Detailed unit content

In this specification bold text refers to higher tier only content. Italic text refers to practical investigations, which students are required to demonstrate an understanding of.

Topic 1

Classification, variation and inheritance

1.1 Demonstrate an understanding of how biologists classify organisms according to how closely they are related to one another including:

- a Species – groups of organisms that have many features in common
- b Genus – contains several species with similar characteristics
- c Family – comprising of several genera
- d Order – comprising of several families
- e Class – comprising of several orders
- f Phylum – comprising of several classes
- g The Five Kingdoms – animalia, plantae, fungi, protoctista and prokaryota

1.2 Describe the main characteristics of the five kingdoms including:

- a Animalia – multicellular, do not have cell walls, do not have chlorophyll, feed heterotrophically
- b Plantae – multicellular, have cell walls, have chlorophyll, feed autotrophically
- c Fungi – multicellular, have cell walls, do not have chlorophyll, feed saprophytically
- d Protoctista – unicellular, have a nucleus
- e Prokaryota – unicellular, have no nucleus

1.3 Explain why scientists do not classify viruses in any of the five kingdoms and regard them as non-living

1.4 Describe the main characteristics of the phylum Chordata as animals with a supporting rod running the length of the body, an example of this being the backbone in vertebrates

1.5 Explain how scientists place vertebrates into groups based on:

- a Oxygen absorption methods – lungs, gills and skin
- b Reproduction – internal or external fertilisation, oviparous or viviparous
- c Thermoregulation – homeotherms and poikilotherms

1.6 Demonstrate an understanding of the problems associated with assigning vertebrates to a specific group based on their anatomy and reproduction methods and why many vertebrates are difficult to classify

1.7 Discuss why the definition of a species as organisms that produce fertile offspring may have limitations: some organisms do not always reproduce sexually and some hybrids are fertile

1.8 **Explain why binomial classification is needed to identify, study and conserve species, and can be used to target conservation efforts**

1.9 Explain how accurate classification may be complicated by:

- a variation within a species
- b **hybridisation in ducks**
- c **ring species**

1.10 Construct and use keys to show how species can be identified

1.11 Explain how organisms are adapted to their environment and how some organisms have characteristics that enable them to survive in extreme environments, including deep-sea hydrothermal vents and polar regions

1.12 Demonstrate an understanding of Darwin's theory of evolution by natural selection including:

- a variation – most populations of organisms contain individuals which vary slightly from one to another
- b over-production – most organisms produce more young than will survive to adulthood
- c struggle for existence – because populations do not generally increase rapidly in size there must therefore be considerable competition for survival between the organisms
- d survival – those with advantageous characteristics are more likely to survive this struggle
- e advantageous characteristics inherited – better adapted organisms are more likely to reproduce successfully passing on the advantageous characteristics to their offspring
- f gradual change – over a period of time the proportion of individuals with the advantageous characteristics in the population will increase compared with the proportion of individuals with poorly adapted characteristics, and the poorly adapted characteristics may eventually be lost

1.13 Describe variation as continuous or discontinuous

1.14 *Investigate the variations within a species to illustrate continuous variation and discontinuous variation*

1.15 Interpret information on variation using normal distribution curves

1.16 Demonstrate an understanding of the causes of variation, including:

- a genetic variation – different characteristics as a result of mutation or reproduction
- b environmental variation – different characteristics caused by an organism's environment (acquired characteristics)

1.17 **Demonstrate an understanding of how speciation occurs as a result of geographic isolation**

1.18 Explain how new evidence from DNA research and the emergence of resistant organisms supports Darwin's theory

1.19 Explain the role of the scientific community in validating new evidence, including the use of:

a scientific journals

b the peer review process

c scientific conferences

1.20 Describe the structure of the nucleus of the cell as containing chromosomes, on which genes are located

1.21 Demonstrate an understanding that genes exist in alternative forms called alleles which give rise to differences in inherited characteristics

1.22 Recall the meaning of, and use appropriately, the terms: dominant, recessive, homozygous, heterozygous, phenotype and genotype

1.23 Analyse and interpret patterns of monohybrid inheritance using a genetic diagram, Punnett squares and family pedigrees

1.24 Calculate and analyse outcomes (using probabilities, ratios and percentages) from monohybrid crosses

1.25 Describe the symptoms of the genetic disorders:

a sickle cell disease

b cystic fibrosis

1.26 **Evaluate the outcomes of pedigree analysis when screening for genetic disorders:**

a **sickle cell disease**

b **cystic fibrosis**

Topic 2

Responses to a changing environment

2.1 Define homeostasis as the maintenance of a stable internal environment

2.2 Demonstrate an understanding of the homeostatic mechanisms of:

a thermoregulation and the effect of temperature on enzymes

b osmoregulation

c blood glucose regulation

2.3 Explain how thermoregulation takes place, with reference to the function of the skin, including:

a the role of the dermis – sweat glands, blood vessels and nerve endings, hair, erector muscles and sebaceous glands

b the role of the hypothalamus – regulating body temperature

2.4 **Explain how thermoregulation takes place, with reference to:**

a **vasoconstriction**

b **vasodilation**

c **negative feedback**

2.5 Recall that hormones are produced in endocrine glands and are transported by the blood to their target organs

2.6 Explain how blood glucose levels are regulated by insulin and excess blood glucose is converted to glycogen in the liver

2.7 **Explain how blood glucose levels are regulated by causing the conversion of glycogen to glucose**

2.8 Recall that Type 1 diabetes is caused by a lack of insulin

2.9 Explain how Type 1 diabetes can be controlled, including the roles of diet and injection of insulin usually into the subcutaneous fat

2.10 Explain how, in Type 1 diabetes, the level of physical activity and diet affect the amount of insulin required

2.11 Recall that Type 2 diabetes is caused by a person becoming resistant to insulin

2.12 Explain how Type 2 diabetes can be controlled by diet and physical activity

2.13 Evaluate the correlation between obesity (including calculations of BMI) and Type 2 diabetes

2.14 Explain how plant growth substances (hormones) bring about:

a positive phototropism in shoots

b positive gravitropism (geotropism) in roots

2.15 Explain how auxins bring about shoot curvature using cell elongation

2.16 *Investigate tropic responses*

2.17 Analyse, interpret and evaluate data from plant hormone experiments, including the action of auxins and gibberellins

2.18 **Demonstrate an understanding of the uses of plant hormones, including:**

- a **selective weedkillers**
- b **rooting powder**
- c **seedless fruit**
- d **fruit ripening**

2.19 Recall that the central nervous system consists of the brain and spinal cord and is linked to sense organs by nerves

2.20 Explain the structure and function of dendrons and axons in the nervous system

2.21 Describe how stimulation of receptors in the sense organs sends electrical impulses along neurones

2.22 *Investigate human responses to external stimuli*

2.23 Describe the structure and function of sensory, relay and motor neurones and synapses including:

- a the role of the myelin sheath
- b the role of neurotransmitters
- c the reflex arc

Topic 3

Problems of, and solutions to a changing environment

3.1 Define a drug as a chemical substance, such as a narcotic or hallucinogen, that affects the central nervous system, causing changes in psychological behaviour and possible addiction

3.2 Describe the general effects of:

- a painkillers that block nerve impulses, including morphine
- b hallucinogens that distort sense perception, including LSD
- c stimulants that increase the speed of reactions and neurotransmission at the synapse, including caffeine
- d depressants that slow down the activity of the brain, including alcohol

3.3 *Investigate reaction times*

3.4 Explain the effects of some chemicals in cigarette smoke, including:

- a nicotine as an addictive drug
- b tar as a carcinogen
- c carbon monoxide reducing the oxygen-carrying ability of the blood

3.5 Evaluate data relating to the correlation between smoking and its negative effects on health

3.6 Evaluate evidence of some harmful effects of alcohol abuse:

- a in the short term – blurred vision, lowering of inhibitions, slowing of reactions
- b in the long term – liver cirrhosis, brain damage

3.7 Discuss the ethics of organ transplants, including:

- a liver transplants for alcoholics
- b heart transplants for the clinically obese
- c the supply of organs

3.8 Recall that infectious diseases are caused by pathogens

3.9 Describe how pathogens are spread, including:

- a in water, including cholera bacterium
- b by food, including *Salmonella* bacterium
- c airborne (eg sneezing), including influenza virus
- d by contact, including athlete's foot fungus
- e by body fluids, including HIV
- f by animal vectors, including:
  - i housefly: dysentery bacterium
  - ii *Anopheles* mosquito: malarial protozoan

3.10 Explain how the human body can be effective against attack from pathogens, including:

- a physical barriers – skin, cilia, mucus
- b chemical defence – hydrochloric acid in the stomach, lysozymes in tears

3.11 Demonstrate an understanding that plants produce chemicals that have antibacterial effects in order to defend themselves, some of which are used by humans

3.12 Describe how antiseptics can be used to prevent the spread of infection

3.13 Explain the use of antibiotics to control infection, including:

- a antibacterials to treat bacterial infections
- b antifungals to treat fungal infections

3.14 **Evaluate evidence that resistant strains of bacteria, including MRSA, can arise from the misuse of antibiotics**

3.15 *Investigate the effects of antiseptics or antibiotics on microbial cultures*

3.16 Recall that interdependence is the dynamic relationship between all living things

3.17 Demonstrate an understanding of how some energy is transferred to less useful forms at each trophic level and this limits the length of a food chain

3.18 Demonstrate an understanding that the shape of a pyramid of biomass is determined by energy transferred at each trophic level

3.19 Explain how the survival of some organisms may depend on the presence of another species:

- a parasitism, including:
  - i fleas
  - ii head lice
  - iii tapeworms
  - iv mistletoe
- b mutualism, including:
  - i oxpeckers that clean other species
  - ii cleaner fish
  - iii **nitrogen-fixing bacteria in legumes**
  - iv **chemosynthetic bacteria in tube worms in deep-sea vents**

3.20 Analyse, interpret and evaluate data on global population change

3.21 Explain how the increase in human population contributes to an increase in the production of pollutants, including phosphates, nitrates and sulfur dioxide (acid rain)

3.22 Explain how eutrophication occurs and the problems associated with eutrophication in an aquatic environment

3.23 *Investigate the effect of pollutants on plant germination and plant growth*

3.24 Demonstrate an understanding of how scientists can use the presence or absence of indicator species as evidence to assess the level of pollution:

- a polluted water indicator – bloodworm, sludgeworm
- b clean water indicator – stonefly, freshwater shrimps
- c air quality indicator – lichen species, blackspot fungus on roses

3.25 Demonstrate an understanding of how recycling can reduce the demand for resources and the problem of waste disposal, including paper, plastics and metals

3.26 Demonstrate an understanding of how carbon is recycled:

- a during photosynthesis plants remove carbon dioxide from the atmosphere
- b carbon compounds pass along a food chain
- c during respiration organisms release carbon dioxide into the atmosphere
- d decomposers release carbon dioxide into the atmosphere
- e combustion of fossil fuels releases carbon dioxide into the atmosphere

3.27 **Demonstrate an understanding of how nitrogen is recycled:**

a **nitrogen gas in the air cannot be used directly by plants and animals**

b **nitrogen-fixing bacteria living in root nodules or the soil can fix nitrogen gas**

c **the action of lightning can convert nitrogen gas into nitrates**

d **decomposers break down dead animals and plants**

e **soil bacteria convert proteins and urea into ammonia**

f **nitrifying bacteria convert this ammonia to nitrates**

g **plants absorb nitrates from the soil**

h **nitrates are needed by plants to make proteins for growth**

i **nitrogen compounds pass along a food chain or web**

j **denitrifying bacteria convert nitrates to nitrogen gas**

Unit B2: The components of life

Overview

Content and How Science Works overview

The three topics in Unit B2 allow a more in-depth study of the structure, development and functioning of organisms. This includes the role of various organ systems in animals and plants.

Practical work throughout the unit will give students opportunities to plan and carry out investigations. They will devise their own models and evaluate them, assess and manage risks, trial their plans and consider how the quality of their data might be improved. They will analyse data, draw conclusions providing evidence to support their conclusions, and evaluate to what degree the conclusions support the hypothesis.

Throughout the unit, students will have the opportunity to improve and demonstrate mathematical skills, including understanding number size and scale, using estimation, understanding and using direct proportion and simple ratios, calculating arithmetic means, plotting and drawing graphs (line graphs, bar charts, pie charts, scatter graphs, histograms) selecting appropriate scales for the axes, translating information between graphical and numeric form, extracting and interpreting information from charts, graphs and tables and understanding the idea of probability.

Topic 1 compares the structure of animal, bacterial and plant cells. Students will learn about the relationship between genes and DNA and find out how cells divide. Exciting scientific developments such as genetic engineering, the Human Genome Project and the use of stem cells are key aspects of this topic. Enzyme properties and the principles of enzyme action are important areas of biology also covered.

The impact of developments in science, including the advantages, disadvantages and risks, will be covered in relation to genetic modification and cloning. There will be opportunities to explore the issues raised by social, economic and environmental effects of developing scientific knowledge, such as in cloning and stem cell research.

Work on cell structure, protein synthesis and the way enzymes work will give students experience in evaluating models and their importance in the development of our understanding of biological processes. Students will also explore the way that scientific ideas develop as a result of the collaboration of scientists, such as in the Human Genome Project, and the importance of creative thought in developing ideas, such as how DNA structure links to protein structure.

In Topic 2 students will learn about the differences between aerobic and anaerobic respiration and investigate the relationship between exercise, breathing rate and heart rate. They go on to study important processes in plants including photosynthesis and water movement. The final section of Topic 2 allows students to explore the relationship between organisms and their environment.

Students will be expected to present data that they have collected, using the appropriate conventions and language, in order to develop arguments and draw conclusions when investigating photosynthesis and respiration. Students will also evaluate 'scientific' claims made in the media about new scientific developments, such as in adverts for energy-boosting products, and how science as yet does not have answers to some questions about these.

Topic 3 includes an interesting study of fossils and the fossil record. Students will also learn about the structure and functions of blood and the heart, and look at the role of blood vessels. Parts of the digestive system and their functions are key areas of human biology and up-to-date issues such as the use of prebiotics and probiotics are discussed.

Students will also evaluate 'scientific' claims made in the media about new scientific developments, such as in adverts for probiotics, and how science as yet does not have answers to some questions about these.

Assessment overview

This unit is externally assessed, through a one hour, 60 mark, tiered written examination, containing six questions.

The examination will contain a mixture of question styles, including objective questions, short answer questions and extended writing questions.

Practical investigations in this unit

Within this unit, students will develop an understanding of the process of scientific investigations, including that investigations:

- use hypotheses which are tested
- require assessment and management of risks
- require the collection, presentation, analysis and interpretation of primary and secondary evidence including the use of appropriate technology
- should include a review of methodology to assess fitness for purpose
- should include a review of hypotheses in the light of outcomes.

The following specification points are practical investigations which that exemplify the scientific process and may appear in the written examination for this unit:

1.8 *Investigate how to extract DNA from cells*

1.32 *Investigate the factors that affect enzyme activity*

2.5 *Investigate the effect of exercise on breathing rate and heart rate*

2.16 *Investigate how factors, including the effect of light intensity, CO_2 concentration or temperature, affect the rate of photosynthesis*

2.21 *Investigate osmosis*

2.22 *Investigate the relationship between organisms and their environment using fieldwork techniques*

2.23 *Investigate the distribution of organisms in an ecosystem, using sampling techniques including:*

a *pooters*

b *sweep nets/pond nets*

c *pitfall traps*

d *quadrats*

and measure environmental factors including:

e *temperature*

f *light intensity*

g *pH*

3.17 *Investigate the effect of different concentrations of digestive enzymes, using and evaluating models of the alimentary canal*

The following are further suggestions for practical work within this unit:

- *Investigate plant and animal cells with a light microscope*
- *Investigate the effect of concentration on rate of diffusion*
- *Investigate the effect of glucose concentration on rate of anaerobic respiration in yeast*
- *Investigate the increase in heart rate and/or breathing rate with exercise*

- *Investigate how the structure of the leaf is adapted for photosynthesis*
- *Investigate how the loss of water vapour from leaves drives transpiration*

The controlled assessment task (CAT) for the GCSE in Biology will be taken from any of these practical investigations (specification points and further suggested practical work). This task will change every year, so future CATs will be chosen from this list.

Detailed unit content

In this specification bold text refers to higher tier only content. Italic text refers to practical investigations, which students are required to demonstrate an understanding of.

Topic 1

The building blocks of cells

1.1 Describe the function of the components of a bacterial cell including chromosomal DNA, plasmid DNA, flagella and cell wall

1.2 Describe the function of the components of a plant cell including chloroplast, large vacuole, cell wall, cell membrane, mitochondria, cytoplasm and nucleus

1.3 Describe the function of the components of an animal cell including cell membrane, mitochondria, cytoplasm and nucleus

1.4 Describe how plant and animal cells can be studied in greater detail with a light microscope

1.5 Demonstrate an understanding of how changes in microscope technology have enabled us to see cells with more clarity and detail than in the past, including simple magnification calculations

1.6 Recall that a gene is a section of a molecule of DNA and that it codes for a specific protein

1.7 Describe a DNA molecule as:

- 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:
  - i adenine (A) with thymine (T)
  - ii cytosine (C) with guanine (G)

1.8 *Investigate how to extract DNA from cells*

1.9 Explain how the structure of DNA was discovered, including the roles of the scientists Watson, Crick, Franklin and Wilkins

1.10 **Demonstrate an understanding of the implications of sequencing the human genome (Human Genome Project) and of the collaboration that took place within this project**

1.11 Demonstrate an understanding of the process of genetic engineering, including the removal of a gene from the DNA of one organism and the insertion of that gene into the DNA of another organism

1.12 Discuss the advantages and disadvantages of genetic engineering to produce GM organisms, including:

- a beta carotene in golden rice to reduce vitamin A deficiency in humans
- b the production of human insulin by genetically modified bacteria
- c the production of herbicide-resistant crop plants

1.13 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

1.14 Recall that mitosis occurs during growth, repair and asexual reproduction

1.15 Recall that, at fertilisation, haploid gametes combine to form a diploid zygote

1.16 Describe the division of a cell by meiosis as 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

1.17 Recall that cloning is an example of asexual reproduction that produces genetically identical copies

1.18 **Demonstrate an understanding of the stages in the production of cloned mammals, including:**

- a **removal of diploid nucleus from a body cell**
- b **enucleation of egg cell**
- c **insertion of diploid nucleus into enucleated egg cell**
- d **stimulation of the diploid nucleus to divide by mitosis**
- e **implantation into surrogate mammals**

1.19 Demonstrate an understanding of the advantages, disadvantages and risks of cloning mammals

1.20 Recall that stem cells in the embryo can differentiate into all other types of cells, but that cells lose this ability as the animal matures

1.21 Demonstrate an understanding of the advantages, disadvantages and risks arising from adult and embryonic stem cell research

1.22 Describe how the order of bases in a section of DNA decides the order of amino acids in the protein

1.23 **Demonstrate an understanding of the stages of protein synthesis, including transcription and translation:**

- a **the production of complementary mRNA strand in the nucleus**
- b **the attachment of the mRNA to the ribosome**
- c **the coding by triplets of bases (codons) in the mRNA for specific amino acids**
- d **the transfer of amino acids to the ribosome by tRNA**
- e **the linking of amino acids to form polypeptides**

1.24 Describe each protein as having its own specific number and sequence of amino acids, resulting in different-shaped molecules that have different functions, including enzymes

1.25 Demonstrate an understanding of how gene mutations change the DNA base sequence and that mutations can be harmful, beneficial or neither

1.26 Describe enzymes as biological catalysts

1.27 Demonstrate an understanding that enzymes catalyse chemical reactions occurring inside and outside living cells, including:

- a DNA replication
- b protein synthesis
- c digestion

1.28 Describe the factors affecting enzyme action, including:

- a temperature
- b substrate concentration
- c pH

1.29 Recall that enzymes are highly specific for their substrate

1.30 Demonstrate an understanding of the action of enzymes in terms of the 'lock-and-key' hypothesis

1.31 Describe how enzymes can be denatured due to changes in the shape of the active site

1.32 *Investigate the factors that affect enzyme activity*

Topic 2

Organisms and energy

2.1 Recall that respiration is a process used by all living organisms that releases the energy in organic molecules

2.2 Explain how the human circulatory system facilitates respiration, including:

- a glucose and oxygen diffuses from capillaries into respiring cells
- b carbon dioxide diffuses from respiring cells into capillaries

2.3 Define diffusion as the movement of particles from an area of high concentration to an area of lower concentration

2.4 Demonstrate an understanding of how aerobic respiration uses oxygen to release energy from glucose and how this process can be modelled using the word equation for aerobic respiration

2.5 *Investigate the effect of exercise on breathing rate and heart rate*

2.6 Explain why heart rate and breathing rate increase with exercise

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

2.8 Demonstrate an understanding of why, during vigorous exercise, muscle cells may not receive sufficient oxygen for their energy requirements and so start to respire anaerobically

2.9 Demonstrate an understanding of how anaerobic respiration releases energy from glucose and how this process can be modelled using the word equation for anaerobic respiration

2.10 Recall that the process of anaerobic respiration releases less energy than aerobic respiration

2.11 Describe how a build-up of lactic acid requires extra oxygen to break it down. This is called excess post-exercise oxygen consumption or EPOC (formerly known as oxygen debt)

2.12 Explain why heart rate and breathing rate remain high after exercise

2.13 Describe how the structure of a leaf is adapted for photosynthesis, including:

a large surface area

b containing chlorophyll in chloroplasts to absorb light

c stomata for gas exchange (carbon dioxide, oxygen and water vapour)

2.14 Demonstrate an understanding of how photosynthesis uses light energy to produce glucose and how this process can be modelled using the word equation for photosynthesis

2.15 Demonstrate an understanding of how limiting factors affect the rate of photosynthesis, including:

a light intensity

b CO_2 concentration

c temperature

2.16 *Investigate how factors, including the effect of light intensity, CO_2 concentration or temperature, affect the rate of photosynthesis*

2.17 Explain how the loss of water vapour from leaves drives transpiration

2.18 Explain how water, glucose and mineral salts are transported through a plant, including:

a mineral uptake in roots by active transport

b the role of the xylem and phloem vessels

2.19 Describe how root hair cells are adapted to take up water by osmosis

2.20 Define osmosis as the movement of water molecules from an area of higher concentration of water to an area of lower concentration of water through a partially permeable membrane

2.21 *Investigate osmosis*

2.22 *Investigate the relationship between organisms and their environment using fieldwork techniques*

2.23 *Investigate the distribution of organisms in an ecosystem, using sampling techniques including:*

a *pooters*

b *sweep nets/pond nets*

c *pitfall traps*

d *quadrats*

and measure environmental factors including:

e *temperature*

f *light intensity*

g *pH*

Topic 3

Common systems

3.1 Evaluate the evidence for evolution based on the fossil record

3.2 Explain why there are gaps in the fossil record, including:

a because fossils do not always form

b because soft tissue decays

c because many fossils are yet to be found

3.3 **Explain how the anatomy of the pentadactyl limb provides scientists with evidence for evolution**

3.4 Describe growth in terms of increase in size, length and mass

3.5 Interpret growth data in terms of percentile charts

3.6 Explain how cell division, elongation and differentiation contribute to the growth and development of a plant

3.7 Explain how cell division and differentiation contribute to the growth and development of an animal

3.8 Recall the structure and function of the following parts of the blood, including:

a red blood cells

b white blood cells

c plasma

d platelets

3.9 Describe the grouping of cells into tissues, tissues into organs, and organs into organ systems

3.10 Explain how the structure of the heart is related to its function, including:

- a the four major blood vessels associated with the heart (pulmonary artery, pulmonary vein, aorta, vena cava)
- b left atrium and ventricle to pump oxygenated blood
- c right atrium and ventricle to pump deoxygenated blood
- d valves to prevent backflow (names not required)
- e left ventricle has a thicker muscle wall than the right ventricle
- f the direction of blood flow through the heart

3.11 Describe how the circulatory system transports substances around the body, including:

- a arteries transport blood away from the heart
- b veins transport blood to the heart
- c capillaries exchange materials with tissues

3.12 Describe the functions of the parts of the digestive system, including:

- a mouth
- b oesophagus
- c stomach
- d small and large intestines
- e pancreas
- f liver
- g **gall bladder**

3.13 Explain the role of the muscular wall of the alimentary canal in peristalsis

3.14 Explain the role of digestive enzymes, including:

- a carbohydrases, including amylase, which digest starch to simple sugars
- b proteases, including pepsin, which digest proteins to amino acids
- c lipase, which digests fats to fatty acids and glycerol

3.15 **Explain the role of bile in neutralising stomach acid and emulsifying fats**

3.16 **Explain how the structure of villi (large surface area, single layer of cells and capillary network) allows efficient absorption of the soluble products of digestion**

3.17 *Investigate the effect of different concentrations of digestive enzymes, using and evaluating models of the alimentary canal*

3.18 Evaluate the evidence for the claimed benefits of the use of functional foods as part of a healthy diet, including:

a probiotics containing Bifidobacteria and lactic acid bacteria Lactobacillus

b prebiotic oligosaccharides

c plant stanol esters

Unit B3: Using biology

Overview

Content and How Science Works overview

In Unit B3 students study three topics that give them the opportunity to explore some areas of biology in more depth. The aim is to engender an interest in biology that makes them want to pursue the subject further or simply enjoy finding out more about themselves, other organisms and the applications of biology in the world in which they live.

Practical work throughout the unit will give students opportunities to plan and carry out investigations, to devise their own models and evaluate them, to assess and manage risks, to trial their plans and consider how the quality of their data might be improved. It also enables them to analyse data, to draw conclusions providing evidence to support their conclusions, and evaluate to what degree the conclusion supports the hypothesis.

Throughout the unit, students will have the opportunity to improve and demonstrate mathematical skills, including understanding and using direct proportion and simple ratios, calculating arithmetic means, plotting and drawing graphs (line graphs, bar charts, pie charts, scatter graphs, histograms) selecting appropriate scales for the axes, translating information between graphical and numeric form, extracting and interpreting information from charts, graphs and tables and understanding the idea of probability.

There are several opportunities to investigate the way scientists collect data, such as in the screening of plants for medical properties, and to see how this data is used to produce advances in science, such as in medical treatment. Further research on these advances highlights drawbacks and risks as well as advantages, and these aspects will be studied in relation to the use of dialysis, contraception and fertility treatments. With many treatments decisions need to be made about the social, economic and environmental effects, and some of these will be explored in the context of immunisation programmes.

Students are always fascinated by the complex functions of the human body. Topic 1 enables them to study systems and processes with which they are largely unfamiliar, for example the structure and function of the kidney, and hormonal control of the menstrual cycle. A study of sex-linked disorders and the principles of immunisation add to the variety of this topic.

The way scientific ideas change over time, and the role of the scientific community in validating those changes, will be considered when studying the role of Jenner in the development of immunisation.

In Topic 2 students will study different types of behaviour, such as courtship and conditioning. Methods of communication within the animal kingdom are also areas of great interest and the work of ethologists such as Tinbergen and Fossey is covered. Different types of evidence for human evolution are looked at in some depth in the final part of Topic 2.

The study of animal and plant behaviour will provide opportunities to see how scientists gather data and use it to construct theories that can be scientifically tested, and then to see how these theories are applied to explain further observations. The continuing development of scientific knowledge, and the fact that science cannot answer all questions, will be explored in the studies of animal behaviour and human migration.

The focus of Topic 3 is on biotechnology and its applications, covering up-to-date issues such as the use of enzyme technology in the manufacture of vegetarian cheese, sweets and biological washing powders. Ethical issues are considered with respect to the genetic modification of crop plants, for example to confer herbicide resistance and insect resistance.

Assessment overview

This unit is externally assessed, through a one hour, 60 mark, tiered written examination, containing six questions.

The examination will contain a mixture of question styles, including objective questions, short answer questions and extended writing questions.

Practical investigations in this unit

Within this unit, students will develop an understanding of the process of scientific investigations, including that investigations:

- use hypotheses which are tested
- require assessment and management of risks
- require the collection, presentation, analysis and interpretation of primary and secondary evidence including the use of appropriate technology
- should include a review of methodology to assess fitness for purpose
- should include a review of hypotheses in the light of outcomes.

The following specification points are practical investigations which that exemplify the scientific process and may appear in the written examination for this unit:

1.28 *Investigate the conditions affecting growth of micro-organisms (using resazurin dye)*

2.8 *Investigate animal behaviour using choice chambers*

3.4 *Investigate the effect of factors on the growth of yeast, including pH*

3.9 *Investigate the effect of different factors on yogurt making*

3.11 *Investigate the use of immobilised lactase to produce lactose-free milk*

3.12 *Investigate the use of enzymes in food production*

The following are further suggestions for practical work within this unit:

- *Investigate the importance of photoperiodicity in plants*
- *Investigate the behaviour of animals rearing their young, using video technology*
- *Investigate different behaviours exhibited by animals*
- *Investigate how animals use a variety of types of signals to communicate*
- *Investigate the use of chymosin in the manufacture of vegetarian cheese*
- *Investigate the use of invertase (sucrase) produced by Saccharomyces cerevisiae (yeast) in the manufacture of sweets*
- *Investigate the use of enzymes in washing powders*

The controlled assessment task (CAT) for the GCSE in Biology will be taken from any of these practical investigations (specification points and further suggested practical work). This task will change every year, so future CATs will be chosen from this list.

Detailed unit content

In this specification bold text refers to higher tier only content. Italic text refers to practical investigations, which students are required to demonstrate an understanding of.

Topic 1

Control systems

1.1 Demonstrate an understanding that cell metabolism leads to the build-up of waste products in the blood, including carbon dioxide and urea

1.2 Recall that urea is produced from the breakdown of excess amino acids in the liver and is removed by the kidneys

1.3 Describe the structure of the urinary system, including:

- a renal artery and vein
- b kidneys
- c ureters
- d bladder
- e urethra

1.4 Describe possible treatments for kidney failure, including kidney dialysis and organ donation

1.5 Describe the structure of a nephron, including:

- a glomerulus and Bowman's capsule
- b convoluted tubules
- c loop of Henlé
- d collecting duct

1.6 Explain how the structure of the nephron is related to its function in filtering the blood and forming urine (osmoregulation), including:

- a filtration in the glomerulus and Bowman's capsule
- b selective reabsorption of glucose
- c reabsorption of water (osmoregulation)
- d removal of excess water in urine

1.7 **Demonstrate an understanding of the role of ADH (produced by the pituitary gland) in regulating the water content of the blood**

1.8 **Demonstrate an understanding of how ADH production is controlled by a negative feedback mechanism**

1.9 Recall that the menstrual cycle is controlled by the hormones oestrogen and progesterone

1.10 Describe the stages of the menstrual cycle including menstruation, uterus lining thickening and ovulation

1.11 Explain why the uterus lining is maintained if fertilisation occurs

1.12 **Demonstrate an understanding of how oestrogen, progesterone, FSH and LH control the menstrual cycle, including:**

- a **FSH stimulates maturation of follicles, which stimulates oestrogen production**
- b **oestrogen is responsible for repair of the uterus wall**
- c **high levels of oestrogen stimulate a surge in LH, which triggers ovulation**
- d **corpus luteum secretes progesterone, which maintains the lining of the uterus**
- e **progesterone inhibits FSH and LH production**
- f **during pregnancy, progesterone levels remain high**
- g **menstruation is triggered by a drop in oestrogen and progesterone levels**
- h **low progesterone levels allow an increase in FSH levels**

1.13 **Demonstrate an understanding of how the menstrual cycle is controlled by a negative feedback mechanism**

1.14 Explain how the structure of an egg is adapted to its function:

- a cytoplasm to provide nutrients
- b haploid nucleus containing one set of the genetic material
- c immediately after fertilisation the cell membrane around the egg changes to block entry of other sperm

1.15 Explain how the structure of a sperm cell is adapted to its function, including:

- a acrosome containing enzymes
- b haploid nucleus containing one set of the genetic material
- c middle section containing mitochondria
- d tail for motility

1.16 Demonstrate an understanding of the advantages and disadvantages of infertility treatments, including:

- a donation of eggs
- b *in vitro* fertilisation (IVF)
- c use of surrogate mothers
- d use of hormones

1.17 Recall that the sex of a person is controlled by one pair of chromosomes, XX in a female and XY in a male

1.18 Explain how the sex of offspring is determined at fertilisation, using a genetic diagram

1.19 Explain (using probabilities, ratios and percentages) how sex-linked genetic disorders are inherited, including:

- a haemophilia
- b colour blindness

1.20 Describe Edward Jenner's contribution to the development of vaccines

1.21 Explain the process of immunisation, including:

- a harmless pathogen or antigenic material introduced
- b the antigens trigger an immune response which causes the production of antibodies
- c the antigens also trigger production of memory lymphocytes

1.22 Demonstrate an understanding of the advantages and risks associated with immunisation

1.23 **Describe the role of memory lymphocytes in secondary responses to antigen; interpret data showing variation in blood antibody levels in response to first and subsequent infections**

1.24 **Describe the production of monoclonal antibodies, including:**

- a **use of B lymphocytes which produce desired antibodies but do not divide**
- b **production of hybridoma cells**
- c **hybridoma cells produce antibodies and they divide**

1.25 **Demonstrate an understanding of the use of monoclonal antibodies, including:**

- a **in pregnancy testing**
- b **in diagnosis including locating the position of blood clots and cancer cells and in treatment of diseases including cancer**
- c **the advantages of using monoclonal antibodies to target specific cells compared to drug and radiotherapy treatments**

1.26 Describe how the exponential growth of a population of bacteria can lead to rapid development of an infection

1.27 Demonstrate an understanding of Louis Pasteur's contribution to the development of aseptic techniques

1.28 *Investigate the conditions affecting growth of micro-organisms (using resazurin dye)*

1.29 Demonstrate an understanding that plants defend themselves against attack from pests and pathogens by producing chemicals, some of which can be used to treat human diseases, disorders or relieve symptoms

1.30 Demonstrate an understanding of the impact that attack by pests and pathogens on plants has on human food supply

1.31 Explain the importance of photoperiodicity in plants, including

- a plant germination
- b growth
- c reproduction

1.32 Demonstrate an understanding of circadian rhythms in living organisms

Topic 2

Behaviour

2.1 Describe that sexual reproduction requires the finding and selection of a suitable mate, and can involve courtship behaviours that advertise an individual's quality

2.2 Describe how animals have different mating strategies, including:

- a a mate for life
- b several mates over a lifetime
- c a mate for a breeding season
- d several mates over one breeding season

2.3 Describe that some animals, in particular birds and mammals, have developed special behaviours for rearing their young

2.4 Demonstrate an understanding of why parental care can be a successful evolutionary strategy, including:

- a increased chance of survival of offspring
- b increased chance of parental genes being passed on by the offspring

2.5 Explain how, within the animal kingdom, parental care may involve risks to the parents

2.6 Describe the different behaviours exhibited by animals, including:

- a innate behaviour
- b imprinting
- c habituation
- d classical conditioning
- e operant conditioning

2.7 Explain how humans can make use of conditioning when training captive animals for specific purposes, including:

- a sniffer dogs
- b police horses
- c dolphins

2.8 *Investigate animal behaviour using choice chambers*

2.9 Describe how some animal behaviour requires communication

2.10 Explain how animals use a variety of types of signals to communicate, including:

- a sound signals
- b chemical signals (pheromones)
- c visual signals (gestures, body language, facial expression)

2.11 Describe how plants can communicate using chemicals, including:

- a with animals (particularly insects)
- b with other plants

2.12 Demonstrate an understanding of the work of ethologists, including:

- a Tinbergen, innate behaviour in gulls
- b Lorenz, imprinting in geese
- c Fossey, social behaviour in gorillas
- d Goodall, social behaviour in chimpanzees

2.13 **Demonstrate an understanding of how plants and animals have co-evolved, including:**

- a **flower structure and insect behaviour in pollination**
- b **plant defence and animal metabolism**

2.14 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 Leakey's discovery of fossils from 1.6 million years ago

2.15 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

2.16 **Describe why mitochondrial DNA provides evidence for the African Eve theory for non-Africans, including:**

- a **its inheritance down the female line**
- b **its high mutation rate**

2.17 **Demonstrate an understanding of why mitochondrial DNA is more useful than nuclear DNA for tracking human migration and evolution, including:**

- a **mitochondrial DNA is less likely to have degraded over time**
- b **mitochondrial DNA is more abundant**

2.18 Demonstrate an understanding of the impact of climate change on human behaviour, including:

- a the effect of the Ice Age
- b human migration

Topic 3

Biotechnology

3.1 Describe biotechnology as the alteration of natural biomolecules using science and engineering to provide goods and services

3.2 Describe a fermenter as a vessel used to cultivate micro-organisms for the production of biomolecules on a large scale

3.3 Explain the need to supply suitable conditions in fermenters, and the effect they have on growth rates, including:

- a aseptic precautions
- b nutrients
- c optimum temperature
- d pH
- e oxygenation
- f agitation

3.4 *Investigate the effect of factors on the growth of yeast, including pH*

3.5 Explain the advantages of using micro-organisms for food production, including:

- a rapid population growth
- b ease of manipulation
- c production independent of climate
- d use of waste products from other industrial processes

3.6 Describe how mycoprotein is manufactured, including the role of the fungus *Fusarium sp.*

3.7 Explain the advantages of using mycoprotein as a food source

3.8 Describe how bacteria are used in the production of yogurt from milk by the conversion of lactose to lactic acid

3.9 *Investigate the effect of different factors on yogurt making*

3.10 Describe the use of enzyme technology including:

- a chymosin, produced by genetically modified micro-organisms, used in the manufacture of vegetarian cheese
- b invertase (sucrase) produced by Saccharomyces cerevisiae (yeast), used in the manufacture of sweets
- c enzymes used in washing powders

3.11 *Investigate the use of immobilised lactase to produce lactose-free milk*

3.12 *Investigate the use of enzymes in food production*

3.13 **Explain recombinant DNA technology using insulin as an example, including:**

- a **restriction enzymes**
- b **ligase**
- c **sticky ends**

3.14 Demonstrate an understanding of the impact of human population growth on global food security

3.15 Explain how *Agrobacterium tumefaciens* is used as a vector in creating transgenic plants

3.16 **Demonstrate an understanding of the advantages and disadvantages of introducing genes for insect resistance from *Bacillus thuringiensis* into crop plants**

3.17 Demonstrate an understanding of the costs and benefits of genetic modification of crop plants in the context of developed and developing countries, including the introduction of flavonoids in the purple tomato

3.18 Explain how increased food production for humans includes:

- a conventional plant breeding programmes
- b pest management strategies
- c genetic modification

3.19 Demonstrate an understanding of the advantages and disadvantages of replacing fossil fuels with biofuels, including the facts that biofuels are renewable and that their production uses carbon dioxide but that growing the crops to make them requires land and may affect the availability of land for growing food