Paper 1:

Topic 1 – Cell Biology Answer Sheet

4.1.1.1 Eukaryotes and Prokaryotes

1. Prokaryotic cell.
2. Inside the nucleus.
3. Cell membrane and cell wall.
4. Plasmids.
5. No nucleus; no membrane-bound organelles.
6. The DNA is free in the cytoplasm as a single circular chromosome, so a nucleus is not needed.

4.1.1.2 Animal and Plant Cells

1. Nucleus.
2. Site of aerobic respiration; releases energy (ATP).
3. Cell wall and chloroplasts.
4. Contain chlorophyll to absorb light energy for photosynthesis.
5. Contains cell sap and maintains turgor pressure to keep the cell rigid.
6. Both have a nucleus, cytoplasm, cell membrane, mitochondria and ribosomes. Plant cells also have a cellulose cell wall, chloroplasts and a permanent vacuole.

Sub-cellular Structures and Their Functions

1. Contains DNA and controls the activities of the cell.
2. Site of protein synthesis.
3. Controls the movement of substances into and out of the cell.
4. They need lots of energy for contraction, so they contain many mitochondria.
5. Different specialised cells have different functions and therefore different numbers of organelles.
6. Nucleus – controls the cell and contains DNA; mitochondria – site of aerobic respiration; ribosomes – protein synthesis; chloroplasts – photosynthesis.

Required Practical 1: Using a Light Microscope

1. Light microscope.
2. To increase contrast and make cell structures easier to see.
3. A title and labels.
4. To show the actual size of the specimen.
5. Place the specimen on a slide, add water and stain if required, lower the coverslip carefully, then observe starting with the lowest magnification.
6. 1000×.

Scale and Size of Cells

1. Micrometres (μm).
2. One millionth (10^{-6}).
3. 1000 μm.
4. 5 mm.
5. 5×10^{-6} m.
6. It makes very small numbers easier to write and compare.

4.1.1.3 Cell Specialisation

1. A cell adapted to carry out a specific function.
2. Sperm cell.
3. Root hair cell.
4. Tail to swim to the egg.
5. Large surface area for absorbing water and mineral ions.
6. Their adaptations enable them to perform their specific functions efficiently.

4.1.1.4 Cell Differentiation

1. The process by which a cell becomes specialised.
2. To carry out a specific function.
3. A specialised cell.
4. During early development.
5. Many plant cells retain the ability to divide and differentiate throughout life.
6. It allows multicellular organisms to have specialised cells that perform different functions efficiently.

4.1.1.5 Microscopy

1. How many times larger the image is than the actual object.
2. The ability to distinguish two close points as separate.
3. Electron microscope.
4. Magnification = Image size ÷ Actual size
5. 1000×.
6. They have much higher magnification and resolution, allowing smaller structures to be seen.

4.1.1.6 Culturing Microorganisms (Biology Only)

1. By binary fission.
2. A type of asexual reproduction where one bacterium divides into two identical cells.
3. Every 20 minutes.
4. Warm temperature and nutrients. *(Also accept moisture.)*
5. 4 bacteria.
6. To grow and study bacteria.

Aseptic Technique

1. To kill microorganisms and prevent contamination.
2. To prevent contamination by unwanted microorganisms.
3. To sterilise it before transferring bacteria.
4. To reduce contamination while allowing oxygen to enter.
5. To reduce the risk of growing harmful pathogens.
6. To prevent contamination and ensure reliable results.

Required Practical 2: Antibiotics and Antiseptics

1. The size of the zone of inhibition.
2. The clear area around an antibiotic disc where bacteria have not grown.
3. The antibiotic is more effective against the bacteria.
4. To make it a fair test.
5. To produce an even lawn of bacteria for reliable results.
6. Area = πr^2

4.1.2 Cell Division

4.1.2.1 Chromosomes

1. In the nucleus.
2. DNA.
3. A section of DNA that codes for a protein.
4. Two copies (one from each parent).
5. DNA makes up genes, and genes are found on chromosomes.
6. So each new cell receives an identical set of chromosomes.

4.1.2.2 Mitosis and the Cell Cycle

1. Mitosis.
2. It is replicated.
3. Genetically identical to each other and the parent cell.
4. Growth and tissue repair. *(Also accept asexual reproduction in some organisms.)*
5. Cell growth → DNA replication → Cell division (mitosis).
6. It produces genetically identical cells for growth, repair and replacement.

4.1.2.3 Stem Cells

1. An unspecialised cell that can divide and differentiate.
2. In embryos.
3. Many different specialised cell types.
4. Bone marrow.
5. Any type of plant cell.
6. Replacing damaged cells, e.g. treating leukaemia with bone marrow stem cells.

4.1.3 Transport in Cells

4.1.3.1 Diffusion

1. The net movement of particles from a high concentration to a low concentration.
2. From high concentration to low concentration.
3. Oxygen. *(Also accept carbon dioxide.)*
4. Concentration gradient, temperature and surface area.

5. More particles can cross the membrane at the same time.
6. It allows substances to diffuse quickly enough to meet the cell's needs.

Surface Area to Volume Ratio

1. The amount of surface area compared with the volume.
2. It decreases.
3. 24 cm^2.
4. 8 cm^3.
5. They have a low surface area to volume ratio and cannot rely on diffusion alone.
6. Small cells have a larger surface area to volume ratio, making diffusion more efficient.

Exchange Surfaces

1. Alveoli. *(Also accept small intestine.)*
2. Root hair cells. *(Also accept leaves.)*
3. Large surface area.
4. Large surface area, thin walls and a good blood supply.
5. Large surface area, thin exchange surface and good blood flow.
6. Large surface area, thin structure and stomata for gas exchange.

4.1.3.2 Osmosis

1. The net movement of water molecules through a partially permeable membrane from a dilute solution to a concentrated solution.
2. Water molecules.
3. A partially permeable membrane.
4. From a dilute solution to a concentrated solution.
5. It becomes turgid.
6. It becomes plasmolysed.

Required Practical 3: Osmosis in Plant Tissue

1. Potato cylinders.
2. To investigate the effect of different concentrations on osmosis.
3. To calculate the change in mass due to water movement.
4. 20%.
5. To make it a fair test.
6. To improve the reliability of the results.

4.1.3.3 Active Transport

1. The movement of substances from a low concentration to a high concentration against the concentration gradient.
2. Yes.
3. From low concentration to high concentration.
4. Respiration.
5. To absorb mineral ions from dilute soil.
6. Diffusion does not require energy and moves down a concentration gradient; active transport requires energy and moves against the concentration gradient.

Topic 1 Review

1. Prokaryotic cells have no nucleus or membrane-bound organelles; eukaryotic cells do.
2. Mitochondria.
3. They are adapted to carry out specific functions efficiently.
4. Diffusion, osmosis and active transport.
5. Mitosis.
6. As organisms become larger, diffusion alone is too slow, so transport systems move substances efficiently around the body.

Topic 2 – Organisation Answer Sheet

4.2.1 Principles of Organisation

1. Cells.
2. A group of similar cells working together to carry out a particular function.
3. A group of different tissues working together to perform a particular function.
4. A group of organs working together to carry out a particular function.
5. Cell → Tissue → Organ → Organ system → Organism.
6. Different tissues perform different functions and work together to allow the organ to carry out its role.

4.2.2.1 The Human Digestive System

1. To break down food into small soluble molecules that can be absorbed into the blood.
2. The mouth.
3. The small intestine.
4. Completes digestion and absorbs soluble products of digestion into the bloodstream.
5. Small soluble molecules can pass through the walls of the small intestine into the blood.
6. The digestive system breaks food into soluble molecules, which the circulatory system transports to cells throughout the body.

Enzymes and Metabolism

1. Proteins.
2. To act as biological catalysts that speed up chemical reactions.
3. The part of the enzyme where the substrate binds.
4. Each enzyme has an active site with a specific shape that only fits one substrate.
5. The substrate has a complementary shape to the enzyme's active site.
6. High temperatures change the shape of the active site (denature the enzyme), reducing or stopping enzyme activity.

Digestive Enzymes

1. Amylase.
2. Protease.
3. Lipase.
4. Amino acids.
5. Fatty acids and glycerol.
6. They are small and soluble, so they can pass through the wall of the small intestine into the bloodstream.

Bile

1. The liver.
2. The gall bladder.
3. Neutralises stomach acid and emulsifies fats.
4. To provide the optimum alkaline pH for enzymes in the small intestine.
5. It breaks large fat droplets into smaller droplets, increasing the surface area for lipase.

6. Emulsification increases the surface area, allowing lipase to digest fats more quickly.

Required Practical 4: Testing for Biological Molecules

1. Iodine solution.
2. Biuret reagent.
3. Benedict's solution.
4. Blue to brick-red (after heating).
5. Each reagent reacts specifically with a different biological molecule.
6. Add iodine for starch (blue-black if present); add Biuret reagent for protein (lilac if present); add Benedict's solution and heat for reducing sugars (blue to green/yellow/orange/brick-red).

Required Practical 5: Effect of pH on Amylase

1. Amylase.
2. Starch.
3. Iodine solution.
4. pH affects enzyme activity, so it must be kept constant for a fair test.
5. Temperature also affects enzyme activity and must be controlled.
6. The shorter the time taken for starch to disappear, the faster the enzyme is working.

4.2.2.2 The Heart and Blood Vessels

1. To pump blood around the body.
2. A double circulatory system.
3. The right side.
4. The left side.
5. Aorta, vena cava, pulmonary artery, pulmonary vein and coronary arteries.
6. Blood passes through the heart twice during one complete circulation of the body.

Structure of the Heart

1. The heart.
2. To pump blood out of the heart.
3. To receive blood returning to the heart.
4. It pumps blood at higher pressure around the whole body.

5. The heart muscle needs oxygen and glucose for aerobic respiration.
6. It generates electrical impulses that control the heart rate and is found in the right atrium of the heart.

The Lungs and Gas Exchange

1. Oxygen.
2. Carbon dioxide.
3. Alveoli.
4. Capillaries.
5. Large surface area, moist surface, thin walls (one cell thick) and a good blood supply.
6. It maintains a steep concentration gradient for rapid diffusion.

Blood Vessels

1. Arteries, veins and capillaries.
2. Arteries.
3. Veins.
4. To withstand the high pressure of blood pumped from the heart.
5. To provide a short diffusion distance for substances.
6. Arteries have thick muscular, elastic walls and a small lumen; veins have thinner walls, a large lumen and valves; capillaries have walls one cell thick for efficient exchange.

4.2.2.3 Blood

1. A connective tissue.
2. Plasma.
3. Plasma, red blood cells, white blood cells and platelets.
4. To transport oxygen.
5. To defend the body against pathogens.
6. They contain haemoglobin, have no nucleus and are biconcave, giving a large surface area for oxygen transport.

4.2.2.4 Coronary Heart Disease: A Non-Communicable Disease

1. A non-communicable disease.
2. Fatty deposits (plaques).
3. Blood flow to the heart muscle.

4. To keep the coronary artery open.
5. They reduce blood cholesterol levels.
6. Less oxygen means less aerobic respiration, so less energy is released and heart muscle cells can die.

Treatments for Cardiovascular Disease

1. To keep narrowed coronary arteries open.
2. To reduce blood cholesterol levels.
3. A damaged heart valve.
4. A heart transplant or an artificial heart.
5. An artificial heart or a ventricular assist device (VAD).
6. Treatments vary in effectiveness, recovery time, side effects and risk of complications.

4.2.2.5 Health Issues

1. The state of physical and mental well-being.
2. Communicable and non-communicable diseases.
3. Diet. *(Also accept exercise, stress or life situation.)*
4. One disease can increase the likelihood or severity of another.
5. They reduce the body's ability to fight infection.
6. Smoking, poor diet, lack of exercise and alcohol can increase disease risk.

4.2.2.6 The Effect of Lifestyle on Some Non-Communicable Diseases

1. A factor that increases the chance of developing a disease.
2. Smoking. *(Also accept poor diet, alcohol or lack of exercise.)*
3. It damages the lungs and can cause diseases such as COPD and lung cancer.
4. Diets high in saturated fat increase blood cholesterol and the risk of coronary heart disease.
5. Obesity can reduce the body's response to insulin.
6. Alcohol can damage liver cells and affect brain function.

Risk Factors and Data

1. A relationship between two variables.
2. A scatter graph.
3. A factor that increases the chance of developing a disease.

4. Other variables may be responsible for the relationship.
5. They analyse data to identify patterns and possible risk factors.
6. They produce more reliable and representative results.

4.2.2.7 Cancer

1. Uncontrolled cell division.
2. A mass of abnormal cells.
3. Benign tumours do not spread; malignant tumours invade other tissues and spread.
4. They can spread to other parts of the body through the bloodstream or lymphatic system.
5. Smoking.
6. Cancer cells break away from the original tumour and form secondary tumours elsewhere in the body.

4.2.3 Plant Tissues, Organs and Systems

4.2.3.1 Plant Tissues

1. An organ.
2. Palisade mesophyll tissue.
3. Transports water and mineral ions from the roots to the leaves.
4. Transports dissolved sugars (products of photosynthesis) around the plant.
5. They contain many chloroplasts near the upper surface of the leaf to absorb maximum light.
6. Different tissues are specialised for functions such as photosynthesis, transport and protection, enabling the plant to survive.

Leaf Structure

1. Epidermal tissue.
2. To open and close the stomata.
3. Pores in the leaf that allow gas exchange.
4. To allow gases to diffuse through the leaf.
5. Guard cells open and close the stomata to regulate water loss and gas exchange.
6. A large surface area, thin structure, palisade cells with many chloroplasts, air spaces in the spongy mesophyll and stomata all increase the efficiency of photosynthesis.

4.2.3.2 Plant Organ System

1. Roots, stem and leaves.
2. Water and mineral ions.
3. Dissolved sugars.
4. Transpiration.
5. They have a large surface area and thin walls, allowing efficient absorption of water by osmosis and mineral ions by active transport.
6. Transpiration is the loss of water from leaves; translocation is the movement of dissolved sugars in the phloem.

Root Hair Cells, Xylem and Phloem

1. Osmosis.
2. Active transport.
3. Lignin.
4. Dissolved sugars.
5. It increases the rate of absorption of water and mineral ions.
6. Xylem vessels are dead, hollow tubes strengthened with lignin, allowing water and mineral ions to move efficiently.

Transpiration and Stomata

1. The loss of water vapour from the leaves.
2. Stomata.
3. To control the opening and closing of the stomata.
4. Light intensity, temperature, humidity and air movement (wind).
5. Higher temperatures increase evaporation and diffusion, increasing transpiration.
6. Higher light intensity opens the stomata for photosynthesis, increasing transpiration.

Measuring Transpiration

1. Water uptake.
2. A potometer.
3. To improve the reliability of the results.
4. 2 cm^3 per hour.
5. To ensure a fair test.
6. It ensures that any changes in water uptake are due only to the independent variable.

Topic 2 Review

1. Cell → Tissue → Organ → Organ system → Organism.
2. Enzymes are biological catalysts that speed up the breakdown of large insoluble food molecules into small soluble molecules for absorption.
3. The heart pumps deoxygenated blood to the lungs and oxygenated blood to the rest of the body in a double circulatory system.
4. Plasma – transports blood cells and dissolved substances; red blood cells – transport oxygen; white blood cells – defend against pathogens; platelets – help blood to clot.
5. Lifestyle factors such as smoking, poor diet, lack of exercise and excessive alcohol consumption increase the risk of non-communicable diseases.
6. Xylem transports water and mineral ions, phloem transports dissolved sugars, root hair cells absorb water and mineral ions efficiently, and leaves are adapted for photosynthesis with many chloroplasts and a large surface area.

Topic 3 – Infection and Response Answer Sheet

4.3.1.1 Communicable (Infectious) Diseases

1. A microorganism that causes disease.
2. Bacteria, viruses, fungi and protists.
3. A disease caused by pathogens that can be spread between organisms.
4. Air, water and direct contact. *(Also accept contaminated food.)*
5. They reproduce inside body cells, damaging or destroying them.
6. They produce toxins that damage tissues and make people feel ill.

4.3.1.2 Viral Diseases

1. A virus.
2. By droplets from coughs and sneezes.
3. Red skin rash. *(Also accept fever.)*
4. It attacks white blood cells of the immune system.
5. Through sexual contact or exchange of body fluids (e.g. blood).
6. It causes discolouration of leaves, reducing chlorophyll and photosynthesis.

Measles

1. A virus.
2. By droplets from coughs and sneezes.
3. Red skin rash and fever.
4. To provide immunity and prevent the disease spreading.
5. It can lead to serious complications such as pneumonia or encephalitis.
6. Vaccinated people are immune, reducing the spread of the virus through the population.

HIV

1. A virus.
2. White blood cells.
3. Unprotected sexual contact. *(Also accept blood-to-blood contact or shared needles.)*
4. AIDS.
5. Their immune system is weakened and cannot fight off infections effectively.
6. They stop the virus reproducing, slowing damage to the immune system.

Tobacco Mosaic Virus (TMV)

1. A virus.
2. Plants.
3. A mosaic pattern of discoloured patches on the leaves.
4. It reduces photosynthesis.
5. Less chlorophyll is available to absorb light for photosynthesis.
6. Less photosynthesis means less glucose is produced for growth, reducing crop yield.

4.3.1.3 Bacterial Diseases

1. Bacteria.
2. By eating contaminated food, especially poultry.
3. Fever and stomach cramps. *(Also accept vomiting or diarrhoea.)*
4. They damage body cells and tissues.
5. Through sexual contact.
6. Some strains have become resistant to antibiotics.

Salmonella

1. Bacteria.
2. By eating contaminated food.
3. Fever and diarrhoea. *(Also accept stomach cramps or vomiting.)*
4. Vaccinating poultry.
5. It reduces the spread of bacteria and contamination of food.
6. Toxins produced by the bacteria damage cells and tissues, causing illness.

Gonorrhoea

1. Bacteria.
2. Through sexual contact.
3. Pain when urinating. *(Also accept thick yellow or green discharge.)*
4. Penicillin.
5. Overuse of antibiotics has led to antibiotic-resistant strains.
6. Using barrier contraception (e.g. condoms) and treating infected people with appropriate antibiotics.

4.3.1.4 Fungal Diseases

1. Rose black spot.
2. Rose plants.
3. Purple or black spots on leaves.
4. By water or wind.
5. It reduces photosynthesis because leaves are damaged or lost.
6. Use fungicides and remove or burn infected leaves.

4.3.1.5 Protist Diseases

1. A protist.
2. Female mosquito.
3. Malaria.
4. Recurrent fever. *(Also accept chills or flu-like symptoms.)*
5. Mosquitoes transmit the protist between humans.
6. Destroy mosquito breeding sites and use insecticide-treated bed nets.

4.3.1.6 Human Defence Systems

1. The skin.
2. Hydrochloric acid.
3. They trap pathogens and prevent them entering the lungs.
4. To defend the body against pathogens.
5. Phagocytosis, producing antibodies and producing antitoxins.
6. White blood cells engulf and digest pathogens.

White Blood Cells

1. White blood cell.
2. Phagocytosis.
3. Antigens.
4. Toxins produced by bacteria.
5. Each antibody has a complementary shape to a specific antigen.
6. They engulf pathogens, produce antibodies to destroy them and produce antitoxins to neutralise bacterial toxins.

4.3.1.7 Vaccination

1. Dead or inactive pathogens, or parts of pathogens (antigens).
2. Dead or inactive.
3. White blood cells (lymphocytes).
4. They produce antibodies rapidly, destroying the pathogen before symptoms develop.
5. It stimulates the immune system to produce memory cells without causing disease.
6. Fewer people can become infected, reducing the spread of the disease (herd immunity).

4.3.1.8 Antibiotics and Painkillers

1. Bacteria.
2. Penicillin.
3. Viruses reproduce inside body cells, so antibiotics cannot target them.
4. To relieve pain but not kill pathogens.
5. Because antibiotic-resistant bacteria are developing.
6. Random mutations make some bacteria resistant; these survive treatment, reproduce and pass on the resistance allele.

4.3.1.9 Discovery and Development of Drugs

1. The foxglove plant.
2. Willow.
3. Alexander Fleming.
4. To test toxicity, efficacy and dosage using cells, tissues and live animals.
5. Toxicity, efficacy and optimum dose in healthy volunteers and patients.
6. To ensure they are safe, effective and the correct dose before being licensed.

Drug Testing

1. Whether the drug is harmful.
2. Whether the drug works.
3. The most effective dose with the fewest side effects.
4. To reduce the risk of harmful side effects.
5. A dummy treatment with no active drug.
6. To prevent bias and produce valid, reliable results.

4.3.2 Monoclonal Antibodies (Biology Only HT)

4.3.2.1 Producing Monoclonal Antibodies

1. Antibodies produced from a single clone of cells that are identical and specific to one antigen.
2. Lymphocytes.
3. A hybridoma cell.
4. Divide repeatedly and produce identical antibodies.
5. To produce large quantities of identical monoclonal antibodies.
6. They bind to one specific antigen because they are all identical.

4.3.2.2 Uses of Monoclonal Antibodies

1. Pregnancy tests. *(Also accept treating cancer or identifying pathogens.)*
2. They bind to the hormone hCG, producing a coloured line if it is present.
3. They bind to specific antigens on pathogens.
4. They are attached to fluorescent dyes that bind to target molecules.
5. They carry drugs or radioactive substances directly to cancer cells.
6. They target specific cells, reducing damage to healthy cells.

4.3.3 Plant Disease (Biology Only)

4.3.3.1 Detection and Identification of Plant Diseases

1. Stunted growth. *(Also accept spots on leaves, areas of decay, malformed stems or discolouration.)*
2. Virus. *(Also accept bacteria, fungi or protists.)*
3. The plant may be diseased or have a mineral ion deficiency.
4. By using testing kits containing monoclonal antibodies.
5. Magnesium ion deficiency.
6. Magnesium ions are needed to make chlorophyll for photosynthesis.

Plant Ion Deficiencies

1. Magnesium ions.
2. Nitrate ions.
3. Stunted growth.
4. Chlorosis (yellow leaves).
5. Nitrate ions are needed to make amino acids and proteins for growth.
6. Magnesium is needed to make chlorophyll, so less photosynthesis occurs.

4.3.3.2 Plant Defence Responses

1. Cellulose cell walls. *(Also accept waxy cuticle.)*
2. Cellulose.
3. It forms a barrier to prevent pathogens entering the plant.
4. Antibacterial chemicals. *(Also accept poisons.)*
5. Thorns or hairs.
6. They prevent pathogens entering the plant or discourage animals from damaging it.

Topic 3 Review

1. Bacteria, viruses, fungi and protists.
2. They reproduce inside living cells.
3. They stimulate the immune system to produce memory cells, providing immunity.
4. Viruses reproduce inside body cells, so antibiotics cannot destroy them.
5. To bind to specific antigens on pathogens.
6. Plants use physical, chemical and mechanical defences to reduce infection and damage.

Topic 4 – Bioenergetics Answer Sheet

4.4.1.1 Photosynthetic Reaction

1. Photosynthesis.
2. Carbon dioxide and water.
3. Oxygen.
4. Carbon dioxide + water → glucose + oxygen.
5. CO_2, H_2O, O_2, $C_6H_{12}O_6$.
6. Light energy is absorbed to drive the reaction.

Photosynthesis and Chloroplasts

1. Chloroplasts.
2. Chlorophyll.
3. Chloroplast.
4. They contain chlorophyll, which absorbs light energy for photosynthesis.
5. It is converted into chemical energy to produce glucose.
6. Carbon dioxide provides the carbon needed to make glucose.

4.4.1.2 Rate of Photosynthesis

1. Light intensity. *(Also accept carbon dioxide concentration, temperature or chlorophyll concentration.)*
2. A factor that limits the rate of photosynthesis.
3. The rate increases until another factor becomes limiting.
4. The rate increases until another factor becomes limiting.
5. At high temperatures, enzymes denature, causing the rate to decrease.
6. Increasing one factor will not increase the rate if another factor is limiting.

Required Practical 6: Investigating Light Intensity and Photosynthesis

1. Pondweed (e.g. *Cabomba*).
2. The number of oxygen bubbles produced per minute. *(Or the volume of oxygen produced.)*
3. To change the light intensity.
4. To ensure a fair test.
5. 12 bubbles per minute.
6. To improve the reliability of the results.

Graphs and Limiting Factors (HT)

1. Light intensity.
2. Rate of photosynthesis.
3. Another factor becomes limiting.
4. Carbon dioxide concentration or temperature.
5. They increase light intensity, carbon dioxide concentration and temperature to maximise the rate of photosynthesis.
6. Heating, lighting and supplying carbon dioxide all have financial costs.

4.4.1.3 Uses of Glucose from Photosynthesis

1. Glucose.
2. Starch.
3. Cellulose.
4. Lipids (fats and oils).
5. Proteins.
6. Nitrate ions are needed to make amino acids, which are joined together to make proteins.

4.4.2.1 Aerobic and Anaerobic Respiration

1. The process of transferring energy from glucose.
2. In mitochondria.
3. Oxygen.
4. Glucose + oxygen → carbon dioxide + water.
5. Aerobic respiration produces carbon dioxide and water; anaerobic respiration in muscles produces lactic acid.
6. It does not completely break down glucose, so less energy is transferred.

Aerobic Respiration

1. A chemical reaction.
2. Exothermic.
3. Carbon dioxide and water.
4. It is used for processes such as building larger molecules, muscle contraction and maintaining body temperature.
5. Muscle contraction, active transport and building larger molecules.
6. Organisms need energy continuously for essential life processes.

Anaerobic Respiration

1. Without oxygen.
2. When there is not enough oxygen available during vigorous exercise.
3. Lactic acid.
4. Ethanol and carbon dioxide.
5. Anaerobic respiration in yeast that produces ethanol and carbon dioxide.
6. It allows energy to continue being transferred when oxygen is limited.

4.4.2.2 Response to Exercise

1. It increases.
2. It increases.
3. To increase the rate of aerobic respiration and release more energy.
4. Lactic acid.
5. The amount of extra oxygen needed to oxidise lactic acid and return the body to its resting state.
6. Lactic acid builds up during anaerobic respiration, causing muscles to become fatigued.

Oxygen Debt and Lactic Acid

1. In muscle cells.
2. There is insufficient oxygen for aerobic respiration.
3. The liver.
4. Carbon dioxide and water.
5. To oxidise the lactic acid produced during anaerobic respiration.
6. Extra oxygen is used to oxidise lactic acid in the liver, repaying the oxygen debt.

Investigating Exercise Effects

1. Heart rate and breathing rate.
2. It gradually returns to the resting rate.
3. It gradually returns to the resting rate.
4. To improve the reliability of the results.
5. 60 bpm.
6. Exercise increases respiration because muscles need more energy for contraction.

4.4.2.3 Metabolism

1. The sum of all the chemical reactions in a cell or the body.
2. In cells.
3. Glycogen.
4. Glycerol and fatty acids.
5. Amino acids.
6. Respiration transfers the energy needed for metabolic reactions.

Metabolism and Biological Molecules

1. Amino acids.
2. Simple sugars (glucose).
3. Glycerol and fatty acids.
4. Energy storage in animals.
5. Glucose molecules are joined together to form cellulose for cell walls.
6. Glucose provides energy through respiration, while nitrate ions are used to make amino acids, which are joined together to form proteins.

Topic 4 Review

1. Carbon dioxide + water → glucose + oxygen.
2. Light intensity, carbon dioxide concentration and temperature.
3. Glucose + oxygen → carbon dioxide + water.
4. Aerobic respiration requires oxygen; anaerobic respiration does not.
5. Lactic acid builds up because there is not enough oxygen for aerobic respiration.
6. Glucose is used in respiration, stored as starch or glycogen, converted into cellulose, lipids and proteins.

Paper 2:

Topic 5: Homeostasis and Response Answer Sheet

4.5.1 Homeostasis

1. The maintenance of a constant internal environment within narrow limits.
2. Body temperature / blood glucose concentration / water levels.
3. Receptors detect changes in the internal or external environment.
4. Effectors produce a response to correct a change.
5. Receptors, coordination centres and effectors.
6. Enzymes require stable conditions to work effectively; large changes can reduce activity or denature enzymes.

4.5.2.1 Structure and Function of the Human Nervous System

1. To detect stimuli and coordinate responses.
2. Electrical impulses.
3. Brain and spinal cord.
4. Stimulus → receptor → sensory neurone → relay neurone → motor neurone → effector → response.
5. Sensory neurones carry impulses from receptors to the CNS; motor neurones carry impulses from the CNS to effectors.
6. Nervous responses are rapid because electrical impulses travel quickly along neurones.

4.5.2.1 Reflex Arc

1. A rapid automatic response to a stimulus.
2. Sensory neurone.
3. Motor neurone.
4. Relay neurones connect sensory neurones to motor neurones in the CNS.
5. Neurotransmitters diffuse across the synapse and trigger an impulse in the next neurone.

6. Reflex actions are controlled by the spinal cord, so they happen without conscious thought.

Required Practical 7: Investigating Reaction Time

1. The time taken to respond to a stimulus.
2. Age / caffeine / tiredness / distractions / practice.
3. Ruler drop test or computer reaction timer.
4. To calculate a more reliable mean and reduce the effect of anomalies.
5. Add all results together and divide by the number of results.
6. Controlling variables ensures the investigation is fair and only the independent variable affects the results.

4.5.2.2 The Brain (Biology Only)

1. The brain.
2. Neurones.
3. Cerebral cortex.
4. Cerebellum.
5. Medulla.
6. The brain is difficult to investigate because it is complex, protected inside the skull and studying it can cause damage.

4.5.2.3 The Eye (Biology Only)

1. Light.
2. Retina.
3. Carries electrical impulses from the retina to the brain.
4. The process of changing the shape of the lens to focus light on the retina.
5. The lens becomes thicker and more curved to refract light more strongly.
6. Spectacle lenses change the direction of light so it is focused correctly onto the retina.

4.5.2.4 Control of Body Temperature (Biology Only)

1. 37°C.
2. Hypothalamus.
3. Blood vessels widen (vasodilation), increasing blood flow near the skin.
4. Evaporation of sweat removes heat energy from the skin.

5. Muscles contract rapidly, causing shivering.
6. Vasodilation increases blood flow to the skin, allowing more heat to be transferred to the surroundings.

4.5.3.1 Human Endocrine System

1. A chemical messenger released by glands and transported in the blood.
2. Endocrine glands.
3. Through the bloodstream.
4. Nervous coordination uses electrical impulses and is fast; hormonal coordination uses hormones and is slower but longer lasting.
5. Controls the release of hormones from other glands.
6. Pancreas, ovaries/testes and thyroid gland.

4.5.3.2 Control of Blood Glucose Concentration

1. Pancreas.
2. Insulin.
3. Converted into glycogen and stored in the liver and muscles.
4. Glucagon.
5. The pancreas produces little or no insulin.
6. Insulin causes glucose to move from the blood into cells and converts excess glucose into glycogen, lowering blood glucose concentration.

Type 1 and Type 2 Diabetes

1. Type 1 diabetes is caused by the immune system destroying insulin-producing cells in the pancreas.
2. Type 2 diabetes is caused by body cells becoming less sensitive to insulin and is linked to lifestyle factors.
3. Insulin injections.
4. Being overweight / obesity / lack of exercise / poor diet.
5. Exercise increases glucose uptake by muscles and helps control blood glucose levels.
6. Type 1 diabetes is caused by lack of insulin production; Type 2 diabetes is caused by insulin resistance.

4.5.3.3 Maintaining Water and Nitrogen Balance (Biology Only)

1. Kidneys.
2. A waste liquid containing water, urea and ions removed from the blood.
3. Urea and excess water.
4. Excess amino acids cannot be stored and would be harmful if they build up.
5. Ammonia, which is converted into urea in the liver.
6. The kidneys filter the blood and adjust how much water is removed in urine.

ADH and Kidney Control (HT Only)

1. Antidiuretic hormone.
2. Pituitary gland.
3. When the blood contains too little water or is too concentrated.
4. It increases the permeability of kidney tubules, causing more water to be reabsorbed.
5. It reduces water loss by producing more concentrated urine.
6. Negative feedback keeps water levels stable by increasing or decreasing ADH release depending on water concentration.

4.5.3.4 Hormones in Human Reproduction

1. Oestrogen is produced by the ovaries.
2. Testosterone is produced by the testes.
3. Follicle-stimulating hormone (FSH).
4. The release of an egg from an ovary.
5. Luteinising hormone (LH).
6. Progesterone maintains the uterus lining during the menstrual cycle.

Menstrual Cycle (HT Only)

1. Approximately 28 days.
2. FSH causes an egg to mature in the ovary.
3. LH triggers ovulation.
4. The uterus lining thickens to prepare for implantation.
5. Oestrogen and progesterone.
6. FSH causes egg maturation and stimulates oestrogen production; oestrogen stimulates the release of LH; LH causes ovulation; progesterone maintains the uterus lining.

4.5.3.5 Contraception

1. Methods used to prevent pregnancy.
2. Oral contraceptive pill / contraceptive implant / contraceptive injection.
3. Condoms prevent sperm reaching an egg.
4. Oestrogen or progesterone.
5. They stop ovulation by preventing the release of FSH and LH.
6. Contraceptive methods prevent fertilisation by stopping sperm reaching the egg or prevent implantation by changing the uterus lining.

4.5.3.6 Use of Hormones to Treat Infertility (HT Only)

1. The inability to become pregnant naturally.
2. FSH and LH.
3. In vitro fertilisation, where an egg is fertilised outside the body.
4. FSH stimulates eggs to mature in the ovaries.
5. Fertilised eggs are inserted into the uterus.
6. IVF increases the chance of pregnancy by controlling egg maturation, fertilisation and embryo implantation.

4.5.3.7 Negative Feedback (HT Only)

1. A control system that reverses changes to maintain a stable internal environment.
2. Adrenal glands.
3. It increases heart rate and prepares the body for action.
4. Thyroid gland.
5. Thyroxine controls the metabolic rate.
6. If thyroxine levels become too high, the release of hormones stimulating the thyroid is reduced; if levels are too low, more is released.

4.5.4.1 Plant Hormones: Control and Coordination (Biology Only)

1. Auxin.
2. The growth response of plants towards light.
3. The growth response of plants in response to gravity.
4. Auxin is produced in the tips of shoots and roots.
5. Auxin causes cells on the shaded side of a shoot to elongate, making the shoot grow towards light.
6. Unequal distribution of auxin causes different rates of cell elongation, producing growth responses.

Required Practical 8: Plant Responses to Light or Gravity

1. Auxin is a plant hormone that controls growth responses.
2. Seedlings such as cress seedlings.
3. The direction or length of seedling growth.
4. The variable that is changed by the investigator.
5. To improve reliability and calculate a more accurate mean.
6. Auxin moves to the shaded side of the shoot, causing cells there to elongate more, making the shoot bend towards light.

4.5.4.2 Uses of Plant Hormones (HT Only)

1. Auxin.
2. Auxin.
3. Ethene.
4. Gibberellins are used to increase seed germination and promote flowering and growth.
5. Ethene is used to control fruit ripening during storage and transport.
6. Plant hormones can be used to control growth, increase crop production, prevent weed growth and improve farming practices.

Paper 2:

Topic 6: Inheritance, Variation and Evolution Answer Sheet

4.6.1.1 Sexual and Asexual Reproduction

1. Mitosis.
2. Meiosis.
3. Sexual reproduction is the process where genetic material from two parents combines to produce offspring.
4. Male and female gametes fuse to form a fertilised egg cell (zygote).
5. It combines genetic information from two parents, creating genetically different offspring.
6. It involves one parent, no fusion of gametes, produces genetically identical offspring and uses mitosis.

4.6.1.2 Meiosis

1. To produce genetically different gametes with half the normal chromosome number.
2. In reproductive organs such as the ovaries and testes.
3. It halves the chromosome number so gametes are haploid.
4. Four gametes.
5. Chromosomes are shuffled during meiosis, creating different combinations of alleles.
6. Fertilisation combines two haploid gametes to restore the normal diploid chromosome number.

4.6.1.3 Advantages and Disadvantages of Sexual and Asexual Reproduction

1. It produces variation in offspring, increasing the chance that some survive environmental changes.
2. Variation means some individuals may have adaptations that help them survive and reproduce.
3. Humans select organisms with desirable characteristics and breed them over many generations.
4. It is faster and only requires one parent.
5. It does not require finding a mate or producing gametes.
6. Offspring are produced by mitosis, so they have identical genetic information.

4.6.1.4 DNA and the Genome

1. DNA (deoxyribonucleic acid).
2. In the nucleus of cells.
3. A section of DNA that codes for a protein.
4. A protein.
5. The entire genetic material of an organism.
6. It helps scientists understand inherited diseases and develop treatments.

4.6.1.5 DNA Structure

1. A polymer.
2. A double helix.
3. Adenine, thymine, cytosine and guanine.

4. The order of bases determines the order of amino acids, which determines the protein produced.
5. A change in the DNA sequence.
6. It may change the amino acid sequence, producing an altered protein.

4.6.1.6 Genetic Inheritance

1. A different version of a gene.
2. A dominant allele is expressed when one copy is present; a recessive allele is only expressed when two copies are present.
3. Genotype is the alleles an organism has; phenotype is the characteristics shown.
4. Having two identical alleles.
5. Having two different alleles.
6. They show possible allele combinations and the probability of inherited characteristics.

4.6.1.7 Inherited Disorders

1. Some disorders are caused by faulty alleles that are passed from parents to offspring.
2. A dominant allele.
3. A recessive allele.
4. A process where embryos are tested for genetic disorders before being implanted during IVF.
5. It allows embryos without certain faulty alleles to be selected.
6. Concerns include deciding which characteristics should be selected and the possibility of reducing genetic variation.

4.6.1.8 Sex Determination

1. 23 pairs.
2. Sex chromosomes.
3. XX.
4. XY.
5. Using a genetic cross showing the possible combinations of X and Y chromosomes from the parents.
6. 50% chance of a male child and 50% chance of a female child.

4.6.2.1 Variation

1. Differences between individuals of the same species.
2. Differences in genes caused by mutation and sexual reproduction.
3. Differences caused by environmental conditions.
4. Genes provide potential characteristics, while the environment affects how these characteristics develop.
5. Most mutations have no effect or are harmful.
6. A beneficial mutation may give an advantage, causing individuals with it to survive and reproduce more successfully.

4.6.2.2 Evolution

1. The change in inherited characteristics of populations over generations.
2. Natural selection causes individuals with advantageous characteristics to survive and reproduce, passing on their alleles.
3. They are more likely to survive, reproduce and pass on their genes.
4. They are inherited through genes passed from parents to offspring.
5. Populations become isolated and accumulate different mutations over time.
6. A group of organisms that can reproduce to produce fertile offspring.

4.6.2.3 Selective Breeding

1. The process of choosing parents with desirable characteristics to produce offspring.
2. To produce organisms with useful characteristics such as increased yield or disease resistance.
3. Organisms with desired features are selected as parents.
4. The process is repeated over many generations to increase the desired characteristic.
5. Increased food production, improved characteristics and useful traits.
6. Inbreeding can reduce genetic variation and increase the chance of inherited disorders.

4.6.2.4 Genetic Engineering

1. Changing an organism's DNA using technology.
2. A desired gene.
3. Crops that contain genes introduced using genetic engineering.
4. To increase yield, improve resistance to pests or increase nutritional value.
5. A human insulin gene is inserted into a bacterial plasmid, and the bacteria produce insulin.
6. Possible risks include effects on ecosystems and unknown long-term impacts.

4.6.2.5 Cloning

1. Producing genetically identical copies of organisms or cells.
2. They contain the same genetic material from the same original organism.
3. Small groups of plant cells are grown in sterile conditions with nutrients and hormones to produce identical plants.
4. A piece of plant stem is cut and grown into a new genetically identical plant.
5. The nucleus from an adult body cell is inserted into an egg cell with its nucleus removed, then stimulated to divide.
6. Benefits include producing organisms with desirable characteristics and preserving endangered species; risks include reduced genetic variation and ethical concerns.

4.6.3.1 Theory of Evolution

1. Charles Darwin.
2. He collected evidence from fossils and observations of organisms, including species on the Galapagos Islands.
3. Individuals with advantageous characteristics survive and reproduce more, causing these characteristics to become more common.
4. They are more likely to survive, reproduce and pass on their alleles.
5. It challenged religious beliefs and there was limited evidence and understanding of genetics at the time.
6. Genetics explained how characteristics were inherited and passed on through genes.

4.6.3.2 Speciation

1. The formation of new species.
2. Alfred Russel Wallace.
3. They experience different environmental conditions and develop different adaptations.
4. Populations become isolated, accumulate different mutations and eventually become unable to breed successfully.
5. They have become genetically different and cannot produce fertile offspring together.
6. Wallace independently developed ideas about natural selection and supported Darwin's theory.

4.6.3.3 Understanding of Genetics

1. Gregor Mendel.
2. He discovered that characteristics are inherited through separate factors

passed from parents to offspring.
3. Factors (now called genes).
4. On chromosomes.
5. Scientists used techniques such as X-ray diffraction and work by scientists including Watson, Crick, Franklin and Wilkins.
6. Understanding has developed from discovering inheritance patterns to identifying DNA, genes and genetic technologies.

4.6.3.4 Evidence for Evolution

1. Fossils, antibiotic resistance, DNA evidence and observations of organisms.
2. Fossils show how organisms have changed over time and provide evidence of extinct species.
3. Resistant bacteria survive antibiotic treatment and pass on resistance genes, showing evolution in action.
4. Similarities in DNA sequences show relationships between organisms.
5. Large amounts of evidence from different scientific areas support the theory.
6. Evidence from fossils, genetics and observations all provide consistent support for evolution.

4.6.3.5 Fossils

1. The remains or traces of organisms that lived millions of years ago.
2. They can be preserved when conditions prevent decay, such as lack of oxygen.
3. Minerals replace hard parts of organisms, creating fossil structures.
4. Footprints, burrows or impressions left by organisms.
5. Many organisms do not fossilise and many fossils have been destroyed.
6. They provide evidence about how organisms have changed over time.

4.6.3.6 Extinction

1. The permanent loss of a species.
2. When no individuals of that species remain alive.
3. Changes in climate, new diseases, new predators, competition and habitat loss.
4. If organisms cannot compete successfully for resources, their population may decrease and become extinct.
5. Human activities such as deforestation, pollution, hunting and climate change can cause extinction.
6. Extinction shows that species are not fixed and can disappear as environments change.

4.6.3.7 Resistant Bacteria

1. Bacteria reproduce quickly and mutations can occur during reproduction.
2. Mutations can create genes that make bacteria resistant to antibiotics.
3. Resistant bacteria survive antibiotic treatment and reproduce.
4. They reproduce and pass the resistance gene to future generations, increasing the resistant population.
5. Using antibiotics correctly, completing courses and reducing unnecessary use.
6. Bacteria can quickly evolve resistance, making it difficult to find antibiotics that remain effective.

4.6.4 Classification of Living Organisms

1. To organise organisms, identify them and show relationships between species.
2. Carl Linnaeus.
3. Kingdom, phylum, class, order, family, genus and species.
4. A two-part naming system using the genus and species names.
5. Archaea, Bacteria and Eukarya.
6. They show evolutionary relationships and how closely related organisms are.

Topic 7: Ecology Answer Sheet

4.7.1.1 Communities

1. A system made up of all the organisms living in an area and the physical environment they interact with.
2. All the populations of different species living in an area.
3. Light, water, space, nutrients, minerals.
4. Food, mates, territory, shelter.
5. Organisms depend on each other for survival.
6. Removing one species can affect food chains and cause changes in population sizes of other species.

4.7.1.2 Abiotic Factors

1. Non-living factors that affect organisms.
2. Temperature, light intensity, water availability.
3. Greater light intensity increases photosynthesis, allowing plants to grow faster.
4. Temperature affects enzyme activity and the rate of biological reactions.
5. Soil pH affects enzyme activity and the availability of nutrients needed for plant growth.

6. Changes in abiotic factors can make an environment more or less suitable, affecting where species can survive.

4.7.1.3 Biotic Factors

1. Living factors that affect organisms.
2. Competition and predation.
3. Less food availability reduces survival and reproduction, decreasing population size.
4. New predators may reduce prey populations and affect other species in the food web.
5. Pathogens can cause disease and reduce population size.
6. A species that outcompetes another can reduce its population, lowering biodiversity.

4.7.1.4 Adaptations

1. A feature that helps an organism survive and reproduce in its environment.
2. Structural, behavioural and functional adaptations.
3. Thick fur in polar bears.
4. Migration or changing activity patterns.
5. Organisms that live in extreme environments.
6. Adaptations increase an organism's chances of survival and reproduction.

4.7.2.1 Levels of Organisation

1. An organism that produces its own food, usually through photosynthesis.
2. An organism that obtains energy by eating other organisms.
3. An organism that hunts and kills other animals for food.
4. An organism that is hunted and eaten by predators.
5. Producers convert light energy into chemical energy, providing energy for all other organisms.
6. Predator numbers increase when prey numbers are high; prey numbers decrease when predator numbers increase.

4.7.2.2 How Materials Are Cycled

1. The carbon cycle and the water cycle.
2. Carbon dioxide.
3. Respiration and combustion.
4. Microorganisms break down dead material and release carbon dioxide through respiration.

5. Water evaporates, condenses into clouds and returns as precipitation.
6. Materials are limited, so ecosystems must recycle them to support life.

4.7.2.3 Decomposition

1. The breakdown of dead organisms and waste materials.
2. Microorganisms such as bacteria and fungi.
3. Temperature, oxygen availability and water availability.
4. Higher temperatures increase enzyme activity, increasing decomposition rate up to an optimum.
5. Compost provides nutrients and minerals for plant growth.
6. Anaerobic decay produces methane gas as microorganisms break down material without oxygen.

4.7.2.4 Impact of Environmental Change (HT)

1. Temperature change, water availability and changes in atmospheric gases.
2. Temperature changes can affect survival, reproduction and distribution of organisms.
3. Changes in water availability can affect where species can live and reproduce.
4. Changes in gases such as carbon dioxide can alter climate and affect ecosystems.
5. Human activities such as pollution, deforestation and climate change can alter habitats and species distribution.
6. Environmental changes can make conditions unsuitable, causing populations to decline and species to become extinct.

4.7.3.1 Biodiversity

1. The variety of different species living in an area.
2. Biodiversity provides resources, maintains ecosystems and supports stability.
3. A greater variety of species makes ecosystems more resistant to change.
4. Deforestation, pollution, farming and climate change.
5. Deforestation destroys habitats, reducing the number of species that can survive.
6. Humans depend on biodiversity for food, medicines, materials and ecosystem services.

4.7.3.2 Waste Management

1. A larger population produces more waste from homes, industry and agriculture.

2. Air pollution, water pollution and land pollution.
3. Sewage can introduce harmful microorganisms and nutrients into water ecosystems.
4. Fertilisers can cause eutrophication by increasing nutrient levels in water.
5. Pollution can kill organisms and reduce the number of species in an ecosystem.
6. Waste management prevents pollution and protects ecosystems.

4.7.3.3 Land Use

1. Farming, building and conservation.
2. Building destroys habitats and reduces available resources for organisms.
3. Peat bogs store carbon and provide habitats for many species.
4. Destroying peat releases stored carbon dioxide into the atmosphere.
5. Peat can be used as fuel or compost, but destroying peatlands damages biodiversity and increases carbon emissions.
6. Changes in land use can destroy habitats, alter food webs and reduce biodiversity.

4.7.3.4 Deforestation

1. The removal of forests.
2. Tropical forests are cleared for farming, timber, mining and building.
3. Agriculture and logging.
4. It destroys habitats, causing species loss and reduced biodiversity.
5. Fewer trees means less carbon dioxide is removed by photosynthesis, increasing atmospheric carbon dioxide.
6. Deforestation causes habitat destruction, biodiversity loss, soil erosion and increased greenhouse gases.

4.7.3.5 Global Warming

1. The increase in the Earth's average temperature due to greenhouse gases.
2. Carbon dioxide, methane and water vapour.
3. Burning fossil fuels and deforestation increase carbon dioxide levels.
4. It can change habitats, alter food availability and cause species extinction.
5. Climate change changes temperature and rainfall patterns, affecting where organisms can survive.
6. Evidence is based on many scientific studies, measurements and observations collected over time.

4.7.3.6 Maintaining Biodiversity

1. Protecting and managing species and habitats.
2. To increase populations of endangered species.
3. Protected habitats provide safe areas where organisms can survive and reproduce.
4. Hedgerows provide habitats and food sources for many species.
5. Recycling reduces waste, pollution and the use of natural resources.
6. Conservation methods can protect species, but they may be expensive and require careful management.

4.7.4.1 Trophic Levels

1. A position in a food chain showing an organism's feeding level.
2. First trophic level.
3. Organisms that eat producers.
4. Organisms that eat primary consumers.
5. Top predators with no natural predators.
6. Decomposers break down dead material and recycle nutrients back into the ecosystem.

4.7.4.2 Pyramids of Biomass

1. The mass of living material in an organism or group of organisms.
2. The amount of biomass at each trophic level in a food chain.
3. Producers.
4. Biomass decreases because energy and materials are lost between trophic levels.
5. They are constructed by measuring the total dry mass of organisms at each trophic level.
6. Less biomass is available at each higher trophic level, so the pyramid becomes narrower.

4.7.4.3 Transfer of Biomass

1. Approximately 10%.
2. Some biomass is lost as faeces and is not absorbed by the organism.
3. Energy is lost during respiration and released as heat.
4. Less biomass and energy are available at higher trophic levels.
5. Biomass transfer efficiency = (biomass available after transfer ÷ biomass available before transfer) × 100.
6. Food chains are usually short because energy is lost at each trophic level.

4.7.5.1 Factors Affecting Food Security

1. Having enough food available for the population.
2. A growing population increases demand for food.
3. Pests damage crops and reduce food production.
4. Climate change can affect temperature, rainfall and crop growth.
5. Conflict can prevent food production and distribution.
6. Sustainable methods help produce enough food without damaging the environment.

4.7.5.2 Farming Techniques

1. Use fertilisers, pesticides, selective breeding, irrigation and intensive farming.
2. To control conditions and increase growth and productivity.
3. To increase growth rate and meat production.
4. Intensive farming allows more food to be produced using less land.
5. Increased food production and efficient use of land.
6. It can cause pollution, reduce animal welfare and decrease biodiversity.

4.7.5.3 Sustainable Fisheries

1. Overfishing reduces fish populations faster than they can reproduce.
2. Fishing methods that allow fish populations to remain at sustainable levels.
3. They limit the number of fish caught, allowing populations to recover.
4. Larger nets allow young fish to escape and reproduce.
5. Some methods can damage habitats or catch unwanted species.
6. Sustainable fisheries protect fish populations and maintain future food supplies.

4.7.5.4 Role of Biotechnology

1. The use of biological organisms or processes to make useful products.
2. Fusarium.
3. Warm conditions with oxygen and nutrients.
4. Bacteria are genetically modified to produce human insulin.
5. GM crops can increase yield, improve resistance to pests and improve nutritional value.
6. Biotechnology can increase food production and provide alternative food sources for a growing population.