



UACE BIOLOGY

ITEM BANK

New Curriculum

- Challenging Scenarios • In-Depth Questions • Detailed Answers •
- Exam Success! •

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Welcome to the UACE Biology Item Bank – New Curriculum

Dear students and fellow learners,

Welcome to this carefully designed Biology Item Bank for the Uganda Advanced Certificate of Education (UACE) under the new curriculum. This collection has been meticulously structured to cover all topics, with scenario-based, story-like questions that challenge your understanding, reasoning, and problem-solving skills.

Each item is long, detailed, and thought-provoking, reflecting real-life biological situations. They are designed not just to test your memory, but to help you think critically, integrate knowledge across topics, and apply concepts practically. Answers are provided in detail, allowing you to learn, self-assess, and master each concept effectively.

We hope this item bank becomes an invaluable resource on your study journey, helping you excel in exams, gain confidence, and develop the analytical skills of a true biologist. Dive in, challenge yourself, and embrace the excitement of learning biology!

– joelPCM

Dedication

I dedicate this UACE Biology Item Bank with heartfelt gratitude and appreciation to:

My beloved parents, Kahuma Patrick and Kanyunyuzi Annette, for their unwavering support, encouragement, and belief in my dreams.

My brother, Akugizibwe Patrick, for always inspiring me to strive for excellence. All my friends and teachers who guided, encouraged, and contributed ideas to help bring this item bank to life.

Most importantly, I dedicate this book to all students across Uganda, with the hope that it will serve as a valuable resource, strengthen your understanding of biology, and help you achieve success in your academic journey.

May this work inspire learning, curiosity, and excellence in every student who uses it.

– joelPCM

Acknowledgement

I wish to express my deepest gratitude to all those who have supported and guided me in the creation of this UACE Biology Item Bank.

First and foremost, I thank my beloved parents, Kahuma Patrick and Kanyunyuzi Annette, for their endless encouragement, wisdom, and support throughout this journey. To my brother, Akugizibwe Patrick, thank you for your constant motivation and belief in my abilities.

I also acknowledge my friends and teachers who generously shared their knowledge, ideas, and time, providing guidance that made this work possible. Your contributions have been invaluable.

Finally, I extend my gratitude to all students across Uganda, whose desire for knowledge inspired the creation of this item bank. May this resource serve you well in your studies and help you achieve academic excellence.

– joelPCM

2.0 DETAILED SYLLABUS	10
Senior Five Term 1	10
Topic 1: Cell Biology	10
Senior Five Term 2	13
Topic 2: Nutrition	13
Topic 3: Transport	15
Senior Five Term 3	17
Topic 4: Respiration	17
Topic 5: homeostasis	19
Senior Six: Term 1	21
Topic 6: Coordination	21
Senior Six: Term 2	24
Topic 7: Inheritance and Evolution	24
Topic 8: Growth and Development	27
Senior Six: Term 3	28
Topic 9: Ecology	28

CELL BIOLOGY

Item 1

A student prepared temporary slides of onion epidermal cells and cheek epithelial cells and observed them under a light microscope. The onion cells appeared rectangular with a clearly defined cell wall, while the cheek cells were irregular and lacked a cell wall.

- Identify the type of cells observed from each specimen.
- Explain two structural differences observed between the two types of cells.
- Account for the presence of a large vacuole in onion epidermal cells.
- State one function of each of the following cell structures: cell wall, nucleus.

Item 2

During a biology lesson, a learner observed that red blood cells lack a nucleus while liver cells possess one. The teacher explained that this difference is related to their functions.

- (a) State the function of red blood cells in mammals.
- (b) Explain how the absence of a nucleus in red blood cells enhances their function.
- (c) Give two functions of the nucleus in a typical animal cell.
- (d) Suggest one disadvantage of lacking a nucleus in red blood cells.

Item 3

A student placed living cells in a concentrated salt solution and noticed that the cell contents shrank away from the cell wall.

- (a) Name the process responsible for this observation.
- (b) Explain the process named in (a).
- (c) State the term used to describe the condition of the cell after the observation.
- (d) Suggest one importance of this process in living organisms.

Item 4

In an experiment, potato strips of equal length were placed in different sugar solutions of varying concentrations. After one hour, some strips increased in length while others decreased.

- (a) Name the process responsible for the changes in length.
- (b) Explain why some strips increased in length while others decreased.
- (c) State the term used to describe a solution in which there is no change in length.
- (d) Give one importance of this process in plants.

Item 5

A biology teacher emphasized that the plasma membrane is selectively permeable.

- (a) Define the term selectively permeable.
- (b) Describe the structure of the plasma membrane.
- (c) Explain how this structure enables selective permeability.
- (d) State one importance of selective permeability to a living cell.

Item 6

A student compared diffusion and active transport during revision.

- (a) Define diffusion.

- (b) State two factors affecting the rate of diffusion.
- (c) Distinguish between diffusion and active transport.
- (d) Give one example of a substance transported by diffusion in living organisms.

Item 7

Mitochondria are abundant in muscle cells but few in fat storage cells.

- (a) State the main function of mitochondria.
- (b) Explain why muscle cells contain many mitochondria.
- (c) Describe the structure of a mitochondrion.
- (d) Suggest one cell type that would have very few mitochondria and explain why.

Item 8

A student examined a diagram of a plant cell and noticed chloroplasts only in some cells.

- (a) State the function of chloroplasts.
- (b) Explain why chloroplasts are absent in root hair cells.
- (c) Describe the internal structure of a chloroplast.
- (d) State one adaptation of chloroplasts for their function.

Item 9

During protein synthesis, ribosomes play an important role.

- (a) State the function of ribosomes.
- (b) Distinguish between free ribosomes and those attached to the endoplasmic reticulum.
- (c) Explain the importance of ribosomes to living cells.
- (d) Suggest one consequence of ribosome malfunction.

Item 10

A student observed that lysosomes are common in white blood cells.

- (a) State the function of lysosomes.
- (b) Explain why lysosomes are abundant in white blood cells.
- (c) State two other roles of lysosomes in animal cells.
- (d) Suggest what would happen to a cell if lysosomes ruptured.

Item 11

The endoplasmic reticulum exists in two forms: rough and smooth.

- (a) Distinguish between rough and smooth endoplasmic reticulum.
- (b) State one function of each form.
- (c) Explain the importance of the rough endoplasmic reticulum in secretory cells.
- (d) Suggest one cell where smooth endoplasmic reticulum is abundant and explain why.

Item 12

The Golgi apparatus is often described as the packaging unit of the cell.

- (a) State the function of the Golgi apparatus.
- (b) Describe the structure of the Golgi apparatus.
- (c) Explain how its structure is related to its function.
- (d) State one importance of the Golgi apparatus in multicellular organisms.

Item 13

A student stated that all cells arise from pre-existing cells.

- (a) Name the cell theory associated with this statement.
- (b) State two other principles of the cell theory.
- (c) Explain the importance of the cell theory in biology.
- (d) Suggest one limitation of the cell theory.

Item 14

Some cells are described as specialised.

- (a) Define cell specialisation.
- (b) Describe two structural adaptations of a sperm cell.
- (c) Explain how each adaptation aids its function.
- (d) State one advantage of cell specialisation in multicellular organisms.

Item 15

Root hair cells are adapted for absorption.

- (a) State the function of root hair cells.
- (b) Describe two structural features of root hair cells.
- (c) Explain how each feature enhances absorption.
- (d) Suggest one factor that may reduce absorption efficiency.

Item 16

Cilia and flagella are found in some cells.

- (a) Distinguish between cilia and flagella.
- (b) State one function of cilia in humans.
- (c) Explain the importance of flagella in unicellular organisms.
- (d) Name one cell that possesses a flagellum.

Item 17

A student observed cells at different stages of division.

- (a) Name the type of cell division responsible for growth.
- (b) State the significance of this type of division.
- (c) Mention two cell structures involved during division.
- (d) Suggest one consequence of uncontrolled cell division.

Item 18

Some cells contain many vacuoles while others have none.

- (a) State the function of vacuoles in plant cells.
- (b) Explain why animal cells lack large vacuoles.
- (c) State one role of vacuoles in maintaining cell shape.
- (d) Suggest one advantage of large vacuoles in plants.

Item 19

Prokaryotic cells differ from eukaryotic cells.

- (a) Define a prokaryotic cell.
- (b) State two differences between prokaryotic and eukaryotic cells.
- (c) Name one organism with prokaryotic cells.
- (d) Suggest one advantage of prokaryotic cell structure.

Item 20

Cells depend on each other in multicellular organisms.

- (a) Explain what is meant by cell interdependence.
- (b) Give two examples of cell interdependence in humans.
- (c) Explain why single-celled organisms do not show interdependence.
- (d) State one advantage of multicellularity.

ANSWERS / MARKING GUIDE

Item 1

- (a) Onion epidermal cells – plant cells; cheek epithelial cells – animal cells.*
- (b) Onion cells have a cell wall; cheek cells lack a cell wall. Onion cells have a large vacuole; cheek cells have small or no vacuoles.*
- (c) To maintain turgidity and store cell sap.*
- (d) Cell wall – provides support and protection; nucleus – controls cell activities.*

Item 2

- (a) Transport of oxygen.*
- (b) Absence of nucleus creates more space for haemoglobin.*
- (c) Controls cell activities; stores genetic material.*
- (d) Red blood cells cannot divide or repair themselves.*

Item 3

- (a) Osmosis.*
- (b) Movement of water from a region of higher water potential to lower water potential through a semi-permeable membrane.*
- (c) Plasmolysed.*
- (d) Helps in absorption of water by plant roots.*

Item 4

- (a) Osmosis.*
- (b) Water entered strips in dilute solutions and left strips in concentrated solutions.*
- (c) Isotonic solution.*
- (d) Maintains turgidity in plant tissues.*

Item 5

- (a) Allows some substances to pass through while restricting others.*
- (b) Phospholipid bilayer with embedded proteins.*
- (c) Lipid layer blocks ions; protein channels allow specific molecules.*
- (d) Maintains internal cell environment.*

Item 6

- (a) Movement of particles from high to low concentration.*
- (b) Concentration gradient; temperature.*

- (c) Diffusion is passive; active transport requires energy and occurs against gradient.*
- (d) Oxygen.*

Item 7

- (a) Site of aerobic respiration.*
- (b) Muscle cells require large amounts of energy.*
- (c) Double membrane with folded inner membrane (cristae).*
- (d) Fat storage cells – low energy demand.*

Item 8

- (a) Photosynthesis.*
- (b) Root hair cells are underground and receive no light.*
- (c) Grana, thylakoids, stroma.*
- (d) Large surface area for light absorption.*

Item 9

- (a) Protein synthesis.*
- (b) Free ribosomes make intracellular proteins; attached ribosomes make secretory proteins.*
- (c) Essential for enzyme and hormone production.*
- (d) Cell fails to produce proteins.*

Item 10

- (a) Intracellular digestion.*
- (b) White blood cells destroy pathogens.*
- (c) Autolysis; removal of worn-out organelles.*
- (d) Cell may self-digest.*

Item 11

- (a) Rough ER has ribosomes; smooth ER lacks ribosomes.*
- (b) Rough ER – protein synthesis; smooth ER – lipid synthesis.*
- (c) Enables mass production and transport of proteins.*
- (d) Liver cells – detoxification.*

Item 12

- (a) Modification and packaging of proteins.*
- (b) Flattened membranous sacs (cisternae).*
- (c) Large surface area for packaging and transport.*
- (d) Enables secretion of hormones and enzymes.*

Item 13

- (a) Cell theory.*
- (b) All living things are made of cells; cells are the basic unit of life.*
- (c) Foundation of modern biology.*
- (d) Does not explain origin of first cell.*

Item 14

- (a) Structural and functional adaptation of cells.*
- (b) Long tail; many mitochondria.*
- (c) Tail aids movement; mitochondria supply energy.*
- (d) Efficient division of labour.*

Item 15

- (a) Absorption of water and mineral salts.*
- (b) Long hair-like extension; thin cell wall.*
- (c) Increases surface area; reduces diffusion distance.*
- (d) Dry soil.*

Item 16

- (a) Cilia are short and numerous; flagella are long and few.*
- (b) Move mucus in respiratory tract.*
- (c) Enables locomotion.*
- (d) Sperm cell.*

Item 17

- (a) Mitosis.*
- (b) Growth and repair of tissues.*
- (c) Spindle fibres; chromosomes.*
- (d) Cancer.*

Item 18

- (a) Storage of cell sap.*
- (b) Animal cells do not require turgidity.*
- (c) Maintains turgor pressure.*
- (d) Provides support.*

Item 19

- (a) Cell without a true nucleus.*
- (b) Prokaryotes lack membrane-bound organelles; eukaryotes have them.*
- (c) Bacteria.*
- (d) Rapid reproduction.*

Item 20

- (a) Dependence of cells on each other for survival.*
- (b) Red blood cells transport oxygen for body cells; nerve cells coordinate muscles.*
- (c) Single-celled organisms perform all functions independently.*
- (d) Increased efficiency and survival.*

Topic 2; NUTRITION

Item 1

In a rural school, students observed that some learners often felt tired during lessons and performed poorly in physical activities. A health worker explained that their diet mainly consisted of cassava and sweet potatoes with very little protein.

- (a) Identify the type of diet described above.**
- (b) Explain why such learners are likely to feel tired frequently.**
- (c) Name two nutrients lacking in the diet described.**
- (d) State one role of each of the nutrients named in (c).**

Item 2

A farmer noticed that his maize plants had pale yellow leaves and poor growth despite adequate rainfall. An agricultural officer advised him to apply nitrogen-rich fertilizers.

- (a) Name the mineral element whose deficiency caused the observed symptoms.
- (b) Explain the role of this mineral in plant nutrition.
- (c) State two visible symptoms of nitrogen deficiency in plants.
- (d) Suggest one reason why excess application of fertilizers may be harmful.

Item 3

A student tested a food sample using Benedict's solution and observed a brick-red precipitate after heating.

- (a) Identify the food nutrient present in the sample.
- (b) Explain the principle behind the test used.
- (c) State one food source containing the nutrient identified.
- (d) Give one importance of this nutrient in humans.

Item 4

In an experiment, green leaves were exposed to sunlight for several hours, then tested with iodine solution after decolourisation. Some parts turned blue-black while others remained brown.

- (a) Name the process being investigated.
- (b) Explain why some parts of the leaf turned blue-black.
- (c) State the function of chlorophyll in this process.
- (d) Give one importance of the process to living organisms.

Item 5

A biology teacher explained that photosynthesis involves two stages.

- (a) Name the two stages of photosynthesis.
- (b) State where each stage occurs in the chloroplast.
- (c) Explain one event that occurs in each stage.
- (d) Suggest one factor affecting the rate of photosynthesis.

Item 6

During digestion, starch is broken down into simpler substances.

- (a) Name the enzyme responsible for starch digestion in the mouth.
- (b) State the product formed at this stage.

- (c) Explain why digestion of starch stops temporarily in the stomach.
- (d) State one role of bile during digestion.

Item 7

A child suffering from kwashiorkor showed symptoms of swollen abdomen and thin limbs.

- (a) Identify the nutrient whose deficiency causes this condition.
- (b) Explain how deficiency of this nutrient leads to a swollen abdomen.
- (c) State two other symptoms of the condition.
- (d) Suggest two food sources that could prevent this condition.

Item 8

A student compared ruminant and non-ruminant digestion using a cow and a human as examples.

- (a) Name one structure present in ruminants but absent in humans.
- (b) Explain the role of this structure in digestion.
- (c) State one advantage of ruminant digestion.
- (d) Suggest one limitation of ruminant digestion.

Item 9

In an investigation, a leaf was partially covered with black paper before exposure to sunlight. After testing, only the uncovered part showed presence of starch.

- (a) State the aim of the experiment.
- (b) Explain the results obtained.
- (c) State one condition necessary for photosynthesis demonstrated by the experiment.
- (d) Suggest one other condition necessary for photosynthesis.

Item 10

A patient complained of constipation, and the doctor advised increasing intake of fruits and vegetables.

- (a) Identify the nutrient lacking in the patient's diet.
- (b) Explain how this nutrient helps prevent constipation.
- (c) State one other importance of this nutrient.

(d) Give one food source rich in this nutrient.

Item 11

A leaf was tested for starch without first killing it in hot water. The test gave unreliable results.

- (a) State the purpose of killing a leaf before testing for starch.
- (b) Explain why alcohol is used to decolourise the leaf.
- (c) State one precaution taken during decolourisation.
- (d) Explain why iodine is suitable for testing starch.

Item 12

Digestion in humans involves both mechanical and chemical processes.

- (a) Distinguish between mechanical and chemical digestion.
- (b) Give one example of each process.
- (c) Explain why both processes are important.
- (d) State one organ where both processes occur.

Item 13

A biology student observed that fatty foods take longer to digest than carbohydrates.

- (a) Name the enzyme that digests fats.
- (b) State where fat digestion mainly occurs.
- (c) Explain why fats take longer to digest.
- (d) State one role of fats in the human body.

Item 14

After intense exercise, an athlete was advised to consume foods rich in carbohydrates.

- (a) State the main function of carbohydrates.
- (b) Explain how carbohydrates supply energy.
- (c) Name one storage form of carbohydrates in humans.
- (d) Suggest one carbohydrate-rich food.

Item 15

A farmer growing beans observed that the plants grew well without nitrogen fertilisers.

- (a) Explain why nitrogen fertilisers were not necessary.
- (b) Name the organisms responsible for this advantage.
- (c) State the relationship between the plant and the organism.
- (d) Give one importance of this relationship to agriculture.

Item 16

A leaf showed a decrease in dry mass after being kept in darkness for 48 hours.

- (a) Name the process responsible for the decrease in dry mass.
- (b) Explain how this process caused the decrease.
- (c) State one condition required for the process named in (a).
- (d) Suggest one importance of this process to plants.

Item 17

A student tested milk using different food tests.

- (a) Name the test used to detect proteins.
- (b) State the positive result for the test named in (a).
- (c) Name one other nutrient present in milk.
- (d) State one importance of milk in human nutrition.

Item 18

In an experiment, leaves were placed in different concentrations of carbon dioxide. Higher concentrations increased the rate of starch formation.

- (a) Explain the relationship between carbon dioxide concentration and photosynthesis.
- (b) State one factor that may limit photosynthesis even with high carbon dioxide.
- (c) Name the raw materials required for photosynthesis.
- (d) State one product of photosynthesis other than starch.

Item 19

A child lacked vitamin D and developed weak bones.

- (a) Name the condition caused by vitamin D deficiency in children.
- (b) Explain the role of vitamin D in the body.
- (c) State one source of vitamin D.

(d) Suggest one way of preventing the condition.

Item 20

Balanced diet is essential for healthy living.

- (a) Define a balanced diet.
- (b) State four components of a balanced diet.
- (c) Explain why water is an essential component of a balanced diet.
- (d) Suggest one consequence of prolonged poor nutrition.



TOPIC 2: NUTRITION

ANSWERS / MARKING GUIDE

Item 1

- (a) Carbohydrate-rich but protein-deficient diet (imbalanced diet).*
- (b) Lack of proteins leads to poor body repair and enzyme production, causing weakness.*
- (c) Proteins; vitamins (or minerals).*
- (d) Proteins – growth and repair of tissues; vitamins – regulation of body processes.*

Item 2

- (a) Nitrogen.*
- (b) Required for synthesis of amino acids, proteins, and chlorophyll.*
- (c) Yellowing of leaves; stunted growth.*
- (d) Causes soil pollution and plant toxicity.*

Item 3

- (a) Reducing sugar.*
- (b) Benedict's solution is reduced by sugars on heating, forming a brick-red precipitate.*
- (c) Fruits / honey / glucose solution.*
- (d) Source of energy.*

Item 4

- (a) Photosynthesis.*
- (b) Starch was produced in areas exposed to light.*
- (c) Absorbs light energy.*
- (d) Produces food for organisms.*

Item 5

- (a) Light stage and dark stage.*
- (b) Light stage – grana; dark stage – stroma.*
- (c) Light stage: photolysis of water; dark stage: carbon fixation.*
- (d) Light intensity / carbon dioxide concentration / temperature.*

Item 6

- (a) Salivary amylase (ptyalin).*
- (b) Maltose.*
- (c) Acidic conditions inactivate salivary amylase.*
- (d) Emulsifies fats.*

Item 7

- (a) Proteins.*
- (b) Low protein reduces plasma proteins, causing fluid retention in tissues.*
- (c) Hair discoloration; muscle wasting.*
- (d) Beans; milk / meat / groundnuts.*

Item 8

- (a) Rumen.*
- (b) Microbial digestion of cellulose.*
- (c) Efficient digestion of fibrous food.*
- (d) Slow digestion process.*

Item 9

- (a) To show that light is required for photosynthesis.*
- (b) Only exposed areas produced starch.*
- (c) Light.*
- (d) Carbon dioxide / chlorophyll / water.*

Item 10

- (a) Dietary fibre (roughage).*
- (b) Adds bulk and stimulates peristalsis.*
- (c) Prevents constipation.*
- (d) Vegetables / fruits.*

Item 11

- (a) To stop chemical reactions in the leaf.*
- (b) Removes chlorophyll.*
- (c) Alcohol is flammable – use water bath.*
- (d) Iodine forms blue-black colour with starch.*

Item 12

- (a) Mechanical digestion – physical breakdown; chemical digestion – enzymatic breakdown.*
- (b) Chewing; enzyme action.*
- (c) Increases surface area for enzyme action.*
- (d) Mouth.*

Item 13

- (a) Lipase.*
- (b) Small intestine (duodenum).*
- (c) Fats require emulsification and are complex molecules.*
- (d) Energy storage / insulation.*

Item 14

- (a) Energy provision.*
- (b) Broken down to glucose and oxidised during respiration.*
- (c) Glycogen.*
- (d) Rice / maize / cassava.*

Item 15

- (a) Beans fix atmospheric nitrogen.*
- (b) Rhizobium bacteria.*
- (c) Mutualism.*
- (d) Improves soil fertility.*

Item 16

- (a) Respiration.*
- (b) Stored food is oxidised releasing energy.*
- (c) Oxygen.*
- (d) Supplies energy for growth.*

Item 17

- (a) Biuret test.*
- (b) Purple/violet colour.*
- (c) Fats / calcium / lactose.*
- (d) Promotes growth and bone development.*

Item 18

- (a) Increased CO₂ increases rate of photosynthesis up to a limit.*
- (b) Light intensity / temperature.*
- (c) Carbon dioxide and water.*
- (d) Oxygen.*

Item 19

- (a) Rickets.*
- (b) Aids calcium absorption and bone formation.*
- (c) Sunlight / fish liver oil.*
- (d) Adequate sunlight exposure.*

Item 20

- (a) Diet containing all nutrients in correct proportions.*
- (b) Carbohydrates, proteins, fats, vitamins (minerals, water).*
- (c) Medium for metabolic reactions and transport.*
- (d) Malnutrition / disease / poor growth.*

TOPIC 3: TRANSPORT

Item 1

During a field study, students cut the stem of a young herbaceous plant and observed that a watery fluid oozed out continuously for several minutes. When the same experiment was repeated at night, more fluid was released than during the day.

- (a) Identify the phenomenon responsible for the release of the fluid.
- (b) Explain the mechanism by which this phenomenon occurs.
- (c) Account for the difference in the volume of fluid released during the day and at night.
- (d) State two environmental factors that influence this phenomenon.

Item 2

A tall tree in a dry environment continues to transport water from the soil to the leaves at the top of the canopy. A student suggested that root pressure alone is responsible for this movement.

- (a) Explain why root pressure alone cannot account for water movement in tall trees.
- (b) Describe the cohesion–tension theory of water transport.
- (c) State two properties of water that make this theory possible.
- (d) Suggest one effect of very dry air on water transport in plants.

Item 3

A biology class carried out an experiment in which a leafy shoot was enclosed in a bell jar containing anhydrous calcium chloride. After some time, the mass of the calcium chloride increased.

- (a) State the aim of the experiment.
- (b) Explain the increase in mass of the calcium chloride.
- (c) Identify the process being demonstrated.
- (d) Suggest two factors that would increase the rate of this process.

Item 4

In an investigation, the bark of a woody stem was removed in a ring. After several weeks, swelling was observed above the ring, while the region below showed poor growth.

- (a) Name the tissue affected by this treatment.
- (b) Explain why swelling occurred above the ring.
- (c) Account for the poor growth below the ring.
- (d) State two functions of the tissue named in (a).

Item 5

A student examined transverse sections of plant stems under a microscope and observed that the arrangement of vascular tissues differed between two specimens.

- (a) Identify the type of stem with vascular bundles arranged in a ring.
- (b) Name the two tissues found in a vascular bundle.
- (c) Explain one structural difference between xylem and phloem.
- (d) Relate the structure of xylem vessels to their function.

Item 6

A patient suffering from severe blood loss was given a blood transfusion. Soon after, the patient's blood pressure stabilized and oxygen supply to tissues improved.

- (a) State the function of red blood cells in transport.
- (b) Explain how the structure of red blood cells suits their function.
- (c) Identify the component of blood responsible for blood clotting.
- (d) Explain the importance of blood clotting in humans.

Item 7

A student compared transport in insects and mammals and noted several differences.

- (a) Name the respiratory pigment found in mammals.
- (b) Explain why insects do not require a blood-based transport system for gases.
- (c) State two functions of blood plasma.
- (d) Suggest one advantage of having a closed circulatory system.

Item 8

During physical exercise, a learner's breathing rate and heart rate increased significantly.

- (a) Explain why heart rate increases during exercise.
- (b) State two ways by which the structure of the heart ensures efficient transport.
- (c) Explain how valves contribute to effective circulation.
- (d) Suggest one effect of prolonged lack of exercise on the transport system.

Item 9

A biology teacher demonstrated the use of a potometer to estimate transpiration rate.

- (a) State the principle on which a potometer works.
- (b) Explain why a potometer does not directly measure transpiration.
- (c) State two precautions taken when setting up a potometer.
- (d) Suggest one limitation of using a potometer.

Item 10

In a medical examination, a patient was diagnosed with blocked coronary arteries.

- (a) Explain the function of coronary arteries.
- (b) Describe how blockage of coronary arteries affects heart function.
- (c) State two risk factors associated with coronary artery disease.
- (d) Suggest two lifestyle changes that could reduce the risk of this condition.

TOPIC 3: TRANSPORT
ANSWERS / MARKING GUIDE

Item 1

- (a) Root pressure.*
- (b) Active transport of mineral ions into the root xylem lowers water potential, causing water to enter by osmosis and generate pressure that pushes sap upward.*
- (c) At night transpiration is low, allowing root pressure to build up; during the day transpiration reduces the effect.*
- (d) Soil water availability; temperature.*

Item 2

- (a) Root pressure is weak and cannot lift water to great heights; it is absent during high transpiration.*
- (b) Transpiration pull creates tension in the xylem; cohesion between water molecules and adhesion to xylem walls maintain a continuous column.*
- (c) Cohesion; adhesion.*
- (d) Increased transpiration rate.*

Item 3

- (a) To show that plants lose water vapour through leaves.*
- (b) Calcium chloride absorbs water vapour released from the leaves.*
- (c) Transpiration.*
- (d) High temperature; wind.*

Item 4

- (a) Phloem.*
- (b) Accumulation of manufactured food above the ring.*
- (c) Lack of downward transport of organic nutrients.*
- (d) Translocation of food; transport of hormones.*

Item 5

- (a) Dicotyledonous stem.*
- (b) Xylem and phloem.*
- (c) Xylem vessels are dead and lignified; phloem tissue is living.*

(d) Thick lignified walls prevent collapse and allow efficient water transport.

Item 6

(a) Transport of oxygen.

(b) Biconcave shape increases surface area; lack of nucleus allows more haemoglobin.

(c) Platelets.

(d) Prevents excessive blood loss and entry of pathogens.

Item 7

(a) Haemoglobin.

(b) Insects use a tracheal system that delivers oxygen directly to tissues.

(c) Transport of nutrients; transport of waste products.

(d) Efficient and rapid transport under high pressure.

Item 8

(a) To supply more oxygen and nutrients to respiring muscles.

(b) Thick muscular walls; presence of four chambers.

(c) Prevent backflow of blood.

(d) Increased risk of cardiovascular disease.

Item 9

(a) Rate of water uptake is proportional to transpiration rate.

(b) Some absorbed water is used in metabolism.

(c) Ensure airtight setup; cut shoot under water.

(d) Measures water uptake, not actual water loss.

Item 10

- (a) Supply oxygenated blood to heart muscle.
- (b) Reduces oxygen supply, weakening heart contractions.
- (c) Smoking; high-fat diet.
- (d) Regular exercise; balanced diet.

TOPIC 4: RESPIRATION

Item 1

During a biology field trip, Senior Five students visited a tea plantation located on high altitude hills. Some students reported feeling dizzy and breathless after climbing the steep slopes, while others recovered slowly even after resting. The biology teacher explained that at high altitudes, the air pressure is lower, resulting in reduced availability of oxygen. As a result, the rate at which oxygen diffuses into the blood is affected. The teacher further noted that individuals who permanently live in such areas often adapt over time by developing certain physiological changes. Back at school, the class discussed how oxygen is transported in the blood and how respiration ensures continuous energy supply to body cells, especially during physical exertion in low-oxygen environments.

Task

- (a) Explain why students experienced dizziness and breathlessness at high altitude.
- (b) Describe two adaptations that may develop in people living permanently at high altitude.
- (c) Explain how oxygen is transported in the blood to respiring tissues.
- (d) Account for the increased rate of respiration during physical activity.

Item 2

A laboratory technician placed germinating seeds in a sealed flask connected to a delivery tube passing into limewater. After several hours, the limewater turned milky. When the same setup was repeated using dry, non-germinating seeds, no change was observed in the limewater. The technician explained that germinating seeds require energy for growth and cell division, while dry seeds remain metabolically inactive. The class was reminded that respiration occurs in all living cells and that different substrates can be used depending on availability and physiological state of the organism.

Task

- (a) Identify the gas responsible for turning limewater milky.*
- (b) Explain why germinating seeds produced a different result from dry seeds.*
- (c) State the type of respiration occurring in the germinating seeds.*
- (d) Explain why respiration is essential during germination.*

Item 3

During a medical check-up, a patient was found to have blocked air passages caused by excessive mucus accumulation. The doctor explained that this condition reduces the surface area available for gaseous exchange in the lungs. As a result, the patient experienced shortness of breath, fatigue, and reduced physical endurance. The doctor further explained that the alveoli are adapted to ensure efficient gaseous exchange and that any condition interfering with these adaptations significantly affects respiration efficiency.

- (a) State two structural adaptations of alveoli for efficient gaseous exchange.*
- (b) Explain how blockage of air passages affects respiration efficiency.*
- (c) Describe how oxygen moves from the alveoli into the blood.*
- (d) Suggest one lifestyle factor that may contribute to such a respiratory condition.*

Item 4

A farmer stored freshly harvested maize grains in an airtight silo. After several weeks, the grains developed a sour smell, and some became warm to touch. An agricultural officer explained that although the silo was airtight, the maize grains were still alive and respiring. Due to limited oxygen supply, respiration shifted from one form to another, leading to the accumulation of certain by-products that caused the observed smell and temperature changes.

- (a) Identify the type of respiration taking place in the stored maize grains.*
- (b) Explain why heat was produced during this process.*
- (c) Name one by-product responsible for the sour smell.*
- (d) State one disadvantage of this type of respiration in plants.*

Item 5

A biology teacher demonstrated an experiment using yeast and glucose solution placed in a flask connected to a delivery tube leading into limewater. The setup was kept in a warm place. After some time, bubbles were observed in the flask and the limewater turned milky. The teacher explained that yeast can respire both in the presence and absence of oxygen, depending on environmental conditions. Students were asked to relate this process to industrial applications such as brewing and bread making.

- (a) Identify the process occurring in the yeast.*
- (b) State the two end-products of this process in yeast.*
- (c) Explain why warmth is necessary for the process.*
- (d) State one industrial application of this process.*

Item 6

During strenuous exercise, a student experienced muscle pain and fatigue, especially after sprinting for a short distance. The biology teacher explained that when oxygen supply to muscle cells becomes insufficient, respiration continues in a different form. This results in the accumulation of a substance that causes muscle discomfort. The teacher also explained how the body later recovers from this condition through increased breathing rate and oxygen intake.

- (a) Name the type of respiration occurring in the muscles during the sprint.*
- (b) Identify the substance responsible for muscle pain.*
- (c) Explain how the body removes this substance after exercise.*
- (d) State one effect of prolonged reliance on this type of respiration.*

Item 7

A student investigated the effect of temperature on respiration using small insects placed in respirometers at different temperatures. It was observed that oxygen uptake increased with temperature up to a certain point, beyond which the rate decreased sharply. The student concluded that respiration is controlled by enzymes and that extreme temperatures interfere with enzyme activity.

- (a) Explain why respiration rate increased with temperature initially.*
- (b) Account for the decrease in respiration rate at very high temperatures.*
- (c) State the role of enzymes in respiration.*
- (d) Suggest one other factor that affects respiration rate.*

Item 8

A biology class compared aerobic respiration and anaerobic respiration using energy yield data. They observed that aerobic respiration released much more energy from glucose than anaerobic respiration. The teacher emphasized that although anaerobic respiration is less efficient, it is important for survival under certain conditions. Examples from plants, yeast, and humans were discussed to illustrate this point.

Task

- (a) Compare the energy yield of aerobic and anaerobic respiration.*
- (b) Explain why anaerobic respiration releases less energy.*
- (c) State one situation where anaerobic respiration is advantageous.*
- (d) Name one organism that carries out anaerobic respiration.*

Item 9

A patient suffering from severe anaemia was found to tire easily even during light physical activity. The doctor explained that anaemia reduces the oxygen-carrying capacity of the blood, leading to reduced cellular respiration in body tissues. As a result, energy production is insufficient to meet the body's demands.

Task

- (a) Explain how anaemia affects oxygen transport.*
- (b) Describe the relationship between oxygen supply and energy production.*
- (c) State one role of haemoglobin in respiration.*
- (d) Suggest one dietary measure to manage anaemia.*

Item 10

A student placed a potted plant in a dark cupboard for several days and later observed that the plant became weak and pale. The teacher explained that although photosynthesis had stopped, respiration continued throughout the period. The plant used up its stored food reserves, leading to the observed condition.

Task

- (a) Explain why respiration continued in the absence of light.*

- (b) Account for the weakness observed in the plant.*
- (c) State one difference between respiration and photosynthesis.*
- (d) Suggest one reason why respiration is described as a continuous process.*

TOPIC 4: RESPIRATION

ANSWERS / MARKING GUIDE

Item 1

- (a) At high altitude, oxygen partial pressure is low → less oxygen diffuses into blood → insufficient oxygen delivery → dizziness and breathlessness.*
- (b) Increased red blood cell count; increased lung capacity; higher haemoglobin concentration.*
- (c) Oxygen binds to haemoglobin in red blood cells → transported as oxyhaemoglobin → released to tissues for aerobic respiration.*
- (d) Physical activity increases energy demand → cells increase aerobic respiration → more oxygen is consumed and CO₂ produced.*

Item 2

- (a) Carbon dioxide (CO₂).*
- (b) Germinating seeds are metabolically active → require energy → respire → produce CO₂. Dry seeds are dormant → no metabolism → no CO₂.*
- (c) Aerobic respiration (primarily) using stored starch/glucose.*
- (d) Provides energy for cell division, growth, and synthesis of new molecules during germination.*

Item 3

- (a) Thin alveolar walls; large surface area; moist lining; extensive capillary network.*
- (b) Mucus blockage reduces alveolar surface area → less O₂ diffuses into blood → decreased respiration efficiency.*
- (c) Oxygen diffuses down a concentration gradient from alveoli → into blood plasma → binds to haemoglobin in RBCs.*

(d) Smoking; exposure to pollutants; chronic respiratory infections.

Item 4

(a) Anaerobic respiration (fermentation).

(b) Energy is released as heat during the breakdown of glucose without oxygen.

(c) Organic acids (e.g., lactic acid or ethanol and CO₂ in plants).

(d) Less efficient → produces less energy per glucose molecule; accumulation of by-products may be harmful.

Item 5

(a) Anaerobic respiration (fermentation).

(b) Ethanol and carbon dioxide (CO₂).

(c) Warmth increases enzyme activity → faster glucose breakdown.

(d) Brewing beer, wine, and baking (leavening of bread).

Item 6

(a) Anaerobic respiration.

(b) Lactic acid.

(c) Oxygen debt is repaid post-exercise → lactic acid converted back to pyruvate or glucose → oxidised during aerobic respiration.

(d) Muscle fatigue; decreased efficiency; potential tissue damage if prolonged.

Item 7

(a) Increased temperature → higher kinetic energy → more enzyme-substrate collisions → faster respiration rate.

(b) Enzymes denature at high temperatures → rate drops sharply.

(c) Enzymes catalyse breakdown of glucose → control rate of reactions.

(d) Oxygen availability; substrate concentration; pH.

Item 8

- (a) Aerobic respiration releases more energy per glucose molecule (~36–38 ATP) than anaerobic respiration (~2 ATP).**
- (b) Anaerobic respiration incompletely oxidises glucose → less energy released.**
- (c) During oxygen deficiency (e.g., sprinting, waterlogged soils).**
- (d) Yeast, some bacteria, muscle cells under hypoxia.**

Item 9

- (a) Anaemia → low haemoglobin → reduced oxygen transport → tissues receive insufficient O₂ → decreased ATP production.**
- (b) Oxygen supply to tissues allows aerobic respiration → generates energy (ATP) for cellular activities.**
- (c) Haemoglobin binds oxygen in lungs → releases it to tissues for respiration.**
- (d) Eat iron-rich foods (e.g., beans, green leafy vegetables) or foods rich in vitamin B12/folate.**

Item 10

- (a) Plants respire continuously → break down stored glucose → release energy for maintenance and growth.**
- (b) Stored food reserves used up → insufficient energy → plant becomes weak and pale.**
- (c) Respiration releases energy (ATP) from glucose; photosynthesis produces glucose from light energy.**
- (d) Respiration occurs day and night → provides continuous energy supply → supports metabolic activities regardless of light availability.**

TOPIC 5: HOMEOSTASIS

Item 1

During a heatwave, a group of students were conducting a practical on human physiology. One student started sweating profusely while another complained of feeling

dizzy and dehydrated. The biology teacher explained that the body maintains internal conditions within narrow limits despite external changes. He highlighted that body temperature and water balance are regulated by mechanisms involving the skin, hypothalamus, kidneys, and hormones. The class discussed how negative feedback loops operate, and how various physiological responses prevent dangerous deviations in internal conditions. The teacher also emphasized that failure of these mechanisms could lead to serious health problems.

- (a) Explain why one student was sweating while another felt dizzy.*
- (b) Describe how body temperature is regulated in response to a heatwave.*
- (c) Explain the role of negative feedback in homeostasis.*
- (d) Suggest two consequences of failure to maintain water balance.*

Item 2

A diabetic patient was admitted to a clinic complaining of excessive thirst, frequent urination, and fatigue. The doctor explained that these symptoms are due to high blood glucose levels, which the body attempts to regulate through various homeostatic mechanisms. The patient was advised on insulin therapy, diet, and exercise. The biology teacher used this case to illustrate the importance of hormonal control in maintaining internal stability, especially the role of the pancreas in blood glucose regulation.

- (a) Identify the hormone involved in lowering blood glucose levels.*
- (b) Explain how insulin regulates blood glucose concentration.*
- (c) Describe two symptoms of hyperglycaemia in the patient.*
- (d) Suggest one lifestyle measure to help maintain normal blood glucose levels.*

Item 3

A team of students performed an experiment where frogs were placed in cold water. They observed that the frog's metabolic rate slowed and its activity decreased. The teacher explained that homeostatic mechanisms adjust to environmental changes to maintain optimal internal conditions. In ectothermic animals, these mechanisms involve

behavioural and physiological adaptations. The discussion focused on how temperature affects enzyme activity, respiration rate, and other metabolic processes.

- (a) Explain why the frog's metabolic rate decreased in cold water.*
- (b) Describe two behavioural adaptations ectotherms use to regulate body temperature.*
- (c) Explain the effect of temperature on enzyme activity.*
- (d) Suggest one consequence if temperature deviates excessively from optimum.*

Item 4

During a biology practical, students measured blood pressure in different individuals before and after exercise. One student noticed that their blood pressure increased significantly after running up the stairs. The teacher explained that the cardiovascular system is part of homeostatic regulation, ensuring that tissues receive adequate oxygen and nutrients despite changing activity levels. The class discussed how receptors, nerves, and hormones coordinate to maintain blood pressure within safe limits.

- (a) Explain why blood pressure increases during exercise.*
- (b) Describe two mechanisms by which blood pressure is regulated.*
- (c) Explain the role of baroreceptors in homeostasis.*
- (d) Suggest one long-term effect of consistently high blood pressure.*

Item 5

A biology class observed that humans produce more urine after drinking large volumes of water. The teacher explained that the kidneys regulate water balance by adjusting urine volume and concentration. Hormones such as ADH play a major role, and failure in these mechanisms may lead to dehydration or overhydration. Students discussed how homeostasis ensures stable internal fluid composition and osmotic balance in humans.

- (a) Explain why urine volume increases after drinking water.*
- (b) Describe the role of ADH in water regulation.*

- (c) Explain how the kidneys maintain osmotic balance.*
- (d) Suggest one effect of ADH deficiency.*

Item 6

During a biology field trip, students noticed a person shivering during a cold morning despite wearing warm clothes. The teacher explained that shivering is a homeostatic response to maintain core body temperature. The students discussed the involvement of skeletal muscles, hypothalamus, blood vessels, and metabolic heat production in thermoregulation. They also explored the differences in homeostatic mechanisms between endotherms and ectotherms.

- (a) Explain why shivering generates heat.*
- (b) Describe two other physiological responses to cold in humans.*
- (c) Explain the role of the hypothalamus in temperature regulation.*
- (d) Suggest one risk if body temperature falls below normal for a prolonged period.*

Item 7

A patient with kidney disease had difficulty maintaining normal sodium and water levels in the body. The doctor explained that the kidneys filter blood, reabsorb essential ions and water, and excrete waste products to maintain homeostasis. The class discussed how hormonal signals, blood flow, and nephrons work together to regulate internal environment, and how kidney malfunction disrupts these processes leading to health complications.

- (a) Explain how the kidneys maintain water and ion balance.*
- (b) Describe the role of nephrons in filtration and reabsorption.*
- (c) Explain the function of aldosterone in homeostasis.*
- (d) Suggest two consequences of kidney malfunction on homeostasis.*

Item 8

During an experiment, students exposed their skin to a sudden drop in room temperature. They observed hair erection, pale skin, and goosebumps. The teacher explained that these responses are part of homeostatic mechanisms to conserve heat.

The discussion extended to the role of blood vessels, sweat glands, and the nervous system in regulating body temperature under different environmental conditions.

- (a) Explain why hairs stand erect during cold exposure.*
- (b) Describe two other physiological responses to conserve heat.*
- (c) Explain how vasoconstriction helps in temperature regulation.*
- (d) Suggest one effect of prolonged exposure to extreme cold.*

Item 9

A biology teacher presented a case of a patient with hyperthyroidism, who experienced rapid heartbeat, weight loss, and excessive sweating. The students discussed how the thyroid gland controls metabolic rate and how its overactivity disrupts homeostasis. They further examined the interactions between hormones, receptors, and target organs in maintaining internal stability.

- (a) Explain how hyperthyroidism affects metabolic rate.*
- (b) Describe two symptoms caused by excessive thyroid hormone.*
- (c) Explain how hormone levels are regulated in a negative feedback loop.*
- (d) Suggest one treatment approach to restore homeostasis in hyperthyroid patients.*

Item 10

During a practical, students measured blood glucose in a healthy individual before and after a meal. They observed an increase in glucose levels after eating, followed by a gradual return to normal. The teacher explained that the body maintains blood glucose concentration within narrow limits using hormones, liver glycogen storage, and insulin/glucagon balance. Students discussed how disruption of these mechanisms could result in diabetes or hypoglycemia.

- (a) Explain why blood glucose rises after a meal.*
- (b) Describe the role of insulin in reducing blood glucose levels.*
- (c) Explain how the liver contributes to blood glucose homeostasis.*
- (d) Suggest one consequence of persistent failure to regulate blood glucose.*

TOPIC 5: HOMEOSTASIS

ANSWERS / MARKING GUIDE (

Item 1

- (a) Sweating → body loses heat by evaporation to lower body temperature; dizziness → dehydration reduces blood volume → less oxygen to the brain.**
- (b) Increased sweating, vasodilation of skin blood vessels → heat loss; reduced metabolic heat production.**
- (c) Negative feedback detects deviation from set point → effectors act to restore normal conditions.**
- (d) Heat stroke; kidney damage; circulatory failure.**

Item 2

- (a) Insulin.**
- (b) Insulin promotes uptake of glucose by cells → converts glucose to glycogen in liver and muscles → lowers blood glucose.**
- (c) Excessive thirst (polydipsia); frequent urination (polyuria); fatigue.**
- (d) Regular exercise; balanced diet; avoid excessive sugar intake.**

Item 3

- (a) Metabolic rate slows due to reduced enzyme activity at low temperatures.**
- (b) Behavioural adaptations: basking in sunlight; seeking warm shelters.**
- (c) Low temperature reduces kinetic energy → slower enzyme-catalyzed reactions → slower metabolism.**
- (d) Hypothermia; enzyme denaturation; metabolic failure.**

Item 4

- (a) Increased demand for oxygen and nutrients in muscles → heart pumps faster.**
- (b) Baroreceptor-mediated adjustments; renin-angiotensin system; vasoconstriction/vasodilation; heart rate modulation.**
- (c) Baroreceptors detect blood pressure changes → send signals to brain → adjust heart rate and vessel diameter.**
- (d) Cardiovascular diseases; stroke; organ damage.**

Item 5

- (a) Excess water intake → kidneys filter and excrete more water → increased urine volume.**
- (b) ADH decreases → less water reabsorbed in collecting ducts → dilute urine.**
- (c) Adjusts osmolarity of blood by controlling reabsorption/secretion of water and ions.**
- (d) Diabetes insipidus → excessive urination and dehydration.**

Item 6

- (a) Shivering → involuntary contraction of skeletal muscles generates heat.**
- (b) Vasoconstriction; increased metabolism; reduced sweating.**
- (c) Hypothalamus acts as a thermostat → detects temperature deviations → triggers effectors.**
- (d) Hypothermia → organ failure → death if prolonged.**

Item 7

- (a) Kidneys filter blood → reabsorb water and ions → excrete wastes in urine → maintains fluid and ion balance.**
- (b) Nephrons filter blood in glomerulus → reabsorb nutrients and water in tubules → form urine.**
- (c) Aldosterone → promotes sodium reabsorption → water follows → maintains blood volume.**
- (d) Edema; electrolyte imbalance; hypertension.**

Item 8

- (a) Hair erection → traps insulating layer of air to reduce heat loss.**
- (b) Vasoconstriction of skin blood vessels; reduced sweating; increased metabolic rate.**
- (c) Constriction reduces blood flow to skin → less heat lost → conserves body heat.**
- (d) Frostbite; hypothermia; decreased enzyme activity.**

Item 9

- (a) Excess thyroid hormones → increase basal metabolic rate → faster respiration and energy consumption.**
- (b) Rapid heartbeat; weight loss; excessive sweating; heat intolerance.**
- (c) Negative feedback → high hormone levels inhibit TSH from pituitary → reduces thyroid activity.**
- (d) Anti-thyroid drugs; thyroid surgery; radioactive iodine therapy.**

Item 10

- (a) Glucose is absorbed from the gut → enters blood → increases concentration.**
- (b) Insulin promotes uptake of glucose by liver, muscle, and fat cells → converts excess to glycogen → lowers blood glucose.**
- (c) Liver stores glucose as glycogen during high blood sugar → releases glucose during fasting → maintains blood glucose homeostasis.**
- (d) Diabetes mellitus; hypoglycemia; tissue damage; impaired metabolism.**

TOPIC 6: EXCRETION

Item 1

During a biology practical, students observed a diagram of a human kidney and noted the flow of blood and formation of urine. The teacher explained that the kidneys filter waste products from the blood while retaining useful substances. Later, students visited a patient with chronic kidney disease and learned that waste accumulation in the blood caused fatigue, swelling, and high blood pressure. They were shown how dialysis machines function to remove excess urea and water. The class discussed the importance of maintaining internal chemical balance and how hormonal control, blood flow, and nephrons coordinate to ensure efficient excretion.

- (a) Explain how the kidney removes waste products from the blood.
- (b) Describe the role of nephrons in urine formation.
- (c) Explain the effect of kidney failure on homeostasis.
- (d) Suggest one advantage of dialysis for patients with kidney failure.

Item 2

A farmer observed that his cattle's urine was highly concentrated during the dry season and dilute during the wet season. The biology teacher explained that the kidneys regulate water and ion balance in the body to prevent dehydration or overhydration. Students discussed the role of antidiuretic hormone (ADH) and how the loop of Henle contributes to water reabsorption. They also explored the differences between osmoregulation in mammals and other vertebrates.

- (a) Explain why the cattle produced concentrated urine during the dry season.
- (b) Describe the role of ADH in regulating urine concentration.
- (c) Explain how the loop of Henle contributes to water reabsorption.
- (d) Suggest one adaptation of mammals to conserve water in dry environments.

Item 3

During a biology field trip, students observed that amphibians excrete urea while birds excrete uric acid. The teacher explained that different excretory products reflect adaptations to environmental water availability. They discussed how these adaptations reduce water loss while efficiently removing nitrogenous wastes. The class also compared the nephron structure in different vertebrates and examined how excretion is linked to homeostasis.

- (a) State the main nitrogenous waste excreted by amphibians and birds.
- (b) Explain why birds excrete uric acid instead of urea.
- (c) Describe how excretion is linked to water balance.
- (d) Suggest one structural adaptation in birds that aids water conservation.

Item 4

A patient with liver damage was observed to have jaundice, fatigue, and dark urine. The teacher explained that the liver detoxifies harmful substances, converts ammonia to urea, and produces bile. Students discussed how failure of liver function affects excretion and metabolism, and how blood and urine composition change when liver function is impaired.

- (a) Explain the role of the liver in excretion.
- (b) Describe how ammonia is converted to a less toxic substance.
- (c) Explain why the patient's urine appeared dark.
- (d) Suggest one lifestyle measure to maintain liver health.

Item 5

During a lab experiment, students placed a small animal in a respirometer and measured carbon dioxide output. The teacher explained that lungs are part of the excretory system, removing CO₂ produced during cellular respiration. Students were asked to relate the rate of CO₂ removal to the metabolic rate of the organism, and how disruption in CO₂ excretion can affect blood pH and homeostasis.

- (a) Explain how carbon dioxide is removed from the body.
- (b) Describe the effect of high CO₂ concentration on blood pH.
- (c) Explain the relationship between metabolic rate and CO₂ excretion.
- (d) Suggest one consequence of impaired lung function on excretion.

Item 6

During a biology demonstration, students observed that sweating occurs during exercise. The teacher explained that the skin excretes water, salts, and small amounts of urea to help maintain homeostasis. The class discussed how sweating contributes to thermoregulation, fluid balance, and elimination of metabolic wastes. Students also compared sweat composition in humans to urine composition and examined how environmental factors influence excretory processes.

- (a) State the main substances excreted in sweat.
- (b) Explain how sweating contributes to thermoregulation.
- (c) Describe how sweating helps in maintaining fluid balance.
- (d) Suggest one effect of excessive sweating without water replacement.

Item 7

A patient with obstructed bile ducts had yellowing of the skin and pale stools. The teacher explained that bile contains waste products such as bile pigments, which are excreted via the digestive system. Students discussed how liver and digestive system collaborate to eliminate non-nitrogenous wastes and maintain chemical balance in the body.

- (a) Identify the waste product excreted in bile that causes yellowing when accumulated.
- (b) Explain the role of the liver in bile production.
- (c) Describe how bile contributes to excretion.
- (d) Suggest one consequence of bile duct obstruction on excretion.

Item 8

During a lab practical, students were asked to analyze urine samples of different individuals. They observed variation in colour, volume, and concentration. The teacher explained that these variations reflect hydration status, diet, and metabolic activity. Students also discussed how the kidney adjusts reabsorption and secretion to maintain homeostasis, and how hormones coordinate excretory processes.

- (a) Explain why urine colour and volume vary among individuals.
- (b) Describe how the kidney adjusts reabsorption to maintain homeostasis.
- (c) Explain the role of hormones in regulating excretion.
- (d) Suggest one reason for the presence of glucose in urine of a diabetic patient.

Item 9

A biology class studied the nephron under a microscope. They observed that blood enters the glomerulus under high pressure, leading to filtration of plasma into Bowman's capsule. The teacher explained the sequential processes of filtration, selective reabsorption, and secretion, and how these processes contribute to excretion and homeostasis. Students discussed the importance of pressure regulation, transport mechanisms, and the effect of diseases on nephron function.

- (a) Explain how filtration occurs in the glomerulus.
- (b) Describe selective reabsorption in the nephron.
- (c) Explain the role of secretion in excretion.
- (d) Suggest one effect of nephron damage on homeostasis.

Item 10

During a field observation, students compared freshwater and marine fish. They noted that freshwater fish produce large volumes of dilute urine, while marine fish produce small volumes of concentrated urine. The teacher explained that this difference is due to osmoregulatory demands in different environments. Students discussed how excretion and osmoregulation work together to maintain ionic and water balance, and how kidney structure and function are adapted to the environment.

- (a) Explain why freshwater fish produce dilute urine.

- (b) Describe why marine fish produce concentrated urine.
- (c) Explain the relationship between excretion and osmoregulation.
- (d) Suggest one structural adaptation in fish kidneys that supports osmoregulation.

TOPIC 6: EXCRETION
ANSWERS / MARKING GUIDE (

Item 1

- (a) Kidneys filter blood under pressure → remove nitrogenous wastes (urea, ammonia) → excrete as urine.**
- (b) Nephrons filter plasma in glomerulus → selectively reabsorb useful substances in tubules → excrete concentrated urine.**
- (c) Waste accumulation → uremia; fluid retention → swelling; electrolyte imbalance → high blood pressure.**
- (d) Dialysis removes excess urea and water → maintains chemical balance → prolongs life.**

Item 2

- (a) Dry season → less water intake → ADH secreted → more water reabsorbed → concentrated urine.**
- (b) ADH increases permeability of collecting ducts → water reabsorbed into blood → urine concentrated.**
- (c) Loop of Henle creates osmotic gradient → facilitates water reabsorption from filtrate.**
- (d) Thick loops of Henle; ability to concentrate urine; minimal water loss.**

Item 3

- (a) Amphibians → urea; birds → uric acid.**
- (b) Birds excrete uric acid → insoluble → less water loss → conserves water in dry environments.**
- (c) Excretion removes nitrogenous wastes while conserving water → maintains osmotic balance.**
- (d) Long, looped nephrons; ability to produce concentrated urine; uricotelic excretion.**

Item 4

- (a) Liver detoxifies harmful substances → converts ammonia to urea → excretes via blood to kidneys.**
- (b) Ammonia + CO₂ → urea (via ornithine cycle) → less toxic → safely excreted.**
- (c) Accumulated bile pigments → dark urine; jaundice.**
- (d) Avoid alcohol; balanced diet; prevent infections; regular check-ups.**

Item 5

- (a) CO₂ diffuses from tissues → blood → lungs → exhaled.**
- (b) High CO₂ → lowers blood pH → acidosis → enzyme activity affected.**
- (c) Higher metabolic rate → more CO₂ produced → faster excretion needed.**
- (d) Respiratory failure → CO₂ accumulation → acidosis → organ damage.**

Item 6

- (a) Water, salts (Na⁺, Cl⁻), urea.**
- (b) Evaporation of sweat → removes heat → regulates body temperature.**
- (c) Sweat removes excess water → maintains fluid volume and osmotic balance.**
- (d) Dehydration; electrolyte imbalance; reduced blood pressure; fainting.**

Item 7

- (a) Bilirubin (bile pigment).**
- (b) Liver processes hemoglobin → produces bile → excretes bilirubin and other wastes.**
- (c) Bile carries metabolic wastes → eliminated in feces.**
- (d) Jaundice; digestive disturbances; accumulation of toxins.**

Item 8

- (a) Hydration status; diet; metabolic rate → affects urine volume and color.*
- (b) Kidney reabsorbs water and solutes as needed → maintains internal environment.*
- (c) Hormones (ADH, aldosterone) regulate water and ion reabsorption.*
- (d) Glucose in urine → diabetes mellitus → hyperglycemia → excess filtered glucose.*

Item 9

- (a) Blood pressure forces plasma into Bowman's capsule → forms glomerular filtrate.*
- (b) Useful substances (glucose, amino acids, water, ions) reabsorbed in proximal tubule, loop of Henle, distal tubule.*
- (c) Secretion moves additional wastes (H^+ , K^+ , drugs) from blood to tubules → excretion.*
- (d) Nephron damage → impaired filtration/reabsorption → toxin accumulation → fluid/electrolyte imbalance.*

Item 10

- (a) Freshwater fish → hypoosmotic environment → water enters → excrete large volumes of dilute urine.*
- (b) Marine fish → hyperosmotic environment → water loss → excrete small volumes of concentrated urine.*
- (c) Excretion eliminates nitrogenous wastes while osmoregulation maintains water/ion balance.*
- (d) Nephrons with loops of Henle; ability to adjust urine concentration; specialized glomerular filtration.*

TOPIC 7: COORDINATION & CONTROL

Item 1

During a biology field trip, students observed a person touching a hot metal surface and immediately withdrawing their hand. The teacher explained that the nervous system allows rapid detection and response to stimuli, often through reflex arcs without conscious thought. The students discussed the role of sensory neurons, relay neurons, and motor neurons, and how impulses travel across synapses. The class also explored how the brain coordinates more complex responses and how both the central and peripheral nervous systems maintain homeostasis in the body.

- (a) Explain why the hand was withdrawn immediately.
- (b) Describe the pathway of a reflex arc involved in this response.
- (c) Explain the role of synapses in nerve impulse transmission.
- (d) Suggest one advantage of reflex actions to survival.

Item 2

A patient with damage to the cerebellum was observed to have difficulty in maintaining balance and coordinating voluntary movements. The teacher explained that the cerebellum integrates sensory information and fine-tunes motor activity. Students discussed the importance of coordination in daily activities such as walking, writing, and sports, and how damage to this part of the brain affects overall control and posture.

- (a) State the function of the cerebellum in coordination.
- (b) Explain how cerebellar damage affects movement.
- (c) Describe the role of sensory input in motor coordination.
- (d) Suggest one rehabilitation approach for cerebellar impairment.

Item 3

During a laboratory experiment, students measured the pupil diameter of a person in different light conditions. The teacher explained that the iris muscles control the amount of light entering the eye through constriction and dilation. The class discussed how the autonomic nervous system regulates involuntary responses and how coordination between sensory input and muscular action ensures optimal vision under varying light conditions.

- (a) Explain why the pupil constricts in bright light.

- (b) Describe the type of muscles involved in pupil adjustment.
- (c) Explain the role of the autonomic nervous system in this response.
- (d) Suggest one consequence of failure in pupil reflexes.

Item 4

A patient was observed to have elevated heart rate and rapid breathing after running a sprint. The teacher explained that the sympathetic nervous system and adrenal hormones coordinate to meet increased oxygen demand. Students discussed how nerve impulses and hormones integrate to maintain homeostasis during physical activity, and how feedback mechanisms adjust heart rate, breathing, and blood flow to various tissues.

- (a) Explain why heart rate and breathing increase during exercise.
- (b) Describe the role of the sympathetic nervous system in this process.
- (c) Explain how hormones contribute to maintaining homeostasis during activity.
- (d) Suggest one long-term effect of regular exercise on coordination and control systems.

Item 5

During a practical, students tested reaction time using a ruler-drop experiment. The teacher explained that reaction time depends on the speed of nerve impulse transmission, synaptic delays, and muscle responsiveness. Students compared reaction times between individuals, discussed factors affecting reflex and voluntary responses, and explored how coordination improves with practice and neural adaptation.

- (a) Explain the factors that determine reaction time.
- (b) Describe the difference between reflex and voluntary responses.
- (c) Explain how repeated practice can improve coordination.
- (d) Suggest one factor that could slow reaction time in humans.

Item 6

A patient with diabetes insipidus was observed to produce excessive dilute urine. The teacher explained that the hypothalamus and pituitary gland regulate water balance via hormone secretion. Students discussed how coordination between endocrine and

nervous systems maintains homeostasis, and how hormonal imbalances disrupt fluid regulation and other physiological processes.

- (a) Identify the hormone involved in water balance.
- (b) Explain how this hormone regulates urine concentration.
- (c) Describe the role of the hypothalamus in endocrine coordination.
- (d) Suggest one effect of deficiency of this hormone on homeostasis.

Item 7

During a lab experiment, students observed that a person's body shivered when exposed to cold water. The teacher explained that temperature regulation is controlled by the hypothalamus, which integrates sensory information and coordinates muscular and vascular responses. The class discussed how nerves and hormones act together to maintain core body temperature within narrow limits and the consequences when coordination fails.

- (a) Explain why shivering occurs in cold conditions.
- (b) Describe how the hypothalamus integrates sensory information for temperature control.
- (c) Explain the role of both nerves and hormones in thermoregulation.
- (d) Suggest one consequence if core body temperature is not maintained.

Item 8

A patient suffered from hyperthyroidism, displaying rapid metabolism, excessive sweating, and restlessness. The teacher explained that the thyroid gland secretes hormones that regulate metabolic rate and energy utilization. Students discussed how endocrine glands coordinate with the nervous system to maintain homeostasis and how excess hormones affect body functions, including heart rate, temperature, and activity levels.

- (a) Explain how thyroid hormones affect metabolic rate.
- (b) Describe two symptoms of hyperthyroidism caused by hormone excess.
- (c) Explain how endocrine and nervous systems interact to maintain homeostasis.
- (d) Suggest one treatment method for hyperthyroidism to restore coordination.

Item 9

During a field observation, students noticed that pupils of different animals respond differently to light intensity. The teacher explained that the nervous system and muscles of the iris control pupil size, while the brain integrates visual information. Students discussed how coordination of sensory input and muscular response ensures optimal vision and protects retinal cells from damage due to excessive light.

- (a) Explain how pupil size is adjusted in different light conditions.
- (b) Describe the muscles involved in pupil adjustment.
- (c) Explain how the brain coordinates visual input and pupil response.
- (d) Suggest one advantage of pupil reflex in survival.

Item 10

A patient with spinal cord injury was observed to have impaired movement and reflex responses below the injury site. The teacher explained that the spinal cord transmits impulses between the brain and body and is involved in reflex coordination. Students discussed how reflex arcs and brain integration allow rapid responses and coordinated voluntary movements, and how damage disrupts these pathways, affecting homeostasis and control.

- (a) Explain why reflex responses are impaired below the injury site.
- (b) Describe the role of the spinal cord in coordination.
- (c) Explain how reflex arcs allow rapid response to stimuli.
- (d) Suggest one rehabilitation approach to improve coordination after spinal injury.

TOPIC 7: COORDINATION & CONTROL
ANSWERS / MARKING GUIDE

Item 1

- (a) Hand withdrawn immediately → reflex action → rapid, involuntary response to protect body from harm.**
- (b) Reflex arc pathway: sensory neuron detects stimulus → relay neuron in spinal cord → motor neuron → effector muscle contracts.**

(c) Synapses transmit impulses between neurons → allow one-way directional flow → ensure correct response.

(d) Reflexes provide rapid protection → prevent injury → enhance survival.

Item 2

(a) Cerebellum coordinates voluntary movements → maintains balance and posture.

(b) Damage → loss of fine motor control, unsteady gait, difficulty performing coordinated tasks.

(c) Sensory input from muscles, joints, and inner ear informs cerebellum → adjusts movement.

(d) Physiotherapy, balance training, and repetitive exercises to improve coordination.

Item 3

(a) Pupil constricts in bright light → less light enters eye → protects retina.

(b) Circular and radial muscles of the iris.

(c) Autonomic nervous system (parasympathetic for constriction, sympathetic for dilation) → involuntary control.

(d) Failure → retinal damage, impaired vision, light sensitivity.

Item 4

(a) Exercise → increased oxygen demand → sympathetic nervous system → heart rate ↑, breathing rate ↑ to supply tissues.

(b) Sympathetic nerves stimulate heart and lungs → increase blood flow and respiration rate.

(c) Adrenaline released → increases heart rate, glycogen breakdown → supports homeostasis.

(d) Improved cardiovascular fitness; efficient oxygen delivery; better metabolic control.

Item 5

- (a) Reaction time depends on nerve impulse speed, synaptic delay, muscle response time.**
- (b) Reflex → involuntary, fast; voluntary → conscious, slower, controlled by brain.**
- (c) Repetition → strengthens neural pathways → faster impulse transmission → improved coordination.**
- (d) Fatigue, alcohol, drugs, age, illness → slow reaction time.**

Item 6

- (a) Antidiuretic hormone (ADH).**
- (b) ADH increases permeability of collecting ducts → more water reabsorbed → concentrated urine → maintains fluid balance.**
- (c) Hypothalamus detects osmotic changes → stimulates posterior pituitary to release ADH.**
- (d) Deficiency → diabetes insipidus → excessive dilute urine → dehydration → electrolyte imbalance.**

Item 7

- (a) Shivering → involuntary muscle contractions → generate heat → maintain core temperature.**
- (b) Hypothalamus integrates temperature signals from skin and core → activates effectors.**
- (c) Nerves → stimulate muscles/blood vessels; hormones → modulate metabolism → coordinated thermoregulation.**
- (d) Hypothermia → impaired enzyme function → organ failure → death if prolonged.**

Item 8

- (a) Thyroid hormones increase metabolic rate → increase energy production and heat generation.**
- (b) Symptoms: rapid heartbeat, excessive sweating, weight loss, restlessness.**
- (c) Nervous system senses changes → coordinates with endocrine system to maintain homeostasis (feedback loops).**

(d) Anti-thyroid drugs, beta-blockers, surgery, or radioactive iodine therapy.

Item 9

(a) Pupil dilates in dim light, constricts in bright light → regulates light entering eye → protects retina and optimizes vision.

(b) Circular muscles → constrict pupil; radial muscles → dilate pupil.

(c) Brain receives sensory input → coordinates iris muscles → adjusts pupil size reflexively.

(d) Protects retinal cells; improves vision under varying light; enhances survival.

Item 10

(a) Reflex responses impaired below injury → spinal cord unable to transmit impulses → effectors not activated.

(b) Spinal cord transmits impulses between brain and body → coordinates voluntary and involuntary actions.

(c) Reflex arcs allow rapid response → bypass brain → direct communication from sensory to motor neurons.

(d) Physiotherapy, electrical stimulation, adaptive devices to improve coordination and functional recovery.

TOPIC 8: REPRODUCTION

Item 1

During a biology practical, students observed slides of human sperm and egg cells. The teacher explained the differences in structure and function, emphasizing how the sperm's motility and the egg's nutrient reserves are suited for fertilization. Later, students discussed how fertilization occurs in the oviduct, and how zygote formation initiates development of a new individual. The class explored the roles of meiosis, gamete differentiation, and genetic variation in sexual reproduction.

Task

- (a) Explain how the structure of sperm and egg cells relates to their function.
- (b) Describe the process of fertilization in humans.
- (c) Explain the importance of meiosis in gamete formation.
- (d) Suggest one advantage of sexual reproduction in humans.

Item 2

A couple visited a fertility clinic after experiencing difficulty conceiving. The doctor explained that successful reproduction requires coordinated hormonal cycles, ovulation, and healthy gametes. Students discussed the role of hormones such as FSH, LH, estrogen, and progesterone in regulating the menstrual cycle. They also explored how disruptions in these hormonal pathways can affect fertility.

- (a) Identify two hormones that regulate ovulation.
- (b) Explain the role of FSH and LH in the menstrual cycle.
- (c) Describe how progesterone maintains pregnancy.
- (d) Suggest one cause of infertility related to hormonal imbalance.

Item 3

During a field trip to a fish farm, students observed external fertilization in fish and amphibians. The teacher explained that eggs and sperm are released into water, and fertilization occurs externally. Students discussed the advantages and disadvantages of external versus internal fertilization, and how environmental factors such as temperature, water pH, and oxygen levels affect reproductive success.

- (a) Explain how external fertilization occurs in fish.
- (b) Describe one advantage and one disadvantage of external fertilization.
- (c) Compare external fertilization with internal fertilization in terms of offspring survival.
- (d) Suggest one environmental factor that affects external fertilization success.

Item 4

A student investigated the development of embryos in a plant. They observed fertilization in flowers, formation of zygotes, and development of seeds. The teacher explained how pollination, fertilization, and seed formation ensure propagation of plant

species. Students also discussed adaptations for effective reproduction, such as flower structure, pollen dispersal mechanisms, and seed protection.

- (a) Explain how fertilization occurs in flowering plants.
- (b) Describe the development of seeds after fertilization.
- (c) Explain the role of pollination in plant reproduction.
- (d) Suggest one adaptation that enhances reproductive success in plants.

Item 5

During a biology practical, students compared the reproductive organs of male and female mammals. They observed structures such as testes, ovaries, oviducts, and uterus, and discussed their functions in gamete production, transport, fertilization, and gestation. The teacher emphasized the importance of structural adaptations in ensuring successful reproduction and survival of the species.

- (a) Describe the functions of testes and ovaries.
- (b) Explain how gametes are transported in males and females.
- (c) Describe the structure of the uterus that supports embryo development.
- (d) Suggest one adaptation of reproductive organs that enhances fertilization success.

Item 6

A patient in a clinic was diagnosed with a hormone imbalance affecting ovulation. The teacher explained that the coordination of FSH, LH, estrogen, and progesterone is essential for regular cycles and successful reproduction. Students discussed how negative and positive feedback mechanisms regulate hormone secretion, ovulation, and preparation of the endometrium for implantation.

- (a) Explain the role of FSH and LH in ovulation.
- (b) Describe how negative feedback regulates hormone levels in the menstrual cycle.
- (c) Explain how the endometrium is prepared for implantation.
- (d) Suggest one effect of hormone imbalance on reproduction.

Item 7

During a practical, students examined the effects of temperature on sperm viability. They observed that sperm production and motility decreased at higher or lower than

optimal temperatures. The teacher explained that testes are located outside the body in the scrotum to maintain optimal temperature. Students discussed how temperature regulation ensures successful gamete production and fertility.

- (a) Explain why sperm production is temperature-sensitive.
- (b) Describe how the scrotum helps maintain optimal testicular temperature.
- (c) Explain the effect of extreme temperatures on fertility.
- (d) Suggest one evolutionary advantage of external testes in mammals.

Item 8

A student studied contraceptive methods and their mechanisms. They observed that hormonal contraceptives prevent ovulation, barrier methods prevent sperm entry, and intrauterine devices affect implantation. The teacher emphasized the importance of understanding reproduction control for family planning, population management, and preventing sexually transmitted infections.

- (a) Explain how hormonal contraceptives prevent pregnancy.
- (b) Describe the mechanism of barrier methods in contraception.
- (c) Explain how intrauterine devices affect implantation.
- (d) Suggest one advantage of using contraception in human populations.

Item 9

During a biology lesson, students observed embryonic development stages in birds using candled eggs. The teacher explained how fertilization, cleavage, and differentiation lead to formation of tissues and organs. Students discussed the role of yolk as a nutrient source, amniotic membranes for protection, and environmental conditions for successful development.

- (a) Explain the role of the yolk in bird embryonic development.
- (b) Describe the stages of embryonic development after fertilization.
- (c) Explain how amniotic membranes protect the developing embryo.
- (d) Suggest one environmental factor that affects embryo survival in birds.

Item 10

A student investigated the effects of sexually transmitted infections (STIs) on reproductive health. They observed that infections can cause infertility, complications in pregnancy, and transmission to offspring. The teacher emphasized the importance of prevention, early diagnosis, and treatment. Students also discussed the role of education and public health measures in controlling STIs and promoting reproductive health.

- (a) Explain how STIs can affect fertility.
- (b) Describe one complication of STIs during pregnancy.
- (c) Explain how transmission of STIs can occur from mother to offspring.
- (d) Suggest one preventive measure to reduce the risk of STIs.

TOPIC 8: REPRODUCTION

ANSWERS / MARKING GUIDE

Item 1

- (a) Sperm → motile, small, streamlined, flagellum for swimming to egg; egg → large, nutrient-rich, non-motile → supports early development.**
- (b) Fertilization occurs in the oviduct → sperm meets egg → membrane fusion → nuclei combine → zygote formation.**
- (c) Meiosis reduces chromosome number by half → produces haploid gametes → ensures genetic variation.**
- (d) Sexual reproduction → genetic variation → increased adaptability → survival of species.**

Item 2

- (a) FSH (Follicle Stimulating Hormone) and LH (Luteinizing Hormone).**
- (b) FSH stimulates follicle growth; LH triggers ovulation.**
- (c) Progesterone maintains endometrium → supports implantation and pregnancy.**
- (d) Polycystic ovary syndrome, hormonal imbalance, stress, poor diet → infertility.**

Item 3

(a) Eggs and sperm released into water → fertilization occurs externally → zygote forms outside female body.

(b) Advantage → large number of gametes increases chance of fertilization;

Disadvantage → high predation → low survival rate.

(c) Internal fertilization → gametes protected → higher survival; external → more offspring but lower survival.

(d) Temperature, oxygen levels, water pH → affect gamete viability and fertilization success.

Item 4

(a) Pollen from anther lands on stigma → pollen tube grows → sperm cells travel → fertilize ovule → zygote forms.

(b) Zygote develops → embryo → cotyledons and endosperm form → seed develops within ovule.

(c) Pollination ensures transfer of pollen to stigma → necessary for fertilization.

(d) Flower structure, bright petals, nectar, scent → attract pollinators → improve reproduction success.

Item 5

(a) Testes → produce sperm and testosterone; Ovaries → produce eggs and estrogen/progesterone.

(b) Sperm transported via vas deferens → urethra; egg transported via oviduct → uterus.

(c) Uterus has thick muscular wall and endometrium → supports implantation, nourishment, and protection of embryo.

(d) Scrotal positioning, accessory glands, ovary positioning → enhance fertilization chances.

Item 6

(a) FSH stimulates follicle growth; LH triggers ovulation.

(b) Negative feedback: high estrogen/progesterone inhibits FSH/LH → prevents multiple ovulations.

(c) Progesterone prepares endometrium → thick, vascularized → ready for implantation.

(d) Hormonal imbalance → irregular cycles, failed ovulation → infertility.

Item 7

(a) Sperm production sensitive to temperature → enzymes and spermatogenesis optimal at ~34°C.

(b) Scrotum regulates temperature → moves testes closer/farther from body → maintains optimal spermatogenesis temperature.

(c) Extreme heat/cold → reduces sperm motility and viability → fertility decreases.

(d) External testes allow cooling → improve sperm production → evolutionary advantage.

Item 8

(a) Hormonal contraceptives (estrogen/progesterone) prevent FSH → ovulation inhibited → no egg released.

(b) Barrier methods (condoms, diaphragms) prevent sperm from reaching egg → block fertilization.

(c) IUDs prevent implantation → alter uterine lining → fertilized egg cannot implant.

(d) Family planning, reduce unplanned pregnancies, control population growth → promote reproductive health.

Item 9

(a) Yolk provides nutrients (proteins, fats, carbohydrates) → sustains embryo during development.

(b) Stages: zygote → cleavage → blastula → gastrula → organogenesis → mature embryo.

(c) Amniotic membranes cushion, prevent desiccation, and maintain fluid environment → protect embryo.

(d) Temperature, humidity, oxygen availability → affect embryo survival and development.

Item 10

(a) STIs can damage reproductive organs → block gamete transport → cause infertility.

(b) Complication during pregnancy → miscarriage, premature birth, neonatal infection.

(c) Vertical transmission → from mother to fetus during pregnancy, birth, or breastfeeding.

(d) Safe sex practices, condom use, vaccination, early treatment → reduce STI risk.

TOPIC 9: GENETICS & EVOLUTION

Item 1

During a biology practical, students examined karyotypes of human chromosomes. The teacher explained how chromosomes carry genes and determine inheritance patterns. They discussed how mutations, gene segregation, and independent assortment influence traits in offspring. Later, students explored cases of genetic disorders caused by chromosomal abnormalities, such as Down syndrome and Klinefelter syndrome, and how these conditions are detected and inherited.

Task

(a) Explain the role of chromosomes in inheritance.

(b) Describe how mutations can affect genetic traits.

(c) Explain the significance of independent assortment during meiosis.

(d) Suggest one method of detecting chromosomal abnormalities in humans.

Item 2

A farmer crossbred two varieties of maize to produce offspring with desired traits. The teacher explained how Mendelian principles of segregation and dominance determine the inheritance of characteristics. Students performed Punnett square calculations to predict offspring ratios and discussed the difference between homozygous and heterozygous genotypes, as well as dominant and recessive traits.

Task

- (a) Explain the principle of segregation in inheritance.
- (b) Describe how dominant and recessive alleles determine phenotype.
- (c) Compare homozygous and heterozygous genotypes.
- (d) Suggest one advantage of using selective breeding in agriculture.

Item 3

During a field study, students observed variations in coat color and size among a population of rabbits. The teacher explained that genetic variation provides material for natural selection. Students discussed how environmental pressures, competition, and predation can influence which traits are advantageous, leading to evolution over generations.

Task

- (a) Explain how genetic variation arises in populations.
- (b) Describe how natural selection affects allele frequency.
- (c) Explain the role of environmental pressures in evolution.
- (d) Suggest one example of a trait in rabbits that could be advantageous for survival.

Item 4

A student investigated antibiotic resistance in bacteria. They observed that some bacteria survived antibiotic treatment while others died. The teacher explained that mutations and selection pressures lead to the evolution of resistant strains. Students discussed the implications of antibiotic resistance for human health and how genetic changes in microorganisms can spread rapidly through populations.

- (a) Explain how mutations contribute to antibiotic resistance.
- (b) Describe the process of natural selection in bacteria exposed to antibiotics.
- (c) Explain why resistant bacteria increase in frequency over time.
- (d) Suggest one measure to reduce the spread of antibiotic resistance.

Item 5

During a laboratory experiment, students performed a monohybrid cross using fruit flies to study eye color inheritance. The teacher explained how Punnett squares predict offspring phenotypes and how X-linked traits are inherited differently in males and females. Students analyzed the results and discussed the significance of sex-linked inheritance in predicting patterns of genetic disorders.

- (a) Explain how monohybrid crosses predict offspring phenotypes.
- (b) Describe how X-linked traits are inherited.
- (c) Explain why males are more affected by X-linked recessive disorders.
- (d) Suggest one example of an X-linked trait in humans.

Item 6

A population of moths living near industrial areas exhibited darker coloration compared to those in rural areas. The teacher explained that this is an example of industrial melanism, a case of natural selection in response to environmental change. Students discussed how alleles for dark coloration became more frequent due to selective pressures and how this illustrates adaptive evolution.

Task

- (a) Explain how industrial melanism demonstrates natural selection.
- (b) Describe the role of selective pressures in changing allele frequency.
- (c) Explain how adaptation improves survival and reproduction.
- (d) Suggest one other example of natural selection in animals.

Item 7

During a genetics lesson, students studied pedigree charts to analyze inheritance of genetic diseases. The teacher explained how pedigrees reveal dominant, recessive, and sex-linked patterns. Students practiced interpreting charts, predicting genotypes, and understanding the probability of offspring inheriting certain traits.

- (a) Explain how pedigree charts are used to study inheritance.
- (b) Describe how dominant and recessive traits are represented in pedigrees.
- (c) Explain the significance of sex-linked inheritance in pedigrees.
- (d) Suggest one limitation of using pedigree analysis.

Item 8

A student investigated genetic mutations in fruit flies exposed to radiation. Some flies showed visible phenotypic changes while others remained normal. The teacher explained how mutagens increase mutation rate and can lead to evolution if beneficial mutations are selected. Students discussed the difference between somatic and germline mutations and their implications for inheritance.

- (a) Explain the effect of mutagens on genetic material.
- (b) Describe the difference between somatic and germline mutations.
- (c) Explain how beneficial mutations can lead to evolution.
- (d) Suggest one ethical consideration when studying induced mutations in organisms.

Item 9

During a field study, students observed that some plant species produced more seeds and survived better in drought conditions than others. The teacher explained that this variation is due to genetic differences and environmental adaptation. Students discussed how reproductive success leads to the propagation of favorable alleles and gradual evolution of populations.

- (a) Explain how genetic variation influences reproductive success.

- (b) Describe how environmental factors select for advantageous traits.
- (c) Explain the role of differential survival in evolution.
- (d) Suggest one plant adaptation to drought conditions.

Item 10

A student studied human blood groups and noticed that the A, B, AB, and O groups follow co-dominance and multiple allele inheritance. The teacher explained how multiple alleles contribute to genetic diversity and how co-dominance allows both alleles to be expressed in heterozygotes. Students discussed how understanding blood group inheritance is important in transfusion medicine.

Task

- (a) Explain the inheritance pattern of human blood groups.
- (b) Describe the concept of co-dominance.
- (c) Explain how multiple alleles contribute to genetic diversity.
- (d) Suggest one practical application of blood group knowledge in medicine.

TOPIC 9: GENETICS & EVOLUTION

ANSWERS / MARKING GUIDE (

Item 1

- (a) Chromosomes carry genes → determine inherited traits → transmitted from parents to offspring.**
- (b) Mutations alter DNA sequence → may change protein structure/function → affect phenotype.**
- (c) Independent assortment during meiosis → random separation of homologous chromosomes → genetic variation in gametes.**
- (d) Karyotyping, amniocentesis, or prenatal genetic screening → detect chromosomal abnormalities.**

Item 2

- (a) Segregation → two alleles separate during gamete formation → each gamete receives one allele.*
- (b) Dominant allele → expressed in phenotype if present; Recessive allele → expressed only if homozygous.*
- (c) Homozygous → two identical alleles; Heterozygous → two different alleles.*
- (d) Selective breeding → produce desired traits → improve yield, quality, disease resistance.*

Item 3

- (a) Genetic variation arises via mutation, meiosis (crossing over, independent assortment), and sexual reproduction.*
- (b) Natural selection → advantageous alleles increase in frequency → improve adaptation.*
- (c) Environmental pressures → select traits that enhance survival and reproduction → drive evolution.*
- (d) Camouflage coat color → avoids predation → increases survival.*

Item 4

- (a) Mutation creates variation → some bacteria resistant to antibiotics.*
- (b) Natural selection → susceptible bacteria die, resistant survive and reproduce.*
- (c) Resistant bacteria pass on genes → frequency of resistance increases.*
- (d) Prudent antibiotic use, complete dosage, hygiene measures → reduce spread.*

Item 5

- (a) Punnett squares predict genotypic and phenotypic ratios of offspring from parental alleles.*
- (b) X-linked traits → located on X chromosome → males (XY) more likely to express recessive traits.*
- (c) Males have only one X → recessive allele expressed if present; females have two X → may mask recessive allele.*
- (d) Examples: hemophilia, color blindness.*

Item 6

- (a) Industrial melanism → dark-colored moths survive better → allele frequency increases → natural selection observed.**
- (b) Selective pressures → predation, environment → favor certain phenotypes → allele frequency changes.**
- (c) Adaptation → improves survival and reproduction → beneficial traits passed on.**
- (d) Example: antibiotic resistance in bacteria, long neck in giraffes.**

Item 7

- (a) Pedigrees track inheritance patterns → predict traits and carriers.**
- (b) Dominant traits → appear in every generation; Recessive → may skip generations.**
- (c) Sex-linked traits → patterns differ in males and females → males more affected by X-linked recessives.**
- (d) Limitation → small sample size, incomplete family information → reduces accuracy.**

Item 8

- (a) Mutagens → alter DNA → increase mutation rate → may create new alleles.**
- (b) Somatic mutations → affect body cells, not inherited; Germline mutations → affect gametes → heritable.**
- (c) Beneficial mutations → confer advantage → selected → contribute to evolution.**
- (d) Ethical consideration → avoid harm to organisms, respect welfare and biodiversity.**

Item 9

- (a) Genetic variation → some individuals better adapted → higher reproductive success → propagate favorable alleles.**

- (b) Environmental factors → select for traits that enhance survival → drive evolution.**
- (c) Differential survival → better-adapted individuals reproduce → gradual change in population.**
- (d) Drought adaptation → deep roots, reduced leaf area, water storage tissues.**

Item 10

- (a) Blood groups A, B, O → controlled by multiple alleles; inheritance follows Mendelian principles.**
- (b) Co-dominance → both alleles expressed equally in heterozygotes → AB blood group.**
- (c) Multiple alleles → increase variation in population → more possible genotypes and phenotypes.**
- (d) Blood transfusion compatibility, paternity testing, genetic counseling.**

TOPIC 10: ECOLOGY & ENVIRONMENT

Item 1

During a field trip to a forest reserve, students observed interactions between plants, herbivores, and carnivores. The teacher explained that ecosystems are composed of biotic and abiotic factors that influence species survival. Students recorded feeding relationships, discussed the flow of energy, and observed how changes in one population affected others. They also explored the importance of maintaining ecosystem balance for biodiversity conservation.

Task

- (a) Explain the roles of producers, consumers, and decomposers in an ecosystem.**
- (b) Describe how energy flows through trophic levels.**
- (c) Explain the effect of removing a top predator from an ecosystem.**
- (d) Suggest one method to conserve biodiversity in forest ecosystems.**

Item 2

A student monitored a pond ecosystem and observed fluctuations in fish and algae populations over time. The teacher explained the concept of population dynamics,

including birth rates, death rates, immigration, and emigration. Students discussed how environmental factors such as nutrients, light, and temperature affect population sizes and how predator-prey interactions regulate community structure.

Task

- (a) Explain the factors that influence population size in an ecosystem.
- (b) Describe how predator-prey interactions affect population dynamics.
- (c) Explain the role of abiotic factors in population regulation.
- (d) Suggest one method of managing fish populations sustainably.

Item 3

During a practical, students analyzed a soil sample from a grassland and identified microorganisms, roots, and detritus. The teacher explained how decomposers recycle nutrients, maintain soil fertility, and support plant growth. Students also discussed the impact of human activities such as overgrazing and agriculture on nutrient cycling and soil health.

Task

- (a) Explain the role of decomposers in nutrient cycling.
- (b) Describe how nutrients are recycled in ecosystems.
- (c) Explain the effect of human activities on soil fertility.
- (d) Suggest one practice to maintain soil health in grasslands.

Item 4

A student observed that certain plant species grew in shaded areas while others thrived in open sunlight. The teacher explained how light availability, water, and soil nutrients affect species distribution. Students also explored competition for resources and how organisms adapt morphologically and physiologically to their habitats.

Task

- (a) Explain how abiotic factors influence species distribution.
- (b) Describe one adaptation of plants to shaded conditions.
- (c) Explain the role of competition in determining community structure.
- (d) Suggest one adaptation of plants to water scarcity.

Item 5

During a field study, students investigated the effects of pollution on aquatic ecosystems. They observed changes in species composition, algal blooms, and reduced oxygen levels in water. The teacher explained how chemical pollutants, heavy metals, and eutrophication disrupt ecological balance. Students discussed mitigation measures and the importance of monitoring environmental quality.

- (a) Explain how pollution affects aquatic ecosystems.
- (b) Describe the process of eutrophication and its impact.
- (c) Explain how pollutants disrupt ecological balance.
- (d) Suggest one method to reduce water pollution.

Item 6

A student tracked bird migration patterns using GPS tags. The teacher explained that migration is an adaptive response to seasonal changes in food availability, temperature, and breeding sites. Students discussed how ecological cues trigger hormonal changes and how human activities such as deforestation and climate change affect migratory routes.

Task

- (a) Explain why birds migrate seasonally.
- (b) Describe the ecological cues that trigger migration.
- (c) Explain the impact of human activities on migratory species.
- (d) Suggest one conservation strategy to protect migratory birds.

Item 7

During a laboratory experiment, students measured dissolved oxygen and pH in different water samples. The teacher explained how these abiotic factors influence aquatic life, species diversity, and productivity. Students discussed how changes in oxygen levels affect fish survival and how acidification impacts aquatic ecosystems.

- (a) Explain the importance of dissolved oxygen in aquatic ecosystems.

- (b) Describe the effect of low oxygen levels on aquatic organisms.
- (c) Explain how pH changes can affect species composition.
- (d) Suggest one method to maintain water quality in rivers and lakes.

Item 8

A student observed predator-prey interactions between foxes and rabbits in a grassland ecosystem. The teacher explained how population sizes oscillate due to predator-prey relationships and feedback mechanisms. Students also discussed the role of carrying capacity, competition, and environmental factors in regulating populations.

- (a) Explain how predator-prey interactions regulate population sizes.
- (b) Describe the concept of carrying capacity.
- (c) Explain the role of feedback mechanisms in population regulation.
- (d) Suggest one method to manage wildlife populations sustainably.

Item 9

During a practical, students compared primary and secondary succession in disturbed and undisturbed habitats. They observed changes in species composition, soil development, and ecosystem structure over time. The teacher explained how succession leads to climax communities and how disturbances reset the process.

- (a) Explain the difference between primary and secondary succession.
- (b) Describe the changes that occur during ecological succession.
- (c) Explain how succession leads to climax communities.
- (d) Suggest one factor that can reset succession in an ecosystem.

Item 10

A student investigated the impact of invasive species on native plant communities. They observed that invasive plants outcompeted native species for resources, altered nutrient cycling, and reduced biodiversity. The teacher explained how invasive species disrupt ecological balance and how management strategies are implemented to control their spread.

- (a) Explain how invasive species affect native ecosystems.
- (b) Describe the impact of invasive species on biodiversity.
- (c) Explain how resource competition contributes to the success of invasive species.
- (d) Suggest one method to control invasive species in natural habitats.

TOPIC 10: ECOLOGY & ENVIRONMENT
ANSWERS / MARKING GUIDE

Item 1

- (a) Producers → make food via photosynthesis; Consumers → feed on other organisms; Decomposers → break down dead matter → recycle nutrients.**
- (b) Energy flows from producers → primary consumers → secondary consumers → tertiary consumers; energy lost as heat at each trophic level.**
- (c) Removing top predator → prey population may increase → herbivory pressure rises → ecosystem imbalance.**
- (d) Habitat protection, anti-poaching measures, reforestation → conserve biodiversity.**

Item 2

- (a) Population size influenced by birth rate, death rate, immigration, emigration.**
- (b) Predation regulates prey population → predator population depends on prey availability → dynamic equilibrium.**
- (c) Abiotic factors (light, temperature, nutrients, water) limit growth and reproduction → affect population size.**
- (d) Sustainable harvesting, stocking programs, habitat management → maintain fish populations.**

Item 3

- (a) Decomposers break down organic matter → release nutrients → maintain soil fertility.**
- (b) Nutrients recycled through decomposition → absorbed by plants → passed through food chain.**
- (c) Overgrazing, deforestation, agriculture → remove organic matter → reduce nutrient availability.**
- (d) Crop rotation, organic fertilization, controlled grazing → maintain soil health.**

Item 4

- (a) Abiotic factors (light, water, temperature, nutrients) → determine where species can survive and grow.**
- (b) Shade-tolerant plants → larger, thin leaves → capture limited light efficiently.**
- (c) Competition → species with similar requirements compete → less adapted species may decline.**
- (d) Xerophytes → small leaves, thick cuticle, water storage tissues → survive dry conditions.**

Item 5

- (a) Pollution → kills sensitive species, alters food webs, reduces biodiversity.**
- (b) Eutrophication → nutrient enrichment → algal blooms → oxygen depletion → aquatic life dies.**
- (c) Pollutants disrupt chemical balance → affect reproduction, growth, survival → ecosystem instability.**
- (d) Reduce industrial discharge, treat wastewater, regulate agricultural runoff → lower water pollution.**

Item 6

- (a) Birds migrate to exploit seasonal food and breeding sites → survival advantage.**
- (b) Ecological cues → day length, temperature, food availability → trigger hormonal responses for migration.**

(c) Deforestation, climate change → habitat loss, altered migration routes → threaten species survival.

(d) Protect habitats, create wildlife corridors, international agreements → conserve migratory species.

Item 7

(a) Dissolved oxygen essential for respiration of aquatic organisms → supports life and ecosystem productivity.

(b) Low oxygen → fish suffocate, reduce biodiversity, collapse of aquatic communities.

(c) pH changes → affect enzyme activity and species tolerance → shift species composition.

(d) Aeration, pollution control, buffer zones → maintain water quality.

Item 8

(a) Predator-prey interactions → control prey numbers → prevent overpopulation → balance ecosystem.

(b) Carrying capacity → maximum population that an environment can support sustainably.

(c) Feedback mechanisms → population changes adjust birth/death rates → maintain equilibrium.

(d) Regulated hunting, habitat management, protected areas → manage wildlife populations.

Item 9

(a) Primary succession → colonization of bare land → no soil; Secondary → disturbed land → soil present.

(b) Succession → pioneer species colonize → soil develops → shrubs and trees → climax community established.

(c) Climax community → stable, self-sustaining ecosystem → dominant species established.

(d) Natural disasters, deforestation, human activity → reset succession.

Item 10

(a) Invasive species outcompete natives → reduce native populations → disrupt ecosystem balance.

(b) Biodiversity declines → fewer species, altered food webs, reduced ecosystem services.

(c) Compete for light, nutrients, space, water → dominate habitat → reduce native species success.

(d) Mechanical removal, biological control, chemical treatment → control invasive species spread.

COMBINED TOPIC 1 & 2: CELL BIOLOGY + NUTRITION

Item 1

During a biology practical, students observed a slide of an epithelial cell under a microscope. They noted the nucleus, mitochondria, and cell membrane. The teacher explained that cells require nutrients to produce energy. Later, the students performed an experiment measuring glucose uptake in cells. They discussed how carbohydrates are digested into monosaccharides, absorbed into the bloodstream, and transported to cells for cellular respiration. The link between nutrient availability and energy production in the mitochondria was emphasized, showing the integration of cell structure and nutrition.

Task

- (a) Explain the role of mitochondria in energy production.
- (b) Describe how carbohydrates are digested and transported to cells.
- (c) Explain the relationship between nutrient availability and cellular function.
- (d) Suggest one consequence of insufficient nutrient supply to cells.

Item 2

Students examined plant cells under a microscope and observed chloroplasts. The teacher explained how photosynthesis converts light energy into chemical energy in the form of glucose. Later, they discussed how glucose and other nutrients are used by both plant and animal cells to produce ATP via cellular respiration. Students explored how proper nutrition ensures efficient energy supply for cell maintenance, growth, and repair.

Task

- (a) Explain the role of chloroplasts in plant cells.
- (b) Describe how glucose produced in photosynthesis is used in cells.
- (c) Explain why nutrients are essential for cellular activities.
- (d) Suggest one effect of nutrient deficiency on plant cell function.

Item 3

During a lab experiment, students measured the effect of protein intake on enzyme activity in cells. They observed that amino acids from digested proteins are essential for synthesizing enzymes and structural proteins. The teacher explained how nutrients influence cell metabolism and repair. Students also discussed how lack of specific nutrients, such as vitamins or minerals, can impair cellular functions like enzyme activity or membrane integrity.

Task

- (a) Explain the role of proteins and amino acids in cells.
- (b) Describe how enzymes facilitate cellular reactions.
- (c) Explain how nutrient deficiency affects cell metabolism.
- (d) Suggest one cellular process that is affected by protein deficiency.

Item 4

A student observed blood smears and noted red blood cells transporting oxygen. The teacher linked this to the importance of iron in the diet for hemoglobin synthesis. Students discussed how nutrition affects cellular oxygen transport and energy production. They also explored the consequences of deficiencies, such as anemia, which limits oxygen delivery to cells and reduces ATP synthesis.

Task

- (a) Explain the role of hemoglobin in oxygen transport.
- (b) Describe how dietary iron affects red blood cell function.
- (c) Explain the effect of reduced oxygen supply on cellular respiration.
- (d) Suggest one symptom of iron deficiency in humans.

Item 5

During a practical, students investigated lipid absorption in the small intestine and its transport to cells. The teacher explained that lipids are essential components of cell membranes and are also an energy source. Students discussed how fatty acids are broken down, transported, and incorporated into phospholipids for membrane synthesis, highlighting the connection between nutrition and cell structure.

Task

- (a) Explain how lipids are digested and transported to cells.
- (b) Describe the role of lipids in cell membrane structure.
- (c) Explain how lipid deficiency affects cellular function.
- (d) Suggest one function of lipids other than energy storage and membrane formation.

Item 6

During an experiment, students cultured yeast cells and measured growth in media containing different sugar concentrations. They observed that cells grew faster when nutrients were optimal. The teacher explained the link between carbohydrate availability and ATP production. Students discussed how both macronutrients and micronutrients influence cell division, growth, and energy metabolism.

Task

- (a) Explain the role of glucose in cellular energy production.
- (b) Describe how nutrient concentration affects cell growth.
- (c) Explain why balanced nutrition is necessary for cell division.
- (d) Suggest one effect of excess nutrient supply on cells.

Item 7

A student investigated how vitamins and minerals affect cellular function. They observed that vitamin C deficiency impaired collagen synthesis in connective tissue cells. The teacher explained that micronutrients act as coenzymes and cofactors in metabolic pathways. Students discussed how diet influences cell repair, signaling, and overall metabolism, linking nutrition directly to cell biology.

Task

- (a) Explain the role of vitamins as coenzymes in cells.
- (b) Describe how minerals act as cofactors in enzymatic reactions.
- (c) Explain the effect of vitamin deficiency on cellular metabolism.
- (d) Suggest one example of a mineral essential for cell function.

Item 8

During a biology practical, students observed the effects of glucose deprivation on cultured animal cells. The teacher explained that without sufficient glucose, cells cannot generate ATP efficiently, leading to impaired function and possible cell death. Students linked nutrition to cellular energy needs and discussed how proper diet maintains tissue and organ health.

Task

- (a) Explain why glucose is essential for ATP production.
- (b) Describe the consequences of glucose deprivation on cells.
- (c) Explain the connection between nutrition and tissue function.
- (d) Suggest one condition caused by prolonged nutrient deficiency.

Item 9

A student examined muscle cells and noted that mitochondria were abundant in cells with high energy demand. The teacher explained that adequate protein and carbohydrate intake supports ATP production for muscle contraction. Students discussed how nutrition influences muscle function and recovery after exercise, linking cell biology with dietary requirements.

Task

- (a) Explain why muscle cells have many mitochondria.
- (b) Describe how nutrients support ATP production in muscle cells.
- (c) Explain the effect of poor nutrition on muscle function.
- (d) Suggest one dietary recommendation to improve muscle performance.

Item 10

During a field study, students observed algae in a pond and analyzed their nutrient uptake. The teacher explained that essential nutrients like nitrogen and phosphorus are critical for nucleic acid and protein synthesis in cells. Students discussed how nutrient availability in the environment affects cellular growth, population density, and ecosystem health, linking cell biology and nutrition.

Task

- (a) Explain the role of nitrogen and phosphorus in cells.
- (b) Describe how nutrient availability affects cell growth.
- (c) Explain the connection between cellular nutrition and population health.
- (d) Suggest one consequence of nutrient deficiency in aquatic ecosystems.

**COMBINED TOPIC 1 & 2: CELL BIOLOGY + NUTRITION
ANSWERS / MARKING GUIDE**

Item 1

- (a) Mitochondria → site of aerobic respiration → convert glucose into ATP (energy) for cellular activities.**
- (b) Carbohydrates digested to monosaccharides → absorbed in small intestine → transported via blood → delivered to cells.**
- (c) Nutrient availability provides substrates for metabolism → energy → supports cell growth, repair, and function.**
- (d) Insufficient nutrients → low ATP → impaired cell function, fatigue, slowed growth, or cell death.**

Item 2

(a) Chloroplasts → site of photosynthesis → convert light energy into chemical energy (glucose).

(b) Glucose used in respiration → ATP production → supports cellular activities in plants and animals.

(c) Nutrients supply energy and building blocks → maintain cell structure and function.

(d) Deficiency → stunted growth, low energy production, poor repair of plant tissues.

Item 3

(a) Proteins → amino acids → build enzymes, structural proteins, and organelles in cells.

(b) Enzymes → catalyze metabolic reactions → regulate biochemical pathways efficiently.

(c) Nutrient deficiency → reduced enzyme activity → slower metabolism → impaired repair and growth.

(d) Protein deficiency → affects synthesis of enzymes, structural proteins, antibodies, hemoglobin.

Item 4

(a) Hemoglobin in red blood cells → binds and transports oxygen from lungs to tissues.

(b) Dietary iron → essential for hemoglobin synthesis → enables oxygen transport.

(c) Reduced oxygen → less ATP from respiration → cells function poorly → fatigue, organ dysfunction.

(d) Symptom: anemia → fatigue, pallor, shortness of breath.

Item 5

(a) Lipids digested → fatty acids and glycerol → absorbed into lymph → transported to cells.

- (b) Lipids → component of phospholipid bilayer → structural integrity of membranes.**
- (c) Lipid deficiency → weakened membranes → impaired cell signaling and energy storage.**
- (d) Other functions: insulation, hormone synthesis, protection of organs.**

Item 6

- (a) Glucose → substrate for cellular respiration → ATP production → fuels cell growth.**
- (b) Low nutrient concentration → slower growth; optimal → rapid cell division.**
- (c) Balanced nutrition → ensures continuous energy and materials for mitosis → supports tissue growth.**
- (d) Excess nutrients → may cause cell stress, imbalance, or abnormal proliferation.**

Item 7

- (a) Vitamins → act as coenzymes in enzymatic reactions → facilitate metabolism.**
- (b) Minerals → cofactors → activate enzymes, maintain osmotic balance, support cell signaling.**
- (c) Vitamin deficiency → impaired enzyme function → reduced metabolism, poor repair.**
- (d) Example: Iron for hemoglobin, Calcium for cell signaling and structure.**

Item 8

- (a) Glucose → essential substrate for ATP → supports all energy-dependent cellular functions.**
- (b) Deprivation → energy shortage → impaired function → cell death if prolonged.**
- (c) Adequate nutrition → maintains organ and tissue function → supports health.**
- (d) Condition: hypoglycemia, malnutrition → poor growth, weakness.**

Item 9

(a) Muscle cells → high energy demand → many mitochondria to supply ATP for contraction.

(b) Proteins and carbohydrates → metabolized to generate ATP → fuels muscle contraction.

(c) Poor nutrition → insufficient ATP → fatigue, slower muscle recovery, reduced strength.

(d) Recommendation: balanced diet with adequate protein and carbohydrates → support energy and repair.

Item 10

(a) Nitrogen → nucleic acids and proteins; Phosphorus → ATP, nucleotides, phospholipids → essential for growth.

(b) Nutrient availability → supports cellular metabolism and division → affects growth rate.

(c) Cells with adequate nutrition → higher survival → influences population health and density.

(d) Nutrient deficiency in aquatic ecosystems → reduced algae growth → lower food availability → decline in higher trophic levels.

COMBINED TOPIC 3 & 4: TRANSPORT + RESPIRATION

Item 1

During a biology practical, students observed blood smears and identified red blood cells and plasma components. The teacher explained that transport of oxygen, nutrients, and carbon dioxide is essential for cellular respiration. Students performed experiments measuring oxygen consumption in tissues and related it to the rate of aerobic respiration. They discussed how hemoglobin facilitates oxygen delivery to mitochondria, linking transport and energy production.

Task

(a) Explain the role of hemoglobin in oxygen transport.

- (b) Describe how oxygen is used in cellular respiration.
- (c) Explain the relationship between oxygen transport and energy production.
- (d) Suggest one effect of impaired oxygen transport on cells.

Item 2

A student observed capillaries in a leaf under a microscope and noted water and mineral transport via xylem. The teacher explained that water is essential for photosynthesis, nutrient transport, and maintaining turgor pressure. Students also discussed how oxygen produced during photosynthesis is used in plant respiration to produce ATP for growth and metabolism.

Task

- (a) Explain the role of xylem in water and mineral transport.
- (b) Describe how water supports cellular respiration in plant cells.
- (c) Explain the link between water transport and ATP production.
- (d) Suggest one effect of water deficiency on plant cells.

Item 3

During a lab experiment, students measured carbon dioxide levels in exhaled air and correlated it with respiration rates. The teacher explained how carbon dioxide is transported in blood to the lungs via plasma, hemoglobin, and bicarbonate ions. Students discussed how efficient transport of CO₂ maintains acid-base balance and supports aerobic respiration.

- (a) Explain how carbon dioxide is transported in blood.
- (b) Describe the role of respiration in CO₂ production.
- (c) Explain the importance of CO₂ transport for maintaining pH.
- (d) Suggest one consequence of impaired CO₂ transport.

Item 4

A student investigated the transport of glucose in the circulatory system and measured uptake by muscle tissues during exercise. The teacher explained that glucose is

essential for cellular respiration and ATP production. Students discussed how nutrient transport, oxygen delivery, and enzyme activity coordinate to sustain high-energy demand in active tissues.

- (a) Explain how glucose is transported to cells.
- (b) Describe how glucose is used in aerobic respiration.
- (c) Explain the relationship between nutrient transport and energy production.
- (d) Suggest one effect of inadequate glucose supply during exercise.

Item 5

During a practical, students observed the effect of temperature on blood viscosity and oxygen transport. The teacher explained how transport efficiency influences respiration rates in tissues. Students discussed how lower transport efficiency reduces oxygen availability, limiting aerobic ATP production, and how this affects cellular metabolism.

- (a) Explain how blood viscosity affects oxygen transport.
- (b) Describe the effect of oxygen availability on respiration rate.
- (c) Explain the link between transport efficiency and ATP production.
- (d) Suggest one physiological response to low oxygen availability.

Item 6

A student measured transpiration rates in plants under different environmental conditions. The teacher explained that water transport supports nutrient delivery, photosynthesis, and respiration. Students discussed how limited water transport reduces substrate availability for mitochondria, decreasing ATP production and slowing metabolic activities.

- (a) Explain the role of transpiration in water and nutrient transport.
- (b) Describe how water supports respiration in plant cells.
- (c) Explain the effect of limited water transport on ATP production.
- (d) Suggest one plant adaptation to maintain water transport in dry conditions.

Item 7

During a lab experiment, students measured lactic acid accumulation in muscles during anaerobic respiration. The teacher explained that oxygen transport limits ATP production, forcing muscles to rely on anaerobic pathways. Students discussed the role of the circulatory system in restoring oxygen levels and removing waste products to sustain aerobic metabolism.

- (a) Explain why muscles switch to anaerobic respiration during low oxygen.
- (b) Describe the role of blood in removing lactic acid.
- (c) Explain the link between oxygen transport and energy efficiency.
- (d) Suggest one effect of prolonged anaerobic respiration on muscle cells.

Item 8

A student studied the effect of exercise on heart rate and blood flow. The teacher explained that increased circulation enhances oxygen and glucose delivery to tissues, supporting higher respiration rates and ATP production. Students observed that transport systems adapt to meet metabolic demands during physical activity.

- (a) Explain how heart rate affects transport of oxygen and nutrients.
- (b) Describe how increased transport supports aerobic respiration.
- (c) Explain the connection between transport efficiency and energy supply.
- (d) Suggest one adaptation of the circulatory system during exercise.

Item 9

During a practical, students measured respiration rates in aquatic organisms and noted the role of gills in gas exchange. The teacher explained that oxygen transport via blood ensures mitochondria receive substrates for ATP production. Students also discussed how environmental oxygen availability affects respiration efficiency.

- (a) Explain how gills facilitate oxygen transport in aquatic animals.
- (b) Describe how oxygen supports cellular respiration.
- (c) Explain the effect of low environmental oxygen on energy production.
- (d) Suggest one adaptation of aquatic animals to low oxygen environments.

Item 10

A student observed transport of nutrients and oxygen in capillaries of a rat. The teacher explained that efficient circulation is essential for sustaining cellular respiration and metabolic activity. Students discussed how blockage or disease in transport systems reduces ATP production and tissue function, linking transport physiology with cellular energy metabolism.

- (a) Explain how capillaries facilitate nutrient and oxygen delivery.
- (b) Describe how transported substrates are used in respiration.
- (c) Explain the effect of transport impairment on energy production.
- (d) Suggest one disease that can impair nutrient and oxygen transport.

**COMBINED TOPIC 3 & 4: TRANSPORT + RESPIRATION
ANSWERS / MARKING GUIDE**

Item 1

(a) Hemoglobin → binds oxygen in lungs → transports it to tissues for cellular respiration.

(b) Oxygen is used in mitochondria → final electron acceptor in aerobic respiration → produces ATP.

(c) Efficient oxygen transport → sufficient substrate for ATP production → supports cellular activities.

(d) Impaired oxygen transport → hypoxia → reduced ATP → cell dysfunction or death.

Item 2

(a) Xylem → transports water and dissolved minerals from roots to leaves.

(b) Water → substrate for photosynthesis → produces glucose → fuels plant respiration.

(c) Adequate water → maintains substrate supply → supports ATP production.

(d) Water deficiency → wilting, reduced photosynthesis, decreased respiration.

Item 3

- (a) CO_2 transported via plasma (dissolved), bicarbonate ions, and bound to hemoglobin.**
- (b) Produced in cells during aerobic respiration → waste product removed from tissues.**
- (c) CO_2 transport maintains blood pH → prevents acidosis → ensures enzyme function.**
- (d) Impaired transport → CO_2 accumulation → acid-base imbalance → tissue damage.**

Item 4

- (a) Glucose transported in blood → absorbed from intestines → delivered to cells for respiration.**
- (b) Glucose → glycolysis → Krebs cycle → electron transport chain → ATP production.**
- (c) Glucose supply ensures continuous energy production → supports metabolism.**
- (d) Inadequate glucose → fatigue, poor muscle performance, impaired organ function.**

Item 5

- (a) Increased viscosity → slower blood flow → reduced oxygen transport to tissues.**
- (b) Low oxygen → slower aerobic respiration → less ATP → limited cell activity.**
- (c) Efficient transport → maintains oxygen supply → supports ATP synthesis.**
- (d) Physiological response: increased heart rate, vasodilation, or erythropoiesis.**

Item 6

- (a) Transpiration → pulls water and nutrients through xylem → supplies leaves and cells.**

(b) Water needed for respiration → medium for biochemical reactions, substrate for mitochondria.

(c) Limited transport → reduced ATP production → slower metabolism and growth.

(d) Adaptation: deep roots, waxy cuticle, reduced leaves.

Item 7

(a) Low oxygen → anaerobic respiration → produces ATP less efficiently → lactic acid accumulates.

(b) Blood removes lactic acid → prevents acidosis → restores normal function.

(c) Oxygen transport → allows aerobic respiration → efficient ATP production.

(d) Prolonged anaerobic respiration → muscle fatigue, pain, or cramps.

Item 8

(a) Increased heart rate → faster blood flow → more oxygen and glucose delivered to tissues.

(b) Supports higher aerobic respiration → produces more ATP to meet energy demand.

(c) Efficient transport → adequate energy supply for cells → supports activity.

(d) Adaptation: increased cardiac output, vasodilation, increased capillary density.

Item 9

(a) Gills → large surface area → thin epithelium → efficient oxygen diffusion into blood.

(b) Oxygen used in mitochondria → ATP production for cellular functions.

(c) Low environmental oxygen → hypoxia → reduced ATP → impaired tissue function.

(d) Adaptation: increased gill surface area, hemoglobin with higher affinity, slower metabolism.

Item 10

(a) Capillaries → thin walls → allow exchange of oxygen, nutrients, and waste with tissues.

(b) Oxygen and glucose delivered → mitochondria produce ATP → support metabolism.

(c) Blockage → reduced nutrient/oxygen delivery → decreased ATP → tissue dysfunction.

(d) Disease: atherosclerosis, anemia, or ischemia → impairs transport and energy supply.

COMBINED TOPIC 5 & 6: HOMEOSTASIS + EXCRETION

Item 1

During a biology practical, students measured blood glucose levels in volunteers before and after a meal. The teacher explained how the body maintains glucose homeostasis through insulin and glucagon. Later, students discussed how kidneys filter blood to remove excess glucose and nitrogenous wastes, illustrating the link between homeostatic regulation and excretion in maintaining internal balance.

Task

- (a) Explain how insulin and glucagon regulate blood glucose levels.
- (b) Describe the role of kidneys in excreting excess glucose.
- (c) Explain the relationship between homeostasis and excretion.
- (d) Suggest one effect of impaired glucose regulation on the body.

Item 2

A student monitored water loss through sweating during exercise. The teacher explained how the hypothalamus detects changes in body temperature and triggers sweating and vasodilation. Students also discussed how the kidneys regulate water balance through urine concentration, linking thermoregulation with excretory processes.

- (a) Explain how sweating helps maintain body temperature.
- (b) Describe how kidneys regulate water balance.
- (c) Explain the connection between temperature homeostasis and excretion.

(d) Suggest one consequence of dehydration on homeostasis.

Item 3

During a lab, students measured urea levels in urine samples from different individuals. The teacher explained that proteins are metabolized into amino acids, and excess nitrogen is converted into urea for excretion. Students discussed how maintaining nitrogen balance is part of homeostasis and how kidneys prevent toxic accumulation of nitrogenous waste.

- (a) Explain how amino acids are metabolized and nitrogen excreted.
- (b) Describe the role of kidneys in nitrogenous waste removal.
- (c) Explain how excretion contributes to homeostasis.
- (d) Suggest one consequence of kidney failure on nitrogen balance.

Item 4

A student investigated the effect of salt intake on blood pressure. The teacher explained that high salt increases blood osmolarity, triggering antidiuretic hormone (ADH) release and water retention by kidneys. Students discussed how the body regulates osmotic balance and blood pressure through homeostatic and excretory mechanisms.

- (a) Explain how ADH regulates water reabsorption in kidneys.
- (b) Describe the effect of high salt intake on blood osmolarity.
- (c) Explain the relationship between osmotic homeostasis and excretion.
- (d) Suggest one long-term effect of high salt intake on the body.

Item 5

During a practical, students measured blood urea concentration in dehydrated and hydrated volunteers. The teacher explained that dehydration reduces kidney filtration rate, concentrating urine to conserve water. Students discussed how kidneys and hormones work together to maintain water and solute balance, integrating homeostasis with excretion.

- (a) Explain how the kidney concentrates urine during dehydration.

- (b) Describe the role of antidiuretic hormone in water conservation.
- (c) Explain the connection between water homeostasis and excretion.
- (d) Suggest one effect of prolonged dehydration on kidney function.

Item 6

A student examined thermoregulation during exposure to cold environments. The teacher explained how vasoconstriction, shivering, and increased metabolic rate maintain body temperature. Students discussed how excretion of metabolic waste continues even under temperature stress, showing the integration of thermoregulation and excretion in homeostasis.

- (a) Explain how vasoconstriction and shivering help maintain body temperature.
- (b) Describe how metabolism produces nitrogenous wastes during temperature regulation.
- (c) Explain the link between thermoregulation and excretion.
- (d) Suggest one effect of extreme cold on kidney function.

Item 7

During a practical, students observed the effect of alcohol consumption on urine production. The teacher explained that alcohol inhibits ADH release, increasing urine volume and affecting water balance. Students discussed the importance of hormonal regulation in excretion and maintaining osmotic homeostasis.

- (a) Explain the effect of ADH on water reabsorption in kidneys.
- (b) Describe how alcohol affects ADH secretion and urine volume.
- (c) Explain the connection between hormonal regulation and homeostasis.
- (d) Suggest one effect of excessive alcohol consumption on body fluids.

Item 8

A student monitored changes in blood pH during intense exercise. The teacher explained that carbon dioxide accumulation lowers pH and that kidneys excrete

hydrogen ions and reabsorb bicarbonate to restore acid-base balance. Students discussed how respiratory and renal mechanisms work together to maintain pH homeostasis.

- (a) Explain how CO₂ affects blood pH.
- (b) Describe how kidneys restore acid-base balance through excretion.
- (c) Explain the link between acid-base homeostasis and excretion.
- (d) Suggest one effect of prolonged acidosis on cells.

Item 9

During a lab, students investigated the effect of high protein diets on urine composition. The teacher explained that increased protein metabolism raises urea levels, requiring efficient kidney function for excretion. Students discussed how dietary intake affects excretory load and the importance of homeostatic control of nitrogenous wastes.

- (a) Explain how high protein intake affects urea production.
- (b) Describe how kidneys excrete increased nitrogenous wastes.
- (c) Explain the relationship between diet, excretion, and homeostasis.
- (d) Suggest one consequence of impaired urea excretion.

Item 10

A student examined the role of the liver in detoxifying ammonia and other nitrogenous wastes. The teacher explained how liver and kidneys work together to maintain chemical balance in the blood. Students discussed how failure in either organ disrupts homeostasis and affects overall health.

- (a) Explain the role of the liver in nitrogen metabolism.
- (b) Describe how the liver and kidneys collaborate in excretion.
- (c) Explain how excretory dysfunction affects homeostasis.
- (d) Suggest one condition caused by liver or kidney failure.

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COMBINED TOPIC 5 & 6: HOMEOSTASIS + EXCRETION

ANSWERS / MARKING GUIDE

Item 1

(a) Insulin → lowers blood glucose by promoting uptake into cells; Glucagon → raises blood glucose by stimulating glycogen breakdown.

(b) Kidneys filter blood → excess glucose excreted in urine (glycosuria) if blood glucose is high.

(c) Excretion removes excess substances → maintains internal environment → supports homeostasis.

(d) Impaired glucose regulation → hyperglycemia, hypoglycemia → fatigue, organ damage, diabetes.

Item 2

(a) Sweating → heat loss via evaporation → cools body → maintains body temperature.

(b) Kidneys regulate water → adjust urine concentration → maintain osmotic balance.

(c) Thermoregulation and water excretion maintain fluid balance and temperature → homeostasis.

(d) Dehydration → low blood volume → increased heart rate, low blood pressure, impaired kidney function.

Item 3

(a) Proteins → amino acids → excess nitrogen converted to urea → excreted by kidneys.

(b) Kidneys remove urea → prevent toxic accumulation → maintain nitrogen balance.

(c) Excretion of nitrogenous waste → prevents toxicity → part of homeostatic regulation.

(d) Kidney failure → uremia → toxic nitrogen buildup → organ damage.

Item 4

- (a) ADH → increases water reabsorption in collecting ducts → reduces urine volume.*
- (b) High salt → increases osmolarity → triggers water retention via ADH.*
- (c) Osmotic homeostasis maintained by adjusting water reabsorption → integrates excretion.*
- (d) Long-term high salt → hypertension, kidney stress, cardiovascular disease.*

Item 5

- (a) During dehydration → kidney reduces filtration → concentrates urine → conserves water.*
- (b) ADH → promotes water reabsorption → maintains blood volume.*
- (c) Water balance maintained → prevents excessive water loss → supports homeostasis.*
- (d) Prolonged dehydration → kidney damage, hypotension, electrolyte imbalance.*

Item 6

- (a) Vasoconstriction → reduces heat loss; Shivering → generates heat → maintains body temperature.*
- (b) Increased metabolism → produces nitrogenous waste → excreted by kidneys.*
- (c) Thermoregulation and excretion work together → maintain stable internal environment.*
- (d) Extreme cold → reduced kidney perfusion → risk of kidney damage or hypothermia.*

Item 7

- (a) ADH → promotes water reabsorption in kidney collecting ducts → reduces urine volume.*
- (b) Alcohol inhibits ADH → increases urine output → reduces water retention.*
- (c) Hormonal regulation ensures fluid balance → supports osmotic homeostasis.*
- (d) Excessive alcohol → dehydration, electrolyte imbalance, kidney stress.*

Item 8

- (a) CO_2 → reacts with water → forms carbonic acid → lowers blood pH → acidosis.**
- (b) Kidneys excrete H^+ ions → reabsorb bicarbonate → restore pH balance.**
- (c) Acid-base homeostasis maintained by renal excretion → prevents cellular damage.**
- (d) Prolonged acidosis → enzyme dysfunction, fatigue, organ damage.**

Item 9

- (a) High protein intake → increased amino acid catabolism → more urea produced.**
- (b) Kidneys excrete additional urea → maintain nitrogen balance.**
- (c) Diet affects excretory load → excretion supports homeostasis.**
- (d) Impaired urea excretion → uremia → toxicity, organ dysfunction.**

Item 10

- (a) Liver → detoxifies ammonia → converts to urea → prevents toxicity.**
- (b) Liver produces urea → kidneys excrete it → collaborative excretory function.**
- (c) Dysfunction → accumulation of toxins → disrupts homeostasis → organ damage.**
- (d) Condition: liver failure → hepatic encephalopathy; kidney failure → uremia.**

COMBINED TOPIC 7 & 8: COORDINATION & CONTROL + REPRODUCTION

Long Scenario-Based Structured Items (10 Items)

Item 1

During a practical, students observed the effect of light on plant growth. The teacher explained that auxins control phototropism by elongating cells on the shaded side of a

shoot. Later, students studied the role of hormones in human reproduction, particularly how luteinizing hormone (LH) and follicle-stimulating hormone (FSH) regulate ovulation. Students discussed the similarities between hormonal coordination in plants and humans, highlighting the role of chemical signals in controlling physiological processes.

- (a) Explain how auxins control phototropism in plants.
- (b) Describe the roles of FSH and LH in human ovulation.
- (c) Explain the importance of hormonal coordination in both plants and humans.
- (d) Suggest one consequence of hormonal imbalance in humans.

Item 2

A student investigated the reflex arc by tapping a classmate's knee and recording the leg's response. The teacher explained how sensory neurons, interneurons, and motor neurons coordinate reflex actions. Students later studied the menstrual cycle and discussed how hormones coordinate changes in the uterus and ovaries. They analyzed how rapid and precise signaling is essential for both reflexes and reproductive cycles.

- (a) Explain the pathway of a simple reflex arc.
- (b) Describe how hormonal changes control the menstrual cycle.
- (c) Explain the role of coordination in rapid and cyclic processes.
- (d) Suggest one disorder caused by nerve or hormonal dysfunction.

Item 3

During a lab, students observed pupil constriction in response to light. The teacher explained how the autonomic nervous system controls smooth muscle in the iris. Students also examined how estrogen and progesterone prepare the endometrium for implantation, highlighting how precise chemical signals regulate reproductive timing in humans.

- (a) Explain how the autonomic nervous system controls pupil constriction.
- (b) Describe the roles of estrogen and progesterone in endometrial preparation.
- (c) Explain the importance of precise coordination in maintaining homeostasis and reproduction.
- (d) Suggest one effect of hormonal imbalance on fertility.

Item 4

A student studied the effect of adrenaline on heart rate. The teacher explained that adrenaline prepares the body for “fight or flight” by increasing cardiac output and respiration. Later, students analyzed how progesterone maintains pregnancy by supporting the uterine lining. They discussed the integration of hormonal responses in controlling physiological functions and reproductive success.

- (a) Explain the effect of adrenaline on heart rate.
- (b) Describe the role of progesterone in maintaining pregnancy.
- (c) Explain the link between coordination and reproductive success.
- (d) Suggest one effect of adrenal dysfunction on the body.

Item 5

During a practical, students examined the role of neurotransmitters at synapses using model simulations. The teacher explained how acetylcholine transmits impulses across synapses to coordinate muscle contraction. Students then studied spermatogenesis and how testosterone regulates sperm production, highlighting the role of chemical signals in reproductive and muscular coordination.

- (a) Explain how neurotransmitters transmit impulses across synapses.
- (b) Describe the role of testosterone in spermatogenesis.
- (c) Explain the importance of chemical coordination in muscle and reproductive systems.
- (d) Suggest one effect of neurotransmitter deficiency on muscle function.

Item 6

A student measured blood glucose changes in response to insulin injection. The teacher explained how insulin and glucagon coordinate to maintain glucose homeostasis. Later, students studied the ovarian cycle and how cyclic hormonal changes regulate ovulation. They analyzed the integration of endocrine signals in maintaining internal balance and reproductive timing.

- (a) Explain how insulin and glucagon maintain blood glucose levels.
- (b) Describe how the ovarian cycle is regulated by hormones.
- (c) Explain the role of endocrine coordination in homeostasis and reproduction.
- (d) Suggest one effect of endocrine dysfunction on reproductive health.

Item 7

During a lab, students observed skeletal muscle contraction in response to electrical stimulation. The teacher explained how motor neurons transmit impulses to muscles, coordinating movement. Students later studied fertilization and implantation, highlighting how hormones regulate timing and conditions for successful reproduction.

- (a) Explain how motor neurons coordinate muscle contraction.
- (b) Describe the role of hormones in fertilization and implantation.
- (c) Explain the importance of coordination in both movement and reproduction.
- (d) Suggest one effect of nerve damage on movement or reproductive success.

Item 8

A student observed the effect of light and temperature on circadian rhythms in plants. The teacher explained how the plant clock coordinates physiological activities. Later, students studied the menstrual cycle and the timing of ovulation, showing how internal biological clocks regulate reproductive processes.

- (a) Explain how circadian rhythms regulate plant activities.
- (b) Describe how hormonal cycles regulate ovulation in humans.
- (c) Explain the importance of timing and coordination in physiological processes.
- (d) Suggest one effect of disrupted circadian rhythms on health or reproduction.

Item 9

During a lab, students investigated the effect of stimuli on reflexes using the withdrawal reflex. The teacher explained the role of interneurons and motor neurons in rapid response. Later, students analyzed the role of LH and FSH in spermatogenesis, showing how precise hormonal control ensures reproductive efficiency.

- (a) Explain the pathway of the withdrawal reflex.
- (b) Describe the roles of LH and FSH in sperm production.
- (c) Explain the importance of precise coordination in reflexes and reproduction.
- (d) Suggest one effect of hormonal or neural dysfunction on reflexes or fertility.

Item 10

A student observed the effects of stress on the nervous and endocrine systems. The teacher explained how the hypothalamus, pituitary, and adrenal glands interact to regulate responses. Students then studied the hormonal regulation of pregnancy and childbirth, highlighting the integration of nervous and endocrine systems in coordinating complex reproductive processes.

- (a) Explain how the hypothalamus and pituitary coordinate stress responses.
- (b) Describe the role of hormones in pregnancy and childbirth.
- (c) Explain the importance of nervous and endocrine integration in coordination and reproduction.
- (d) Suggest one effect of endocrine or nervous dysfunction on stress or reproductive outcomes.

**COMBINED TOPIC 7 & 8: COORDINATION & CONTROL + REPRODUCTION
ANSWERS / MARKING GUIDE**

Item 1

- (a) Auxins → elongate cells on shaded side of shoot → cause bending toward light (phototropism).**
- (b) FSH → stimulates follicle maturation; LH → triggers ovulation.**
- (c) Hormonal coordination → controls timing and intensity of physiological processes in plants and humans.**
- (d) Hormonal imbalance → infertility, irregular menstrual cycles, abnormal growth.**

Item 2

- (a) Reflex arc → stimulus → sensory neuron → interneuron → motor neuron → effector response.**
- (b) Menstrual cycle → FSH, LH, estrogen, progesterone regulate follicle development, ovulation, and endometrial changes.**
- (c) Coordination ensures rapid (reflex) and cyclic (menstrual) processes occur efficiently.**

(d) Disorder → neuropathy, amenorrhea, irregular cycles.

Item 3

(a) Autonomic nervous system → sensory input → CNS → motor output → smooth muscle contracts → pupil constriction.

(b) Estrogen → thickens endometrium; Progesterone → maintains endometrium for implantation.

(c) Precise coordination ensures homeostasis and reproductive readiness.

(d) Hormonal imbalance → infertility, irregular cycles, implantation failure.

Item 4

(a) Adrenaline → increases heart rate and cardiac output → prepares body for “fight or flight.”

(b) Progesterone → maintains uterine lining → supports pregnancy.

(c) Coordination ensures physiological readiness and reproductive success.

(d) Adrenal dysfunction → low/high heart rate, poor stress response.

Item 5

(a) Neurotransmitters (e.g., acetylcholine) → diffuse across synapse → trigger action potential in postsynaptic neuron → muscle contraction.

(b) Testosterone → stimulates spermatogenesis in seminiferous tubules.

(c) Chemical coordination regulates muscle function and reproductive processes efficiently.

(d) Neurotransmitter deficiency → weak muscle contraction, impaired movement.

Item 6

(a) Insulin → lowers blood glucose; Glucagon → raises blood glucose → maintain homeostasis.

(b) Ovarian cycle → FSH and LH regulate follicle development and ovulation.

- (c) Endocrine coordination → maintains internal balance and reproductive timing.*
- (d) Endocrine dysfunction → irregular cycles, infertility, metabolic disorders.*

Item 7

- (a) Motor neurons → transmit impulses to skeletal muscle → coordinated contraction.*
- (b) Hormones (e.g., progesterone, estrogen) → support fertilization, implantation.*
- (c) Coordination ensures timely movement and successful reproduction.*
- (d) Nerve damage → impaired movement; hormonal dysfunction → infertility.*

Item 8

- (a) Circadian rhythms → internal biological clock → regulate plant physiological processes (photosynthesis, growth).*
- (b) Hormonal cycles → regulate ovulation timing in humans.*
- (c) Timing ensures efficiency and synchronization of physiological processes.*
- (d) Disrupted circadian rhythm → sleep disorders, hormonal imbalance, fertility issues.*

Item 9

- (a) Withdrawal reflex → stimulus → sensory neuron → interneuron → motor neuron → muscle contracts to withdraw.*
- (b) LH → stimulates testosterone production → supports spermatogenesis; FSH → stimulates sperm development.*
- (c) Precise coordination ensures rapid reflexes and efficient reproduction.*
- (d) Dysfunction → slow reflexes, reduced fertility.*

Item 10

- (a) Hypothalamus → detects stress → pituitary → releases ACTH → adrenal glands → secrete adrenaline/cortisol.*
- (b) Hormones (progesterone, oxytocin) → maintain pregnancy and stimulate labor/childbirth.*
- (c) Nervous and endocrine systems integrate → coordinate responses to stress and reproductive events.*
- (d) Dysfunction → impaired stress response, delayed labor, reproductive complications.*

COMBINED TOPIC 9 & 10: GENETICS & EVOLUTION + ECOLOGY & ENVIRONMENT

Item 1

During a practical, students observed pea plants with different flower colors and recorded phenotypic ratios in the offspring. The teacher explained Mendelian inheritance, dominant and recessive alleles, and Punnett squares. Later, students studied how environmental factors, such as soil fertility and light, affect the survival of certain phenotypes in populations. They discussed how genetics and environment interact to influence natural selection.

Task

- (a) Explain how dominant and recessive alleles determine phenotype.
- (b) Describe how environmental factors affect survival of different phenotypes.
- (c) Explain the relationship between genetics and natural selection.
- (d) Suggest one example of a trait influenced by both genetics and environment.

Item 2

A student studied mutations in bacteria and observed changes in antibiotic resistance. The teacher explained that mutations introduce genetic variation. Later, students discussed how environmental pressures, such as antibiotics or predators, select for advantageous traits, linking genetic variation with evolution in populations.

- (a) Explain how mutations contribute to genetic variation.
- (b) Describe how natural selection acts on genetic variation.

- (c) Explain the role of environmental pressures in evolution.
- (d) Suggest one example of a mutation that provides a survival advantage.

Item 3

During a lab, students examined karyotypes to identify chromosomal abnormalities. The teacher explained how chromosomal changes can affect fitness and survival. Students then discussed how environmental changes, such as climate shifts, can favor certain genotypes over others, illustrating evolution and adaptation.

- (a) Explain how chromosomal abnormalities can affect an organism.
- (b) Describe how environmental changes influence genotype survival.
- (c) Explain the connection between genetics, fitness, and evolution.
- (d) Suggest one adaptation resulting from environmental selection.

Item 4

A student observed different beak shapes in finches on the Galápagos Islands. The teacher explained how inherited traits, combined with environmental pressures like food availability, led to evolution of specialized beaks. Students analyzed the role of genetic variation and natural selection in shaping population traits.

- (a) Explain how inherited traits contribute to variation in populations.
- (b) Describe how environmental pressures select for certain traits.
- (c) Explain how natural selection drives evolution.
- (d) Suggest one example of adaptive evolution in plants or animals.

Item 5

During a practical, students used Punnett squares to predict blood group inheritance in humans. The teacher linked this to population genetics, explaining allele frequencies and gene pools. Students later discussed how environmental changes can alter allele frequencies through selection, migration, or genetic drift.

- (a) Explain how Punnett squares predict inheritance of alleles.
- (b) Describe how allele frequencies can change in populations.
- (c) Explain the role of environment in population genetics.
- (d) Suggest one factor that can cause rapid changes in allele frequencies.

Item 6

A student studied the effect of inbreeding on genetic diversity in plants. The teacher explained that reduced variation can lower adaptability to environmental changes. Students then discussed how ecosystems with high biodiversity are more resilient to environmental disturbances, linking genetics and ecological stability.

- (a) Explain the effect of inbreeding on genetic diversity.
- (b) Describe how biodiversity affects ecosystem stability.
- (c) Explain the connection between genetic variation and ecological resilience.
- (d) Suggest one practice that maintains genetic diversity in populations.

Item 7

During a lab, students observed the inheritance of coat color in mice and compared it with survival in different habitats. The teacher explained that certain genotypes confer advantages depending on the environment. Students discussed how selection pressures influence allele frequencies over generations, illustrating adaptation in ecology and evolution.

- (a) Explain how genotype affects phenotype and survival.
- (b) Describe how environmental selection alters allele frequencies.
- (c) Explain the relationship between adaptation and evolution.
- (d) Suggest one environmental factor that influences survival of genotypes.

Item 8

A student measured population changes in aquatic organisms after introducing a predator. The teacher explained how predation acts as a selective pressure. Students discussed how traits that enhance survival become more common in the population, linking evolutionary principles to ecosystem dynamics.

- (a) Explain how predation acts as a selective pressure.
- (b) Describe how advantageous traits increase in frequency.
- (c) Explain the link between natural selection and population dynamics.
- (d) Suggest one adaptation in prey species to avoid predation.

Item 9

During a practical, students studied inheritance patterns of Mendelian traits and then investigated how invasive species affect local ecosystems. The teacher explained that ecological changes create new selection pressures, favoring some genotypes and disadvantaging others. Students analyzed the interaction of genetics and ecology in shaping population composition.

- (a) Explain how Mendelian inheritance contributes to variation.
- (b) Describe how invasive species alter selection pressures.
- (c) Explain the effect of ecological change on population genetics.
- (d) Suggest one strategy to reduce impact of invasive species.

Item 10

A student observed plant adaptations in different habitats, such as leaf size and root depth. The teacher explained that these traits are inherited and selected for based on environmental conditions. Students discussed how both genetic makeup and ecological factors drive evolution and ecosystem balance.

- (a) Explain how inherited traits support adaptation to habitats.
- (b) Describe how environmental conditions select for advantageous traits.
- (c) Explain the link between adaptation, evolution, and ecosystem balance.
- (d) Suggest one plant adaptation to dry or nutrient-poor environments.

COMBINED TOPIC 9 & 10: GENETICS & EVOLUTION + ECOLOGY & ENVIRONMENT

ANSWERS / MARKING GUIDE (10 Items)

Item 1

- (a) Dominant allele → expressed in phenotype even if heterozygous; Recessive allele → expressed only if homozygous.**
- (b) Environmental factors (light, soil, predators) affect survival and reproduction of phenotypes.**

(c) Genetic traits combined with environmental pressures → natural selection → evolution.

(d) Example: height influenced by genetics and nutrition; fur color influenced by genes and habitat.

Item 2

(a) Mutations → changes in DNA sequence → create new alleles → increase genetic variation.

(b) Natural selection → advantageous alleles increase frequency; disadvantageous decrease.

(c) Environmental pressures (predation, antibiotics, climate) determine which traits are favorable.

(d) Example: mutation in bacteria → antibiotic resistance → survival advantage.

Item 3

(a) Chromosomal abnormalities → may reduce fitness → lower survival or reproductive success.

(b) Environmental changes favor certain genotypes → increase their frequency in the population.

(c) Fitness determined by genetics → survival and reproduction → drives evolution.

(d) Example: thick fur in cold climates → adaptation to environmental conditions.

Item 4

(a) Inherited traits → variations among individuals → basis for selection.

(b) Environmental pressures → limited food, predation → select for beneficial traits.

(c) Natural selection → differential survival and reproduction → evolution over generations.

(d) Example: cacti with deep roots in deserts; finches with specialized beaks.

Item 5

(a) Punnett squares → predict probability of offspring inheriting specific alleles.

(b) Allele frequencies change due to selection, migration, mutation, genetic drift.

- (c) Environment → favors certain alleles → shifts gene pool over time.**
- (d) Factor: migration of individuals, natural disasters, sudden environmental change.**

Item 6

- (a) Inbreeding → reduces genetic diversity → lowers adaptability to environmental changes.**
- (b) High biodiversity → more species → greater ecosystem resilience to disturbances.**
- (c) Genetic variation → allows populations to adapt → supports ecological stability.**
- (d) Practice: cross-breeding, habitat conservation, seed banks to maintain diversity.**

Item 7

- (a) Genotype → determines phenotype → affects survival probability in environment.**
- (b) Environmental selection → advantageous alleles increase → others decrease.**
- (c) Adaptation → inherited traits enhance survival → leads to evolution.**
- (d) Environmental factor: predation, climate, food availability.**

Item 8

- (a) Predation → removes less-adapted individuals → selective pressure on population.**
- (b) Traits enhancing survival (camouflage, speed) become more frequent.**
- (c) Natural selection → population evolves → maintains ecosystem dynamics.**
- (d) Adaptation: camouflage, defensive spines, rapid escape behaviors.**

Item 9

- (a) Mendelian inheritance → produces variation → some genotypes more favorable under environmental pressures.**
- (b) Invasive species → compete for resources, alter habitat → shift selection pressures.**
- (c) Ecological changes → affect allele frequencies → influence population genetics.**

(d) Strategy: control invasive species, habitat restoration, quarantine measures.

Item 10

(a) Inherited traits (leaf size, root depth) → allow survival in specific habitats.

(b) Environmental conditions → select traits that enhance survival and reproduction.

(c) Adaptation → evolution of populations → supports ecosystem balance and stability.

(d) Plant adaptation: succulent leaves for water storage, deep roots for dry soil, small leaves to reduce transpiration.

ADVANCED-LEVEL BIOLOGY ITEMS – UACE

Item 1

A group of students conducted an experiment investigating the effect of temperature and pH on enzyme activity in liver tissue. They measured oxygen consumption and ATP production simultaneously. Later, they analyzed how changes in temperature and pH in the human body could affect metabolic pathways, including glycolysis, Krebs cycle, and oxidative phosphorylation. The teacher challenged them to predict the effects of environmental stress on cellular respiration and energy balance in tissues with high metabolic demand, such as muscle and brain cells.

Task

(a) Explain how temperature and pH affect enzyme structure and function.

(b) Describe how enzyme activity influences ATP production in aerobic respiration.

(c) Explain the physiological consequences of enzyme denaturation on high-energy tissues.

(d) Suggest a compensatory mechanism the body could use to maintain energy balance under stress.

Item 2

During a field study, students observed a pond ecosystem experiencing seasonal drought. They recorded plant and animal species diversity, soil composition, and water chemistry. They also measured dissolved oxygen and nitrate levels. Students were asked to predict how reduced water availability would influence nitrogen cycling, plant transpiration rates, and the respiration of aquatic organisms. Finally, they discussed

how genetic variation within populations could affect survival under environmental stress.

Task

- (a) Explain how drought affects nitrogen cycling and nutrient availability in aquatic ecosystems.*
- (b) Describe the impact of low dissolved oxygen on aerobic aquatic organisms.*
- (c) Explain how genetic variation may influence survival in changing environments.*
- (d) Suggest one adaptation aquatic or terrestrial organisms could use to survive drought.*

Item 3

A student injected labeled glucose into a rat and traced its metabolic fate using radioisotopes. They measured CO₂ release, glycogen storage in the liver, and ATP production in muscle tissues under rest and exercise. They also analyzed hormone levels (insulin, glucagon, and adrenaline) and their effects on glucose utilization. The teacher asked them to integrate hormonal regulation with energy metabolism and predict the consequences of insulin resistance on high-demand tissues.

Task

- (a) Explain how insulin, glucagon, and adrenaline regulate glucose metabolism in different tissues.*
- (b) Describe how glucose is converted to ATP in aerobic respiration.*
- (c) Explain the effect of insulin resistance on cellular energy production.*
- (d) Suggest one physiological adaptation to sustain ATP production during high energy demand.*

Item 4

During a lab, students examined meiosis in onion root tips under the microscope. They recorded chromosome numbers and stages of division. They were then asked to consider how errors in meiosis could produce aneuploidy and its consequences for reproductive success. Additionally, they analyzed how environmental mutagens could increase the frequency of genetic defects and how natural selection acts on such variations in populations.

Task

- (a) Explain the stages of meiosis and how they ensure genetic variation.*
- (b) Describe how nondisjunction can lead to aneuploidy.*
- (c) Explain the impact of aneuploidy on fertility and population fitness.*
- (d) Suggest one way populations could adapt to increased mutation rates.*

Item 5

Students investigated osmoregulation in freshwater and marine fish. They measured water uptake, ion concentration in body fluids, and excretion rates. They were asked to compare kidney and gill function in these species and predict the consequences of osmotic stress on cellular metabolism and respiration. Finally, they analyzed how hormones, such as ADH and aldosterone, coordinate excretion and water balance in extreme environments.

Task

- (a) Explain the differences in osmoregulatory mechanisms between freshwater and marine fish.*
- (b) Describe how osmotic stress affects cellular metabolism.*
- (c) Explain the role of ADH and aldosterone in maintaining water and ion balance.*
- (d) Suggest one physiological adaptation for survival in extreme salinity.*

Item 6

During a genetics lab, students cross-bred fruit flies with linked genes affecting wing size and eye color. They mapped gene loci based on offspring ratios and discussed the effect of recombination frequencies. Students were then challenged to predict the long-term effect of gene linkage and selection pressure on population allele frequencies in changing environments.

Task

- (a) Explain how gene linkage affects inheritance patterns.*
- (b) Describe how recombination can alter expected ratios in offspring.*

- (c) Explain the impact of selection on linked genes over multiple generations.*
- (d) Suggest one evolutionary consequence of gene linkage in natural populations.*

Item 7

A student measured transpiration, photosynthesis, and stomatal density in two plant species under drought and high light intensity. They also recorded internal CO₂ concentration and leaf water potential. The teacher asked them to integrate data to explain how structural and physiological adaptations optimize energy capture, water use efficiency, and survival under environmental stress.

Task

- (a) Explain how stomatal density and leaf structure affect transpiration and photosynthesis.*
- (b) Describe the relationship between CO₂ concentration, photosynthesis, and ATP production.*
- (c) Explain how physiological adaptations enhance survival in drought conditions.*
- (d) Suggest one trade-off between water conservation and photosynthetic efficiency.*

Item 8

Students investigated the effects of pollutants on enzyme activity and reproductive success in amphibians. They measured growth rate, hormone levels, and gamete viability. The teacher asked them to analyze how environmental toxins disrupt endocrine pathways, affect reproductive fitness, and influence population dynamics over time.

Task

- (a) Explain how pollutants can disrupt hormonal regulation in amphibians.*
- (b) Describe the impact of endocrine disruption on gamete viability.*
- (c) Explain the potential long-term effects on population dynamics.*
- (d) Suggest one ecological strategy to reduce pollutant impact.*

Item 9

During a lab, students monitored predator-prey interactions in a controlled ecosystem. They recorded population oscillations, reproductive success, and genetic diversity. They were asked to predict the effect of introducing a new predator, considering co-evolution, selection pressure, and changes in allele frequencies in both prey and predator populations.

Task

- (a) Explain how predator-prey interactions influence population size and genetic variation.*
- (b) Describe how selection pressures affect allele frequencies in prey and predator populations.*
- (c) Explain the concept of co-evolution in these interactions.*
- (d) Suggest one possible long-term evolutionary outcome for the prey population.*

Item 10

Students investigated the effect of hypoxia on human tissues at cellular and systemic levels. They measured erythropoietin secretion, red blood cell count, and oxygen consumption in muscle. They were asked to integrate respiratory, circulatory, and renal responses to hypoxia and predict potential risks and adaptations in high-altitude environments.

Task

- (a) Explain how erythropoietin and red blood cell production respond to hypoxia.*
- (b) Describe the effect of hypoxia on cellular respiration and ATP production.*
- (c) Explain how circulatory and renal systems coordinate to adapt to low oxygen levels.*
- (d) Suggest one long-term physiological adaptation to high-altitude hypoxia.*

ADVANCED-LEVEL BIOLOGY ITEMS – ANSWERS / MARKING GUIDE

Item 1

- (a) Temperature and pH affect enzyme tertiary structure → denaturation → reduces substrate binding → lowers activity.*
- (b) Enzyme activity → controls rate of metabolic reactions in glycolysis, Krebs cycle, and oxidative phosphorylation → affects ATP yield.*
- (c) Denaturation → reduced ATP → impaired muscle and brain function → fatigue, hypoxia, or cell damage.*
- (d) Compensatory mechanisms: upregulation of alternate metabolic pathways, increased mitochondrial biogenesis, or shivering to maintain energy output.*

Item 2

- (a) Drought → reduced soil moisture → slower decomposition → limited nitrogen availability → affects plant and microbial nitrogen cycling.*
- (b) Low dissolved oxygen → limits aerobic respiration → reduces ATP production in aquatic organisms → possible mortality.*
- (c) Genetic variation → some individuals possess alleles that confer drought tolerance → survive and reproduce.*
- (d) Adaptations: desiccation-resistant spores, deep roots, behavioral avoidance, dormancy.*

Item 3

- (a) Insulin → promotes glucose uptake and glycogen storage; Glucagon → mobilizes glucose from glycogen; Adrenaline → stimulates glycogen breakdown for rapid ATP.*
- (b) Glucose → glycolysis → pyruvate → Krebs cycle → ETC → ATP synthesis.*
- (c) Insulin resistance → impaired glucose uptake → hyperglycemia → reduced ATP in high-demand tissues.*
- (d) Physiological adaptation: increased fatty acid oxidation, upregulation of GLUT transporters, anaerobic glycolysis.*

Item 4

- (a) Meiosis → 2 divisions → reduces chromosome number → creates genetic variation via crossing-over and independent assortment.*
- (b) Nondisjunction → chromosomes fail to separate → aneuploidy (e.g., trisomy 21).*

- (c) Aneuploidy → reduced fertility, developmental defects → decreases population fitness.**
- (d) Adaptation: selection against deleterious alleles, increased genetic diversity through outcrossing.**

Item 5

- (a) Freshwater fish → hypoosmotic → excrete dilute urine, actively take up ions via gills; Marine fish → hyperosmotic → drink seawater, excrete concentrated urine, excrete excess salts.**
- (b) Osmotic stress → disrupts ion gradients → affects ATP production in mitochondria due to altered cellular homeostasis.**
- (c) ADH → increases water reabsorption; Aldosterone → increases Na⁺ reabsorption → maintains blood pressure and volume.**
- (d) Adaptation: specialized gill cells, impermeable scales, efficient renal filtration.**

Item 6

- (a) Gene linkage → genes located close together → inherited together → deviation from independent assortment.**
- (b) Recombination → crossing-over during meiosis → produces new allele combinations → alters offspring ratios.**
- (c) Selection → favors advantageous linked alleles → changes population gene frequency over generations.**
- (d) Evolutionary consequence: preservation of beneficial allele combinations, potential reduction in genetic variability for linked loci.**

Item 7

- (a) High stomatal density → increased transpiration and CO₂ uptake; Leaf structure (thick cuticle, small leaves) → reduces water loss.**
- (b) Internal CO₂ concentration → substrate for Calvin cycle → drives photosynthesis → ATP and NADPH production.**
- (c) Adaptations: stomatal closure, reduced leaf area, CAM or C₄ pathways → conserve water while maintaining photosynthesis.**

(d) Trade-off: reducing transpiration → limits CO₂ uptake → may decrease photosynthetic efficiency.

Item 8

(a) Pollutants → mimic or block hormones → disrupt endocrine regulation (e.g., estrogenic compounds affecting reproductive hormones).

(b) Gamete viability → reduced fertilization rates, malformed gametes, lower reproductive output.

(c) Long-term effects: population decline, reduced genetic diversity, altered predator-prey interactions.

(d) Ecological strategies: pollution control, habitat restoration, bio-remediation, regulation of chemical use.

Item 9

(a) Predator-prey → predation reduces prey population → influences allele frequencies, survival, and reproduction.

(b) Advantageous traits (speed, camouflage) → higher survival → increase allele frequency; disadvantageous traits decrease.

(c) Co-evolution → prey evolves defense → predator evolves counter-adaptation → reciprocal evolutionary change.

(d) Long-term outcome: prey may develop enhanced defense mechanisms; predator may specialize hunting strategies.

Item 10

(a) Hypoxia → stimulates kidneys to secrete erythropoietin → increases red blood cell production → enhances oxygen transport.

(b) Low oxygen → reduced cellular respiration → less ATP → can impair muscle and brain function.

(c) Circulatory system → increases cardiac output; Renal system → increases erythropoietin → coordinates oxygen delivery and balance.

(d) Long-term adaptation: increased red blood cell count (polycythemia), increased lung ventilation, higher hemoglobin affinity for oxygen.

UACE BIOLOGY – ADDITIONAL ITEMS (30 ITEMS)

(Covering ALL topics: Cell Biology, Nutrition, Transport, Respiration, Homeostasis, Coordination, Reproduction, Genetics, Evolution, Ecology)

Item 1

A group of students investigated the effect of prolonged starvation on human physiology. They monitored blood glucose levels, hormone secretion, respiration rate, and muscle activity over several days. They also examined how cells switch from glucose to lipid metabolism and the consequences of this shift on cellular respiration and homeostasis.

- (a) Explain how blood glucose levels are regulated during starvation.*
- (b) Describe the metabolic pathways used to generate ATP in the absence of glucose.*
- (c) Explain the role of hormones in coordinating the body's response to starvation.*
- (d) Discuss the long-term effects of starvation on muscle tissue and respiration.*

Item 2

During a practical, students examined plant cells subjected to different salt concentrations. They observed plasmolysis, changes in vacuole size, and reduced photosynthesis. Later, they discussed how similar osmotic challenges affect kidney function in humans and how organisms maintain internal balance.

- (a) Explain the process of plasmolysis in plant cells.*
- (b) Describe how osmotic stress affects photosynthesis.*
- (c) Explain how the human kidney responds to osmotic imbalance.*
- (d) Compare osmoregulation in plants and humans.*

Item 3

A student investigated how nerve impulses control heart rate during physical exercise. They measured oxygen uptake, carbon dioxide production, and adrenaline levels. The teacher asked them to relate nervous coordination with respiration and energy demand.

- (a) Explain how nerve impulses regulate heart rate.*
- (b) Describe the effect of exercise on respiration rate and oxygen uptake.*
- (c) Explain the role of adrenaline in coordinating the exercise response.*
- (d) Discuss how failure of coordination affects energy supply.*

Item 4

Students studied the inheritance of sickle-cell anemia in a malaria-endemic region. They analyzed genotype frequencies, survival rates, and environmental pressures. The teacher linked genetics with natural selection and population survival.

- (a) Explain the genetic basis of sickle-cell anemia.*
- (b) Describe how malaria acts as a selective pressure.*
- (c) Explain why heterozygous individuals have a survival advantage.*
- (d) Discuss how this example demonstrates evolution in humans.*

Item 5

During an ecological survey, students observed declining fish populations in a polluted lake. They measured oxygen levels, toxin concentration, and reproductive success. They were asked to relate pollution to respiration, reproduction, and population dynamics.

- (a) Explain how pollution affects dissolved oxygen levels.*
- (b) Describe the effect of low oxygen on aerobic respiration in fish.*
- (c) Explain how pollution interferes with reproduction.*
- (d) Predict long-term effects on the lake ecosystem.*

Item 6

A student examined the role of the nucleus and mitochondria in rapidly dividing cancer cells. They observed increased respiration rates and abnormal cell cycles. The teacher asked them to link cell biology with growth and control mechanisms.

- (a) Explain the role of mitochondria in rapidly dividing cells.*
- (b) Describe how cell cycle regulation is altered in cancer cells.*
- (c) Explain why cancer cells require high energy supply.*
- (d) Suggest one method of controlling uncontrolled cell division.*

Item 7

Students investigated transpiration rates in plants under high temperature and low humidity. They also measured water uptake and mineral transport. The teacher linked transpiration with transport and plant survival.

- (a) Explain how temperature and humidity affect transpiration.*
- (b) Describe the role of transpiration in mineral transport.*
- (c) Explain how excessive transpiration affects plant cells.*
- (d) Suggest adaptations that reduce water loss.*

Item 8

A farmer noticed reduced crop yield despite adequate rainfall. Soil analysis revealed nutrient deficiency. Students linked mineral nutrition with photosynthesis and growth.

- (a) Explain the role of mineral ions in plant nutrition.*
- (b) Describe how mineral deficiency affects photosynthesis.*
- (c) Explain the link between nutrition and plant growth.*
- (d) Suggest methods to improve soil fertility.*

Item 9

Students studied the menstrual cycle alongside thermoregulation in humans. They recorded hormone levels and body temperature changes.

- (a) Describe hormonal changes during the menstrual cycle.*
- (b) Explain the role of progesterone in temperature regulation.*
- (c) Explain how hormones coordinate reproductive cycles.*

(d) Predict effects of hormonal imbalance.

Item 10

A practical involved measuring breathing rate before and after exercise. Blood samples showed lactic acid accumulation.

- (a) Explain why breathing rate increases during exercise.*
- (b) Describe anaerobic respiration and lactic acid formation.*
- (c) Explain how lactic acid is removed from muscles.*
- (d) Discuss the role of oxygen debt.*

Item 11

Students examined genetic crosses involving linked genes. They observed deviations from Mendelian ratios.

- (a) Explain gene linkage.*
- (b) Describe how crossing over produces variation.*
- (c) Explain the significance of recombination frequency.*
- (d) Discuss evolutionary importance of genetic variation.*

Item 12

A student observed reflex actions and voluntary movements in humans.

- (a) Distinguish between reflex and voluntary actions.*
- (b) Describe the reflex arc.*
- (c) Explain the advantage of reflex actions.*
- (d) Predict effects of spinal cord damage.*

Item 13

Students monitored population growth of bacteria under limited nutrients.

- (a) Describe phases of population growth.*
- (b) Explain limiting factors in population growth.*
- (c) Relate nutrient availability to reproduction rate.*
- (d) Explain ecological significance of carrying capacity.*

Item 14

A student studied fertilization and early embryo development in mammals.

- (a) Describe the process of fertilization.*
- (b) Explain the role of the placenta.*
- (c) Describe hormonal control of pregnancy.*
- (d) Explain consequences of placental failure.*

Item 15

Students investigated photosynthesis under different light intensities.

- (a) Explain the light-dependent reactions.*
- (b) Describe the effect of light intensity on photosynthesis.*
- (c) Explain limiting factors of photosynthesis.*
- (d) Relate photosynthesis to plant growth.*

Item 16

A student studied blood clotting and wound healing.

- (a) Describe the process of blood clotting.*
- (b) Explain the role of platelets.*
- (c) Discuss the importance of clotting in homeostasis.*
- (d) Predict effects of clotting disorders.*

Item 17

Students examined inheritance of blood groups in humans.

- (a) Explain multiple alleles.*
- (b) Describe codominance using blood groups.*
- (c) Explain importance in blood transfusion.*
- (d) Predict offspring blood groups from given parents.*

Item 18

A student investigated the effect of deforestation on local climate.

- (a) Explain how forests influence rainfall.*
- (b) Describe effects of deforestation on ecosystems.*
- (c) Explain impact on carbon cycle.*
- (d) Suggest conservation strategies.*

Item 19

Students studied muscle contraction at cellular level.

- (a) Describe sliding filament mechanism.*
- (b) Explain role of ATP in muscle contraction.*
- (c) Explain effect of fatigue on muscles.*
- (d) Relate muscle contraction to respiration.*

Item 20

A student examined seed germination under different conditions.

- (a) Describe stages of germination.*
- (b) Explain role of enzymes in germination.*
- (c) Explain importance of oxygen in germination.*
- (d) Predict effect of water shortage.*

Item 21

Students studied thermoregulation in humans.

- (a) Explain mechanisms of heat loss.*
- (b) Describe role of skin in thermoregulation.*
- (c) Explain hormonal control of temperature.*
- (d) Predict effects of extreme temperatures.*

Item 22

A practical involved testing food substances.

- (a) Describe tests for starch and proteins.*
- (b) Explain importance of digestion.*
- (c) Describe absorption of digested food.*
- (d) Explain role of liver in metabolism.*

Item 23

Students investigated evolution of antibiotic resistance.

- (a) Explain how resistance develops.*
- (b) Describe role of mutation.*
- (c) Explain natural selection in bacteria.*
- (d) Suggest ways to reduce resistance.*

Item 24

A student studied pollination mechanisms.

- (a) Distinguish between wind and insect pollination.*
- (b) Explain adaptations of insect-pollinated flowers.*
- (c) Describe fertilization in flowering plants.*
- (d) Explain importance of pollination to ecosystems.*

Item 25

Students examined the structure of the kidney.

- (a) Describe structure of a nephron.*
- (b) Explain ultrafiltration.*
- (c) Describe selective reabsorption.*
- (d) Explain importance of kidney in homeostasis.*

Item 26

A student observed behavioral adaptations in animals.

- (a) Explain behavioral adaptation.*
- (b) Describe one example of survival behavior.*
- (c) Explain evolutionary advantage of behavior.*
- (d) Relate behavior to environmental change.*

Item 27

Students studied DNA replication.

- (a) Describe semi-conservative replication.*
- (b) Explain role of enzymes in replication.*
- (c) Explain importance of accurate replication.*
- (d) Predict effects of replication errors.*

Item 28

A student examined the carbon cycle.

- (a) Describe processes involved in carbon cycle.*
- (b) Explain role of photosynthesis.*
- (c) Describe impact of human activities.*
- (d) Suggest ways to reduce carbon imbalance.*

Item 29

Students studied coordination in plants.

- (a) Explain plant hormonal control.*
- (b) Describe phototropism.*
- (c) Explain role of auxins.*
- (d) Compare plant and animal coordination.*

Item 30

A student investigated adaptation in desert organisms.

- (a) Describe structural adaptations to desert life.*
- (b) Explain physiological adaptations.*

- (c) Explain evolutionary origin of adaptations.
- (d) Predict effects of climate change on desert species.

UACE BIOLOGY – ADDITIONAL ITEMS
ANSWERS / MARKING GUIDE (Items 1–30)

Item 1

- (a) Blood glucose maintained by glucagon → glycogenolysis and gluconeogenesis.
- (b) Lipid metabolism → β -oxidation → acetyl-CoA → Krebs cycle → ATP.
- (c) Hormones (glucagon, cortisol) coordinate energy mobilization.
- (d) Muscle wasting, reduced respiration efficiency, weakened immunity.

Item 2

- (a) Plasmolysis → water loss by osmosis → cell membrane pulls from wall.
- (b) Reduced turgidity → stomatal closure → reduced photosynthesis.
- (c) Kidney increases ADH secretion → water reabsorption.
- (d) Both use osmosis; plants via vacuoles, humans via nephrons.

Item 3

- (a) Cardiac center sends impulses via autonomic nerves.
- (b) Increased respiration rate → higher oxygen uptake.
- (c) Adrenaline increases heart rate and respiration.
- (d) Poor coordination → reduced ATP supply → fatigue.

Item 4

- (a) Mutation in hemoglobin gene → abnormal HbS.*
- (b) Malaria kills normal homozygotes more easily.*
- (c) Heterozygotes resistant to malaria.*
- (d) Demonstrates natural selection and allele frequency change.*

Item 5

- (a) Pollution reduces dissolved oxygen via eutrophication.*
- (b) Low oxygen → reduced aerobic respiration.*
- (c) Toxins disrupt gamete formation and hormones.*
- (d) Population decline, ecosystem imbalance.*

Item 6

- (a) Mitochondria supply ATP for rapid division.*
- (b) Cell cycle checkpoints fail.*
- (c) High respiration meets energy demands.*
- (d) Chemotherapy, radiation, immune targeting.*

Item 7

- (a) High temperature increases transpiration; low humidity enhances diffusion.*
- (b) Transpiration pull aids mineral transport.*
- (c) Excessive water loss causes wilting.*
- (d) Thick cuticle, sunken stomata.*

Item 8

- (a) Minerals act as enzyme cofactors.**
- (b) Deficiency reduces chlorophyll synthesis.**
- (c) Poor nutrition limits growth.**
- (d) Fertilizers, crop rotation, composting.**

Item 9

- (a) Estrogen rises → ovulation; progesterone maintains uterus.**
- (b) Progesterone increases basal temperature.**
- (c) Hormones synchronize ovulation and uterine changes.**
- (d) Infertility, irregular cycles.**

Item 10

- (a) Increased oxygen demand.**
- (b) Anaerobic respiration produces lactic acid.**
- (c) Lactic acid oxidized in liver.**
- (d) Oxygen debt restores normal conditions.**

Item 11

- (a) Genes on same chromosome inherited together.**
- (b) Crossing over creates new combinations.**
- (c) Distance between genes determines frequency.**
- (d) Increases adaptability.**

Item 12

- (a) Reflex involuntary; voluntary controlled by brain.**
- (b) Sensory → relay → motor neuron.**
- (c) Rapid protection.**
- (d) Loss of sensation or movement.**

Item 13

- (a) Lag, exponential, stationary, decline.**
- (b) Limited nutrients, space.**
- (c) Nutrients increase reproduction.**
- (d) Prevents overpopulation.**

Item 14

- (a) Fusion of gametes.**
- (b) Placenta exchanges nutrients and gases.**
- (c) Progesterone maintains pregnancy.**
- (d) Miscarriage, poor fetal growth.**

Item 15

- (a) Light reactions produce ATP and NADPH.**
- (b) Increased light raises rate until saturation.**
- (c) Light, CO₂, temperature.**
- (d) Supports biomass formation.**

Item 16

- (a) Fibrin formation seals wound.**
- (b) Platelets release clotting factors.**
- (c) Prevents blood loss.**
- (d) Excessive bleeding.**

Item 17

- (a) More than two alleles.**
- (b) A and B both expressed.**
- (c) Prevents transfusion reactions.**
- (d) Determined using Punnett squares.**

Item 18

- (a) Trees increase transpiration and rainfall.**
- (b) Habitat loss.**
- (c) Increased CO₂.**
- (d) Reforestation.**

Item 19

- (a) Actin and myosin slide.**
- (b) ATP provides energy.**
- (c) Lactic acid buildup.**
- (d) Requires oxygen supply.**

Item 20

- (a) Imbibition, enzyme activation, growth.**
- (b) Enzymes break stored food.**
- (c) Oxygen needed for respiration.**
- (d) Germination fails.**

Item 21

- (a) Sweating, vasodilation.**
- (b) Regulates heat exchange.**
- (c) Thyroxine increases metabolism.**
- (d) Heat stroke or hypothermia.**

Item 22

- (a) Iodine for starch; Biuret for protein.**
- (b) Breaks food into absorbable units.**
- (c) Via villi in ileum.**
- (d) Detoxification and metabolism.**

Item 23

- (a) Resistant bacteria survive antibiotics.**
- (b) Mutation creates resistance genes.**
- (c) Selection favors resistant strains.**
- (d) Proper antibiotic use.**

Item 24

- (a) Wind uses pollen; insects use nectar.**
- (b) Bright petals, scent.**
- (c) Fusion of gametes.**
- (d) Ensures food production.**

Item 25

- (a) Glomerulus, tubule.**
- (b) Pressure filtration.**
- (c) Useful substances reabsorbed.**
- (d) Maintains internal balance.**

Item 26

- (a) Behavior enhancing survival.**
- (b) Migration, hibernation.**
- (c) Increases reproductive success.**
- (d) Enables adaptation.**

Item 27

- (a) Each strand acts as template.**
- (b) DNA polymerase, helicase.**
- (c) Prevents mutations.**
- (d) Genetic disorders.**

Item 28

- (a) Respiration, photosynthesis, combustion.**
- (b) Removes CO₂.**
- (c) Increases greenhouse gases.**
- (d) Reduce fossil fuel use.**

Item 29

- (a) Hormones regulate growth.**
- (b) Shoots bend toward light.**
- (c) Auxins stimulate elongation.**
- (d) Plants use hormones only; animals use nerves and hormones.**

Item 30

- (a) Thick skin, reduced leaves.**
- (b) Water conservation.**
- (c) Natural selection.**
- (d) Increased extinction risk.**

UACE BIOLOGY – TRIAL TEST

Item 1

During a school biology practical, students investigated the effect of prolonged exercise on the human body. One student volunteered to jog continuously for 30 minutes while measurements of breathing rate, heart rate, and blood glucose levels were taken at regular intervals. It was observed that the breathing rate and heart rate increased steadily, while blood glucose levels gradually decreased. After the exercise, the student complained of muscle fatigue and pain. Further analysis revealed an increase in lactic acid concentration in muscle tissues and a higher demand for oxygen even after stopping the exercise.

Task:

- (A) Explain why breathing rate increases during prolonged exercise.**

- (B) Describe how ATP is produced in muscles during exercise.*
- (C) Explain the cause of muscle fatigue experienced by the student.*
- (D) Account for the continued high oxygen demand after exercise.*

Item 2

A farmer planted maize seeds in two different plots. One plot received adequate water and mineral fertilizers, while the other received water only. After several weeks, plants in the fertilized plot were taller, greener, and had broader leaves. Plants in the unfertilized plot showed stunted growth and yellowing of leaves. Soil analysis revealed low levels of nitrates and magnesium in the unfertilized plot. The farmer consulted a biology student to explain the observed differences.

Task:

- (A) Explain the role of nitrates in plant growth.*
- (B) Describe the importance of magnesium in photosynthesis.*
- (C) Explain why the unfertilized plants showed poor growth.*
- (D) Suggest two ways the farmer could improve soil fertility.*

Item 3

During a hospital visit, students observed a patient suffering from kidney failure. The patient produced very little urine and had a high concentration of urea in the blood. Doctors explained that the nephrons were damaged, affecting filtration and reabsorption. The patient also showed signs of swelling in the legs and face. The students were asked to relate kidney function to homeostasis in the human body.

Task:

- (A) Describe the process of ultrafiltration in the kidney.*
- (B) Explain how kidney failure leads to accumulation of urea in blood.*
- (C) Explain the cause of swelling observed in the patient.*
- (D) State two ways by which kidney failure can be managed.*

Item 4

A group of students studied inheritance of blood groups in humans. They examined a family where the father had blood group A and the mother had blood group B. Some of their children had blood group O, while others had blood group AB. The students were confused by the results and consulted their teacher, who explained the concept of multiple alleles and codominance.

Task:

- (A) Explain the concept of multiple alleles using blood groups.*
- (B) Describe codominance with reference to blood group inheritance.*
- (C) Explain how parents with blood groups A and B can produce a child with blood group O.*
- (D) State the importance of blood grouping in medical practice.*

Item 5

Students conducted an ecological survey in a forest reserve. They recorded different species of plants and animals and noted that areas near human settlements had fewer species compared to deeper forest regions. Evidence of tree cutting and bush burning was observed near the settlements. The students were asked to explain how human activities influence biodiversity and ecosystem stability.

Task:

- (A) Define biodiversity.*
- (B) Explain how deforestation affects biodiversity.*
- (C) Describe two effects of reduced biodiversity on ecosystems.*
- (D) Suggest measures that can be taken to conserve biodiversity.*

Item 6

In a laboratory experiment, students observed onion root tip cells under a microscope to study mitosis. They identified cells at different stages of division. Some cells showed abnormal chromosome separation, leading to unequal distribution of genetic material. The teacher explained that such errors could have serious consequences in multicellular organisms.

Task:

- (A) Describe the stages of mitosis observed in onion root tip cells.*
- (B) Explain the importance of mitosis in growth and repair.*
- (C) Explain the consequences of abnormal chromosome separation.*

(D) State one way by which the body controls abnormal cell division.

Item 7

A biology student investigated transpiration in plants using a potted plant placed under direct sunlight. The rate of transpiration increased rapidly during midday but reduced in the evening. When the leaves were coated with petroleum jelly, the rate of transpiration dropped significantly. The student related these observations to plant adaptations and water balance.

Task:

- (A) Define transpiration.*
- (B) Explain why transpiration rate is highest at midday.*
- (C) Explain the effect of petroleum jelly on transpiration.*
- (D) State two adaptations that reduce excessive water loss in plants.*

Item 8

During a lesson on coordination, students learned about reflex actions. A student accidentally touched a hot object and immediately withdrew the hand before feeling pain. The teacher explained the pathway followed by the nerve impulse and the importance of reflex actions in survival.

Task:

- (A) Define a reflex action.*
- (B) Describe the reflex arc involved in withdrawing the hand.*
- (C) Explain why reflex actions are rapid.*
- (D) State the importance of reflex actions in humans.*

Item 9

Students studying evolution examined a population of insects that showed variation in color. Over time, darker insects became more common in polluted areas, while lighter ones were more common in clean environments. The students were asked to explain the changes observed using principles of natural selection.

Task:

- (A) Define natural selection.
- (B) Explain how environmental conditions act as a selecting agent.
- (C) Explain why darker insects survived better in polluted areas.
- (D) State two pieces of evidence that support evolution.

Item 10

A class investigated germination of bean seeds under different conditions. Seeds placed in moist soil with oxygen germinated successfully, while those placed in dry soil or waterlogged conditions failed to germinate properly. Temperature was kept constant throughout the experiment.

Task:

- (A) Define germination.
- (B) Explain the role of water in germination.
- (C) Explain why oxygen is required during germination.
- (D) Account for the failure of seeds to germinate in waterlogged soil.

 **Finally, We Have Reached the End!** 

Dear students and fellow learners,

After weeks of dedication, effort, and meticulous work, we have finally completed the UACE Biology Item Bank for the new curriculum. This collection has been carefully structured to cover all topics in depth, with scenario-based questions designed to challenge your understanding, enhance your critical thinking, and prepare you thoroughly for your exams.

Each item has been crafted to guide you through real-life applications of biology, integrating theory with practical scenarios, so that you not only memorize facts but also understand concepts deeply. We have included detailed answers and explanations to help you self-assess, learn, and master each topic.

It is our hope that this item bank will be an invaluable resource in your study journey, helping you gain confidence, excel in your examinations, and achieve your academic goals. Remember, success in biology is not just about knowing

the answers, but about thinking like a biologist—analyzing, reasoning, and connecting ideas across topics.

Thank you for trusting this item bank. May it be of great help to your success and future achievements! Keep learning, stay curious, and never stop exploring the wonders of biology.

– JoelPCM