigma. Once a matching pollen grain lands on this sticky surface, it absorbs moisture and germinates, growing a specialized tubular structure down through the style to safely deliver male gametes into the ovary.



Solution: Step 1: The physical transfer of pollen grains from the male anther to the female stigma is called pollination, which can happen via wind, water, or animal pollinators.
Step 2: After landing on a compatible stigma, the pollen grain germinates and grows a long cellular extension called a pollen tube, which tunnels downward through the style toward the ovary.
Step 3: This specialized pollen tube functions as a protected pathway, carrying the non-motile male gametes down to the ovule to complete fertilization.
Final Answer: Pollination is transfer of pollen to stigma; pollen tube carries male gametes.

Answer: (See above)

Go Back to Question 19

Q20.

Solution

Concept: Plant physiology and biochemical engineering rely on specialized metabolic pathways to manage energy production and nutrient absorption. Biological nitrogen fixation converts inert atmospheric nitrogen gas (N_2) into bio-available compounds like ammonia (NH_3), a conversion driven by the enzyme nitrogenase in symbiotic bacteria. In a separate process, the light-dependent reactions of photosynthesis use solar energy to split water molecules inside chloroplasts, providing the electrons needed to power carbon fixation.

Solution: Step 1: Biological nitrogen fixation breaks down strong triple bonds in atmospheric nitrogen gas using the nitrogenase enzyme complex, converting it into usable nutrients for plants.
Step 2: In a completely separate pathway, the light-dependent reactions of photosynthesis use absorbed light energy to drive the photolysis of water molecules inside the thylakoid membranes.
Step 3: Splitting water molecules generates free protons and electrons to power ATP synthesis, while releasing molecular oxygen (O_2) as a metabolic byproduct. This shows how both systems rely on specific chemical conversions to sustain plant growth.
Final Answer: nitrogen; water.

Answer: (See above)

Go Back to Question 20

Q21.

Solution

Concept: Histology addresses how specialized groups of organized cells manage different bodily functions. Matching complex tissue terms requires linking cellular structures to their functional roles. In multicellular organisms, different specialized tissues take on distinct structural and physiological responsibilities. These specialized systems handle tasks like metabolic storage, structural protection, external mechanical movement, and the active conduction of nutrients or vital fluids throughout the biological framework.

Solution: Step 1: Parenchyma cells are simple, unspecialized vegetative structures with thin cell walls that remain alive at functional maturity. They serve primarily as the main storage tissue for organic nutrients and starches.
Step 2: Xylem is a complex vascular tissue that acts as a primary internal transport conduit, utilizing hollow tracheary elements to move water and dissolved inorganic ions upward from roots.
Step 3: Epithelial tissue forms thin, tightly packed sheets that line internal organs and cover external body surfaces for protection. Muscle tissue is made of specialized contractile protein filaments that shorten to generate mechanical force and movement.
Final Answer: (a)-(ii), (b)-(i), (c)-(iii), (d)-(iv).

Answer: (See above)

Go Back to Question 21

Q22.

Solution

Concept: Molecular genetics maps out how information stored in DNA sequence variations is converted into functional cellular structures. A gene is the fundamental physical and functional unit of heredity, consisting of a specific sequence of nucleotides that carries instructions to build a specific protein. During translation, the cell reads these genetic instructions in triplets of nucleotides called codons. Each codon specifies a single amino acid, and the standard codon sequence AUG serves as the universal start signal to initiate protein synthesis.

Solution: Step 1: The specific physical unit of genetic material that carries an inherited trait across generations is defined as a gene, which occupies a fixed position on a chromosome.
Step 2: During translation at the ribosome, the specialized triplet nucleotide sequence AUG serves as the mandatory start codon that establishes the reading frame for protein synthesis.
Step 3: Beyond functioning as the initiation signal, this specific codon brings the initial amino acid into the growing polypeptide chain, coding exclusively for methionine.
Final Answer: gene; methionine.

Answer: (See above)

Go Back to Question 22

Q23.

Solution

Concept: Medical immunology and clinical pharmacology use completely different methods to treat pathogenic infections. Vaccines establish immunity by exposing the host to harmless antigens, which triggers the production of long-lived memory lymphocytes that remain in the body to fight future infections. In contrast, standard antibiotics are selective chemical agents that disrupt metabolic pathways unique to prokaryotes. Because viruses lack their own cell wall structures and metabolic machinery, antibiotics are completely ineffective against viral diseases.

Solution: Step 1: The initial statement is true. Vaccination exposes the immune system to safe antigens, producing memory cells that remain in circulation for years to mount a rapid defense upon re-exposure.
Step 2: The second statement is false. Antibiotics specifically target bacterial components like peptidoglycan cell walls or 70S ribosomes. They have no effect on viral pathogens like the measles virus.
Step 3: Viral diseases require targeted prevention through vaccines or treatment with specific antiviral drugs that disrupt viral replication inside host cells, rather than standard antibiotics.
Final Answer: T; F.

Answer: (See above)
Go Back to Question 23

Q24.

Solution

Concept: The endocrine system regulates systemic physiology by secreting biochemical messengers directly into the bloodstream. These ductless endocrine glands form an integrated network where specialized organs monitor and adjust metabolic states. The master gland manages subordinate tissues by secreting trophic hormones, while peripheral glands release specific hormones like thyroxine to regulate metabolism, insulin to manage blood glucose levels, and adrenaline to trigger immediate acute stress responses.

Solution: Step 1: The pituitary gland acts as the master regulator of the endocrine system, releasing trophic hormones that control the secretion pathways of other peripheral glands.
Step 2: The thyroid gland uses dietary iodine to synthesize and release thyroxine, which regulates basal metabolic rates and cellular energy consumption throughout the body.
Step 3: The pancreas contains endocrine islet cells that secrete insulin to reduce blood glucose levels, while the adrenal medulla releases adrenaline into the bloodstream to trigger immediate fight-or-flight responses.
Final Answer: (a)-(ii), (b)-(i), (c)-(iv), (d)-(iii).

Answer: (See above)
Go Back to Question 24

Q25.

Solution

Concept: Organismal ecology and metabolic biochemistry evaluate how environmental resources influence an animal's physical health. An organism's habitat is the natural physical environment where it normally lives, finds resources, and reproduces. Within these habitats, specific nutritional elements are required to maintain normal body function. For example, terrestrial vertebrates need regular dietary intake of the trace element iodine to synthesize thyroid hormones, and a shortage of this nutrient disrupts hormone production.

Solution: Step 1: The specific geographical area and ecological zone where a particular species naturally lives and interacts with its environment is defined as its habitat.
Step 2: Nutritional studies show that a chronic lack of iodine in an organism's diet directly impairs the thyroid gland's ability to manufacture the metabolic hormone thyroxine.
Step 3: This drop in hormone levels causes the anterior pituitary gland to release excess thyroid-stimulating hormone. This over-stimulation forces the thyroid gland to enlarge, resulting in the clinical condition known as goitre.
Final Answer: habitat; goitre.

Answer: (See above)

Go Back to Question 25

Q26.

Solution

Concept: Biotechnology utilizes molecular tools to alter the genetic material of living organisms for agricultural and clinical applications. Creating recombinant DNA requires specific enzymes to manipulate DNA sequences with high precision. This molecular toolkit includes specialized enzymes to cut DNA backbones, joining enzymes to seal fragments together, and small vectors to transport genes. These tools are used to develop transgenic crops that carry beneficial traits, such as built-in resistance to insect pests.

Solution: Step 1: Molecular cloning requires restriction endonucleases to scan DNA strands for specific recognition sequences and cleanly cut the sugar-phosphate backbone at precise locations.
Step 2: The enzyme DNA ligase acts as a molecular glue, forming covalent phosphodiester bonds to securely join loose DNA fragments together into a continuous strand.
Step 3: Small circular plasmids serve as cloning vectors to deliver foreign genes into host cells. In agriculture, this method is used to insert bacterial genes into crops like Bt cotton, making them resistant to insect pests.
Final Answer: (a)-(ii), (b)-(i), (c)-(iii), (d)-(iv).

Answer: (See above)

Go Back to Question 26

Q27.

Solution

Concept: Evolutionary taxonomy organizes life into distinct kingdoms based on cellular structure and metabolic strategies. The kingdom Monera consists of single-celled prokaryotes that lack a membrane-bound nucleus and internal organelles. Cyanobacteria belong to this prokaryotic group and use chlorophyll to perform oxygenic photosynthesis. In contrast, the kingdom Fungi contains eukaryotic organisms that lack chlorophyll entirely. Fungi cannot produce their own food and must survive as heterotrophs, absorbing nutrients directly from organic substrates.

Solution: Step 1: The first statement is true. Cyanobacteria are prokaryotes belonging to the kingdom Monera, meaning their genetic material is organized in a nucleoid region without a protective nuclear envelope.
Step 2: The second statement is false. Fungi are strictly heterotrophic organisms that lack photosynthetic pigments like chlorophyll. They cannot manufacture their own organic food from sunlight.
Step 3: Instead, fungi grow thread-like hyphae into their surroundings and release digestive enzymes to break down organic matter externally, absorbing the simple nutrients through their cell walls.
Final Answer: T; F.

Answer: (See above)
Go Back to Question 27

Q28.

Solution

Concept: Plant physiology is regulated by phytohormones, which are chemical messengers that coordinate growth, tissue development, and stress responses. These organic compounds are produced in small amounts and work through complex signaling pathways. Some plant hormones stimulate growth by promoting cell division or stretching cell walls, while others act as inhibitors that help the plant survive stress by closing stomata or inducing dormancy.

Solution: Step 1: Auxins are synthesized in growing shoot tips and promote cell elongation, driving the vertical growth pattern known as apical dominance.
Step 2: Gibberellins promote stem elongation by causing internodes to stretch, and they also break seed dormancy to trigger germination.
Step 3: Abscisic acid or ABA acts as a stress hormone, closing stomata during droughts to prevent water loss. Cytokinins work alongside auxins to promote cell division in growing tissues.
Final Answer: (a)-(ii), (b)-(iii), (c)-(i), (d)-(iv).

Answer: (See above)
Go Back to Question 28

Q29.

Solution

Concept: Systematic taxonomy uses binomial nomenclature to organize the vast diversity of life on Earth. Developed by Carl Linnaeus, this naming system assigns every living organism a unique, standardized two-word scientific name derived from Latin roots. This system replaces ambiguous, localized common names with a universal classification standard, ensuring that scientists worldwide can identify the exact same species without confusion.

Solution: Step 1: Binomial nomenclature requires that an organism's scientific name consists of two parts: the genus name, which is capitalized, followed by the species identifier, which remains lowercase.
Step 2: This format is always italicized in print or underlined when handwritten. For example, the scientific name for the common mango tree is written as *Mangifera indica*.
Step 3: This two-part naming standard provides a universal system for scientific communication. It avoids the confusion caused by regional common names, ensuring each organism has a single, globally recognized name.
Final Answer: Two-word scientific naming system; it gives universal and precise names.

Answer: (See above)
Go Back to Question 29

Q30.

Solution

Concept: Plant morphology classifies root systems into categories based on their embryonic origin, structural branching, and growth patterns. Dicots typically develop a taproot system, which grows directly from the embryonic radicle. This system features a dominant central root that grows deep into the soil and produces smaller lateral branches. In contrast, monocots develop a fibrous root system where the short-lived primary root is replaced by a dense cluster of thin, similar-sized roots that grow from the base of the stem.

Solution: Step 1: A taproot system develops directly from the embryonic radicle, producing a single, thick primary root that grows deep vertically and sprouts smaller secondary branches, as seen in mustard plants.
Step 2: A fibrous root system forms when the primary embryonic root stops growing early and is replaced by a cluster of thin, adventitious roots that spread out shallowly from the base of the stem, as seen in wheat.
Step 3: These two layouts suit different ecological needs: deep taproots anchor tall plants and reach deep water tables, while shallow fibrous roots form a dense mat that quickly absorbs surface moisture and prevents soil erosion.
Final Answer: Tap root: radicle-derived main root, mustard; fibrous root: cluster of adventitious roots, wheat.

Answer: (See above)
Go Back to Question 30

Q31.

Solution

Concept: Principles of classical genetics and fungal biology highlight the distinct inheritance mechanisms of eukaryotes and the diverse life strategies of non-photosynthetic organisms. Gregor Mendel's fundamental law of segregation states that allele pairs separate during gamete production, ensuring each gamete carries only one allele for each gene. In fungal biology, organisms are classified as non-green, heterotrophic eukaryotes that possess chitinous cell walls and replicate via spore production, playing a vital role in natural decomposition and modern industrial biotechnology.

Solution: Alternative (i): Step 1: Mendel's first law, the law of segregation, dictates that allele pairs for a specific trait separate dynamically during the process of meiotic gamete formation.
Step 2: In a heterozygous parent organism with the genotype Tt, the homologous chromosomes split, causing individual gametes to receive either the dominant allele T or the recessive allele t, but never both.
Alternative (ii): Step 1: Members of the kingdom Fungi lack photosynthetic pigments like chlorophyll, meaning they cannot make their own food and must survive by absorbing external organic nutrients through a protective cell wall composed of chitin.
Step 2: These organisms reproduce by producing lightweight spores. A prime example is yeast, a single-celled fungus that drives industrial anaerobic fermentation to bake bread and brew beverages.
Final Answer: Segregation: alleles separate into gametes; fungi are heterotrophic spore-formers, e.g., yeast.

Answer: (See above)

Go Back to Question 31

Q32.

Solution

Concept: Plant bioenergetics and microbial respiration manage how energy is stored and released in living systems. Photosynthesis uses solar energy to build complex organic nutrients, while cellular respiration breaks down those nutrients to release stored energy. When oxygen is absent from the environment, organisms switch to alternative metabolic pathways like anaerobic respiration or fermentation to break down sugars and generate ATP without an electron transport chain.

Solution: Alternative (i): Step 1: Photosynthesis is summarized by the balanced chemical equation: $6CO_2 + 6H_2O \xrightarrow[\text{chlorophyll}]{\text{light}} C_6H_{12}O_6 + 6O_2$.

Step 2: In this pathway, specialized chlorophyll pigments inside the chloroplast thylakoid membranes capture photons from sunlight to split water molecules and drive the synthesis of energy-rich glucose.

Alternative (ii): Step 1: Anaerobic respiration is an alternative metabolic pathway where glucose is broken down to extract energy without using molecular oxygen as a final electron acceptor.

Step 2: During this process in yeast, called alcoholic fermentation, glucose undergoes glycolysis and is converted into ethanol and carbon dioxide gas, producing a modest yield of two ATP molecules per reaction.

Final Answer: Photosynthesis equation with chlorophyll as light absorber; anaerobic respiration occurs without oxygen, e.g., yeast fermentation.

Answer: (See above)

Go Back to Question 32

Q33.

Solution

Concept: Quantitative genetic analysis can predict phenotypic distributions in a population using probability rules. Crossing two heterozygous tall pea plants (Tt × Tt) creates a standard monohybrid setup with complete dominance. According to Mendel's laws, independent assortment and segregation produce a predictable phenotypic ratio of 3 : 1 in the next generation, meaning three-quarters of the offspring will display the dominant tall trait, while one-quarter will express the recessive dwarf trait.

Solution: Step 1: The total number of offspring generated from this monohybrid cross is given as 160 plants.

Step 2: Because the allele for tallness (T) shows complete dominance over the dwarf allele (t), both homozygous dominant (TT) and heterozygous (Tt) genotypes produce tall plants. This makes up three-quarters ($\frac{3}{4}$ or 75%) of the total population. Multiplying $160 \times \frac{3}{4}$ gives an expected count of 120 tall plants.

Step 3: The remaining one-quarter ($\frac{1}{4}$ or 25%) of the population inherits the homozygous recessive genotype (tt), which produces a dwarf phenotype. Multiplying $160 \times \frac{1}{4}$ yields an expected count of 40 dwarf plants, confirming the theoretical ratio.

Final Answer: Expected tall plants = 120 and dwarf plants = 40.

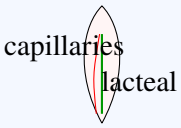
Answer: (See above)

Go Back to Question 33

Q34.

Solution

Concept: The human digestive tract uses specialized structural adaptations to maximize nutrient absorption in the small intestine. The inner mucosal lining features millions of tiny, finger-like projections called villi, which expand the available surface area for absorption. Each individual villus contains an integrated network of tiny blood capillaries wrapped around a single central lymphatic capillary called a lacteal, allowing the body to sort and absorb different types of digested nutrients simultaneously.



Solution: Step 1: In the provided anatomical diagram of an intestinal villus, label A points to the network of blood capillaries that absorb water-soluble nutrients like simple sugars and amino acids directly into the bloodstream.

Step 2: Label B points to the central lymphatic capillary, known as the lacteal, which specializes in absorbing large, hydrophobic lipid molecules and fat-soluble vitamins.

Step 3: These microscopic villi expand the inner surface area of the intestinal wall, accelerating the absorption of digested nutrients to fuel the body's cells.

Final Answer: A = blood capillaries, B = lacteal; villi increase absorption surface.

Answer: (See above)

Go Back to Question 34

Q35.

Solution

Concept: Reproductive medicine and adaptive immunology use specialized biological mechanisms to regulate fertility and defend the body against infections. Contraception uses temporary or permanent interventions to prevent unwanted pregnancies by blocking fertilization or implantation. In a separate defense mechanism, the adaptive immune system uses highly specialized, Y-shaped protective proteins called antibodies to identify, bind, and neutralize foreign antigens moving through body fluids.

Solution: Alternative (i): Step 1: Temporary family planning methods focus on preventing fertilization or implantation without permanently altering reproductive anatomy. Mechanical options like male condoms create a physical barrier that blocks sperm from reaching the egg.
Step 2: Chemical options like oral contraceptive pills use synthetic hormones to stop ovulation, while internal devices like Intrauterine Contraceptive Devices (IUCDs) prevent embryos from implanting in the uterine lining.
Alternative (ii): Step 1: Antibodies, or immunoglobulins, are specialized protective proteins synthesized by the immune system to target specific foreign antigens.
Step 2: When the body detects an antigen, matching B-lymphocytes multiply and mature into active plasma cells, which release millions of targeted antibodies into blood and lymph to neutralize the threat.
Final Answer: Condoms and oral pills; antibodies are antigen-specific proteins made by plasma cells.

Answer: (See above)

Go Back to Question 35

Q36.

Solution

Concept: Quantitative ecosystem ecology uses Raymond Lindeman's ten percent law to model energy transfers between trophic levels. This ecological principle states that when energy moves from one feeding level to the next, only about one-tenth (or 10%) of the available energy is stored as organic biomass. The remaining 90% of energy is consumed by cellular respiration, used for movement, or lost to the environment as metabolic waste and heat.

Solution: Step 1: Consider a simple terrestrial food chain containing a primary producer, a primary consumer, and a secondary predator, structured as: grass → deer → tiger.
Step 2: If the grass level captures and stores 1000 units of chemical energy from sunlight, the deer that graze on the grass will only store about 10% of that energy, accumulating roughly 100 units of energy in their tissues.
Step 3: When a tiger hunts and eats the deer, the energy transfers again with the same efficiency. The tiger stores only 10% of the deer's energy, which amounts to just 10 units of the original energy. The rest is lost as heat, showing why food chains rarely exceed four or five levels.
Final Answer: About 10 percent energy passes to the next trophic level, e.g., 1000 in grass, 100 in deer, 10 in tiger.

Answer: (See above)
Go Back to Question 36

Q37.

Solution

Concept: Cardiovascular anatomy classifies blood vessels into distinct categories based on their structural design, internal blood pressure, and direction of blood flow. The vascular system balances high-pressure outflow from the heart with low-pressure return pathways. To handle these different physical demands, the walls of these transport channels are built with varying amounts of muscular and elastic tissue, ensuring that blood flows continuously in one direction through the body.

Solution: Step 1: Arteries are muscular vessels that carry blood away from the heart chambers toward peripheral tissues under high pressure, while veins function as return vessels that carry blood under lower pressure back toward the heart.
Step 2: To withstand high, pulsing blood pressure, arteries are built with thick, elastic walls that stretch and contract. Because this pressure keeps blood moving forward, arteries do not require internal valves to prevent backflow.
Step 3: In contrast, veins have thinner walls with less muscle tissue because they handle lower blood pressure. To prevent blood from pooling due to gravity, veins contain one-way internal valves that keep blood moving steadily back toward the heart.
Final Answer: Arteries: away from heart, thick elastic walls; veins: towards heart, thinner walls with valves.

Answer: (See above)
Go Back to Question 37

Q38.

Solution

Concept: Accurate scientific definitions help organize complex systems across ecology, immunology, and biotechnology. Ecology studies how groups of organisms interact within shared environments. Immunology focuses on the defense mechanisms the body uses to fight off diseases. Meanwhile, biotechnology develops advanced tools to modify genetic material, creating new combinations of genes that do not exist in nature.

Solution: Step 1: In ecology, a population is defined as a collective group of individuals belonging to the same biological species that live in a specific geographic area at the same time, such as all the mango trees growing inside a managed orchard.

Step 2: In immunology, a vaccine is a biological preparation that safely exposes the immune system to weak or dead pathogens, triggering protective immunity without causing illness, like the standard measles vaccine.

Step 3: In biotechnology, recombinant DNA refers to a functional molecule created in a lab by splicing together DNA fragments from different organisms, such as inserting a human insulin gene into a circular bacterial plasmid for medical production.

Final Answer: Population: members of same species in an area; vaccine: immunity-inducing preparation; recombinant DNA: DNA made by joining foreign DNA fragments.

Answer: (See above)

Go Back to Question 38

Q39.

Solution

Concept: Regulatory homeostasis and global biogeochemical cycles rely on balanced feedback loops and chemical conversions to sustain life. Animal physiology uses negative feedback mechanisms to keep internal conditions stable, such as monitoring blood sugar levels with pancreatic hormones. On a global scale, the nitrogen cycle uses specialized soil bacteria to move nitrogen between the atmosphere, soil layers, and living organisms, ensuring this vital nutrient is always available.

Solution: Alternative (i): Step 1: When blood glucose levels rise after a meal, the pancreas releases insulin. This hormone signals cells to absorb glucose and store it as glycogen in the liver, bringing blood sugar back down.

Step 2: If blood glucose drops too low, the pancreas releases glucagon. This hormone signals the liver to break stored glycogen back down into glucose, raising blood sugar back to a safe balance.

Alternative (ii): Step 1: The global nitrogen cycle uses nitrogen-fixing bacteria to convert inert atmospheric nitrogen gas (N_2) into bio-available ammonia.

Step 2: Next, nitrifying soil bacteria convert this ammonia into nitrites and nitrates that plants can easily absorb. Finally, denitrifying bacteria convert excess soil nitrates back into nitrogen gas, releasing it into the atmosphere to complete the cycle.

Final Answer: Insulin lowers and glucagon raises blood glucose; nitrogen cycle includes fixation, nitrification and denitrification.

Answer: (See above)

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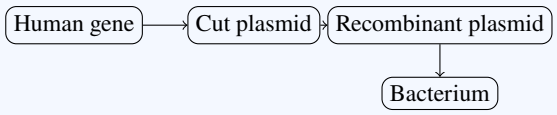
Q40.

Solution

Concept: Recombinant DNA technology alters genetic material by inserting a target gene from a donor organism into a carrier vector, allowing it to replicate inside a host cell. This genetic engineering process uses a series of precision biochemical steps: slicing DNA at specific sequences, splicing the target gene into a plasmid vector, and introducing the new plasmid into host bacteria to clone and express the gene.



Solution: Step 1: The engineering process begins by isolating the target human gene sequence and extracting circular plasmid vectors from helper bacterial cells.

Step 2: Both the human gene and the plasmid vector are cut using the same restriction endonuclease enzyme, creating matching, single-stranded "sticky ends" on both pieces of DNA.

Step 3: The target human gene and the open plasmid are mixed together with the enzyme DNA ligase, which welds their matching ends together with strong covalent bonds to form a recombinant plasmid.

Step 4: This recombinant plasmid is introduced into host bacteria via transformation. The bacteria are then grown on selective media to isolate and multiply the modified cells.

Final Answer: Cut gene and plasmid, ligate them to make recombinant DNA, transform bacteria and select modified cells.

Answer: (See above)

Go Back to Question 40

Q41.

Solution

Concept: Quantitative analysis of inheritance patterns and human reproductive endocrinology reveals the precise mechanics of genetic transmission and physiological regulation. Gregor Mendel's fundamental laws establish that when heterozygous organisms are self-crossed, their alleles segregate into haploid gametes with equal probability. In human physiology, the female menstrual cycle operates as a highly coordinated monthly sequence controlled by an upstream neuroendocrine axis, where shifting balances of pituitary and ovarian hormones orchestrate tissue remodeling.

Solution: Alternative (i): Step 1: In a monohybrid cross, a heterozygous plant with the genotype Rr undergoes meiosis to produce two types of gametes, with exactly half carrying the dominant allele R and the other half carrying the recessive allele r.

Step 2: Combining these gametes in a self-cross ($\text{Rr} \times \text{Rr}$) produces four offspring variations: one homozygous dominant (RR), two heterozygous (Rr), and one homozygous recessive (rr). This distribution establishes a predictable genotypic ratio of $1 : 2 : 1$.

Step 3: Because the R allele displays complete dominance over the recessive r allele, both the RR and Rr variations express the dominant red color, while only the rr variation shows white, yielding a phenotypic ratio of 3 red to 1 white.

Alternative (ii): Step 1: The standard menstrual cycle is divided into sequential clinical phases: the initial destructive menstrual phase, the proliferative follicular phase, a central ovulatory event, and the secretory luteal phase.

Step 2: Follicle-Stimulating Hormone (FSH) stimulates early follicle maturation, while a surge in Luteinizing Hormone (LH) triggers ovulation. Following this, estrogen and progesterone levels rise to thicken and prepare the uterine lining for a potential embryo.

Final Answer: Genotype ratio $1RR : 2Rr : 1rr$, phenotype ratio 3 red:1 white; menstrual cycle is controlled by FSH, LH, estrogen and progesterone.

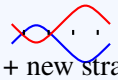
Answer: (See above)

Go Back to Question 41

Q42.

Solution

Concept: Plant bioenergetics, microbial symbiosis, and molecular genetics govern how autotrophs synthesize food and how cells pass down instructions. Plant photosynthesis splits these metabolic duties between two distinct operational phases. In a separate molecular mechanism, DNA replication uses a semi-conservative blueprint to ensure accurate genetic transmission. During cell division, the double helix separates so each original strand can guide the assembly of a new complementary partner strand.



old + new strands

Solution: Alternative (i): Step 1: The light-dependent reactions of photosynthesis take place in the thylakoid grana, where chlorophyll absorbs sunlight to split water molecules. This photolysis reaction releases oxygen gas and stores chemical energy as ATP and NADPH.

Step 2: The light-independent dark reactions take place in the surrounding stroma, using the newly made ATP and NADPH to fix carbon dioxide gas into energy-rich carbohydrates.

Step 3: In agricultural ecosystems, symbiotic *Rhizobium* bacteria inside legume root nodules fix atmospheric nitrogen gas, converting it into soluble ammonia compounds that plants can easily use for growth.

Alternative (ii): Step 1: During semi-conservative DNA replication, the double helix unzips as hydrogen bonds break between base pairs, leaving two separate parental template strands.

Step 2: DNA polymerase links complementary nucleotides onto each template strand. This creates two identical daughter helices, each keeping one original parental strand and one newly built strand.

Step 3: This sequence is translated via the universal genetic code, a triplet system where groups of three mRNA bases form codons that specify individual amino acids during protein synthesis.

Final Answer: Light reaction forms ATP/NADPH and releases oxygen; dark reaction fixes carbon dioxide; root nodules fix nitrogen. DNA replication is semi-conservative; genetic code is triplet and nearly universal.

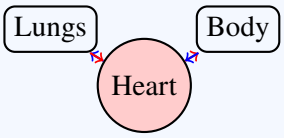
Answer: (See above)

Go Back to Question 42

Q43.

Solution

Concept: Human cardiovascular anatomy, ecosystem dynamics, and public health guidelines maintain functional balance across different biological scales. The mammalian heart uses double circulation to completely separate oxygen-rich and oxygen-poor blood, maximizing metabolic efficiency. In a similar balancing act, natural ecosystems use complex, multi-layered feeding pathways to move nutrients and energy through communities, while human public health relies on targeted nutrition, personal hygiene, and preventative medicine to ward off diseases.



Solution: Alternative (i): Step 1: The pulmonary circuit pumps oxygen-poor blood from the right side of the heart out to the lungs to drop off carbon dioxide and absorb fresh oxygen, before returning it to the left side of the heart.

Step 2: The systemic circuit pumps this fresh, oxygen-rich blood from the left side of the heart out to the rest of the body tissues, eventually returning the depleted, deoxygenated blood back to the right side to start the cycle again.

Step 3: Growing adolescents need a nutrient-dense, balanced diet to support rapid bone and muscle development, navigate changing hormone levels, maintain strong immune systems, and provide steady energy for daily activities.

Alternative (ii): Step 1: A simple food chain models a single, direct feeding pathway through an ecosystem, tracking energy as it moves from a producer to a herbivore and on to a carnivore (grass $\rightarrow$ grasshopper $\rightarrow$ frog).

Step 2: A complex food web links many overlapping food chains together, mapping out alternative feeding choices that help buffer the ecosystem and keep wildlife populations stable if one food source drops.

Step 3: Reliable public health practices include protecting clean drinking water, managing vaccination schedules, washing hands regularly, and disposing of waste safely to stop the spread of infectious pathogens.

Final Answer: Double circulation includes pulmonary and systemic circuits; balanced diet supports growth and health. Food chains are linear, food webs are interconnected; hygiene, vaccination and safe water maintain health.

Answer: (See above)

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Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	B	2	A	3	B	4	A	5	B
6	B	7	B	8	B	9	B	10	A
11	C	12	A	13	B	14	D	15	A
16	B								