Edexcel Comb Sci Biology

Topic 1 – Key concepts in biology

Cells

1.1 Explain how the sub-cellular structures of eukaryotic and prokaryotic cells are related to their functions, including: a animal cells – nucleus, cell membrane, mitochondria and ribosomes b plant cells – nucleus, cell membrane, cell wall, chloroplasts, mitochondria, vacuole and ribosomes c bacteria – chromosomal DNA, plasmid DNA, cell membrane, ribosomes and flagella

1. The nucleus contains genetic material that controls the activities of the cell.
2. Mitochondria are adapted for aerobic respiration, providing a large surface area for the reactions that release energy.
3. Ribosomes are the site of protein synthesis.
4. Chloroplasts contain chlorophyll, which absorbs light energy for photosynthesis.
5. The cell wall supports the cell, while the vacuole contains cell sap and helps maintain turgor pressure.
6. Chromosomal DNA contains the main genetic information; plasmid DNA contains additional genes; the cell membrane controls movement of substances; ribosomes synthesise proteins; flagella allow movement.

1.2 Describe how specialised cells are adapted to their function, including: a sperm cells – acrosome, haploid nucleus, mitochondria and tail b egg cells – nutrients in the cytoplasm, haploid nucleus and changes in the cell membrane after fertilisation c ciliated epithelial cells

1. The acrosome contains enzymes that digest the egg cell membrane, allowing the sperm to enter.
2. A sperm cell contains a haploid nucleus so that fertilisation restores the diploid chromosome number.
3. Mitochondria provide energy for movement, while the tail propels the sperm towards the egg.
4. Nutrients provide an energy source for the developing embryo, while the haploid nucleus contains half the genetic information needed by the offspring.

5. The membrane changes so that no more sperm cells can enter the egg.
6. Ciliated epithelial cells have cilia that beat to move substances such as mucus along the surface of tissues.

1.3 Explain how changes in microscope technology, including electron microscopy, have enabled us to see cell structures and organelles with more clarity and detail than in the past and increased our understanding of the role of sub-cellular structures

1. Improvements in microscope technology have increased magnification and resolution, allowing smaller structures to be observed in greater detail.
2. Electron microscopes have a much higher resolution than light microscopes.
3. Electron microscopy has allowed scientists to observe smaller sub-cellular structures and understand their functions in greater detail.
4. Electron microscopes have a higher resolution, allowing structures that are close together to be distinguished.
5. Increased resolution has allowed scientists to identify the detailed structures of organelles and relate their structures to their functions.
6. Higher resolution allows smaller structures and greater detail to be observed.

1.4 Demonstrate an understanding of number, size and scale, including the use of estimations and explain when they should be used

1. Estimations are useful when an exact measurement is difficult or unnecessary.
2. An estimate should be used when an exact measurement cannot be obtained reliably or when an approximate value is sufficient.
3. The scale of the image can be used to compare the structure with a known size and estimate its actual size.
4. The scale allows the actual size of the structure to be interpreted correctly.
5. An order-of-magnitude estimate gives an approximate power of ten and can be compared with the calculated value.
6. Checking against the expected size can identify errors in calculations or unit conversions.

1.5 Demonstrate an understanding of the relationship between quantitative units in relation to cells, including: a milli (10−3) b micro (10−6) c nano (10−9) d pico (10−12) e calculations with numbers written in standard form

1. Milli represents 10−3.
2. Micro represents 10−6.
3. Nano represents 10−9.
4. Pico represents 10−12.

5. There are 1000 micrometres in one millimetre.
6. Multiply or divide the numbers and separately apply the powers of ten.

1.6 Core Practical: Investigate biological specimens using microscopes, including magnification calculations and labelled scientific drawings from observations

1. Magnification = image size ÷ actual size.
2. Magnification = image size ÷ actual size.
3. The units must be the same so that the ratio between image size and actual size is correct.
4. A scientific drawing should show clear outlines, accurate proportions, appropriate detail and labels with straight label lines.
5. Clear single lines show the observed structures accurately without adding features that were not observed.
6. Observe the specimen carefully, draw the structures using clear lines and accurate proportions, and add appropriate labels.

1.7 Explain the mechanism of enzyme action including the active site and enzyme specificity

1. The active site is the region of an enzyme where the substrate binds.
2. The substrate binds to the active site and forms an enzyme-substrate complex.
3. An enzyme is specific because its active site has a particular shape that is complementary to its substrate.
4. Only a substrate with a complementary shape can bind effectively to the active site.
5. An enzyme-substrate complex forms when the substrate binds to the active site.
6. Enzyme specificity ensures that enzymes only catalyse particular reactions involving complementary substrates.

1.8 Explain how enzymes can be denatured due to changes in the shape of the active site

1. A denatured enzyme has had its active-site shape changed so that it can no longer function effectively.
2. High temperatures can break bonds holding the enzyme's structure together, changing the shape of the active site.
3. Extreme pH can alter bonds in the enzyme, changing the shape of the active site.
4. The active site changes shape.
5. The substrate is no longer complementary to the active site and cannot bind effectively.

6. The changes to the enzyme's structure are usually permanent, so the original active-site shape cannot be restored.

1.9 Explain the effects of temperature, substrate concentration and pH on enzyme activity

1. Enzyme activity increases as temperature increases up to the optimum because particles have more kinetic energy and collide more frequently.
2. High temperatures denature the enzyme, changing the shape of its active site.
3. Increasing substrate concentration increases the rate because more enzyme-substrate complexes can form, until the enzymes become saturated.
4. All active sites become occupied, so increasing substrate concentration further cannot increase the rate.
5. Changes in pH can alter the shape of an enzyme's active site and therefore affect its activity.
6. Different enzymes have different structures and therefore different pH conditions at which their active sites work most effectively.

1.10 Core Practical: Investigate the effect of pH on enzyme activity

1. Use the same concentration and volume of enzyme and substrate, vary the pH using buffer solutions, and measure the rate of reaction at each pH.
2. The pH should be changed.
3. Temperature, enzyme concentration, substrate concentration and volumes should be controlled.
4. Measure the amount of product formed in a fixed time or the time taken to produce a fixed amount of product.
5. This ensures that differences in reaction rate are due to pH rather than changes in enzyme or substrate concentration.
6. The pH giving the highest rate of reaction is the optimum pH.

1.11 Demonstrate an understanding of rate calculations for enzyme activity

1. Rate = change in quantity ÷ time.
2. Rate = change in product concentration ÷ time.
3. Units could include cm^3 s^{-1}, cm^3 min^{-1} or concentration per unit time.
4. The rate would double.
5. Calculate the gradient of the graph; a greater gradient represents a greater rate of enzyme activity.
6. A steeper gradient indicates a faster reaction and therefore greater enzyme activity.

1.12 Explain the importance of enzymes as biological catalysts in the synthesis of carbohydrates, proteins and lipids and their breakdown into sugars, amino acids and fatty acids and glycerol

1. Enzymes increase the rate of reactions involved in building up and breaking down biological molecules.
2. Carbohydrates are broken down into sugars.
3. Proteins are broken down into amino acids.
4. Lipids are broken down into fatty acids and glycerol.
5. Enzymes lower the activation energy of reactions, allowing synthesis and breakdown to occur rapidly under suitable biological conditions.
6. Without enzymes, these reactions would occur too slowly to support normal biological processes.

1.15 Explain how substances are transported into and out of cells, including by diffusion, osmosis and active transport

1. Diffusion is the net movement of particles from an area of higher concentration to an area of lower concentration.
2. A steeper concentration gradient increases the net rate of diffusion.
3. Osmosis is the net movement of water molecules from a dilute solution to a more concentrated solution through a partially permeable membrane.
4. Osmosis involves the movement of water through a partially permeable membrane, whereas diffusion can involve different types of particles and does not necessarily require a membrane.
5. Active transport moves substances against their concentration gradient using energy, whereas diffusion moves substances down their concentration gradient without energy.
6. Active transport requires energy released by respiration to move substances against their concentration gradient.

1.16 Core Practical: Investigate osmosis in potatoes

1. Place potato cylinders in solutions of different concentrations and measure their masses before and after the investigation.
2. The mass should be measured before and after.
3. This ensures that differences in mass change are due to solution concentration rather than differences in the size of the potato cylinders.
4. Solution concentration should be changed.
5. Temperature, volume and concentration of solutions, size of potato cylinders and time should be controlled.
6. Plot percentage change in mass against solution concentration. The concentration where there is no change in mass represents no net movement of water.

1.17 Calculate percentage gain and loss of mass in osmosis

1. Percentage change = (change in mass ÷ initial mass) × 100.
2. Percentage gain = ((final mass − initial mass) ÷ initial mass) × 100.
3. Percentage loss = ((initial mass − final mass) ÷ initial mass) × 100.
4. Percentage gain = ((5.0 − 4.0) ÷ 4.0) × 100 = 25%.
5. Percentage loss = ((5.0 − 4.0) ÷ 5.0) × 100 = 20%.
6. Percentage change allows mass changes to be compared fairly when the starting masses are different.

Topic 2 – Cells and control

2.1 Describe mitosis as part of the cell cycle, including the stages interphase, prophase, metaphase, anaphase and telophase and cytokinesis

1. During interphase, the cell grows, carries out normal functions and replicates its DNA.
2. During prophase, chromosomes condense and become visible.
3. During metaphase, chromosomes line up at the centre of the cell.
4. During anaphase, sister chromatids separate and move to opposite poles of the cell.
5. During telophase, chromosomes reach opposite poles and new nuclei form around them.
6. Cytokinesis is the division of the cytoplasm to form two separate daughter cells.

2.2 Describe the importance of mitosis in growth, repair and asexual reproduction

1. Mitosis produces new cells, increasing the number of cells in an organism.
2. Mitosis produces replacement cells that can replace damaged or dead cells.
3. Mitosis allows asexual reproduction because one parent can produce genetically identical offspring.
4. The genetically identical cells produced by mitosis retain the same genetic information and chromosome number as the parent cell.
5. Repeated mitotic divisions produce genetically identical offspring from a single parent.
6. Repeated cell division increases the number of cells required as the organism grows.

2.3 Describe the division of a cell by mitosis as the production of two daughter cells, each with identical sets of chromosomes in the nucleus to the parent cell,

and that this results in the formation of two genetically identical diploid body cells

1. Two daughter cells are produced.
2. Each daughter cell has the same chromosome number as the parent cell.
3. The daughter cells receive identical sets of chromosomes.
4. Each daughter cell contains the same genetic information as the parent cell.
5. Diploid means having two sets of chromosomes.
6. The DNA must be replicated so that each daughter cell receives an identical set of chromosomes.

2.4 Describe cancer as the result of changes in cells that lead to uncontrolled cell division

1. Cancer is a disease caused by changes in cells that result in uncontrolled cell division.
2. Cell division becomes uncontrolled.
3. Changes in genes controlling cell division can cause cells to divide uncontrollably.
4. Uncontrolled cell division can produce a mass of abnormal cells called a tumour.
5. Uncontrolled cell division can disrupt the normal functioning of tissues and organs.
6. Normal cell division is controlled, whereas cancer involves uncontrolled cell division.

2.5 Describe growth in organisms, including: a cell division and differentiation in animals b cell division, elongation and differentiation in plants

1. Cell division and cell differentiation contribute to growth in animals.
2. Cell division increases the number of cells in the organism.
3. Cell differentiation causes cells to become specialised for particular functions.
4. Cell division, cell elongation and cell differentiation contribute to growth in plants.
5. Cell elongation increases the size of plant cells, contributing to the growth of the plant.
6. Cell differentiation produces specialised plant cells with particular functions.

2.6 Explain the importance of cell differentiation in the development of specialised cells

1. Cell differentiation is the process by which cells become specialised.

2. It allows multicellular organisms to develop different types of specialised cells.
3. Different genes are expressed in different cells, causing them to develop different structures and functions.
4. Specialised cells are adapted to perform particular functions efficiently.
5. Differentiation allows specialised cells to form tissues and organs with specific functions.
6. Without differentiation, cells would not become specialised and the organism could not develop normal tissues and organs.

2.7 Demonstrate an understanding of the use of percentiles charts to monitor growth

1. A percentile chart shows how a measurement compares with measurements from other individuals of the same age and sex.
2. Record the child's height and plot it against their age on the appropriate percentile chart.
3. Record the child's mass and plot it against their age on the appropriate percentile chart.
4. It suggests that the child's growth is following a consistent pattern relative to others of the same age and sex.
5. It may indicate an unusual change in the child's growth pattern.
6. Tracking measurements over time can identify whether growth is following an expected pattern or changing significantly.

2.8 Describe the function of embryonic stem cells, stem cells in animals and meristems in plants

1. Embryonic stem cells are unspecialised cells found in early embryos.
2. They can differentiate into many different types of specialised cells.
3. Animal stem cells can divide and differentiate to produce specialised cells for growth and repair.
4. Animal stem cells can differentiate into different cell types because they are not fully specialised.
5. Meristems are regions of actively dividing unspecialised cells in plants.
6. Meristems produce new cells that can divide, elongate and differentiate for plant growth.

2.9 Discuss the potential benefits and risks associated with the use of stem cells in medicine

1. Stem cells could replace damaged or diseased cells and help treat some conditions.
2. They could differentiate into replacement cells for damaged tissues.

3. Embryonic stem cells can differentiate into many different specialised cell types, making them potentially useful for treating disease.
4. One ethical concern is that obtaining embryonic stem cells involves the destruction of an embryo.
5. Stem cell treatments may carry risks such as uncontrolled cell division or immune rejection.
6. Careful control is needed because uncontrolled division of transplanted stem cells could result in tumour formation.

2.13 Explain the structure and function of sensory receptors, sensory neurones, relay neurones in the CNS, motor neurones and synapses in the transmission of electrical impulses, including the axon, dendron, myelin sheath and the role of neurotransmitters

1. Sensory receptors detect stimuli and convert them into electrical impulses.
2. Sensory neurones carry electrical impulses from sensory receptors to the central nervous system.
3. Relay neurones connect sensory and motor neurones within the central nervous system.
4. Motor neurones carry electrical impulses from the central nervous system to effectors.
5. The axon carries impulses away from the cell body, the dendron carries impulses towards the cell body, and the myelin sheath insulates the neurone and increases the speed of impulse transmission.
6. Neurotransmitters are released from one neurone and diffuse across the synapse, where they bind to receptors on the next neurone and initiate an electrical impulse.

2.14 Explain the structure and function of a reflex arc including sensory, relay and motor neurones

1. A reflex action is a rapid, automatic response to a stimulus.
2. Receptor → sensory neurone → relay neurone → motor neurone → effector.
3. The sensory neurone carries the impulse from the receptor to the central nervous system.
4. The relay neurone passes the impulse between the sensory and motor neurones within the central nervous system.
5. The motor neurone carries the impulse from the central nervous system to the effector.
6. Reflex arcs use a short pathway through the central nervous system and do not require conscious processing before the response occurs.

Below are the answers, keeping your headings and questions exactly unchanged, with answers only added.

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Topic 3 – Genetics

3.3 Explain the role of meiotic cell division, including the production of four daughter cells, each with half the number of chromosomes, and that this results in the formation of genetically different haploid gametes The stages of meiosis are not required

1. Meiosis produces gametes for sexual reproduction.
2. Four daughter cells are produced.
3. Each daughter cell has half the number of chromosomes of the original cell.
4. A haploid gamete contains one set of chromosomes.
5. The gametes are genetically different because of the random assortment of chromosomes and genetic variation.
6. Meiosis involves two divisions following DNA replication, producing four cells with half the original chromosome number.

3.4 Describe DNA as a polymer made up of: a two strands coiled to form a double helix b strands linked by a series of complementary base pairs joined together by weak hydrogen bonds c nucleotides that consist of a sugar and phosphate group with one of the four different bases attached to the sugar

1. DNA consists of two strands coiled together to form a double helix.
2. The two strands are held together by weak hydrogen bonds between complementary bases.
3. Complementary base pairing means that each base pairs with a specific other base.
4. Adenine pairs with thymine, and cytosine pairs with guanine.
5. A nucleotide consists of a sugar, a phosphate group and one of four bases.
6. Nucleotides join together to form each DNA strand, with complementary bases linking the two strands.

3.5 Describe the genome as the entire DNA of an organism and a gene as a section of a DNA molecule that codes for a specific protein

1. The genome is the entire DNA of an organism.
2. A gene is a section of DNA that codes for a specific protein.
3. A gene contains the genetic information needed to produce a specific protein.

4. The genome contains all of an organism's DNA, whereas a gene is only a section of DNA.
5. Genes are found on chromosomes.
6. Different sections of DNA contain different sequences of bases, which can code for different proteins.

3.6 Explain how DNA can be extracted from fruit

1. Mash the fruit, add detergent and salt, filter the mixture, then add cold ethanol or propanone to precipitate the DNA.
2. Mashing or blending breaks up the fruit tissue and cells, releasing their contents.
3. Detergent breaks down the cell membranes and nuclear membranes, releasing DNA.
4. Salt helps separate DNA from proteins and other cell components.
5. Filtering removes solid pieces of fruit and other insoluble material.
6. Cold ethanol or propanone causes the DNA to precipitate, making it visible.

3.12 Explain why there are differences in the inherited characteristics as a result of alleles

1. An allele is an alternative form of a gene.
2. Different alleles have different DNA base sequences, which can result in different proteins and characteristics.
3. Individuals can inherit different alleles from their parents.
4. Different combinations of alleles can result in different inherited characteristics.
5. Each parent contributes one allele for a gene, so offspring can receive different combinations.
6. Alleles create different versions of genes, producing genetic variation within a population.

3.13 Explain the terms: chromosome, gene, allele, dominant, recessive, homozygous, heterozygous, genotype, phenotype, gamete and zygote

1. A chromosome is a long, coiled DNA molecule containing many genes.
2. A gene is a section of DNA that codes for a specific protein.
3. An allele is an alternative form of a gene.
4. A dominant allele is expressed in the phenotype when present in either a homozygous or heterozygous genotype.
5. A recessive allele is expressed in the phenotype only when two copies are present.
6. A homozygous genotype has two identical alleles for a gene.
7. A heterozygous genotype has two different alleles for a gene.

8. A genotype is the combination of alleles an organism has.
9. A phenotype is the observable characteristics of an organism.
10. A gamete is a haploid sex cell containing one set of chromosomes.
11. A zygote is the diploid cell formed when two gametes fuse during fertilisation.
12. A zygote is diploid and contains two sets of chromosomes, whereas a gamete is haploid and contains one set.

3.14 Explain monohybrid inheritance using genetic diagrams, Punnett squares and family pedigrees

1. A monohybrid cross investigates the inheritance of one characteristic controlled by a single gene.
2. A Punnett square shows the possible combinations of alleles in offspring.
3. A genetic diagram shows the parental genotypes, gametes and possible offspring genotypes and phenotypes.
4. A family pedigree uses symbols to show how a characteristic is inherited through generations of a family.
5. A dominant allele is expressed in a heterozygous individual.
6. Two heterozygous parents can each pass on the recessive allele, producing a 25% probability of a homozygous recessive offspring.

3.15 Describe how the sex of offspring is determined at fertilisation, using genetic diagrams

1. A human female has two X chromosomes (XX).
2. A human male has one X chromosome and one Y chromosome (XY).
3. All eggs contain an X chromosome.
4. Sperm can contain either an X chromosome or a Y chromosome.
5. An X-bearing sperm produces an XX female offspring, while a Y-bearing sperm produces an XY male offspring.
6. The probability is 50% male and 50% female.

3.16 Calculate and analyse outcomes (using probabilities, ratios and percentages) from monohybrid crosses and pedigree analysis for dominant and recessive traits

1. Count the number of relevant outcomes in the Punnett square and divide by the total number of possible outcomes.
2. Compare the possible offspring genotypes to determine the expected genotype ratio.
3. Compare the possible offspring phenotypes to determine the expected phenotype ratio.
4. Count the outcomes with the homozygous recessive genotype and divide by the total number of possible outcomes.

5. Multiply the probability by 100 to express it as a percentage.
6. A characteristic appearing in every generation is likely to be dominant, whereas a recessive characteristic can skip generations.

3.19 State that most phenotypic features are the result of multiple genes rather than single gene inheritance

1. Polygenic inheritance occurs when a characteristic is influenced by multiple genes.
2. Most phenotypic features are influenced by several genes rather than a single gene.
3. Different genes can each contribute to the development of the same characteristic.
4. Different combinations of alleles at several genes can produce a wide range of phenotypes.
5. Examples include height and skin colour.
6. Single-gene inheritance involves one gene, whereas polygenic inheritance involves multiple genes.

3.20 Describe the causes of variation that influence phenotype, including: a genetic variation – different characteristics as a result of mutation and sexual reproduction b environmental variation – different characteristics caused by an organism's environment (acquired characteristics)

1. Variation is the differences in characteristics between individuals of the same species.
2. Mutations can create new alleles, producing genetic variation.
3. Sexual reproduction produces genetic variation because offspring inherit different combinations of alleles from their parents.
4. Environmental factors such as diet, temperature and lifestyle can affect phenotype.
5. An acquired characteristic is a characteristic that develops during an organism's lifetime due to environmental factors.
6. Genetic variation is caused by differences in genes or alleles, whereas environmental variation is caused by differences in an organism's environment.

3.21 Discuss the outcomes of the Human Genome Project and its potential applications within medicine

1. The main aim was to determine the sequence of bases in the human genome and identify the genes it contains.
2. It determined the sequence of bases in human DNA and helped identify genes within the genome.

3. It can help identify genetic mutations associated with inherited diseases, improving diagnosis.
4. It could allow treatments to be tailored to an individual's genetic information.
5. Comparing genomes can help identify genes associated with particular diseases.
6. Concerns include genetic privacy, discrimination and the possibility of misuse of genetic information.

3.22 State that there is usually extensive genetic variation within a population of a species and that these arise through mutations

1. Genetic variation is differences in the genes or alleles between individuals in a population.
2. Mutations create new alleles, resulting in genetic variation.
3. Mutations can change the DNA base sequence and create new alleles.
4. New alleles increase the number of different genetic forms present in a population.
5. Sexual reproduction produces different combinations of alleles, increasing variation between individuals.
6. Individuals of the same species can inherit different alleles and therefore have different genotypes.

3.23 State that most genetic mutations have no effect on the phenotype, some mutations have a small effect on the phenotype and, rarely, a single mutation will significantly affect the phenotype

1. Most genetic mutations have no effect on phenotype.
2. A mutation may occur in a non-coding section of DNA or may not alter the resulting protein sufficiently to affect phenotype.
3. Some mutations have a small effect on phenotype.
4. A mutation may slightly alter the structure or function of a protein, causing a small change in phenotype.
5. A mutation can rarely cause a major change in the structure or function of an important protein, significantly affecting phenotype.
6. Mutations do not always alter the protein or its function enough to produce a noticeable change in characteristics.

Topic 4 – Natural selection and genetic modification

4.2 Explain Charles Darwin's theory of evolution by natural selection

1. Evolution by natural selection is the change in inherited characteristics of a population over generations due to differences in survival and reproduction.
2. Variation can arise from genetic differences, including mutations and sexual reproduction.
3. Individuals compete for limited resources such as food, water and mates.
4. Individuals with advantageous characteristics are more likely to survive and reproduce, passing their alleles to offspring.
5. The advantageous alleles are inherited by offspring and become more common in the population over generations.
6. Natural selection causes populations to change as advantageous inherited characteristics become more common over time.

4.3 Explain how the emergence of resistant organisms supports Charles Darwin's theory of evolution including antibiotic resistance in bacteria

1. A mutation can produce an allele that gives a bacterium resistance to an antibiotic.
2. The antibiotic kills susceptible bacteria, while resistant bacteria survive.
3. Resistant bacteria survive and reproduce, increasing the proportion of resistant bacteria in the population.
4. Antibiotics act as a selection pressure because they favour bacteria with resistance.
5. Resistant bacteria surviving and reproducing demonstrates natural selection and evolution.
6. Repeated antibiotic use kills susceptible bacteria and allows resistant bacteria to reproduce, making the resistant population more common.

4.4 Describe the evidence for human evolution, based on fossils, including: a Ardi from 4.4 million years ago b Lucy from 3.2 million years ago c Richard Leakey's discovery of fossils from 1.6 million years ago

1. A fossil is the preserved remains or traces of an organism from the past.
2. Fossils from different time periods can show changes in the characteristics of organisms over time.
3. Ardi provides evidence about early human ancestors and their characteristics around 4.4 million years ago.
4. Lucy provides evidence about human ancestors and their characteristics around 3.2 million years ago.
5. Richard Leakey's fossils from about 1.6 million years ago provide further evidence of human ancestors and their changing characteristics.
6. Fossils from different periods can be compared to identify changes in human characteristics over millions of years.

4.5 Describe the evidence for human evolution based on stone tools, including: a the development of stone tools over time b how these can be dated from their environment

1. Stone tools provide evidence of changes in the abilities and behaviour of human ancestors.
2. Stone tools became more complex and sophisticated over time.
3. Increasingly sophisticated tools suggest increasing technological ability and development of human intelligence and behaviour.
4. Changes in stone tools over time provide evidence of changes in human ancestors.
5. The age of stone tools can be estimated by dating materials and rocks in the surrounding environment.
6. Dating allows the development of tools to be placed in chronological order and compared with other evidence of human evolution.

4.7 Describe how genetic analysis has led to the suggestion of the three domains rather than the five kingdoms classification method

1. Classification is the organisation of organisms into groups based on their similarities and differences.
2. The three domains are Bacteria, Archaea and Eukarya.
3. Genetic analysis revealed significant differences in DNA and ribosomal RNA between groups of organisms.
4. Genetic evidence showed that some organisms previously grouped together were not as closely related as previously thought.
5. Genetic information can be compared to identify evolutionary relationships between organisms.
6. The three-domain system divides organisms into Bacteria, Archaea and Eukarya, whereas the five-kingdom system uses five kingdoms.

4.8 Explain selective breeding and its impact on food plants and domesticated animals

1. Selective breeding is the process of choosing parents with desirable characteristics and breeding them to produce offspring with those characteristics.
2. Select parents with the desired characteristic, breed them, select offspring with the characteristic and repeat the process over many generations.
3. Food plants can be bred for characteristics such as increased yield, disease resistance or larger fruits.
4. Domesticated animals can be bred for characteristics such as increased meat or milk production.
5. Repeated selection increases the frequency of alleles associated with desirable characteristics.

6. Selective breeding can reduce genetic variation and increase the risk of inherited genetic disorders.

4.10 Describe genetic engineering as a process which involves modifying the genome of an organism to introduce desirable characteristics

1. Genetic engineering is the process of modifying an organism's genome to introduce a desirable characteristic.
2. The organism's genome is modified.
3. A desired gene is introduced so that the organism develops the characteristic coded for by that gene.
4. A gene coding for the desirable characteristic is transferred into the organism's genome.
5. Genetic engineering directly introduces specific genes, whereas selective breeding involves choosing organisms with desirable characteristics to reproduce.
6. A gene for insect resistance could be introduced into a crop plant.

4.11 Describe the main stages of genetic engineering including the use of: a restriction enzymes b ligase c sticky ends d vectors

1. Restriction enzymes cut DNA at specific base sequences.
2. Sticky ends are short sections of unpaired bases produced by restriction enzymes that can form complementary base pairs with another DNA fragment.
3. DNA ligase joins the sugar-phosphate backbones of DNA fragments.
4. A vector carries the desired gene into a target cell.
5. Isolate the desired gene, cut the gene and vector using the same restriction enzyme, join them using DNA ligase, then introduce the recombinant vector into the target organism.
6. Restriction enzymes produce matching sticky ends, allowing the desired gene to bind to the vector, and ligase joins the DNA fragments together.

4.14 Evaluate the benefits and risks of genetic engineering and selective breeding in modern agriculture and medicine, including practical and ethical implications

1. Genetic engineering can introduce desirable characteristics such as pest resistance or increased nutritional value into crops.
2. Risks include possible effects on ecosystems, unintended effects and concerns about the long-term consequences of modifying organisms.
3. Genetic engineering can be used to produce useful medicines such as human insulin.
4. Concerns can include ethical objections to genetic modification, possible environmental effects and practical difficulties.

5. Selective breeding can increase food production and desirable characteristics, but can reduce genetic variation and increase inherited health problems.
6. Evaluation should consider benefits, risks, effectiveness, environmental effects, cost and ethical concerns.

Topic 5 – Health, disease and the development of medicines

5.1 Describe health as a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity, as defined by the World Health Organization (WHO)

1. Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.
2. Physical, mental and social well-being.
3. A person can be free from disease but still have poor physical, mental or social well-being.
4. Physical well-being relates to the healthy functioning of the body.
5. Mental well-being relates to psychological health, while social well-being relates to a person's ability to interact and function within society.
6. Health includes overall physical, mental and social well-being rather than simply being free from disease.

5.2 Describe the difference between communicable and non-communicable diseases

1. A communicable disease is a disease caused by a pathogen that can be transmitted between organisms.
2. A non-communicable disease cannot be transmitted between organisms.
3. Communicable diseases can spread between individuals, whereas non-communicable diseases do not spread between individuals.
4. Pathogens can be transferred between individuals through routes such as air, water, direct contact or vectors.
5. Cholera is communicable; cardiovascular disease is non-communicable.
6. Non-communicable diseases are not caused by pathogens that are transmitted between individuals.

5.3 Explain why the presence of one disease can lead to a higher susceptibility to other diseases

1. One disease can weaken the immune system, making the person more susceptible to other diseases.
2. A disease can damage or reduce the effectiveness of immune cells.
3. Damage caused by one disease can make it easier for another pathogen to enter or infect the body.
4. HIV destroys white blood cells, weakening the immune system and increasing susceptibility to other diseases.
5. A weakened immune system is less effective at recognising and destroying pathogens.
6. A disease can reduce the body's ability to defend itself, allowing other pathogens to cause infection more easily.

5.4 Describe a pathogen as a disease-causing organism, including viruses, bacteria, fungi and protists

1. A pathogen is a disease-causing organism.
2. Viruses, bacteria, fungi and protists.
3. Pathogens cause disease by entering the body, reproducing or growing and damaging cells or tissues.
4. Viruses reproduce inside host cells, whereas bacteria are living cells that can reproduce independently.
5. Fungi can grow on or within organisms and cause tissue damage.
6. Protists can infect organisms and damage cells or tissues.

5.5 Describe some common infections, including: a cholera (bacteria) causes diarrhoea b tuberculosis (bacteria) causes lung damage c Chalara ash dieback (fungi) causes leaf loss and bark lesions d malaria (protists) causes damage to blood and liver e HIV (virus) destroys white blood cells, leading to the onset of AIDS

1. Cholera is caused by bacteria and causes diarrhoea.
2. Tuberculosis is caused by bacteria and can cause lung damage.
3. Chalara ash dieback is caused by fungi and causes leaf loss and bark lesions.
4. Malaria is caused by protists and causes damage to blood and liver.
5. HIV is caused by a virus and destroys white blood cells.
6. Destruction of white blood cells weakens the immune system, leading to the onset of AIDS.

5.6 Explain how pathogens are spread and how this spread can be reduced or prevented, including: a cholera (bacteria) – water b tuberculosis (bacteria) – airborne c Chalara ash dieback (fungi) – airborne d malaria (protists) – animal vectors

1. Cholera is spread through contaminated water; providing clean water and good sanitation reduces its spread.
2. Tuberculosis is spread through airborne droplets; reducing contact with infected people and improving ventilation can reduce its spread.
3. Chalara ash dieback can be spread through airborne fungal spores; controlling movement of infected material can reduce its spread.
4. Malaria is transmitted by animal vectors, particularly mosquitoes.
5. An animal vector is an animal that carries a pathogen from one organism to another.
6. Clean water prevents waterborne transmission, reducing airborne transmission limits spread through droplets or spores, and vector control reduces transmission by animals.

5.8 Explain how sexually transmitted infections (STIs) are spread and how this spread can be reduced or prevented, including: a Chlamydia (bacteria) b HIV (virus)

1. A sexually transmitted infection is an infection that can be transmitted through sexual contact.
2. Chlamydia is transmitted through sexual contact with an infected person.
3. HIV can be transmitted through sexual contact with an infected person.
4. Using barrier contraception, testing and treating infected individuals can reduce the spread of Chlamydia.
5. Barrier contraception, testing, treatment and avoiding contact with infected blood or bodily fluids can reduce sexual transmission of HIV.
6. Barrier contraception reduces direct contact with infected bodily fluids, reducing the likelihood of transmission.

5.12 Describe how the physical barriers and chemical defences of the human body provide protection from pathogens, including: a physical barriers, including mucus, cilia and skin b chemical defence, including lysozymes and hydrochloric acid

1. The skin forms a physical barrier that prevents pathogens entering the body.
2. Mucus traps pathogens and prevents them from reaching deeper tissues.
3. Cilia move mucus and trapped pathogens out of the airways.
4. Hydrochloric acid in the stomach provides a very acidic environment that kills many pathogens.
5. Lysozymes are enzymes that break down bacterial cell structures.
6. Physical barriers prevent pathogens entering, while chemical defences destroy or inhibit pathogens that enter the body.

5.13 Explain the role of the specific immune system of the human body in defence against disease, including: a exposure to pathogen b the antigens trigger an

immune response which causes the production of antibodies c the antigens also trigger production of memory lymphocytes d the role of memory lymphocytes in the secondary response to the antigen

1. The immune system recognises the pathogen and mounts a specific immune response.
2. Antigens on the pathogen are recognised by lymphocytes, triggering an immune response.
3. Lymphocytes produce antibodies that are complementary to the pathogen's antigens.
4. Memory lymphocytes are long-lasting cells produced during the primary immune response.
5. Memory lymphocytes recognise the antigen quickly during a second exposure and trigger a rapid production of antibodies.
6. The secondary response is faster and produces more antibodies, providing a stronger defence against the pathogen.

5.14 Explain the body's response to immunisation using an inactive form of a pathogen

1. Immunisation involves introducing an inactive form of a pathogen into the body.
2. The inactive pathogen cannot cause the disease but retains antigens that stimulate an immune response.
3. The antigens trigger lymphocytes to produce specific antibodies.
4. Memory lymphocytes are produced during the immune response.
5. On later exposure to the real pathogen, memory lymphocytes produce a rapid secondary immune response.
6. The rapid secondary response can destroy the pathogen before the person develops symptoms or becomes seriously ill.

5.16 Explain that antibiotics can only be used to treat bacterial infections because they inhibit cell processes in the bacterium but not the host organism

1. Antibiotics treat bacterial infections by inhibiting processes in bacterial cells.
2. Antibiotics do not work against viruses because viruses do not carry out the bacterial cell processes targeted by antibiotics.
3. Antibiotics inhibit essential bacterial cell processes, preventing bacteria from surviving or reproducing.
4. Antibiotics target processes or structures specific to bacteria and therefore do not normally affect human cells.
5. Taking antibiotics for a viral infection will not kill the viruses or treat the infection.

6. Bacterial cells have cellular processes that can be targeted by antibiotics, whereas viruses rely on host cells to reproduce.

5.20 Describe that the process of developing new medicines, including antibiotics, has many stages, including discovery, development, preclinical and clinical testing

1. Discovery, development, preclinical testing and clinical testing.
2. Potential medicines are identified or discovered.
3. A promising substance is developed into a suitable medicine for further testing.
4. Preclinical testing investigates safety and effectiveness before testing in humans, using laboratory tests and animals where appropriate.
5. Clinical testing investigates safety, dosage and effectiveness in human participants.
6. The stages identify medicines that are effective and safe enough for use while reducing risks to patients.

5.23 Describe that many non-communicable human diseases are caused by the interaction of a number of factors, including cardiovascular diseases, many forms of cancer, some lung and liver diseases and diseases influenced by nutrition

1. A non-communicable disease is a disease that cannot be transmitted between individuals.
2. Different genetic, lifestyle and environmental factors can interact to increase disease risk.
3. Cardiovascular diseases, many forms of cancer, some lung and liver diseases and diseases influenced by nutrition.
4. Cardiovascular disease can be influenced by factors such as diet, exercise, smoking and genetics.
5. Cancer risk can be influenced by factors such as genetics, smoking, diet and environmental exposure.
6. Several interacting factors contribute to many non-communicable diseases, making a single cause difficult to identify.

5.24 Explain the effect of lifestyle factors on non-communicable diseases at local, national and global levels, including: a exercise and diet on obesity and malnutrition, including BMI and waist : hip calculations, using the BMI equation: mass (kg) / height (m)^2 b alcohol on liver diseases c smoking on cardiovascular diseases

1. Regular exercise and a balanced diet can reduce the risk of obesity, while excessive energy intake and insufficient exercise can increase it.
2. Inadequate or unbalanced nutrition can cause malnutrition.

3. BMI = mass (kg) ÷ height (m)².
4. Waist-to-hip ratio = waist circumference ÷ hip circumference; it can be used to assess the distribution of body fat and associated health risks.
5. Excessive alcohol consumption can damage the liver and increase the risk of liver disease.
6. Smoking damages blood vessels and increases the risk of cardiovascular disease.

5.25 Evaluate some different treatments for cardiovascular disease, including: a life-long medication b surgical procedures c lifestyle changes

1. Lifelong medication can control risk factors or symptoms and reduce the risk of cardiovascular events.
2. Disadvantages can include side effects, the need for long-term adherence and the possibility that medication does not remove the underlying cause.
3. Surgery can provide rapid or effective treatment, but it carries risks such as complications and may require recovery time.
4. Lifestyle changes such as improved diet, regular exercise and stopping smoking can reduce risk factors and improve cardiovascular health.
5. Lifestyle changes can reduce disease risk without the risks or side effects associated with some medical treatments.
6. Treatment should be evaluated by considering effectiveness, risks, side effects, cost, long-term suitability and the individual's circumstances.

Topic 6 – Plant structures and their functions

6.1 Describe photosynthetic organisms as the main producers of food and therefore biomass

1. Photosynthetic organisms are organisms that use light energy to make food by photosynthesis.
2. They are described as producers because they produce organic food from carbon dioxide and water.
3. They are the main producers because they convert light energy into chemical energy stored in glucose.
4. They produce biomass by using glucose made during photosynthesis to make organic substances and build new cells and tissues.
5. Photosynthetic organisms provide food that supplies energy and biomass for other organisms.
6. They form the base of food chains, providing biomass that is transferred to consumers.

6.2 Describe photosynthesis in plants and algae as an endothermic reaction that uses light energy to react carbon dioxide and water to produce glucose and oxygen

1. Photosynthesis is an endothermic reaction in which plants and algae use light energy to convert carbon dioxide and water into glucose and oxygen.
2. Carbon dioxide and water.
3. Glucose and oxygen.
4. It is endothermic because it takes in energy from the surroundings.
5. Light energy.
6. Carbon dioxide enters through the stomata in leaves, while water is absorbed from the soil by the roots.

6.3 Explain the effect of temperature, light intensity and carbon dioxide concentration as limiting factors on the rate of photosynthesis

1. A limiting factor is a factor that limits the rate of photosynthesis when it is in short supply.
2. Increasing light intensity increases the rate of photosynthesis until another factor becomes limiting.
3. Increasing carbon dioxide concentration increases the rate of photosynthesis until another factor becomes limiting.
4. Increasing temperature increases the rate up to an optimum temperature; above this, the rate decreases.
5. Another factor becomes the limiting factor, so increasing the original factor no longer increases the rate.
6. Low light intensity, low carbon dioxide concentration or an unsuitable temperature can each limit the rate of photosynthesis.

6.4 Explain the interactions of temperature, light intensity and carbon dioxide concentration in limiting the rate of photosynthesis

1. The rate of photosynthesis depends on several environmental factors, so more than one can limit the rate at different times.
2. Increasing light intensity increases the rate only while carbon dioxide is available in sufficient concentration; otherwise carbon dioxide becomes limiting.
3. Increasing carbon dioxide concentration increases the rate only if there is sufficient light; otherwise light intensity remains limiting.
4. Increasing temperature increases the rate only up to an optimum because photosynthesis involves enzyme-controlled reactions.
5. Increasing one factor until the rate stops increasing shows that another factor has become limiting.

6. The rate of photosynthesis is determined by whichever of temperature, light intensity or carbon dioxide concentration is most limiting at that time.

6.5 Core Practical: Investigate the effect of light intensity on the rate of photosynthesis

1. Place an aquatic plant at different distances from a lamp and measure the rate of photosynthesis at each distance, for example by measuring oxygen produced in a fixed time.
2. Light intensity.
3. The volume or number of bubbles of oxygen produced in a given time.
4. Temperature, carbon dioxide concentration, type and size of plant, volume of water and time allowed for each measurement.
5. To ensure that changes in the rate of photosynthesis are caused by light intensity rather than other limiting factors.
6. Repeat each measurement and calculate a mean, identifying and investigating any anomalous results.

6.6 Explain how the rate of photosynthesis is directly proportional to light intensity and inversely proportional to the distance from a light source, including the use of the inverse square law calculation

1. The rate of photosynthesis increases in direct proportion to light intensity while light intensity is the limiting factor.
2. It means that if light intensity increases by a certain factor, the rate of photosynthesis increases by the same factor, provided other factors are not limiting.
3. Light intensity decreases as the distance from the light source increases.
4. It means light intensity is proportional to $1/\text{distance}^2$.
5. The distance doubles, so the light intensity decreases by a factor of 4.
6. Use the inverse square relationship: new light intensity / original light intensity = $(\text{original distance} / \text{new distance})^2$.

6.7 Explain how the structure of the root hair cells is adapted to absorb water and mineral ions

1. Root hair cells absorb water and mineral ions from the soil.
2. The long extension provides a large surface area for absorption.
3. The large surface area increases the area available for water to enter the cell.
4. The thin cell wall provides a short distance for water to diffuse through.
5. Mineral ions are absorbed by active transport, using energy to move ions against their concentration gradient.

6. Root hair cells have long extensions, a large surface area and thin cell walls, and contain adaptations for active transport of mineral ions.

6.8 Explain how the structures of the xylem and phloem are adapted to their function in the plant, including: a lignified dead cells in xylem transporting water and minerals through the plant b living cells in phloem using energy to transport sucrose around the plant

1. Xylem transports water and mineral ions from the roots through the plant.
2. Xylem vessels are long, continuous tubes of dead cells with no end walls and lignified walls.
3. Lignin strengthens the vessels and prevents them collapsing when water is transported under tension.
4. Phloem transports sucrose around the plant.
5. Energy is required for the active transport involved in loading sucrose into phloem.
6. Xylem consists of lignified dead cells adapted for transporting water and minerals, whereas phloem consists of living cells adapted for transporting sucrose using energy.

6.9 Explain how water and mineral ions are transported through the plant by transpiration, including the structure and function of the stomata

1. Transpiration is the loss of water vapour from a plant, mainly through the stomata in leaves.
2. Water evaporating from the leaves creates a pull that draws more water up through the xylem.
3. Mineral ions dissolved in water are carried upwards through the xylem.
4. Stomata are pores in the surface of leaves that allow gases and water vapour to move into and out of the leaf.
5. Guard cells open and close the stomata, controlling gas exchange and water vapour loss.
6. Water evaporates from the leaves during transpiration, creating a transpiration stream that pulls water and dissolved mineral ions from the roots to the leaves through the xylem.

6.10 Describe how sucrose is transported around the plant by translocation

1. Translocation is the transport of dissolved sucrose around a plant.
2. Sucrose.
3. Phloem.
4. Sucrose is transported to parts of the plant where it is needed for respiration, growth or storage.
5. Sucrose is transported through the phloem from sources, such as leaves, to sinks, such as roots, fruits or growing tissues.

6. Translocation transports sucrose through the phloem, whereas water and mineral ions are transported through the xylem.

6.12 Explain the effect of environmental factors on the rate of water uptake by a plant, to include light intensity, air movement and temperature

1. Increasing light intensity generally increases the rate of water uptake.
2. Greater light intensity causes stomata to open more, increasing transpiration and therefore water uptake.
3. Increased air movement generally increases the rate of water uptake.
4. Air movement removes water vapour from around the leaf, maintaining a steep concentration gradient for diffusion.
5. Increasing temperature generally increases water uptake because it increases the rate of evaporation and diffusion of water vapour, up to suitable conditions.
6. Increased light intensity, air movement and temperature generally increase transpiration, which increases the rate of water uptake.

6.13 Demonstrate an understanding of rate calculations for transpiration

1. Rate of transpiration = change in mass ÷ time.
2. 6 ÷ 30 = 0.2 g/min.
3. 12 ÷ 2 = 6 g/hour.
4. 0.8 ÷ 20 = 0.04 g/min.
5. 9 ÷ 3 = 3 g/hour.
6. Rate allows fair comparison between plants or conditions even when different amounts of time have been used.

Topic 7 – Animal coordination, control and homeostasis

7.1 Describe where hormones are produced and how they are transported from endocrine glands to their target organs, including the pituitary gland, thyroid gland, pancreas, adrenal glands, ovaries and testes

1. A hormone is a chemical messenger released by an endocrine gland and transported in the blood to a target organ.
2. The pituitary gland is located at the base of the brain and releases hormones that control other endocrine glands and body processes.
3. The thyroid gland is located in the neck and produces thyroxine.
4. The pancreas produces insulin and glucagon, which regulate blood glucose concentration.

5. The adrenal glands are located above the kidneys and produce adrenalin.
6. The ovaries produce oestrogen and progesterone; the testes produce testosterone.

7.2 Explain that adrenalin is produced by the adrenal glands to prepare the body for fight or flight, including: a increased heart rate b increased blood pressure c increased blood flow to the muscles d raised blood sugar levels by stimulating the liver to change glycogen into glucose

1. The adrenal glands produce adrenalin, which prepares the body for rapid physical activity in a fight-or-flight situation.
2. Adrenalin increases heart rate and blood pressure, increasing the delivery of blood to tissues.
3. It increases blood flow to the muscles, providing them with more oxygen and glucose for respiration.
4. Adrenalin stimulates the liver to break down glycogen into glucose, increasing blood glucose concentration.
5. Glycogen.
6. Adrenalin increases heart rate, blood pressure, blood flow to muscles and blood glucose concentration, providing muscles with more oxygen and glucose for increased respiration and activity.

7.3 Explain how thyroxine controls metabolic rate as an example of negative feedback, including: a low levels of thyroxine stimulates production of TRH in hypothalamus b this causes release of TSH from the pituitary gland c TSH acts on the thyroid to produce thyroxine d when thyroxine levels are normal thyroxine inhibits the release of TRH and the production of TSH

1. Thyroxine controls the body's metabolic rate.
2. Low thyroxine levels stimulate the hypothalamus to produce TRH.
3. TRH stimulates the pituitary gland to release TSH.
4. TSH stimulates the thyroid gland to produce thyroxine.
5. Normal thyroxine levels inhibit the release of TRH and the production of TSH.
6. When thyroxine levels fall, TRH and TSH production increase, stimulating thyroxine production. When thyroxine levels return to normal, thyroxine inhibits TRH and TSH production, reducing further thyroxine production.

7.4 Describe the stages of the menstrual cycle, including the roles of the hormones oestrogen and progesterone, in the control of the menstrual cycle

1. The uterus lining breaks down and is lost from the body as menstrual blood.
2. The uterus lining is repaired and thickened in preparation for possible implantation.

3. Ovulation is the release of an egg from an ovary and occurs approximately halfway through the menstrual cycle, around day 14 of a 28-day cycle.
4. Oestrogen stimulates the repair and thickening of the uterus lining.
5. Progesterone maintains the uterus lining after ovulation.
6. The uterus lining breaks down when progesterone levels fall.

7.5 Explain the interactions of oestrogen, progesterone, FSH and LH in the control of the menstrual cycle, including the repair and maintenance of the uterus wall, ovulation and menstruation

1. FSH stimulates the development of an egg-containing follicle and stimulates the production of oestrogen.
2. FSH stimulates the development of a follicle, which produces oestrogen.
3. Oestrogen stimulates the repair and thickening of the uterus lining and inhibits FSH production; high oestrogen levels contribute to the LH surge.
4. LH causes ovulation.
5. Progesterone maintains the uterus lining after ovulation.
6. FSH stimulates follicle development and oestrogen production; oestrogen repairs the uterus lining and influences FSH and LH; LH causes ovulation; progesterone maintains the lining, and falling progesterone leads to menstruation.

7.6 Explain how hormonal contraception influences the menstrual cycle and prevents pregnancy

1. Hormonal contraception uses hormones to prevent ovulation and therefore reduces the chance of fertilisation.
2. Oestrogen and progesterone maintain relatively high hormone levels, inhibiting FSH and LH and preventing ovulation.
3. Hormonal contraception inhibits the release of FSH and LH.
4. Some hormonal contraceptives increase the thickness of cervical mucus, making it more difficult for sperm to reach an egg.
5. Hormonal contraception can alter the uterus lining, reducing the likelihood of implantation.
6. It reduces the probability of ovulation, fertilisation and implantation, thereby reducing the chance of pregnancy.

7.7 Evaluate hormonal and barrier methods of contraception

1. Hormonal contraception uses hormones to prevent ovulation and may also thicken cervical mucus or alter the uterus lining.
2. Barrier contraception physically prevents sperm from reaching an egg.
3. Hormonal contraception is generally more effective at preventing pregnancy when used correctly and does not require use during every act of intercourse.

4. Hormonal contraception can cause side effects and does not generally protect against STIs.
5. Barrier methods such as condoms can reduce the risk of sexually transmitted infections.
6. Consider effectiveness, reliability, side effects, ease of use, convenience, cost and protection against STIs when evaluating methods.

7.8 Explain the use of hormones in Assisted Reproductive Technology (ART) including IVF and clomifene therapy

1. ART includes treatments that assist fertilisation or pregnancy; hormones can stimulate egg production or ovulation.
2. Hormones can stimulate the ovaries to develop and mature multiple eggs during IVF.
3. Eggs are collected and fertilised with sperm in a laboratory; the resulting embryo develops before being transferred to the uterus.
4. The embryo is transferred to the uterus so that it can implant in the uterus lining and develop into a pregnancy.
5. Clomifene stimulates the release of hormones that promote ovulation, increasing the chance of an egg being released.
6. During IVF, hormones stimulate the development of multiple eggs before fertilisation and embryo transfer; clomifene stimulates ovulation to increase the chance of pregnancy.

7.9 Explain the importance of maintaining a constant internal environment in response to internal and external change

1. Maintaining a constant internal environment means keeping conditions inside the body within suitable limits.
2. Cells require stable conditions for their metabolic reactions to occur effectively.
3. Conditions such as temperature, blood glucose concentration and water content are regulated.
4. Changes in the external environment can alter internal conditions, such as body temperature or water balance.
5. Homeostasis is the regulation of the internal conditions of an organism to maintain a stable internal environment.
6. Homeostasis keeps conditions suitable for enzyme activity and cellular processes, allowing cells to function correctly.

7.13 Explain how the hormone insulin controls blood glucose concentration

1. The pancreas releases insulin when blood glucose concentration is too high.
2. Insulin lowers blood glucose concentration.

3. Insulin causes body cells to take up more glucose from the blood.
4. Insulin stimulates the liver and muscles to convert glucose into glycogen for storage.
5. Blood glucose concentration decreases.
6. When blood glucose concentration rises, the pancreas releases insulin. Insulin increases glucose uptake by cells and conversion of glucose to glycogen, reducing blood glucose concentration towards normal.

7.14 Explain how blood glucose concentration is regulated by glucagon

1. The pancreas releases glucagon when blood glucose concentration is too low.
2. Glucagon increases blood glucose concentration.
3. Glucagon stimulates the breakdown of glycogen stored in the liver into glucose.
4. Blood glucose concentration increases.
5. Insulin lowers blood glucose concentration, whereas glucagon increases it.
6. When blood glucose concentration falls, the pancreas releases glucagon, which stimulates glycogen to be converted to glucose in the liver, raising blood glucose concentration towards normal.

7.15 Explain the cause of type 1 diabetes and how it is controlled

1. Type 1 diabetes occurs when the immune system attacks and destroys the insulin-producing cells of the pancreas.
2. There is insufficient insulin to cause cells to take up glucose and for glucose to be converted into glycogen, so blood glucose concentration remains high.
3. The immune system mistakenly attacks the body's insulin-producing cells.
4. It is controlled by administering insulin, usually by injection or an insulin pump.
5. Insulin doses can be adjusted according to food intake, exercise and blood glucose concentration.
6. People with type 1 diabetes produce little or no insulin, so insulin must be supplied to lower and regulate blood glucose concentration.

7.16 Explain the cause of type 2 diabetes and how it is controlled

1. Type 2 diabetes is mainly caused by body cells becoming resistant to insulin; being overweight is an important risk factor.
2. Insulin resistance means body cells respond less effectively to insulin.
3. Cells take up less glucose in response to insulin, so blood glucose concentration remains higher than normal.
4. A healthier diet, weight management and regular exercise can improve insulin sensitivity and help control blood glucose concentration.

5. Medicines such as metformin may be used to help control blood glucose concentration.
6. Type 2 diabetes can be controlled through diet, exercise and weight management, with medication used when necessary.

7.17 Evaluate the correlation between body mass and type 2 diabetes including waist:hip calculations and BMI, using the BMI equation

1. BMI = mass (kg) ÷ height (m)².
2. BMI = 80 ÷ 1.60^2 = 80 ÷ 2.56 = 31.25 kg/m².
3. BMI = 72 ÷ 1.80^2 = 72 ÷ 3.24 = 22.22 kg/m².
4. Waist-to-hip ratio = waist circumference ÷ hip circumference.
5. Higher body mass, particularly excess body fat around the waist, is associated with a higher risk of type 2 diabetes.
6. A correlation shows that two variables are associated, but it does not prove that one directly causes the other because other factors may influence the relationship.

Topic 8 – Exchange and transport in animals

8.1 Describe the need to transport substances into and out of a range of organisms, including oxygen, carbon dioxide, water, dissolved food molecules, mineral ions and urea

1. Multicellular organisms need transport systems to move substances between exchange surfaces and cells throughout the body.
2. Oxygen.
3. Carbon dioxide.
4. Water and dissolved food molecules are needed by cells for metabolic reactions, growth and other cellular processes.
5. Mineral ions are needed for processes such as making proteins and maintaining healthy cells.
6. Urea is a waste product that must be transported to the kidneys for excretion.

8.2 Explain the need for exchange surfaces and a transport system in multicellular organisms including the calculation of surface area : volume ratio

1. Specialised exchange surfaces provide a large area for substances to move into and out of the organism efficiently.

2. A small surface area to volume ratio means there is less surface area available for exchange relative to the volume of cells requiring substances.
3. Surface area : volume = 150 : 125 = 1.2 : 1.
4. Surface area : volume = 600 : 1000 = 0.6 : 1.
5. Volume increases more rapidly than surface area as an organism becomes larger.
6. Exchange surfaces alone cannot supply substances quickly enough to cells that are far from the surface, so a transport system is required.

8.3 Explain how alveoli are adapted for gas exchange by diffusion between air in the lungs and blood in capillaries

1. The large surface area provides more area for diffusion, increasing the rate of gas exchange.
2. The thin alveolar wall gives a short diffusion distance, increasing the rate of diffusion.
3. The extensive blood supply continually brings deoxygenated blood to the alveoli, maintaining a steep concentration gradient for oxygen.
4. Ventilation continually replaces air in the alveoli, maintaining concentration gradients for oxygen and carbon dioxide.
5. Oxygen diffuses from the alveoli into the blood because the oxygen concentration is higher in the alveoli than in the blood.
6. Carbon dioxide diffuses from the blood into the alveoli because its concentration is higher in the blood.

8.6 Explain how the structure of the blood is related to its function: a red blood cells (erythrocytes) b white blood cells (phagocytes and lymphocytes) c plasma d platelets

1. Their biconcave shape provides a large surface area and short diffusion distance for oxygen.
2. It provides more space for haemoglobin, allowing more oxygen to be transported.
3. Phagocytes engulf and digest pathogens; lymphocytes produce antibodies.
4. They can change shape and surround pathogens before engulfing them.
5. Plasma transports substances including glucose, amino acids, carbon dioxide, urea, hormones, mineral ions and heat.
6. Platelets are small cell fragments that help form blood clots, preventing excessive blood loss and entry of pathogens.

8.7 Explain how the structure of the blood vessels is related to their function

1. The thick muscular and elastic wall withstands and maintains the high pressure of blood leaving the heart.

2. The narrow lumen helps maintain high blood pressure.
3. The thin wall provides a short diffusion distance for exchange between blood and tissues.
4. Networks provide a large surface area and ensure most cells are close to a blood supply.
5. Veins have thinner walls, wider lumens and valves to return blood to the heart at low pressure.
6. Valves prevent the backflow of blood, ensuring blood flows towards the heart.

8.8 Explain how the structure of the heart and circulatory system is related to its function, including the role of the major blood vessels, the valves and the relative thickness of chamber walls

1. The left ventricle pumps blood around the whole body, so it needs a thicker muscular wall to generate higher pressure.
2. Valves prevent the backflow of blood and ensure it flows in the correct direction.
3. The septum prevents oxygenated and deoxygenated blood from mixing.
4. The aorta carries oxygenated blood to the body, and the left ventricle pumps this blood.
5. The vena cava carries deoxygenated blood from the body to the heart.
6. Blood is transported through the lungs to pick up oxygen and remove carbon dioxide before being pumped to the rest of the body.

8.9 Describe cellular respiration as an exothermic reaction which occurs continuously in living cells to release energy for metabolic processes, including aerobic and anaerobic respiration

1. It releases energy to the surroundings.
2. Cellular respiration occurs continuously in living cells, with aerobic respiration occurring mainly in mitochondria.
3. Cells continuously require energy for metabolic processes.
4. The energy is used for metabolic processes such as active transport, movement, growth and synthesis of substances.
5. Aerobic respiration uses glucose and oxygen and produces carbon dioxide and water.
6. Aerobic respiration uses oxygen; anaerobic respiration occurs without oxygen.

8.10 Compare the process of aerobic respiration with the process of anaerobic respiration

1. Glucose + oxygen → carbon dioxide + water.
2. Lactic acid.

3. Glucose is only partially broken down, so less energy is released.
4. Ethanol and carbon dioxide.
5. Oxygen supply may not meet the energy demand of muscles during vigorous exercise.
6. Aerobic respiration requires oxygen, whereas anaerobic respiration does not.

8.11 Core Practical: Investigate the rate of respiration in living organisms

1. Place germinating seeds in a sealed respirometer and measure the decrease in gas volume or movement of a marker as oxygen is taken up over time.
2. A respirometer allows changes in gas volume caused by oxygen uptake during respiration to be measured.
3. Temperature, or another suitable independent variable such as the mass of seeds.
4. A control allows changes caused by respiration to be distinguished from changes caused by other factors.
5. Rate of respiration = volume of oxygen taken up ÷ time.
6. Temperature affects the rate of enzyme-controlled reactions involved in respiration, so it must be kept constant for a fair test.

8.12 Calculate heart rate, stroke volume and cardiac output, using the equation cardiac output = stroke volume × heart rate

1. 72 beats/min.
2. Cardiac output = 70 × 75 = 5250 cm^3/min.
3. Stroke volume = 5600 ÷ 80 = 70 cm^3/beat.
4. Cardiac output = 90 × 65 = 5850 cm^3/min.
5. Heart rate = 7200 ÷ 80 = 90 beats/min.
6. Cardiac output = 120 × 150 = 18 000 cm^3/min = 18 dm^3/min.

Topic 9 – Ecosystems and material cycles

9.1 Describe the different levels of organisation from individual organisms, populations, communities, to the whole ecosystem

1. An organism is an individual living thing.
2. A population is all the organisms of one species living in a particular area.
3. A community is all the populations of different species living and interacting in an area.

4. An ecosystem is a community of organisms and the non-living components of their environment.
5. A population consists of one species, whereas a community contains populations of different species.
6. Organism → population → community → ecosystem.

9.2 Explain how communities can be affected by abiotic and biotic factors, including: a temperature, light, water, pollutants b competition, predation

1. An abiotic factor is a non-living factor; temperature affects enzyme activity and therefore the survival and distribution of organisms.
2. Light intensity affects photosynthesis and therefore can affect the growth, distribution and abundance of plants and organisms that depend on them.
3. Water availability affects the survival, growth and distribution of organisms.
4. Pollutants can harm organisms, reduce population sizes and disrupt ecosystems.
5. Competition for resources can reduce population sizes and limit the distribution of organisms.
6. Predation reduces prey numbers and provides food for predators, so changes in prey numbers can affect predator populations.

9.3 Describe the importance of interdependence in a community

1. Interdependence means organisms depend on other organisms for resources or survival.
2. Organisms may depend on other species for food, shelter, pollination or other resources.
3. A reduction in one species can reduce food or resources available to other species, changing their population sizes.
4. A decrease in prey abundance can reduce the size of a predator population.
5. Removing one species can affect organisms that depend on it for food or other resources, causing changes throughout the community.
6. Interdependence means changes to one population can affect others, contributing to interactions that influence community stability.

9.4 Describe how the survival of some organisms is dependent on other species, including parasitism and mutualism

1. Parasitism is a relationship in which one organism benefits while the host is harmed.
2. A parasite obtains resources such as nutrients from its host.

3. The parasite can damage the host, reducing its health or ability to survive and reproduce.
4. Mutualism is a relationship in which both organisms benefit.
5. Both organisms gain an advantage from the relationship.
6. Each organism may depend on the benefits provided by the other for survival or successful reproduction.

9.5 Core Practical: Investigate the relationship between organisms and their environment using field-work techniques, including quadrats and belt transects

1. Place quadrats in different areas and record the number or percentage cover of the organism within each quadrat.
2. Random placement reduces bias and makes the sample more representative of the habitat.
3. Place quadrats at regular intervals along a line through the habitat and record organisms at each position.
4. Several quadrats provide more data and give a more representative estimate of abundance.
5. Place a belt transect from the river away from it, position quadrats at regular intervals and record the abundance of the plant species in each quadrat.
6. Record the number of organisms, percentage cover or frequency of the species in each quadrat and compare these measurements with distance along the transect.

9.6 Explain how to determine the number of organisms in a given area using raw data from field-work techniques, including quadrats and belt transects

1. Add the numbers of organisms in all quadrats and divide by the number of quadrats.
2. Mean = (8 + 12 + 10 + 14 + 6) ÷ 5 = 10 daisies per quadrat.
3. Estimated number = 15 × 200 = 3000 plants.
4. The sampled area is used to calculate population density and extrapolate the number of organisms to the whole habitat.
5. Total organisms = 24 ÷ (10 × 0.5) × 100 = 480 organisms.
6. Compare the number or abundance of organisms in quadrats at different positions along the transect to identify changes across the habitat.

9.9 Explain the positive and negative human interactions within ecosystems and their impacts on biodiversity, including: a fish farming b introduction of non-indigenous species c eutrophication

1. Fish farming produces a reliable supply of fish and can reduce fishing pressure on wild populations.

2. Fish farms can release waste, nutrients, chemicals or escaped fish that may disrupt ecosystems and reduce biodiversity.
3. A non-indigenous species may compete with native species, prey on them or introduce diseases.
4. It can reduce native populations through competition for resources or predation.
5. Fertilisers can enter water and increase nitrate and phosphate concentrations, causing excessive algal growth.
6. Algal blooms block light and eventually die; microorganisms decompose them and use up oxygen, causing aquatic organisms to die.

9.10 Explain the benefits of maintaining local and global biodiversity, including the conservation of animal species and the impact of reforestation

1. Biodiversity is the variety of different species of organisms in an area.
2. Greater biodiversity can make ecosystems more stable and resilient to environmental changes.
3. Conservation prevents species from becoming extinct and maintains the variety of species within ecosystems.
4. Reforestation creates habitats and increases the number of plant and animal species that can live in an area.
5. Biodiversity provides resources such as food, medicines, timber and genetic resources.
6. Reforestation provides habitats, increases biodiversity, stores carbon and can help improve soil and water quality.

9.12 Describe how different materials cycle through the abiotic and biotic components of an ecosystem

1. A material cycle is the continuous movement and recycling of materials between living organisms and the non-living environment.
2. The biotic components are the living organisms in an ecosystem.
3. The abiotic components are the non-living parts of an ecosystem, such as air, water and soil.
4. Organisms take materials from the environment and return them through processes such as respiration, excretion and decomposition.
5. Materials are limited resources, so recycling makes them available for repeated use by organisms.
6. Decomposers break down dead organisms and waste, releasing substances back into the environment for reuse.

9.13 Explain the importance of the carbon cycle, including the processes involved and the role of microorganisms as decomposers

1. Carbon is needed to make carbohydrates, proteins, lipids and other biological molecules.
2. Plants and algae absorb carbon dioxide during photosynthesis and convert the carbon into organic compounds.
3. Respiration releases carbon dioxide back into the atmosphere.
4. Combustion releases carbon stored in fossil fuels as carbon dioxide into the atmosphere.
5. Microorganisms decompose dead organisms and waste materials, releasing carbon dioxide through respiration.
6. Decomposers break down dead material and waste; the microorganisms respire and release carbon dioxide into the atmosphere.

9.14 Explain the importance of the water cycle, including the processes involved and the production of potable water in areas of drought including desalination

1. Water is essential for living organisms and is continually recycled through ecosystems and the environment.
2. Evaporation and transpiration transfer water into the atmosphere as water vapour.
3. Water returns to the Earth's surface by precipitation.
4. Water can be treated by filtration and sterilisation to remove particles and microorganisms and produce potable water.
5. Desalination can provide potable water from seawater when freshwater supplies are limited by drought.
6. Desalination removes dissolved salts from seawater, commonly by distillation or reverse osmosis.

9.15 Explain how nitrates are made available for plant uptake, including the use of fertilisers, crop rotation and the role of bacteria in the nitrogen cycle

1. Plants need nitrate ions to make amino acids and proteins.
2. Nitrogen-fixing bacteria convert atmospheric nitrogen into nitrogen compounds that can enter the nitrogen cycle and become available to plants.
3. Nitrifying bacteria convert ammonium compounds into nitrites and then nitrates.
4. Fertilisers add nitrate ions or compounds containing nitrogen to the soil, increasing nitrate availability.
5. Leguminous plants contain nitrogen-fixing bacteria in root nodules; growing them during crop rotation increases nitrogen compounds in the soil.
6. Bacteria carry out key conversions in the nitrogen cycle that make nitrogen compounds, including nitrates, available for plant uptake.