NIOS Class 12 Biology Sample Paper-8

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. Which pigment present in the chloroplast is primarily responsible for absorbing light energy to drive the reactions of photosynthesis? **(1)**

(A) Haemoglobin

(B) Xanthophyll

(C) Chlorophyll

(D) Melanin

Q2. When both alleles of a gene pair in a heterozygote are fully and independently expressed, so that the phenotype shows both parental characters simultaneously, the phenomenon is called: **(1)**

(A) Complete dominance

(B) Incomplete dominance

(C) Codominance

(D) Epistasis

Q3. Amoeba moves and captures food by extending temporary finger-like projections of cytoplasm called: **(1)**

(A) Pseudopodia

(B) Cilia

(C) Flagella

(D) Setae

Q4. The gradual and orderly replacement of one community of organisms by another in a given area over time, eventually leading to a stable climax community, is called: **(1)**

(A) Eutrophication

(B) Biological magnification

(C) Desertification

(D) Ecological succession

Q5. The final electron acceptor in the electron transport chain (ETC) of aerobic respiration, which combines with electrons and protons to form water, is: **(1)**

(A) Carbon dioxide

(B) NADH

(C) Cytochrome c

(D) Molecular oxygen (O_2)

Q6. The triploid (3n) tissue inside a seed that stores food reserves and nourishes the developing embryo in angiosperms is called the: **(1)**

(A) Nucellus

(B) Testa

(C) Endosperm

(D) Pericarp

Q7. The type of white blood cells (lymphocytes) that directly attack and kill virus-infected cells and cancer cells in the body are called: **(1)**

(A) B-lymphocytes

(B) Cytotoxic T-lymphocytes (killer T-cells)

(C) Platelets

(D) Erythrocytes

Q8. Animals that maintain a constant internal body temperature regardless of the external environment (e.g., birds and mammals) are called: **(1)**

(A) Homeotherms (warm-blooded)

(B) Poikilotherms (cold-blooded)

(C) Ectotherms

(D) Anadromous organisms

Q9. The enzyme nitrogenase, which catalyses the biological fixation of atmospheric nitrogen into ammonia, is irreversibly inactivated by: **(1)**

(A) Water

(B) Oxygen

(C) Carbon dioxide

(D) Glucose

Q10. Proteins in the human diet are essential because they supply the body with: **(1)**

(A) Fatty acids for energy storage

(B) Simple sugars for immediate energy

(C) Inorganic minerals for bone formation

(D) Amino acids for growth and tissue repair

Q11. The three-letter sequence of nucleotides on mRNA that codes for a specific amino acid during translation is called a: **(1)**

(A) Anticodon

(B) Gene

(C) Codon

(D) Intron

Q12. The iron-containing pigment protein present in red blood cells (RBCs) that binds reversibly with oxygen and transports it from the lungs to the body tissues is: **(1)**

(A) Haemoglobin

(B) Myoglobin

(C) Bilirubin

(D) Albumin

Q13. The type of cell division that produces four genetically non-identical daughter cells, each having half the chromosome number of the parent cell, is called: **(1)**

(A) Mitosis

(B) Amitosis

(C) Binary fission

(D) Meiosis

Q14. The technique used to separate DNA fragments of different sizes by making them move through an agarose gel under an electric field is called: **(1)**

(A) Gel electrophoresis

(B) Centrifugation

(C) Chromatography

(D) PCR

Q15. Surgical cutting and tying of the vas deferens in human males to prevent the passage of sperms is a permanent method of contraception called: **(1)**

(A) Tubectomy

(B) Vasectomy

(C) Castration

(D) Amniocentesis

Q16. The tiny pores on the lower epidermis of a leaf, each flanked by two bean-shaped guard cells that regulate their opening and closing, are called: **(1)**

(A) Lenticels

(B) Stomata

(C) Hydathodes

(D) Trichomes

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:

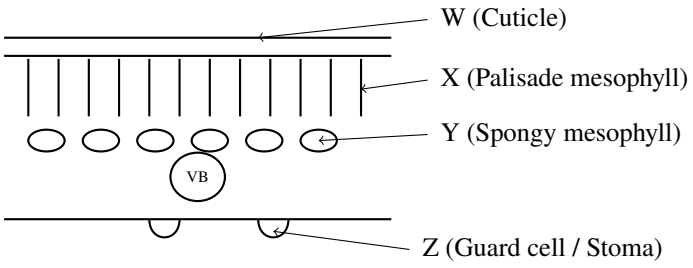
The human circulatory system is a closed system in which blood flows through a continuous network of blood vessels. Arteries carry blood away from the heart to the organs, arterioles are small branches of arteries that lead to capillaries, and capillaries are the thinnest vessels where the actual exchange of gases, nutrients, and wastes between blood and tissues takes place. From the capillaries, blood is collected by venules, which join to form veins that carry blood back to the heart. **(2)**

1. Name the thinnest blood vessels where the exchange of gases and nutrients between blood and tissues actually occurs.
2. What are the small blood vessels that collect blood from the capillaries and merge to form veins called?

Q18. Complete the following sentences using the words given below:
(mitochondria, ribosomes, endoplasmic reticulum, lysosomes, Golgi apparatus) **(2)**

1. The membrane-bound organelles that contain hydrolytic (digestive) enzymes and are responsible for intracellular digestion of worn-out cell parts and foreign materials are called . . . . . .
2. The organelles that are known as the "powerhouses of the cell" because they generate most of the cell's ATP through aerobic respiration are called . . . .

Q19. Study the diagram of the cross-section of a leaf given below and answer the questions that follow. **(2)**



1. Name the waxy layer labelled W on the upper surface of the leaf that reduces water loss by evaporation.
2. What is the collective name for the tissues labelled X and Y, which together make up the photosynthetic ground tissue of the leaf?

Q20. Fill in the blanks: **(2)**

1. The process by which the information encoded in a DNA template strand is copied into a complementary messenger RNA molecule is called .....
2. The small, cloverleaf-shaped RNA molecule that carries a specific amino acid to the ribosome during protein synthesis is called .....

Q21. Match the items in Column I with the most appropriate items in Column II: **(2)**

Column I	**Column II**
(a) Auxin	(i) Promotes cell division; used in tissue culture
(b) Gibberellin	(ii) Promotes cell elongation; causes phototropism
(c) Cytokinin	(iii) Promotes fruit ripening and leaf abscission
(d) Ethylene	(iv) Promotes stem elongation and seed germination

Q22. Fill in the blanks: **(2)**

1. The progressive increase in the concentration of a non-biodegradable toxic substance (such as DDT or mercury) at each successive trophic level of a food chain is called .....
2. The addition of excessive nutrients (nitrogen, phosphorus) to a water body, leading to algal blooms and oxygen depletion, is called .....

Q23. Write TRUE (T) for the correct statement and FALSE (F) for the incorrect statement: **(2)**

1. In humans, the sex of a child is determined by the type of sex chromosome (X or Y) contributed by the father's sperm at the time of fertilisation.
2. A person with blood group AB can donate blood to a person with any blood group (A, B, AB, or O) and is therefore called a universal donor.

Q24. Match the items in Column I with the most appropriate items in Column II: **(2)**

Column I	**Column II**
(a) *Escherichia coli*	(i) Kingdom Fungi – saprophytic, chitinous cell wall
(b) *Paramecium*	(ii) Kingdom Monera – prokaryotic, unicellular
(c) *Mucor* (bread mould)	(iii) Kingdom Animalia – multicellular, heterotrophic, no cell wall
(d) Earthworm	(iv) Kingdom Protista – eukaryotic, unicellular, ciliated

Q25. Fill in the blanks: **(2)**

1. The upward movement of water and dissolved minerals from the roots to the aerial parts of a plant through the xylem is called .....
2. The movement of prepared food (sucrose) from the leaves to other parts of the plant through the phloem is called .....

Q26. Match the items in Column I with the most appropriate items in Column II: **(2)**

Column I	**Column II**
(a) Ozone layer depletion	(i) Increase in global average temperature due to greenhouse gases
(b) Global warming	(ii) Addition of harmful substances to water bodies by industrial effluents
(c) Water pollution	(iii) Caused by chlorofluorocarbons (CFCs); increases UV radiation
(d) Acid rain	(iv) Rain with pH below 5.6 due to SO_2 and NO_x emissions

Q27. Write TRUE (T) for the correct statement and FALSE (F) for the incorrect statement: **(2)**

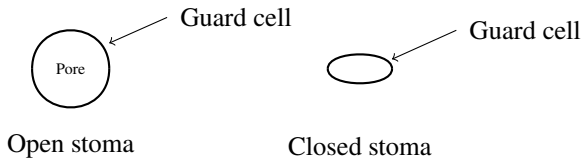
1. Gene therapy is the technique of correcting a genetic disorder by introducing a normal, functional copy of the defective gene into the patient's cells.
2. Antibiotics are effective against viral infections such as the common cold and influenza.

Q28. Match the items in Column I with the most appropriate items in Column II: **(2)**

Column I	**Column II**
(a) Ovary	(i) Receives pollen grains during pollination
(b) Stigma	(ii) Connects the stigma to the ovary
(c) Style	(iii) Contains ovules that develop into seeds after fertilisation
(d) Anther	(iv) Produces and releases pollen grains

Section: B

Q29. With the help of a labelled diagram, describe the process of opening and closing of stomata, mentioning the role of guard cells and turgor pressure. **(2)**



Q30. What is 'vegetative propagation'? Name any two natural methods of vegetative propagation and give one plant example for each method. **(2)**

Q31. (i) What is meant by 'in situ' conservation of biodiversity? Name one example of an *in situ* conservation area in India.

OR

(ii) What is meant by 'ex situ' conservation of biodiversity? Name one example of an *ex situ* conservation facility. **(2)**

Q32. (i) Differentiate between xylem and phloem with respect to (a) the type of material they transport and (b) whether their functional cells are living or dead.

OR

(ii) Differentiate between bone and cartilage with respect to (a) rigidity and (b) the nature of the matrix. **(2)**

Q33. During aerobic respiration, the complete oxidation of one molecule of glucose through glycolysis, the Krebs cycle, and the electron transport chain yields a net total of 36 molecules of ATP. If a cell completely oxidises 5 molecules of glucose aerobically, calculate the total number of ATP molecules produced and the total number of CO_2 molecules released (given that 6 CO_2 are released per glucose molecule). **(2)**

Q34. In a certain plant, red flower colour (R) is incompletely dominant over white flower colour (r), and the heterozygote (Rr) produces pink flowers. If two pink-flowered plants (Rr) are crossed, use a Punnett square to determine the phenotypic ratio of the offspring. **(2)**

	R	r
R	RR	Rr
r	Rr	rr

Q35. (i) What is a 'hormone'? Name one hormone secreted by the ovary and state its function.

OR

(ii) What is a 'hormone'? Name the hormone that regulates blood calcium levels and name the gland that secretes it. **(2)**

Q36. What are 'minerals' in the context of human nutrition? Name the mineral whose deficiency causes anaemia and the one whose deficiency causes dental caries (tooth decay). **(2)**

Q37. Name the three main parts of the human brain. State one major function of each part. **(2)**

Q38. Explain briefly:

A. What is an 'autoimmune disease'? Give one example.

B. What is 'gene therapy'?

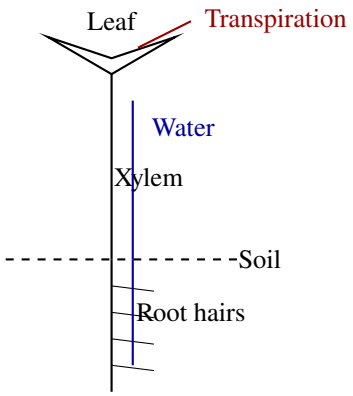
C. Name one human disease for which gene therapy has been attempted. **(3)**

Q39. (i) Explain the ABO blood group system in humans, mentioning the antigens present on RBCs and the antibodies present in plasma for each blood group. State which blood group is the universal recipient.

OR

(ii) Explain what is meant by 'sex-linked inheritance'. Using a suitable cross, show how haemophilia (an X-linked recessive trait) is transmitted from a carrier mother to her sons. **(3)**

Q40. With the help of a labelled diagram, describe how water is absorbed from the soil by root hairs and transported upward through the xylem to the leaves (mention root hair absorption, osmosis, root pressure, and transpiration pull). **(3)**



Q41. (i) Explain what is meant by 'food adulteration'. State two harmful effects of

consuming adulterated food and two measures to prevent food adulteration.

OR

(ii) What are sexually transmitted diseases (STDs)? Name one STD caused by a bacterium and one caused by a virus, and state one preventive measure for STDs. **(3)**

Q42. (i) (a) Describe the stages of the human menstrual cycle (menstrual phase, follicular phase, ovulation, and luteal phase), mentioning the hormones involved.
(b) State what happens to the uterine lining if the egg is not fertilised.

OR

(ii) (a) State Mendel's law of independent assortment.
(b) In a dihybrid cross between a pea plant with round yellow seeds (RrYy) and another plant with round yellow seeds (RrYy), work out the phenotypic ratio of the F_1 generation, showing the 4×4 Punnett square. **(5)**

Q43. (i) Describe the process of aerobic respiration in plants in detail, covering glycolysis (site, inputs, outputs), the Krebs cycle (site, inputs, outputs), and the electron transport chain (site, role). State the net ATP yield per glucose molecule.

OR

(ii) Draw a well-labelled diagram of the internal structure of the human kidney (longitudinal section) showing the cortex, medulla, renal pelvis, and nephron. Describe briefly how urine is formed (glomerular filtration, tubular reabsorption, and tubular secretion). **(5)**

Detailed Solutions

Q1.

Solution

Concept: Chlorophyll is the green pigment found in the chloroplasts of plant cells and algae. It absorbs light energy (primarily in the red and blue wavelengths) and converts it into chemical energy to drive the light-dependent reactions of photosynthesis.

Step 1: Chlorophyll is located in the thylakoid membranes of the chloroplast. It absorbs red and blue light while reflecting green light, which is why plants appear green.
Step 2: The absorbed light energy excites electrons in chlorophyll molecules, initiating the electron transport chain that ultimately produces ATP and NADPH for the Calvin cycle.

Why other options are wrong:

- **Option A:** Haemoglobin is an oxygen-carrying pigment in animal red blood cells, not a photosynthetic pigment.
- **Option B:** Xanthophyll is an accessory pigment (yellow); it assists chlorophyll but is not the primary pigment.
- **Option D:** Melanin is a pigment responsible for skin, hair, and eye colour in animals.

Final Answer: Chlorophyll (Option C)

Answer: (C)

Go Back to Question 1

Q2.

Solution

Concept: Codominance is a pattern of inheritance in which both alleles in a heterozygote are fully and independently expressed, producing a phenotype that simultaneously displays both parental characteristics rather than blending them.

Step 1: In codominance, neither allele is dominant or recessive over the other. Both alleles contribute equally and visibly to the phenotype. Example: In the ABO blood group system, a person with genotype I^AI^B has blood group AB, expressing both A and B antigens on their red blood cells simultaneously.
Step 2: This is different from incomplete dominance, where the heterozygote shows an intermediate (blended) phenotype between the two homozygous phenotypes.

Why other options are wrong:

- **Option A:** In complete dominance, the dominant allele completely masks the recessive one.
- **Option B:** In incomplete dominance, the heterozygote shows a blended intermediate phenotype, not both parental traits simultaneously.
- **Option D:** Epistasis refers to one gene masking the expression of another gene at a different locus.

Final Answer: Codominance (Option C)

Answer: (C)

Go Back to Question 2

Q3.

Solution

Concept: Amoeba is a unicellular eukaryotic organism (Kingdom Protista) that lacks a fixed body shape. It moves and engulfs food by extending temporary, finger-like projections of its cytoplasm called pseudopodia ("false feet").

Step 1: Pseudopodia are formed when the cytoplasm streams outward, pushing the cell membrane to create a temporary extension. The rest of the cell then flows into the pseudopodium, causing locomotion (amoeboid movement).
Step 2: Amoeba also uses pseudopodia to surround and engulf food particles by a process called phagocytosis, forming a food vacuole inside the cell.

Why other options are wrong:

- **Option B:** Cilia are short, hair-like structures used for locomotion by Paramecium, not Amoeba.
- **Option C:** Flagella are long, whip-like structures used by organisms like Euglena, not Amoeba.
- **Option D:** Setae are bristle-like structures found on earthworms for grip during locomotion.

Final Answer: Pseudopodia (Option A)

Answer: (A)

Go Back to Question 3

Q4.

Solution

Concept: Ecological succession is the natural, gradual, and directional process by which the species composition of a community changes over time in a given area, progressing through a series of intermediate (seral) stages until a stable, self-sustaining climax community is reached.

Step 1: Succession begins with pioneer species (e.g., lichens on bare rock or algae in a new pond) that colonise and modify the environment, making it suitable for the next set of species.
Step 2: Each successive community (seral stage) alters the habitat further, facilitating the establishment of more complex species, until the climax community is reached – a stable, self-perpetuating community in equilibrium with the environment.

Why other options are wrong:

- **Option A:** Eutrophication is the nutrient enrichment of water bodies, not a community replacement process.
- **Option B:** Biological magnification is the accumulation of toxins at higher trophic levels.
- **Option C:** Desertification is the degradation of land into desert conditions.

Final Answer: Ecological succession (Option D)

Answer: (D)

Go Back to Question 4

Q5.

Solution

Concept: In the electron transport chain (ETC) of aerobic respiration, electrons are passed through a series of carrier molecules on the inner mitochondrial membrane. At the end of the chain, the electrons must be accepted by a terminal electron acceptor. In aerobic respiration, this acceptor is molecular oxygen (O_2).

Step 1: NADH and $FADH_2$ (produced during glycolysis and the Krebs cycle) donate their electrons to the ETC. These electrons pass through a series of protein complexes, releasing energy that pumps protons across the membrane.
Step 2: At the final complex (Complex IV / cytochrome c oxidase), the electrons are transferred to molecular oxygen (O_2), which simultaneously accepts protons (H^+) to form water (H_2O). Without O_2, the ETC stops, and aerobic respiration cannot continue.

Why other options are wrong:

- **Option A:** CO_2 is a product of the Krebs cycle, not an electron acceptor.
- **Option B:** NADH is an electron donor to the ETC, not an acceptor.
- **Option C:** Cytochrome c is an intermediate electron carrier in the chain, not the final acceptor.

Final Answer: Molecular oxygen (O_2) (Option D)

Answer: (D)

Go Back to Question 5

Q6.

Solution

Concept: In angiosperms, double fertilisation produces a triploid (3n) primary endosperm nucleus that develops into the endosperm – a nutritive tissue inside the seed that stores food reserves (starch, proteins, oils) to nourish the developing embryo during germination.

Step 1: During double fertilisation, one sperm fuses with the egg (syngamy, producing the 2n zygote/embryo) and the second sperm fuses with the two polar nuclei (triple fusion, producing the 3n primary endosperm nucleus).
Step 2: The primary endosperm nucleus divides repeatedly to form the endosperm tissue, which accumulates food reserves. In cereals (wheat, rice, maize), the endosperm persists in the mature seed. In legumes (pea, bean), the endosperm is consumed by the cotyledons before germination.

Why other options are wrong:

- **Option A:** The nucellus is the tissue of the ovule surrounding the embryo sac, not the food storage tissue inside the seed.
- **Option B:** The testa is the outer seed coat, providing physical protection.
- **Option D:** The pericarp is the fruit wall that develops from the ovary wall, not from inside the seed.

Final Answer: Endosperm (Option C)

Answer: (C)

Go Back to Question 6

Q7.

Solution

Concept: The immune system uses different types of lymphocytes for defence. B-lymphocytes produce antibodies (humoral immunity), while T-lymphocytes are involved in cell-mediated immunity. Cytotoxic T-lymphocytes (also called killer T-cells or CD8+ T-cells) directly recognise and destroy virus-infected cells and tumour cells.

Step 1: When a body cell is infected by a virus, viral antigens are displayed on the cell's surface by MHC-I molecules. Cytotoxic T-cells recognise these antigen-MHC complexes.
Step 2: Upon recognition, the cytotoxic T-cell releases perforins and granzymes that create pores in the infected cell's membrane, triggering apoptosis (programmed cell death) and destroying the cell along with the virus inside it.

Why other options are wrong:

- **Option A:** B-lymphocytes produce antibodies that circulate in blood/lymph; they do not directly kill infected cells.
- **Option C:** Platelets are involved in blood clotting, not immune killing.
- **Option D:** Erythrocytes (RBCs) carry oxygen; they have no immune function.

Final Answer: Cytotoxic T-lymphocytes (killer T-cells) (Option B)

Answer: (B)

Go Back to Question 7

Q8.

Solution

Concept: Animals are classified based on their ability to regulate body temperature. Homeotherms (warm-blooded animals) maintain a constant internal body temperature through metabolic heat production, regardless of the external temperature. Poikilotherms (cold-blooded) have body temperatures that vary with the environment.

Step 1: Birds and mammals are homeotherms. They generate internal metabolic heat and use insulation (feathers, fur, fat) and physiological mechanisms (sweating, shivering, vasodilation/vasoconstriction) to maintain a stable core temperature.
Step 2: This constant body temperature allows homeotherms to remain active in a wide range of environmental conditions, including cold climates.

Why other options are wrong:

- **Option B:** Poikilotherms are cold-blooded animals whose body temperature fluctuates with the environment (e.g., fish, frogs, reptiles).
- **Option C:** Ectotherms rely on external heat sources – essentially another term for cold-blooded.
- **Option D:** Anadromous organisms are fish that migrate from sea to freshwater for breeding (e.g., salmon); this is unrelated to thermoregulation.

Final Answer: Homeotherms (warm-blooded) (Option A)

Answer: (A)

Go Back to Question 8

Q9.

Solution

Concept: Nitrogenase is the enzyme complex used by nitrogen-fixing bacteria (Rhizobium, Azotobacter, cyanobacteria) to convert atmospheric N_2 into ammonia. This enzyme is extremely sensitive to oxygen – even traces of O_2 irreversibly inactivate its iron-molybdenum active site.

Step 1: Nitrogenase catalyses the reaction: $N_2 + 8H^+ + 8e^- + 16ATP \rightarrow 2NH_3 + H_2 + 16ADP + 16Pi$. This reaction requires an anaerobic (oxygen-free) environment.

Step 2: In legume root nodules, a special protein called leghaemoglobin binds and scavenges free oxygen, maintaining a low-oxygen environment around the nitrogenase to protect it from inactivation.

Why other options are wrong:

- **Option A:** Water is a universal solvent and does not inactivate nitrogenase.
- **Option C:** Carbon dioxide is not known to irreversibly damage nitrogenase.
- **Option D:** Glucose is a substrate for cellular respiration, not an inhibitor of nitrogenase.

Final Answer: Oxygen (Option B)

Answer: (B)

Go Back to Question 9

Q10.

Solution

Concept: Dietary proteins are digested in the alimentary canal into their building blocks – amino acids – which are absorbed into the blood and used by body cells for growth, tissue repair, enzyme synthesis, and the production of hormones and antibodies.

Step 1: Proteins are large polymers of amino acids linked by peptide bonds. During digestion, proteases break proteins into individual amino acids.
Step 2: These amino acids are essential for building new cells, repairing damaged tissues, manufacturing enzymes and hormones, and forming structural proteins like collagen and keratin. Without adequate dietary protein, growth is stunted and wound healing is impaired.

Why other options are wrong:

- **Option A:** Fatty acids come from the digestion of dietary fats, not proteins.
- **Option B:** Simple sugars come from the digestion of carbohydrates.
- **Option C:** Inorganic minerals (calcium, phosphorus) are separate dietary components, not derived from proteins.

Final Answer: Amino acids for growth and tissue repair (Option D)

Answer: (D)

Go Back to Question 10

Q11.

Solution

Concept: During translation, the ribosome reads the mRNA sequence in sets of three nucleotides. Each such triplet on the mRNA is called a codon, and it specifies a particular amino acid (or a stop signal). The corresponding three-nucleotide sequence on the tRNA that pairs with the codon is called the anticodon.

Step 1: The mRNA molecule is synthesised during transcription. Its nucleotide sequence is read in non-overlapping triplets (codons) by the ribosome during translation. Each codon specifies one amino acid according to the genetic code.
Step 2: For example, the codon AUG codes for methionine and also serves as the start codon. The codons UAA, UAG, and UGA are stop codons that signal the end of translation.

Why other options are wrong:

- **Option A:** An anticodon is the complementary three-nucleotide sequence on tRNA, not on mRNA.
- **Option B:** A gene is an entire segment of DNA coding for a protein, not a three-letter code unit.
- **Option D:** An intron is a non-coding sequence within a gene that is removed during mRNA processing.

Final Answer: Codon (Option C)

Answer: (C)

Go Back to Question 11

Q12.

Solution

Concept: Haemoglobin is a conjugated protein consisting of four polypeptide chains (globin), each associated with an iron-containing haem group. It is found inside red blood cells and is responsible for the transport of oxygen from the lungs to all body tissues.

Step 1: In the lungs, where oxygen concentration is high, haemoglobin binds O_2 to form bright red oxyhaemoglobin (HbO_2). In the body tissues, where oxygen concentration is low and CO_2 concentration is high, haemoglobin releases O_2 for cellular use.
Step 2: Each haemoglobin molecule can bind up to four molecules of O_2 (one per haem group). The iron atom in the haem group is the actual site of oxygen binding.

Why other options are wrong:

- **Option B:** Myoglobin is an oxygen-storing pigment found in muscle cells, not in RBCs.
- **Option C:** Bilirubin is a yellow pigment produced from the breakdown of old haemoglobin.
- **Option D:** Albumin is a plasma protein involved in maintaining osmotic pressure, not oxygen transport.

Final Answer: Haemoglobin (Option A)

Answer: (A)

Go Back to Question 12

Q13.

Solution

Concept: Meiosis is a type of reductive cell division that occurs in reproductive (germ) cells. It involves two successive divisions (meiosis I and meiosis II), producing four genetically non-identical daughter cells, each with half the chromosome number (haploid, n) of the parent cell (diploid, 2n).

Step 1: Meiosis I is the reductional division – homologous chromosomes separate, halving the chromosome number. During this stage, crossing over between non-sister chromatids generates genetic variation.
Step 2: Meiosis II is similar to mitosis – sister chromatids separate. The net result is four haploid cells, each genetically unique due to crossing over and independent assortment.

Why other options are wrong:

- **Option A:** Mitosis produces two genetically identical daughter cells with the same chromosome number as the parent.
- **Option B:** Amitosis is a simple, direct nuclear division without spindle formation, found in some lower organisms.
- **Option C:** Binary fission is the splitting of a prokaryotic cell into two identical cells.

Final Answer: Meiosis (Option D)

Answer: (D)

Go Back to Question 13

Q14.

Solution

Concept: Gel electrophoresis is a laboratory technique used to separate macromolecules (DNA, RNA, or proteins) based on their size and charge. DNA fragments migrate through an agarose or polyacrylamide gel matrix under the influence of an electric field – smaller fragments move faster and farther.

Step 1: DNA is negatively charged (due to phosphate groups). When placed in a gel and subjected to an electric field, DNA fragments migrate toward the positive electrode (anode).
Step 2: The gel acts as a molecular sieve: smaller fragments encounter less resistance and travel faster/farther, while larger fragments move more slowly. After staining (e.g., with ethidium bromide), the separated fragments appear as distinct bands.

Why other options are wrong:

- **Option B:** Centrifugation separates particles based on density using centrifugal force, not electric fields.
- **Option C:** Chromatography separates compounds based on differential affinity for a stationary and mobile phase.
- **Option D:** PCR amplifies a specific DNA segment; it does not separate fragments by size.

Final Answer: Gel electrophoresis (Option A)

Answer: (A)

Go Back to Question 14

Q15.

Solution

Concept: Vasectomy is a permanent surgical method of male sterilisation in which the vas deferens (sperm duct) on each side is cut, a small segment is removed, and the cut ends are tied or sealed. This prevents sperms from reaching the seminal fluid, making the male infertile.

Step 1: In a vasectomy, two small incisions are made in the scrotum, and each vas deferens is cut and sealed. After the procedure, the male continues to produce sperms in the testes, but they cannot pass out and are reabsorbed by the body.
Step 2: The corresponding procedure in females is tubectomy (cutting and tying the fallopian tubes to prevent the egg from reaching the uterus).

Why other options are wrong:

- **Option A:** Tubectomy is the surgical sterilisation of females, not males.
- **Option C:** Castration is the removal of the testes, which is not a standard contraceptive method.
- **Option D:** Amniocentesis is a prenatal diagnostic technique, not a contraceptive method.

Final Answer: Vasectomy (Option B)

Answer: (B)

Go Back to Question 15

Q16.

Solution

Concept: Stomata are microscopic pores found primarily on the lower epidermis of leaves in dicots. Each stoma is surrounded by two specialised, bean-shaped guard cells that control the size of the stomatal opening through changes in turgor pressure, thereby regulating gas exchange and water loss.

Step 1: When guard cells absorb water and become turgid, their inner thick walls curve apart, opening the stomatal pore, allowing CO_2 entry for photosynthesis and O_2 release.
Step 2: When guard cells lose water and become flaccid, the inner walls straighten, closing the pore and reducing water loss through transpiration.

Why other options are wrong:

- **Option A:** Lenticels are pores on the bark of woody stems for gas exchange, not on leaves.
- **Option C:** Hydathodes are structures at leaf margins through which guttation (loss of liquid water) occurs.
- **Option D:** Trichomes are hair-like outgrowths on the epidermis that reduce water loss or deter herbivores.

Final Answer: Stomata (Option B)

Answer: (B)

Go Back to Question 16

Q17.

Solution

Concept: The circulatory system uses a hierarchy of blood vessels: arteries → arterioles → capillaries → venules → veins. Capillaries are the thinnest, single-cell-walled vessels where exchange occurs. Venules are small vessels that collect blood from capillaries and merge to form veins.

Step 1: The passage states that "capillaries are the thinnest vessels where the actual exchange of gases, nutrients, and wastes between blood and tissues takes place." Therefore, the answer to sub-part 1 is **capillaries**.
Step 2: The passage states that "from the capillaries, blood is collected by venules, which join to form veins." Therefore, the answer to sub-part 2 is **venules**.

Final Answer:
1. Capillaries
2. Venules

Answer: (See above)

Go Back to Question 17

Q18.

Solution

Concept: Eukaryotic cells contain various membrane-bound organelles with specialised functions. Lysosomes contain hydrolytic enzymes for intracellular digestion and are sometimes called "suicide bags." Mitochondria are double-membrane organelles that generate ATP through aerobic respiration and are called the "powerhouses of the cell."

Step 1: **Lysosomes** are spherical, membrane-bound organelles containing about 50 different hydrolytic (digestive) enzymes such as proteases, lipases, and nucleases. They digest worn-out organelles, cellular debris, and engulfed foreign materials (bacteria), recycling their components.
Step 2: **Mitochondria** are double-membrane-bound organelles where the Krebs cycle (in the matrix) and the electron transport chain (on the inner membrane) generate most of the cell's ATP through aerobic respiration. Because they are the primary site of energy production, they are called the "powerhouses of the cell."

Final Answer:
1. lysosomes
2. mitochondria

Answer: (See above)
Go Back to Question 18

Q19.

Solution

Concept: The upper surface of a leaf is covered by a waxy, waterproof layer called the cuticle, which reduces water loss. The photosynthetic ground tissue of the leaf, consisting of palisade mesophyll and spongy mesophyll, is collectively called the mesophyll.

Step 1: Layer W is the **cuticle** – a thin, waxy, non-cellular coating secreted by the upper epidermal cells. It is composed of cutin (a waxy lipid polymer) and serves to minimise evaporative water loss from the leaf surface while still allowing light to pass through.
Step 2: Tissues X (palisade mesophyll) and Y (spongy mesophyll) together constitute the **mesophyll** – the photosynthetic ground tissue of the leaf. The palisade mesophyll is densely packed with chloroplasts for maximum photosynthesis, while the spongy mesophyll has air spaces that facilitate gas exchange.

Final Answer:
1. Cuticle
2. Mesophyll

Answer: (See above)
Go Back to Question 19

Q20.

Solution

Concept: Transcription is the first step of gene expression, in which a DNA template strand is copied into a complementary mRNA molecule by RNA polymerase. Transfer RNA (tRNA) is a small, cloverleaf-shaped RNA molecule that acts as an adaptor during translation, carrying specific amino acids to the ribosome.

Step 1: Transcription is the process in which RNA polymerase reads the template strand of DNA (3′ to 5′ direction) and synthesises a complementary mRNA strand (5′ to 3′ direction) using RNA nucleotides (A, U, G, C). The mRNA then carries the genetic code to the ribosome for translation.
Step 2: Transfer RNA (tRNA) is the small RNA molecule that has a specific anticodon at one end and an amino acid attachment site at the other. Each tRNA recognises and binds a specific amino acid, then matches its anticodon to the corresponding codon on the mRNA at the ribosome, ensuring the correct amino acid sequence in the growing polypeptide.

Final Answer:
1. transcription
2. transfer RNA (tRNA)

Answer: (See above)
Go Back to Question 20

Q21.

Solution

Concept: Plant hormones (phytohormones) are chemical messengers produced in minute quantities that regulate various aspects of plant growth and development. Each hormone has specific primary effects.

Step 1: Auxin (e.g., IAA – indole-3-acetic acid) promotes cell elongation, especially in shoots, and is responsible for phototropism (bending toward light) and geotropism, matching pair (a)–(ii).
Step 2: Gibberellin (e.g., GA_3) promotes stem elongation (internode elongation), breaks seed dormancy, and stimulates seed germination, matching pair (b)–(iv).
Step 3: Cytokinin (e.g., kinetin, zeatin) promotes cell division (cytokinesis), delays leaf senescence, and is widely used in plant tissue culture to induce shoot formation, matching pair (c)–(i).
Step 4: Ethylene is a gaseous hormone that promotes fruit ripening, leaf abscission (shedding), and flower senescence, matching pair (d)–(iii).

Final Answer: (a)-(ii), (b)-(iv), (c)-(i), (d)-(iii)

Answer: (See above)
Go Back to Question 21

Q22.

Solution

Concept: Biological magnification (biomagnification) is the progressive increase in the concentration of a persistent, non-biodegradable toxic substance at each successive trophic level. Eutrophication is the excessive nutrient enrichment of a water body, leading to algal blooms and oxygen depletion.

Step 1: Biological magnification (biomagnification) occurs because non-biodegradable toxins (such as DDT, mercury, lead) are not metabolised or excreted. They accumulate in the fatty tissues of organisms and become progressively more concentrated at each higher trophic level. For example, DDT concentration is lowest in water, higher in fish, and highest in fish-eating birds.
Step 2: Eutrophication occurs when excessive quantities of nutrients (especially nitrogen and phosphorus from agricultural runoff, sewage, and detergents) enter a water body. These nutrients stimulate massive algal growth (algal bloom), which blocks sunlight and, upon decomposition, depletes dissolved oxygen, leading to fish kills and biodiversity loss.

Final Answer:
1. biological magnification (biomagnification)
2. eutrophication

Answer: (See above)
Go Back to Question 22

Q23.

Solution

Concept: In the XX-XY system of sex determination, the mother contributes an X chromosome while the father contributes either X or Y. A person with blood group AB has both A and B antigens on RBCs but no anti-A or anti-B antibodies, making them a universal recipient, not a universal donor.

Step 1: Females are XX and can only contribute an X chromosome via their eggs. Males are XY and produce two types of sperm – X-bearing and Y-bearing. If an X-sperm fertilises the egg, the child is XX (female); if a Y-sperm fertilises the egg, the child is XY (male). Therefore, the father's sperm determines the sex of the child. Statement 1 is **True (T)**.
Step 2: Blood group AB has both A and B antigens on RBCs and no anti-A or anti-B antibodies in the plasma. This means AB individuals can *receive* blood from any group (universal recipient), but they *cannot donate* to all groups because their A and B antigens would be attacked by antibodies in the recipient's blood (except AB recipients). The universal *donor* is blood group O. Statement 2 is **False (F)**.

Final Answer:
1. True (T)
2. False (F)

Answer: (See above)
Go Back to Question 23

Q24.

Solution

Concept: Each organism is classified into one of the five kingdoms based on its cell structure, mode of nutrition, body organisation, and reproductive features.

Step 1: *Escherichia coli* is a bacterium – prokaryotic, unicellular, with a cell wall containing peptidoglycan. It belongs to **Kingdom Monera**, matching pair (a)–(ii).
Step 2: *Paramecium* is a eukaryotic, unicellular organism that moves using cilia. It belongs to **Kingdom Protista**, matching pair (b)–(iv).
Step 3: *Mucor* (bread mould) is a eukaryotic, multicellular (filamentous) fungus with a chitinous cell wall and saprophytic nutrition. It belongs to **Kingdom Fungi**, matching pair (c)–(i).
Step 4: The earthworm is a multicellular, eukaryotic, heterotrophic organism without a cell wall. It belongs to **Kingdom Animalia**, matching pair (d)–(iii).

Final Answer: (a)-(ii), (b)-(iv), (c)-(i), (d)-(iii)

Answer: (See above)
Go Back to Question 24

Q25.

Solution

Concept: The transport of substances in a plant occurs through two types of vascular tissue: xylem (for water and minerals) and phloem (for food). The upward movement of water is called ascent of sap, and the transport of prepared food is called translocation.

Step 1: **Ascent of sap** is the upward movement of water and dissolved mineral ions from the roots, through the xylem vessels and tracheids, to the stems, leaves, and other aerial parts of the plant. It is driven primarily by transpiration pull (suction) and aided by root pressure and capillary action.
Step 2: **Translocation** is the transport of organic food substances (primarily sucrose) from the site of synthesis (source, usually leaves) to the sites of utilisation or storage (sinks, such as roots, fruits, and growing tips) through the phloem sieve tubes. It is driven by the pressure-flow (mass-flow) mechanism.

Final Answer:
1. ascent of sap
2. translocation

Answer: (See above)
Go Back to Question 25

Q26.

Solution

Concept: Environmental pollution and global environmental issues arise from human activities. Each major issue has a specific cause, mechanism, and consequence.

Step 1: Ozone layer depletion is caused primarily by chlorofluorocarbons (CFCs) and halons released from refrigerants, aerosol sprays, and industrial processes. CFCs release chlorine atoms that catalytically destroy ozone molecules in the stratosphere, increasing harmful UV radiation reaching the Earth's surface, matching pair (a)–(iii).
Step 2: Global warming is the gradual increase in Earth's average surface temperature caused by the enhanced greenhouse effect due to increased emissions of greenhouse gases (CO_2, CH_4, N_2O) from burning fossil fuels and deforestation, matching pair (b)–(i).
Step 3: Water pollution is the contamination of water bodies by the discharge of harmful substances such as industrial effluents, sewage, pesticides, and heavy metals, matching pair (c)–(ii).
Step 4: Acid rain is precipitation with a pH below 5.6, caused by the dissolution of sulphur dioxide (SO_2) and nitrogen oxides (NO_x) emitted from fossil fuel combustion into atmospheric water, forming sulphuric and nitric acids, matching pair (d)–(iv).

Final Answer: (a)-(iii), (b)-(i), (c)-(ii), (d)-(iv)

Answer: (See above)

Go Back to Question 26

Q27.

Solution

Concept: Gene therapy aims to treat or cure genetic disorders by introducing a functional copy of a defective gene into the patient's cells. Antibiotics are effective only against bacteria, not against viruses.

Step 1: Gene therapy involves identifying the defective gene responsible for a genetic disorder, isolating a normal, functional copy of that gene, and delivering it into the patient's cells using a vector (often a modified virus). The functional gene then produces the missing or defective protein, alleviating the symptoms. Statement 1 is **True (T)**.
Step 2: Antibiotics (e.g., penicillin, tetracycline) work by targeting specific bacterial structures or metabolic pathways (cell wall synthesis, protein synthesis, etc.) that are absent in viruses. Viruses lack cellular machinery and replicate inside host cells, making them inherently resistant to antibiotics. Viral infections require antiviral drugs or are managed by the immune system and vaccination. Statement 2 is **False (F)**.

Final Answer:
1. True (T)
2. False (F)

Answer: (See above)

Go Back to Question 27

Q28.

Solution

Concept: A flower's female reproductive organ (pistil/carpel) consists of three parts: the stigma (receives pollen), the style (connects stigma to ovary), and the ovary (contains ovules). The anther is the part of the stamen (male organ) that produces pollen.

Step 1: The ovary is the swollen basal part of the pistil that contains one or more ovules, each harbouring an egg cell. After fertilisation, ovules develop into seeds and the ovary develops into a fruit, matching pair (a)–(iii).
Step 2: The stigma is the sticky, receptive surface at the top of the pistil where pollen grains land and adhere during pollination, matching pair (b)–(i).
Step 3: The style is the elongated, slender tube connecting the stigma to the ovary. After pollination, the pollen tube grows down through the style to reach the ovule, matching pair (c)–(ii).
Step 4: The anther is the bilobed structure at the top of the stamen's filament. It contains pollen sacs (microsporangia) where pollen grains (containing male gametes) are produced and released, matching pair (d)–(iv).

Final Answer: (a)-(iii), (b)-(i), (c)-(ii), (d)-(iv)

Answer: (See above)

Go Back to Question 28

Q29.

Solution

Concept: Stomata open and close through changes in the turgor pressure of the two guard cells surrounding the stomatal pore. When guard cells absorb water and become turgid, the stoma opens; when they lose water and become flaccid, the stoma closes.

Open Closed

Step 1 – Opening: During the day, photosynthesis in guard cells reduces CO_2 concentration, raising pH. This activates enzymes that convert starch to organic acids and promotes active uptake of K^+ ions. The increased solute concentration lowers the water potential inside guard cells, causing water to enter by osmosis. The guard cells become turgid; because their inner walls are thick and inelastic while outer walls are thin, the cells curve apart, **opening** the stomatal pore.
Step 2 – Closing: In the dark, CO_2 accumulates, K^+ ions move out, and water leaves the guard cells by osmosis. The guard cells become flaccid and straighten, **closing** the pore. This reduces water loss through transpiration during the night when photosynthesis is not occurring.

Final Answer: Stomata open when guard cells become turgid (water influx) and close when guard cells become flaccid (water efflux), regulated by K^+ ion movement and osmosis.

Answer: (See above)

Go Back to Question 29

Q30.

Solution

Concept: Vegetative propagation is a type of asexual reproduction in which new plants develop from vegetative parts (roots, stems, or leaves) of the parent plant, without the formation of seeds or spores. The offspring are genetically identical (clones) to the parent.

Step 1: Vegetative propagation is defined as the formation of a new plant from any vegetative part (root, stem, leaf, or bud) of the parent plant. Since no fusion of gametes is involved, the offspring are genetically identical to the parent.
Step 2: Two natural methods: (a) **Budding by tubers:** A stem tuber (e.g., potato) has "eyes" (buds) on its surface. Each eye can sprout and grow into a new plant. (b) **Runners (stolons):** A runner is a horizontal, above-ground stem that grows along the soil surface. At nodes, it produces adventitious roots and shoots, forming new daughter plants. Example: strawberry.

Final Answer: Vegetative propagation: new plants from vegetative parts without seeds. Examples: tubers (potato) and runners (strawberry).

Answer: (See above)
Go Back to Question 30

Q31.

Solution

Concept: Biodiversity conservation strategies are broadly classified into *in situ* (on-site, in the natural habitat) and *ex situ* (off-site, outside the natural habitat). Both approaches aim to prevent species extinction and maintain genetic diversity.

Alternative (i) – In situ conservation:
Step 1: In situ conservation means protecting and managing species in their natural habitats by establishing protected areas such as national parks, wildlife sanctuaries, and biosphere reserves. The entire ecosystem, including all its biodiversity, is conserved together.
Step 2: Example in India: **Jim Corbett National Park** (Uttarakhand) – India's oldest national park, established in 1936, primarily for the conservation of the Bengal tiger and its habitat.

Alternative (ii) – Ex situ conservation:
Step 1: Ex situ conservation means the conservation of species outside their natural habitats, in artificially maintained environments such as zoos, botanical gardens, aquaria, seed banks, and gene banks.
Step 2: Example: **National Bureau of Plant Genetic Resources (NBPGR), New Delhi** – a seed bank that stores seeds of diverse crop varieties under controlled conditions for long-term conservation. Another example: zoological gardens (e.g., Delhi Zoo) that maintain breeding programmes for endangered species.

Final Answer: (i) In situ: conservation in natural habitat; e.g., Jim Corbett National Park; (ii) Ex situ: conservation outside natural habitat; e.g., seed banks (NBPGR) or zoos.

Answer: (See above)
Go Back to Question 31

Q32.

Solution

Concept: Xylem and phloem are the two complex vascular tissues in plants. Xylem transports water and minerals upward; phloem transports prepared food. Bone and cartilage are specialised connective tissues differing in rigidity and matrix composition.

Alternative (i) – Xylem vs Phloem:
Step 1 (a): **Xylem** transports water and dissolved minerals upward from the roots to the aerial parts. **Phloem** transports prepared organic food (mainly sucrose) from the leaves (source) to all other parts of the plant (sinks).
Step 2 (b): The conducting cells of xylem (tracheids and vessels) are **dead** at maturity – their empty, lignified cell walls form rigid tubes. The conducting cells of phloem (sieve tube elements) are **living** at maturity (though they lack a nucleus and depend on companion cells).

Alternative (ii) – Bone vs Cartilage:
Step 1 (a): **Bone** is extremely rigid and hard, providing strong structural support and protection. **Cartilage** is flexible and semi-rigid, providing support with some pliability (e.g., ear pinna, nose tip).
Step 2 (b): The bone matrix is hard and calcified, containing calcium salts (calcium phosphate) deposited in an organic framework of collagen. The cartilage matrix is soft, non-calcified, and composed mainly of chondroitin sulphate and collagen fibres, giving it elasticity.

Final Answer: (i) Xylem: water/minerals, dead cells; Phloem: food, living cells; (ii) Bone: rigid, calcified matrix; Cartilage: flexible, non-calcified matrix.

Answer: (See above)

Go Back to Question 32

Q33.

Solution

Concept: The complete aerobic oxidation of one glucose molecule yields 36 ATP and releases 6 CO_2. The overall equation is: $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + 36$ ATP.

Step 1: From the data given, 1 glucose molecule yields 36 ATP and 6 CO_2.
Step 2: For 5 glucose molecules:
Total ATP produced = $5 \times 36 = 180$ ATP molecules.
Step 3: Total CO_2 released = $5 \times 6 = 30$ CO_2 molecules.

Final Answer: 180 ATP molecules produced; 30 CO_2 molecules released.

Answer: (See above)

Go Back to Question 33

Q34.

Solution

Concept: Incomplete dominance is a form of non-Mendelian inheritance in which the heterozygote shows an intermediate (blended) phenotype. When two heterozygotes are crossed, the offspring show a $1:2:1$ phenotypic ratio.

	R	r
R	RR	Rr
r	Rr	rr

Step 1: Each pink parent (Rr) produces two types of gametes: R and r, in equal proportions.
Step 2: The Punnett square gives: 1 RR (red) : 2 Rr (pink) : 1 rr (white).
Step 3: Since dominance is incomplete, each genotype produces a distinct phenotype: RR = red, Rr = pink (intermediate), rr = white.
Step 4: Phenotypic ratio = **1 red : 2 pink : 1 white**.

Final Answer: Phenotypic ratio: 1 red : 2 pink : 1 white.

Answer: (See above)

Go Back to Question 34

Q35.

Solution

Concept: A hormone is a chemical messenger produced by an endocrine gland in very small quantities, secreted directly into the bloodstream, and carried to a specific target organ where it produces a specific physiological effect.

Alternative (i):

Step 1: A **hormone** is a chemical substance produced by a ductless (endocrine) gland, secreted in trace amounts into the blood, and transported to a distant target organ where it regulates a specific function.

Step 2: The ovary secretes the hormone **oestrogen** (estrogen). Oestrogen is responsible for the development of female secondary sexual characteristics (breast development, widening of hips), regulation of the menstrual cycle, and maintenance of the reproductive system.

Alternative (ii):

Step 1: A hormone is defined as above.

Step 2: The **parathyroid glands** (four small glands embedded in the posterior surface of the thyroid gland) secrete **parathyroid hormone (PTH / parathormone)**, which regulates blood calcium levels. PTH raises blood calcium by stimulating the release of calcium from bones, increasing calcium absorption in the intestine, and reducing calcium excretion by the kidneys.

Final Answer: (i) Hormone: chemical messenger from endocrine gland; Oestrogen from ovary: develops female secondary sexual characters; (ii) Parathormone from parathyroid glands: raises blood calcium.

Answer: (See above)

Go Back to Question 35

Q36.

Solution

Concept: Minerals are inorganic elements required in the diet in small amounts for various physiological functions including enzyme activity, structural support, and regulation. Deficiency of specific minerals causes specific diseases.

Step 1: **Minerals** (dietary minerals) are inorganic nutrients required by the body in small quantities for normal growth, development, and physiological functioning. They cannot be synthesised by the body and must be obtained from food. Examples include calcium, iron, iodine, phosphorus, zinc, and fluoride.
Step 2: Deficiency of **iron** causes **anaemia** – a condition in which the blood has an insufficient number of healthy red blood cells or insufficient haemoglobin, resulting in fatigue, weakness, and paleness.
Step 3: Deficiency of **fluoride** causes **dental caries (tooth decay)** – a condition in which the tooth enamel weakens, becoming susceptible to bacterial attack and cavity formation. Fluoride strengthens tooth enamel by forming fluorapatite, which resists acid dissolution.

Final Answer: Minerals are inorganic dietary nutrients. Iron deficiency causes anaemia; fluoride deficiency causes dental caries.

Answer: (See above)
Go Back to Question 36

Q37.

Solution

Concept: The human brain is the central organ of the nervous system. It is broadly divided into three main parts: the cerebrum (forebrain), the cerebellum (hindbrain), and the medulla oblongata (brain stem), each controlling different functions.

Step 1: The **cerebrum** is the largest part of the brain. It is the centre for higher mental functions: thinking, reasoning, memory, intelligence, learning, speech, sensory perception, and voluntary motor control.
Step 2: The **cerebellum** is located at the back of the brain, below the cerebrum. Its main function is to coordinate voluntary muscular movements, maintain body balance and posture, and ensure smooth, precise movement.
Step 3: The **medulla oblongata** is located at the base of the brain, continuous with the spinal cord. It controls vital involuntary functions such as heartbeat, breathing rate, blood pressure, swallowing, coughing, and sneezing.

Final Answer: Cerebrum (thinking, memory, voluntary actions); Cerebellum (balance, coordination); Medulla oblongata (heartbeat, breathing, involuntary functions).

Answer: (See above)
Go Back to Question 37

Q38.

Solution

Concept: An autoimmune disease occurs when the immune system mistakenly attacks the body's own tissues. Gene therapy is a therapeutic technique that aims to correct genetic disorders by introducing functional genes. Several genetic diseases are candidates for gene therapy.

Step 1 – Autoimmune disease: An **autoimmune disease** is a condition in which the immune system fails to distinguish "self" from "non-self" and produces antibodies or activated T-cells that attack the body's own healthy cells and tissues. Example: **Rheumatoid arthritis** – the immune system attacks the lining of the joints, causing chronic inflammation, pain, and joint deformity. Another example: Type 1 diabetes mellitus – immune cells destroy insulin-producing beta cells of the pancreas.

Step 2 – Gene therapy: Gene therapy is a biomedical technique in which a normal, functional copy of a defective or missing gene is introduced into the patient's target cells using a vector (usually a modified retrovirus or adenovirus). The inserted gene produces the functional protein that was missing or defective, thereby treating the underlying genetic cause of the disease.

Step 3: Gene therapy has been attempted for **Severe Combined Immunodeficiency (SCID)** (also called "bubble boy disease"), caused by a defective gene for the enzyme adenosine deaminase (ADA). A functional ADA gene is introduced into the patient's lymphocytes.

Final Answer: A. Autoimmune disease: immune system attacks own tissues (e.g., rheumatoid arthritis); B. Gene therapy: inserting a functional gene to correct a genetic disorder; C. Attempted for SCID (ADA deficiency).

Answer: (See above)

Go Back to Question 38

Q39.

Solution

Concept: The ABO blood group system classifies human blood into four groups (A, B, AB, O) based on the antigens on RBCs and antibodies in plasma. Sex-linked inheritance refers to the inheritance of genes located on the sex chromosomes, particularly the X chromosome.

Alternative (i) – ABO blood groups:

Step 1:

Blood Group	Antigen on RBCs	Antibody in Plasma
A	A	Anti-B
B	B	Anti-A
AB	A and B	None
O	None	Anti-A and Anti-B

Step 2: Blood group **AB is the universal recipient** because it has no antibodies (anti-A or anti-B) in the plasma, so it will not attack the RBCs of any donor blood group.

Solution

Alternative (ii) – Sex-linked inheritance:

Step 1: Sex-linked inheritance refers to the pattern of inheritance of genes located on the sex chromosomes (X or Y). Most sex-linked traits are X-linked because the X chromosome carries many more genes than the Y.

Step 2: Haemophilia is caused by a recessive allele (h) on the X chromosome. A carrier mother ($X^H x^h$) has one normal allele and one defective allele. The father is normal ($X^H Y$).

Step 3: Cross: $X^H x^h$ (carrier mother) $\times$ $X^H Y$ (normal father).

Daughters: $X^H X^H$ (normal) and $X^H x^h$ (carrier) – no daughter is affected.

Sons: $X^H Y$ (normal) and $x^h Y$ (**haemophilic**) – 50% chance a son is affected.

Step 4: Sons inherit their single X from the mother. If a son receives x^h, he has no second X to mask it and is haemophilic. This explains why haemophilia predominantly affects males.

Final Answer: (i) ABO system: A (antigen A, anti-B), B (antigen B, anti-A), AB (both, no antibodies – universal recipient), O (none, both antibodies); (ii) Sex-linked: genes on X chromosome; carrier mother ($X^H x^h$) transmits haemophilia to 50% sons.

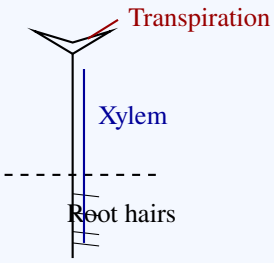
Answer: (See above)

Go Back to Question 39

Q40.

Solution

Concept: Water is absorbed from the soil by root hairs through osmosis and transported upward through the xylem to the leaves, driven primarily by transpiration pull, with contributions from root pressure and capillary action.



Step 1 – Root hair absorption: Root hairs are elongated epidermal cells that greatly increase the surface area of the root. The cell sap inside root hairs has a higher solute concentration (lower water potential) than the surrounding soil water, so water enters root hairs by **osmosis** (from higher water potential to lower water potential).

Step 2 – Root pressure: Mineral ions actively pumped into the xylem of the root lower the water potential inside the xylem. Water then follows by osmosis, creating a positive hydrostatic pressure called **root pressure** that pushes water upward. Root pressure is significant mainly in small, herbaceous plants and at night.

Step 3 – Transpiration pull: As water evaporates from the stomata of the leaves (transpiration), it creates a negative pressure (tension) in the xylem. This **transpiration pull**, combined with the cohesive forces between water molecules (cohesion-tension theory), draws a continuous column of water upward from the roots through the xylem to the leaves. This is the dominant force for water transport in tall plants.

Final Answer: Water enters root hairs by osmosis, is pushed up by root pressure, and is pulled up through xylem by transpiration pull (cohesion-tension mechanism).

Answer: (See above)

Go Back to Question 40

Q41.

Solution

Concept: Food adulteration is the deliberate contamination of food with inferior, harmful, or non-food substances to increase profit. Sexually transmitted diseases (STDs) are infections transmitted primarily through sexual contact.

Alternative (i) – Food adulteration:

Step 1: Food adulteration is the intentional addition of inferior, non-food, or harmful substances to food products, or the removal of vital nutrients, to increase quantity, improve appearance, or reduce cost. Examples: adding brick powder to chilli powder, adding water to milk, using artificial colours in sweets.

Step 2: Harmful effects: (a) Causes serious health problems including stomach disorders, food poisoning, kidney and liver damage, and cancer. (b) Nutritional value of food is reduced, leading to malnutrition.

Step 3: Prevention: (a) Buying food from certified, trusted sources and checking FSSAI labels. (b) Strict implementation of food safety laws (e.g., Food Safety and Standards Act) and regular inspection by food inspectors.

Alternative (ii) – STDs:

Step 1: Sexually transmitted diseases (STDs) are infectious diseases that are primarily transmitted from person to person through sexual contact (vaginal, oral, or anal intercourse). They can also be transmitted from mother to child during pregnancy, birth, or breastfeeding, or through contaminated blood.

Step 2: STD caused by a bacterium: **Gonorrhoea** (caused by *Neisseria gonorrhoeae*). STD caused by a virus: **AIDS** (caused by the Human Immunodeficiency Virus / HIV).

Step 3: Preventive measure: Use of barrier contraceptives (e.g., condoms) during sexual intercourse to prevent the transmission of pathogens.

Final Answer: (i) Food adulteration: intentional contamination of food; harmful effects: health damage, nutritional loss; prevention: buy certified food, enforce food laws; (ii) STDs: sexually transmitted infections; gonorrhoea (bacterial), AIDS (viral); prevention: use condoms.

Answer: (See above)

Go Back to Question 41

Q42.

Solution

Concept: The human menstrual cycle is a monthly hormonal cycle regulated by FSH, LH, oestrogen, and progesterone, consisting of four phases. Mendel's law of independent assortment states that alleles of different genes assort independently during gamete formation.

Alternative (i) – Menstrual cycle:

Step 1 – Menstrual phase (Days 1–5): The uterine lining (endometrium) breaks down and is shed along with blood through the vagina (menstruation). Hormone levels (oestrogen, progesterone) are at their lowest.

Step 2 – Follicular phase (Days 6–13): FSH from the pituitary stimulates the development of a follicle in the ovary. The growing follicle secretes oestrogen, which thickens and repairs the uterine lining.

Step 3 – Ovulation (Day 14): A surge of LH from the pituitary triggers the release of the mature egg (ovum) from the Graafian follicle of the ovary. This is the most fertile period.

Step 4 – Luteal phase (Days 15–28): The ruptured follicle transforms into the corpus luteum, which secretes progesterone (and some oestrogen). Progesterone maintains and further thickens the endometrium, preparing it for implantation.

Step 5 (b): If the egg is not fertilised, the corpus luteum degenerates after about 14 days, progesterone and oestrogen levels drop sharply, and the endometrium can no longer be maintained. It breaks down and is shed, starting a new menstrual cycle.

Solution

Alternative (ii) – Dihybrid cross:

Step 1 (a): **Mendel's law of independent assortment** states that during gamete formation, the alleles of one gene pair segregate independently of the alleles of another gene pair, provided the two genes are located on different (non-homologous) chromosomes. This results in all possible combinations of alleles in the gametes.

Step 2 (b): Cross: RrYy $\times$ RrYy. Each parent produces 4 types of gametes: RY, Ry, rY, ry.

Step 3: The 4×4 Punnett square (16 combinations) yields the classic dihybrid phenotypic ratio:

- 9 Round Yellow (R_Y_)
- 3 Round Green (R_yy)
- 3 Wrinkled Yellow (rrY_)
- 1 Wrinkled Green (rryy)

Step 4: Phenotypic ratio = **9 : 3 : 3 : 1**.

Final Answer: (i) Menstrual cycle: menstrual $\rightarrow$ follicular $\rightarrow$ ovulation $\rightarrow$ luteal; if unfertilised, endometrium sheds; (ii) Independent assortment: genes on different chromosomes segregate independently; RrYy $\times$ RrYy gives 9:3:3:1 phenotypic ratio.

Answer: (See above)

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Q43.

Solution

Concept: Aerobic respiration is the complete, stepwise oxidation of glucose in the presence of oxygen, occurring in three stages: glycolysis, the Krebs cycle, and the electron transport chain. The human excretory system centres on the kidneys, which form urine through filtration, reabsorption, and secretion.

Alternative (i) – Aerobic respiration:

Step 1 – Glycolysis: Site: cytoplasm. Input: 1 glucose (6C). Output: 2 pyruvic acid (3C each) + 2 ATP (net) + 2 NADH. Does not require oxygen.

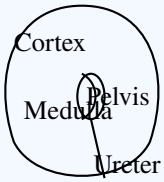
Step 2 – Krebs cycle: Site: mitochondrial matrix. Input: 2 acetyl-CoA (derived from 2 pyruvic acid). Output: 6 CO_2 + 2 ATP (via GTP) + 8 NADH + 2 $FADH_2$. Each turn of the cycle completely oxidises one acetyl group, releasing CO_2.

Step 3 – Electron transport chain (ETC): Site: inner mitochondrial membrane. Role: NADH and $FADH_2$ donate electrons to a chain of carrier proteins. As electrons pass through the chain, energy is released and used to pump H^+ ions across the membrane; the protons flow back through ATP synthase, generating ATP (oxidative phosphorylation). O_2 is the final electron acceptor, forming H_2O. Produces 32–34 ATP.

Step 4: Net ATP yield per glucose molecule $\approx$ **36 ATP** (2 from glycolysis + 2 from Krebs + 32–34 from ETC).

Solution

Alternative (ii) – Human kidney and urine formation:



Step 1: The kidney has an outer **cortex** (contains Bowman's capsules and convoluted tubules of nephrons), an inner **medulla** (contains loops of Henle and collecting ducts), and a central **renal pelvis** (collects urine and drains into the ureter).

Step 2 – Glomerular filtration: Blood enters the glomerulus (capillary tuft inside Bowman's capsule) under high pressure. Water, salts, glucose, amino acids, urea, and other small molecules are filtered out into the Bowman's capsule as **glomerular filtrate**. Blood cells and large proteins remain in the blood.

Step 3 – Tubular reabsorption: As the filtrate passes through the proximal tubule, loop of Henle, and distal tubule, useful substances (glucose, amino acids, most water, and essential ions) are selectively reabsorbed back into the surrounding blood capillaries.

Step 4 – Tubular secretion: Waste substances (excess H^+ ions, K^+ ions, certain drugs) that were not filtered initially are actively secreted from the blood capillaries into the tubular fluid, ensuring their removal. The final fluid in the collecting duct is **urine**, which passes to the renal pelvis and then down the ureter to the bladder.

Final Answer: (i) Aerobic respiration: glycolysis (cytoplasm, 2 ATP), Krebs cycle (matrix, 2 ATP + CO_2), ETC (inner membrane, 32 ATP); total $\approx$ 36 ATP per glucose; (ii) Kidney: cortex, medulla, pelvis; urine formed by glomerular filtration $\rightarrow$ tubular reabsorption $\rightarrow$ tubular secretion.

Answer: (See above)

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Answer Key

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