2c. Content of topics B1 to B6

Topic B1: Cell level systems

B1.1 Cell structures

Summary
Cells are the fundamental units of living organisms. Cells contain many sub-cellular structures that are essential for the functioning of the cell as a whole. Microscopy is used to examine cells and sub-cellular structures.

Underlying knowledge and understanding
Learners should be familiar with cells as the fundamental unit of living organisms, and with the use of light microscopes to view cells. They should also be familiar with some sub-cellular structures, and the similarities and differences between plant and animal cells.

Common misconceptions
Learners commonly have difficulty understanding the concept of a cell as a 3D structure, so this should be addressed during the teaching of this topic.

Tiering
Statements shown in **bold** type will only be tested in the Higher Tier papers. All other statements will be assessed in both Foundation and Higher Tier papers.

Reference	Mathematical learning outcomes	Mathematical skills
BM1.1i	demonstrate an understanding of number, size and scale and the quantitative relationship between units	M2a and M2h
BM1.1ii	use estimations and explain when they should be used	M1d
BM1.1iii	**calculate with numbers written in standard form**	**M1b**

Topic content		Opportunities to cover:		Practical suggestions
Learning outcomes	**To include**	**Maths**	**Working scientifically**	
B1.1a describe how light microscopes and staining can be used to view cells	lenses, stage, lamp, use of slides and cover slips, and the use of stains to view colourless specimens or to highlight different structures/ tissues and calculation of magnification	**M1b**, M1d, M2a, M2h	WS1.2c, WS1.4c, WS1.4d, WS1.4e, WS2a, WS2b, WS2c, WS2d	Investigation of a range of cells using pictures, light micrographs and diagrams. Measure the size and magnification of the cells. (PAG B1, PAG B7) Preparation of cheek cell slides. (PAG B7) Preparation of onion epidermis cells slides. (PAG B7) Use of light microscopes to view plant and animal cells. (PAG B7)
B1.1b explain how the main sub-cellular structures of eukaryotic cells (plants and animals) and prokaryotic cells are related to their functions	nucleus, genetic material, chromosomes, plasmids, mitochondria (contain enzymes for cellular respiration), chloroplasts (contain chlorophyll) and cell membranes (contain receptor molecules, provides a selective barrier to molecules)		WS1.4a, WS2a, WS2b, WS2c, WS2d	Production of 3D model plant and animal cells to illustrate their differences. Investigation of cytoplasmic streaming in Elodea spp. (PAG B6, PAG B7)
B1.1c explain how electron microscopy has increased our understanding of sub-cellular structures	increased resolution in a transmission electron microscope	**M1b**	WS1.1a, WS1.4c, WS1.4d	Comparison of a range of cells using pictures from light and electron micrographs. Comparison of the visible structures visible on light and electron micrographs.

B1.2 What happens in cells (and what do cells need)?

Summary

Life processes depend on biological molecules whose structure is related to their function. Inside every cell is genetic material and this is used as a code to make proteins. Enzymes are important proteins in biology.

Underlying knowledge and understanding

Learners should have a simple understanding of the double helix model of DNA. Learners should be familiar with the idea of enzymes as biological catalysts.

Common misconceptions

Learners commonly hold the misconception that DNA is made of protein or sugar. Learners also think that all enzymes have an optimum temperature of 37°C (human body temperature). The range of optimum temperatures of enzymes should be introduced through the teaching of this topic and further addressed when considering homeostatic mechanisms for controlling temperature.

Tiering

Statements shown in **bold** type will only be tested in the Higher Tier papers. All other statements will be assessed in both Foundation and Higher Tier papers.

Reference	Mathematical learning outcomes	Mathematical skills
BM1.2i	carry out rate calculations for chemical reactions	M1a and M1c
BM1.2ii	understand and use simple compound measures such as the rate of a reaction	M1a and M1c

Topic content			Opportunities to cover:		Practical suggestions
Learning outcomes		To include	Maths	Working scientifically	
B1.2a	describe DNA as a polymer			WS1.4a	Production of 3D models of DNA to illustrate its structure.
B1.2b	describe DNA as being made up of two strands forming a double helix				
B1.2c	describe that DNA is made from four different nucleotides; each nucleotide consisting of a common sugar and phosphate group with one of four different bases attached to the sugar	the pairs of complementary bases (A-T and G-C)		WS1.4a, WS2a, WS2b, WS2c, WS2d	Production of 3D models of DNA to illustrate its structure. Investigation of DNA extraction from a living organism (e.g. kiwi, leek, onion, wheat germ). (PAG B2)
B1.2d ☑	**recall a simple description of protein synthesis**	**the unzipping of the DNA molecule around the gene, copying to mRNA in nucleus (transcription), (translation) of the nucleotide sequence, in the cytoplasm**			Comparison of transcription and translation to a non-lending library. Use of kinaesthetic activities to demonstrate transcription and translation.
B1.2e ☑	**explain simply how the structure of DNA affects the proteins made in protein synthesis**	**triplet code and its use to determine amino acid order in a protein**			

Learning outcomes		To include	Maths	Working scientifically	Practical suggestions
B1.2f	describe experiments that can be used to investigate enzymatic reactions		M1a, M1c, M2g	WS1.1h, WS1.2b, WS1.2c, WS1.2e, WS1.3a, WS1.3b, WS1.3c, WS1.3d, WS1.3e, WS1.3f, WS1.3g, WS2a, WS2b, WS2c, WS2d	Investigations of enzyme activity, including numerical analysis of data and graphical representation of results. (PAG B2, PAG B4, PAG B6)
B1.2g	explain the mechanism of enzyme action	the role of enzymes in metabolism, the role of the active site, enzyme specificity (lock and key hypothesis) and factors affecting the rate of enzyme controlled reactions (pH, temperature, substrate and enzyme concentration)	M1a, M1c, M3d, M4b	WS2a, WS2b, WS2c, WS2d	Investigation into the effect of amylase on a baby rice paste. (PAG B2, PAG B4, PAG B6) Investigation of enzyme controlled reactions. (PAG B2, PAG B4, PAG B6) Work out rate equations using simple algebraic equations. (PAG B4)

B1.3 Respiration

Summary
Metabolic processes such as respiration are controlled by enzymes. Organic compounds are used as fuels in cellular respiration to allow the other chemical reactions necessary for life.

Underlying knowledge and understanding
Learners should also have some underpinning knowledge of respiration. This should include that respiration involves the breakdown of organic molecules to enable all the other chemical processes necessary for life. Learners should be able to recall the word equation for respiration.

Common misconceptions
Learners commonly hold the misconception that ventilation is respiration. They can also get confused between the terms breakup and breakdown.

Tiering
Statements shown in **bold** type will only be tested in the Higher Tier papers. All other statements will be assessed in both Foundation and Higher Tier papers.

Topic content			Opportunities to cover:		Practical suggestions
Learning outcomes		To include	Maths	Working scientifically	
B1.3a	describe cellular respiration as a universal chemical process, continuously occurring that supplies ATP in all living cells			WS1.2a	
B1.3b	describe cellular respiration as an exothermic reaction			WS1.2b	Demonstration of an exothermic reaction (e.g. heat pack).
B1.3c	compare the processes of aerobic respiration and anaerobic respiration	in plants/fungi and animals the different conditions, substrates, products and relative yields of ATP		WS2a, WS2b, WS2c, WS2d	Research into whether plants respire. (PAG B2, PAG B4, PAG B5, PAG B6) Investigation of fermentation in fungi. (PAG B2, PAG B4, PAG B5, PAG B6) Investigation of respiration in yeast using alginate beads to immobilise the fungus. (PAG B2, PAG B4, PAG B5, PAG B6)

Learning outcomes		To include	Maths	Working scientifically	Practical suggestions
B1.3d	explain the importance of sugars in the synthesis and breakdown of carbohydrates	use of the terms monomer and polymer			Demonstration of the synthesis and breakdown of biological molecules (e.g. using Lego bricks).
B1.3e	explain the importance of amino acids in the synthesis and breakdown of proteins	use of the terms monomer and polymer			
B1.3f	explain the importance of fatty acids and glycerol in the synthesis and breakdown of lipids				

B1.4 Photosynthesis

Summary
Life processes depend on photosynthesis. Green plants and algae trap light from the Sun to fix carbon dioxide with hydrogen from water making organic compounds.

Underlying knowledge and understanding
Learners should also have some underpinning knowledge of photosynthesis. They should have an understanding that plants make carbohydrates in their leaves by photosynthesis, and be able to recall the word equation for photosynthesis.

Common misconceptions
Learners often think that plants do not respire.

Tiering
Statements shown in **bold** type will only be tested in the Higher Tier papers. All other statements will be assessed in both Foundation and Higher Tier papers.

Reference	Mathematical learning outcomes	Mathematical skills
BM1.4i	understand and use simple compound measures such as the rate of a reaction	M1a and M1c
BM1.4ii	translate information between graphical and numerical form	M4a
BM1.4iii	plot and draw appropriate graphs, selecting appropriate scales and axes	M4a and M4c
BM1.4iv	extract and interpret information from graphs, charts and tables	M2c and M4a
BM1.4v	**understand and use inverse proportion – the inverse square law and light intensity in the context of factors affecting photosynthesis**	**M1c**

Topic content			Opportunities to cover:		Practical suggestions
Learning outcomes		To include	Maths	Working scientifically	
B1.4a	describe photosynthetic organisms as the main producers of food and therefore biomass for life on Earth				Use of concept cartoons to start discussions about photosynthesis.
B1.4b	describe the process of photosynthesis	reactants and products, two-stage process, location of the reaction (in the chloroplasts)		WS2a, WS2b, WS2c, WS2d	Investigation of photosynthesis e.g. the Priestley experiment using *Cabomba* to collect oxygen or the Ingenhousz experiment to show mass gain. (PAG B4, PAG B5, PAG B6)
B1.4c	describe photosynthesis as an endothermic reaction			WS1.3b, WS1.3c, WS1.3e	Demonstrate of an endothermic reaction (e.g. icepack).
B1.4d	describe experiments to investigate photosynthesis			WS2a, WS2b, WS2c, WS2d	Experiments to show the consequences of light exclusion on photosynthesising plants (e.g. testing geraniums for starch). (PAG B4, PAG B5, PAG B6)
B1.4e	explain the effect of temperature, light intensity and carbon dioxide concentration on the rate of photosynthesis		M1a, M1c, M4a, M4b, M4c, M2g	WS2a, WS2b, WS2c, WS2d	Investigation of photosynthesis in algae using alginate beads to immobilize the algae. (PAG B4, PAG B5, PAG B6)
B1.4f	**explain the interaction of these factors in limiting the rate of photosynthesis**		M1d, M2c, M4a, **M1c**	WS1.2b, WS1.2c, WS1.2e WS1.3a, WS1.3b, WS1.3c, WS1.3d, WS1.3f, WS1.3g, WS1.4e, WS2c, WS2d	

Topic B2: Scaling up

B2.1 Supplying the cell

Summary
Cells transport many substances across their membranes by diffusion, osmosis and active transport. Stem cells are found in both plants and animals. These stem cells can divide, differentiate and become specialised to form tissues, organs and organ systems.

Underlying knowledge and understanding
Learners should be familiar with the role of diffusion in the movement of materials in and between cells.

Common misconceptions
Learners commonly show some confusion regarding surface area: volume ratio, particularly how larger animals have a smaller surface area: volume ratio. They also show some confusion as to stem cells: where they are found and their roles. Care should be taken to give clear definitions when covering this content.

Tiering
Statements shown in **bold** type will only be tested in the Higher Tier papers. All other statements will be assessed in both Foundation and Higher Tier papers.

Reference	Mathematical learning outcomes	Mathematical skills
BM2.1i	use percentiles and calculate percentage gain and loss of mass	M1c

Topic content			Opportunities to cover:		Practical suggestions
Learning outcomes		To include	Maths	Working scientifically	
B2.1a	explain how substances are transported into and out of cells through diffusion, osmosis and active transport	examples of substances moved, direction of movement, concentration gradients and use of the term water potential (no mathematical use of water potential required)	M1c, M1d	WS2a, WS2b, WS2c, WS2d	Observation of osmosis in plant cells using a light microscope. Investigation of 'creaming yeast' to show osmosis. (PAG B6, PAG B8) Investigation into changes in mass of vegetable chips when placed in sucrose/salt concentrations of varying concentrations. (PAG B6, PAG B8)
B2.1b	describe the process of mitosis in growth, including the cell cycle	the stages of the cell cycle as DNA replication, movement of chromosomes, followed by the growth of the cell		WS2a, WS2b, WS2c, WS2d	Modelling of mitosis using everyday objects e.g. shoes, socks etc. Observation of mitosis in stained root tip cells. (PAG B1, PAG B6, PAG B7)
B2.1c	explain the importance of cell differentiation	the production of specialised cells allowing organisms to become more efficient and examples of specialised cells		WS2a, WS2b, WS2c, WS2d	Examination of a range of specialised cells using a light microscope. (PAG 1)
B2.1d	recall that stem cells are present in embryonic and adult animals and meristems in plants				Demonstration of cloning using cauliflower. (PAG B6, PAG B7)
B2.1e	describe the functions of stem cells	division to produce a range of different cell types for development, growth and repair		WS1.1e, WS1.1f, WS1.1h	
B2.1f	describe the difference between embryonic and adult stem cells in animals				Research into the different types of stem cells.

B2.2 The challenges of size

Summary
When organisms become multicellular, the need arises for highly adapted structures including gaseous exchange surfaces and transport systems, enabling living processes to be performed effectively.

Underlying knowledge and understanding
Learners should be familiar with the role of diffusion in the movement of materials in and between cells. They should also be familiar with the human gaseous exchange system.

Common misconceptions
Learners have a view that the slow flow of blood in capillaries is due to the narrow diameter, when in fact it is a function of the total cross-sectional area of the capillaries (1000 times greater than the aorta). When explaining the importance of the slow flow of blood in allowing time for exchange by diffusion, this misunderstanding should be considered.

Tiering
Statements shown in **bold** type will only be tested in the Higher Tier papers.
All other statements will be assessed in both Foundation and Higher Tier papers.

Reference	Mathematical learning outcomes	Mathematical skills
BM2.2i	calculate surface area : volume ratios	M1c
BM2.2ii	use simple compound measures such as rate	M1a and M1c
BM2.2iii	carry out rate calculations	M1a and M1c
BM2.2iv	plot, draw and interpret appropriate graphs	M4a, M4b, M4c and M4d

Topic content			Opportunities to cover:		Practical suggestions
Learning outcomes		To include	Maths	Working scientifically	
B2.2a	explain the need for exchange surfaces and a transport system in multicellular organisms in terms of surface area : volume ratio	surface area, volume and diffusion distances	M1c	WS1.4d, WS1.4e, WS1.4f, WS2a, WS2b, WS2c, WS2d	Investigating surface area : volume ratio using hydrochloric acid and gelatine cubes stained with phenolphthalein or other suitable pH indicator. (PAG B8)
B2.2b	describe some of the substances transported into and out of a range of organisms in terms of the requirements of those organisms	oxygen, carbon dioxide, water, dissolved food molecules, mineral ions and urea			
B2.2c	describe the human circulatory system	the relationship with the gaseous exchange system, the need for a double circulatory system in mammals and the arrangement of vessels			Modelling of the human circulatory system.
B2.2d	explain how the structure of the heart and the blood vessels are adapted to their functions	the structure of the mammalian heart with reference to valves, chambers, cardiac muscle and the structure of blood vessels with reference to thickness of walls, diameter of lumen, presence of valves		WS2a, WS2b, WS2c, WS2d	Investigating heart structure by dissection. Investigation of a blood smear using a light microscope. (PAG B1) Modelling of blood using sweets to represent the components.
B2.2e	explain how red blood cells and plasma are adapted to their transport functions in the blood			WS2a, WS2b, WS2c, WS2d	Examine the gross structure of blood vessels using a light microscope. (PAG B1) Investigating of the elasticity of different blood vessels using hanging masses.

Learning outcomes		To include	Maths	Working scientifically	Practical suggestions
B2.2f	explain how water and mineral ions are taken up by plants, relating the structure of the root hair cells to their function			WS2a, WS2b, WS2c, WS2d	Examination of root hair cells using a light microscope. (PAG B1) Demonstration of the effectiveness of transpiration by trying to suck water from a bottle using a 10m straw. (PAG B8) Investigation of the position of the xylem/phloem in root, stem and leaf tissues using a light microscope. (PAG B1) Interpretation of experimental evidence of the movement of dissolved food materials in a plant. (PAG B1, PAG B8)
B2.2g	describe the processes of transpiration and translocation	the structure and function of the stomata		WS2a, WS2b, WS2c, WS2d	Measurement of plant stomatal density by taking an impression of the leaf using clear nail varnish or spray-on plaster. (PAG B1, PAG B6, PAG B8)
B2.2h	explain how the structure of the xylem and phloem are adapted to their functions in the plant				
B2.2i	explain the effect of a variety of environmental factors on the rate of water uptake by a plant	light intensity, air movement, and temperature	M1a, M1c, M1d	WS2a, WS2b, WS2c, WS2d	Interpreting experimental evidence of investigations into environmental factors that affect water uptake. (PAG B6, PAG B8)
B2.2j	describe how a simple potometer can be used to investigate factors that affect the rate of water uptake		M1a, M1c, M1d, M2g, M3d, M4a, M4b, M4c, M4d	WS1.2b, WS1.2c, WS1.2e WS1.3a, WS1.3b, WS1.3c, WS1.3d, WS1.3e, WS1.3f, WS1.3g, WS2a, WS2b, WS2c, WS2d	Investigation of transpiration rates from a plant cutting. (PAG B6, PAG B8) Work out the rate of transpiration in volume of water/time. (PAG B6, PAG B8)

Topic B3: Organism level systems

B3.1 Coordination and control – the nervous system

Summary
The human nervous system is an important part of how the body communicates with itself and also receives information from its surroundings.

Underlying knowledge and understanding
Learners should have a concept of the hierarchical organism of multicellular organisms from cells to tissues to organs to systems to organisms.

Common misconceptions
Learners commonly think that their eyes see objects 'directly', like a camera, but the reality is that the image formed by the brain is based on the eyes and brains interpretation of the light that comes into the eye i.e. different people will perceive the same object or image differently. Young learners also have the misconception that some sort of 'force' comes out of the eye, enabling it to see.

Tiering
Statements shown in **bold** type will only be tested in the Higher Tier papers. All other statements will be assessed in both Foundation and Higher Tier papers.

Reference	Mathematical learning outcomes	Mathematical skills
BM3.1i	extract and interpret data from graphs, charts and tables	M2c

Topic content		Opportunities to cover:		Practical suggestions
Learning outcomes	**To include**	**Maths**	**Working scientifically**	
B3.1a describe the structure of the nervous system	Central Nervous System, sensory and motor neurones and sensory receptors			Production of 3D models of neurones to illustrate their structure.
B3.1b explain how the components of the nervous system can produce a coordinated response	it goes to all parts of the body, has many links, has different sensory receptors and is able to coordinate responses			Demonstration (by video) of someone trying to do everyday tasks whilst being given mild electric shocks (e.g. BBC Brainiac).
B3.1c explain how the structure of a reflex arc is related to its function			M1d, WS2a, WS2b, WS2c, WS2d	Demonstration of reaction time by getting a learner to catch a falling £5 note. Research into reflexes. (PAG B6) Investigating of reaction times by ruler drop. (PAG B6)

Learning outcomes		To include	Maths	Working scientifically	Practical suggestions
B3.1d ☑	explain how the main structures of the eye are related to their functions	cornea, iris, pupil, lens, retina, optic nerve, ciliary body, suspensory ligaments			Demonstration of the inversion of an image through a beaker full of water. Demonstration of the features of the human eye. Investigation of eye structure by dissection. (PAG B1)
B3.1e ☑	describe common defects of the eye and explain how some of these problems may be overcome	colour blindness, short-sightedness and long-sightedness		WS2a, WS2b, WS2c, WS2d	Measurement of focal length in a variety of situations. (PAG B6) Research into eye defects, their diagnosis and treatment.
B3.1f ☑	describe the structure and function of the brain	cerebrum, cerebellum, medulla, hypothalamus, pituitary			
B3.1g ☑	**explain some of the difficulties of investigating brain function**	**the difficulty in obtaining and interpreting case studies and the consideration of ethical issues**			Discussion of problems associated with brain research including the difficulty in getting research subjects.
B3.1h ☑	**explain some of the limitations in treating damage and disease in the brain and other parts of the nervous system**	**limited ability to repair nervous tissue, irreversible damage to the surrounding tissues, difficulties with accessing parts of the nervous system**		WS1.1e, WS1.1f, WS1.1h	Research into a study of brain injury.

B3.2 Coordination and control – the endocrine system

Summary

Hormones are chemical messengers. In animals, hormones are transported around the body in the blood and affect target tissues and organs. Hormones have a variety of roles in the human body, including controlling reproduction. Plant hormones are chemicals that regulate plant growth and development. They can be used in agriculture to control the rate of growth.

Underlying knowledge and understanding

Learner should be aware of a number of hormones including adrenaline and the male and female sex hormones.

Common misconceptions

With regards to the menstrual cycle, research has shown that learners have problems relating the time of conception to the condition of the lining of the uterus.

Tiering

Statements shown in **bold** type will only be tested in the Higher Tier papers. All other statements will be assessed in both Foundation and Higher Tier papers.

Reference	Mathematical learning outcomes	Mathematical skills
BM3.2i	extract and interpret data from graphs, charts and tables	M2c
BM3.2ii	translate information between numerical and graphical forms	M4a

Topic content		Opportunities to cover:		Practical suggestions
Learning outcomes	To include	Maths	Working scientifically	
B3.2a describe the principles of hormonal coordination and control by the human endocrine system	use of chemical messengers, transport in blood, endocrine glands and receptors			
B3.2b explain the roles of thyroxine and adrenaline in the body	thyroxine as an example of a negative feedback system			

Learning outcomes		To include	Maths	Working scientifically	Practical suggestions
B3.2c	describe the role of hormones in human reproduction including the control of the menstrual cycle	oestrogen, progesterone, FSH and testosterone		WS1.3b, WS1.3e	
B3.2d	**explain the interactions of FSH, LH, oestrogen and progesterone in the control of the menstrual cycle**		M2c, M4a, M2g		Analysis of relative hormones levels from raw data and graphically.
B3.2e	explain the use of hormones in contraception and evaluate hormonal and non-hormonal methods of contraception	relative effectiveness of the different forms of contraception	M2c, M4a	WS1.1d, WS1.1e, WS1.1f	Discussion into the various methods of contraception and their effective/ethical use.
B3.2f	**explain the use of hormones in modern reproductive technologies to treat infertility**			WS1.1d, WS1.1e, WS1.1f, WS1.1h	Research into *Xenopus laevis* pregnancy testing to detect hCG by the stimulation of oogenesis. Research into hormonal treatments for infertility.
B3.2g ☑	explain how plant hormones are important in the control and coordination of plant growth and development, with reference to the role of auxins in phototropisms and gravitropisms	unequal distribution of auxin		WS2a, WS2b, WS2c, WS2d	Investigation of the effects of phototropism using seedlings. (PAG B6)
B3.2h ☑	describe some of the variety of effects of plant hormones, relating to auxins, **gibberellins and ethene**	controlling growth, controlling germination, fruit ripening, flower opening and shedding of leaves		WS2a, WS2b, WS2c, WS2d	Investigation/research into the question 'does one bad banana spoil the fruit bowl?' (PAG B2, PAG B6)
B3.2i ☑	**describe some of the different ways in which people use plant hormones to control plant growth**	**selective herbicides, root cuttings, seedless fruit (parthenocarpic fruit development), altering dormancy**			

B3.3 Maintaining internal environments

Summary
Homeostasis is crucial to the regulation of internal environments and enables organisms to adapt to change, both internally and externally. Internal temperature, blood sugar levels and osmotic balance are regulated by a number of organs and systems working together.

Underlying knowledge and understanding
Learners will build on the knowledge and understanding gained in section 3.1 about coordination and control when considering the topics in this section.

Common misconceptions
Learners often confuse type 1 and type 2 diabetes, and the effective treatments for each. The effect of ADH on the permeability of the kidney tubules is often confused.

Tiering
Statements shown in **bold** type will only be tested in the Higher Tier papers. All other statements will be assessed in both Foundation and Higher Tier papers.

Reference	Mathematical learning outcomes	Mathematical skills
BM3.3i	extract and interpret data from graphs, charts and tables	M2c

Topic content			Opportunities to cover:		Practical suggestions
Learning outcomes		To include	Maths	Working scientifically	
B3.3a	explain the importance of maintaining a constant internal environment in response to internal and external change	allowing metabolic reactions to proceed at appropriate rates		WS1.4a	Research into hypothermia.
B3.3b ☑	describe the function of the skin in the control of body temperature	detection of external temperature, sweating, shivering, change to blood flow		WS2a, WS2b, WS2c, WS2d	Demonstration of the cooling effect of sweating using alcohol based surgical wipes. (PAG B6) Investigation into heat loss by using microwaved plasticine shapes/model 'animals' by using a UV heat camera/thermometers. (PAG B6)
B3.3c	explain how insulin controls blood sugar levels in the body		M2g		

Learning outcomes		To include	Maths	Working scientifically	Practical suggestions
B3.3d	**explain how glucagon interacts with insulin to control blood sugar levels in the body**		M2c	WS2a, WS2b, WS2c, WS2d	Investigations into the glucose content of artificial urine to diagnose diabetes, using e.g. Clinistix. (PAG B6)
B3.3e	compare type 1 and type 2 diabetes and explain how they can be treated				
B3.3f ☑	explain the effect on cells of osmotic changes in body fluids	higher, lower or equal water potentials leading to lysis or shrinking (no mathematical use of water potentials required)		WS2a, WS2b, WS2c, WS2d	Demonstration of the different water potentials on different cells. (PAG B6, PAG B8)
B3.3g ☑	describe the function of the kidneys in maintaining the water balance of the body	varying the amount and concentration of urine and hence water excreted		WS1.3b, WS2a, WS2b, WS2c, WS2d	Investigation of the structure of the structure of a kidney by dissection and the application of H_2O_2 to visualise the nephrons. (PAG B6, PAG B8) Investigations into the glucose content of artificial urine to diagnose diabetes, using e.g. Clinistix. (PAG B6)
B3.3h	describe the gross structure of the kidney and the structure of the kidney tubule				
B3.3i ☑	**describe the effect of ADH on the permeability of the kidney tubules**	**amount of water reabsorbed and negative feedback**		WS2a, WS2b, WS2c, WS2d	Investigation of the different sections of a nephron and the composition of the filtrate from each area. (PAG B2, PAG B6, PAG B8)
B3.3j ☑	**explain the response of the body to different temperature and osmotic challenges**	**challenges to include high sweating and dehydration, excess water intake, high salt intake responses to include mechanism of kidney function, thirst**			Research into sports drinks and evaluation into which is best for athletes. (PAG B2, PAG B6, PAG B8)

Topic B4: Community level systems

B4.1 Ecosystems

Summary
Microorganisms play an important role in the continuous cycling of chemicals in ecosystems. Biotic and abiotic factors interact in an ecosystem and have an effect on communities. Living organisms form populations of single species, communities of many species and are part of ecosystems. Living organisms are interdependent and show adaptations to their environment. Feeding relationships reflect the stability of an ecosystem and indicate the flow of biomass through the ecosystem.

Underlying knowledge and understanding
Learners should be familiar with the idea of a food web and the interrelationships associated with them and that variation allows living things to survive in the same ecosystem. They should also recognise that organisms affect their environment and are affected by it.

Common misconceptions
Research has shown that it is easier for a learner to explain the consequences on a food web if the producers are removed for some reason than if the top predators are taken away. It is also better to start off explaining ideas relating to food webs using small simple webs with animals and plants that learners are likely to know e.g. rabbits and foxes. Learners find arrows showing the flow of biomass from one trophic level to another quite challenging and often mistake it for the direction of predation. This makes problems relating to the manipulation of a food web quite difficult for some.

Tiering
Statements shown in **bold** type will only be tested in the Higher Tier papers. All other statements will be assessed in both Foundation and Higher Tier papers.

Reference	Mathematical learning outcomes	Mathematical skills
BM4.1i ☑	calculate rate changes in the decay of biological material	M1c
BM4.1ii	calculate the percentage of mass	M1c
BM4.1iii	Use fractions and percentages	M1c
BM4.1iv	plot and draw appropriate graphs selecting appropriate scales for the axes	M4a and M4c
BM4.1v	extract and interpret information from charts, graphs and tables	M2c and M4a

Topic content			Opportunities to cover:		Practical suggestions
Learning outcomes		To include	Maths	Working scientifically	
B4.1a	recall that many different materials cycle through the abiotic and biotic components of an ecosystem	examples of cycled materials e.g. nitrogen and carbon			
B4.1b	explain the role of microorganisms in the cycling of materials through an ecosystem	the role of microorganisms in decomposition			Research into the range of ecosystems and examples of micro-organisms that act as decomposers within them. (PAG B1, PAG B3, PAG B4, PAG B7)
B4.1c	explain the importance of the carbon cycle and the water cycle to living organisms	maintaining habitats, fresh water flow of nutrients			
B4.1d ☑	explain the effect of factors such as temperature, water content, and oxygen availability on rate of decomposition	the terms aerobic and anaerobic	M1c, M2c, M4a, M4c	WS1.1b, WS1.1h, WS1.2b, WS1.2c, WS1.2e, WS1.3a, WS1.3b, WS1.3c, WS1.3d, WS1.3e, WS1.3f, WS1.3g, WS2a, WS2b, WS2c, WS2d	Investigation of the most favourable conditions for composting. (PAG B1, PAG B3, PAG B4, PAG B7)
B4.1e	describe different levels of organisation in an ecosystem from individual organisms to the whole ecosystem				
B4.1f	explain how abiotic and biotic factors can affect communities	temperature, light intensity, moisture level, pH of soil, predators, food	M3a	WS1.3a, WS1.3b, WS1.3e WS1.3h, WS2a, WS2b, WS2c, WS2d	Identification of the biotic factors in an ecosystem using sampling techniques. (PAG B3)

Learning outcomes		To include	Maths	Working scientifically	Practical suggestions
B4.1g	describe the importance of interdependence and competition in a community	interdependence relating to predation, mutualism and parasitism		WS1.4a, WS2a, WS2b, WS2c, WS2d	Examination of the roots of a leguminous plant e.g. clover to observe the root nodules. (PAG B1) Investigation of the holly leaf miner or the horse-chestnut leaf miner (*Cameraria ohridella*) (PAG B1, PAG B3)
B4.1h ☑	describe the differences between the trophic levels of organisms within an ecosystem	use of the terms producer and consumer			Investigation of the trophic levels within a children's story (e.g. *The Gruffalo*)
B4.1i ☑	describe pyramids of biomass and explain, with examples, how biomass is lost between the different trophic levels	loss of biomass related to egestion, excretion, respiration	M1c, M4a	WS1.3c, WS1.3e	Discussion of the best food source for humans (e.g. 'wheat vs. meat') Production of ecological pyramids.
B4.1j ☑	calculate the efficiency of biomass transfers between trophic levels and explain how this affects the number of trophic levels in a food chain		M1c		Calculation of the biomass transfers using real data.

Topic B5: Genes, inheritance and selection

B5.1 Inheritance

Summary
Inheritance relies on the genetic information contained in the genome being passed from one generation to the next, whether sexually or asexually. The characteristics of a living organism are influenced by the genome and its interaction with the environment.

Underlying knowledge and understanding
Learners should be familiar with the idea of heredity as the process by which genetic information is passed from one generation to the next. They should have a simple model of chromosomes, genes and DNA.

Common misconceptions
Learners commonly struggle to appreciate the physical relationships between the nucleus, genetic material, the genome, chromosomes and genes. Accurate definitions of these terms will help learners' explanations in this topic. Learners often have well-developed (although not necessarily scientifically accurate) explanations for inheritance before undertaking GCSE study. Some examples include that intra-specific variation is as a result of defects in development or that acquired characteristics can be inherited. Care must also be taken with the concept of dominant and recessive alleles. Whether an allele is dominant or recessive does not affect the mechanism of inheritance of the allele, but is an observed pattern in the phenotype of organisms. Many learners assume that the dominant allele 'dominates' the recessive allele preventing its expression (which is not the case) or that the recessive allele is actually just an absence of the dominant allele (also not generally the case).

Tiering
Statements shown in **bold** type will only be tested in the Higher Tier papers. All other statements will be assessed in both Foundation and Higher Tier papers.

Reference	Mathematical learning outcomes	Mathematical skills
BM5.1i	understand and use direct proportions and simple ratios in genetic crosses	M1c
BM5.1ii	understand and use the concept of probability in predicting the outcome of genetic crosses	M2e
BM5.1iii	extract and interpret information from charts, graphs and tables	M2c and M4a

Topic content			Opportunities to cover:		Practical suggestions
Learning outcomes		To include	Maths	Working scientifically	
B5.1a	explain the following terms: gamete, chromosome, gene, allele/variant, dominant, recessive, homozygous, heterozygous, genotype and phenotype				Use of alleles to work out the phenotype of progeny.
B5.1b	describe the genome as the entire genetic material of an organism				
B5.1c	describe that the genome, and its interaction with the environment, influence the development of the phenotype of an organism	use of examples of discontinuous and continuous variation e.g. eye colour, weight and height			
B5.1d	Recall that all variants arise from mutations, and that most have no effect on the phenotype, some influence phenotype and a very few determine phenotype				
B5.1e ☑	**describe how genetic variants may influence phenotype:** • **in coding DNA by altering the activity of a protein** • **in non-coding DNA by altering how genes are expressed**	• **in coding: DNA related to mutations affecting protein structure, including active sites of enzymes** • **in non-coding: DNA related to stopping transcription of mRNA (use of terms promoter, transcription factor not required)**			
B5.1f ☑	explain some of the advantages and disadvantages of asexual and sexual reproduction in a range of organisms	the number of live offspring per birth, how quickly the organisms can reproduce verses the need for the introduction of variation in a population caused by environmental pressures			
B5.1g	explain the terms haploid and diploid				

Learning outcomes		To include	Maths	Working scientifically	Practical suggestions
B5.1h	explain the role of meiotic cell division in halving the chromosome number to form gametes	that this maintains diploid cells when gametes combine and is a source of genetic variation			
B5.1i	explain single gene inheritance	the context of homozygous and heterozygous crosses involving dominant and recessive genes	M2c, M4a		Prediction of the probability of phenotype for genetic crosses. Investigation into probability by suitable example (e.g. coin toss or die roll).
B5.1j	predict the results of single gene crosses		M1c, M2c, M2e, M4a		
B5.1k	describe sex determination in humans using a genetic cross		M1c, M2c, M2e, M4a		
B5.1l	recall that most phenotypic features are the result of multiple genes rather than single gene inheritance				
B5.1m ☑	describe the development of our understanding of genetics	the work of Mendel		WS1.1a, WS1.1d, WS1.1f, WS1.1i	

B5.2 Natural selection and evolution

Summary

Variation in the genome and changes in the environment drive the process of natural selection, leading to changes in the characteristics of populations. Evolution accounts for both biodiversity and how organisms are all related to varying degrees. Key individuals have played important roles in the development of our understanding of genetics.

Underlying knowledge and understanding

Learners should appreciate that changes in the environment can leave some individuals, or even some entire species, unable to compete and reproduce leading to extinction.

Common misconceptions

Learners are used to hearing the term evolution in everyday life but it is often used for items that have been designed and gradually improved in order to fit a purpose. They therefore find it difficult to grasp the idea that evolution by natural selection relies on random mutations. Learners also tend to imply that individuals change by natural selection. Statements such as 'a moth will change by natural selection in order to become better camouflaged' include both of these common misconceptions.

Tiering

Statements shown in **bold** type will only be tested in the Higher Tier papers. All other statements will be assessed in both Foundation and Higher Tier papers.

Topic content			Opportunities to cover:		Practical suggestions
Learning outcomes		To include	Maths	Working scientifically	
B5.2a	state that there is usually extensive genetic variation within a population of a species				
B5.2b	describe the impact of developments in biology on classification systems	natural and artificial classification systems and use of molecular phylogenetics based on DNA sequencing		WS1.1b	
B5.2c	explain how evolution occurs through the natural selection of variants that have given rise to phenotypes best suited to their environment	the concept of mutation			
B5.2d	describe evolution as a change in the inherited characteristics of a population over time, through a process of natural selection, which may result in the formation of new species				
B5.2e	describe the evidence for evolution	fossils and antibiotic resistance in bacteria		WS1.1c, WS1.1d, WS1.1g	

Learning outcomes		To include	Maths	Working scientifically	Practical suggestions
B5.2f ☑	describe the work of Darwin and Wallace in the development of the theory of evolution by natural selection and explain the impact of these ideas on modern biology	seedbanks being used as a store of biodiversity		WS1.1a, WS1.1d, WS1.1g, WS1.1h, WS1.3i	

Topic B6: Global challenges

This topic seeks to integrate learners' knowledge and understanding of biological systems and processes, with the aim of applying it to global challenges. Biological information is used to help people to improve their own lives and strive to create a sustainable world for future generations. This topic provides opportunities to draw together the concepts covered in earlier topics, allowing synoptic treatment of the subject.

B6.1 Monitoring and maintaining the environment

Summary

Living organisms interact with each other, the environment and with humans in many different ways. If the variety of life is to be maintained we must actively manage our interactions with the environment. We must monitor our environment, collecting and interpreting information about the natural world, to identify patterns and relate possible cause and effect.

Underlying knowledge and understanding

From their study in topic B4, learners should be familiar with ecosystems and the various ways organisms interact. They should understand how biotic and abiotic factors influence communities. Learners should be familiar with the gases of the atmosphere from Key Stage 3.

Common misconceptions

It is important that in the study of this topic learners are given opportunities to explore both positive and negative human interactions within ecosystems.

Tiering

Statements shown in **bold** type will only be tested in the Higher Tier papers. All other statements will be assessed in both Foundation and Higher Tier papers.

Reference	Mathematical learning outcomes	Mathematical skills
BM6.1i	construct and interpret frequency tables and diagrams, bar charts and histograms	M2c
BM6.1ii	understand the principles of sampling as applied to scientific data	M2d

Topic content			Opportunities to cover:		Practical suggestions
Learning outcomes		To include	Maths	Working scientifically	
B6.1a	explain how to carry out a field investigation into the distribution and abundance of organisms in a habitat and how to determine their numbers in a given area	sampling techniques (random and transects, capture-recapture), use of quadrats, pooters, nets, keys and scaling up methods	M2c, M2d, M3a	WS1.2d, WS1.2b, WS1.2c, WS1.2e, WS1.3h, WS2a, WS2b, WS2c, WS2d	Investigation of ecological sampling methods. Using the symbols =, <, <<, >>, >, ∝, ~ in answers where appropriate. (PAG B1, PAG B3) Investigation of sampling using a suitable model (e.g. measuring the red sweets in a mixed selection).
B6.1b	describe both positive and negative human interactions within ecosystems and explain their impact on biodiversity	the conservation of individual species and selected habitats and threats from land use and hunting		WS2a, WS2b, WS2c, WS2d	Investigation into the effectiveness of germination in different strengths of acid rain. (PAG B3, PAG B6) Investigation into the effects of lichen distribution against pollution. (PAG B3)
B6.1c	explain some of the benefits and challenges of maintaining local and global biodiversity	the difficulty in gaining agreements for and the monitoring of conservation schemes along with the benefits of ecotourism			
B6.1d ☑	**evaluate the evidence for the impact of environmental changes on the distribution of organisms, with reference to water and atmospheric gases**				

B6.2 Feeding the human race

Summary
The human population is increasing rapidly and with this comes a need for more food. Biologists are seeking to tackle this increased demand, which will lead to an improvement in the lives of many people around the world. However, there are many things to consider in achieving this aim, not least the impact on ecosystems. There is much debate surrounding the use of gene technology as a potential solution to the problem of food security.

Underlying knowledge and understanding
Learners should be familiar with the content of a healthy human diet and the consequences of imbalances in a healthy daily diet. Their knowledge and understanding from topics 1, 4 and 5 will also be drawn together in this topic. This includes the organisation of DNA, what plants require enabling them to photosynthesise, interactions between species and the idea of variability within species and subsequent selection of characteristics.

Common misconceptions
Learners can often think that genetic engineering leads to the increased use of pesticides.

Tiering
Statements shown in **bold** type will only be tested in the Higher Tier papers. All other statements will be assessed in both Foundation and Higher Tier papers.

Reference	Mathematical learning outcomes	Mathematical skills
BM6.2i	use percentiles and calculate percentage gain and loss of mass	M1c
BM6.2ii	calculate arithmetic means	M2b
BM6.2iii	use fractions and percentages	M1c
BM6.2iv	extract and interpret information from charts, graphs and tables	M2c and M4a

Topic content			Opportunities to cover:		Practical suggestions
Learning outcomes		To include	Maths	Working scientifically	
B6.2a ☑	describe some of the biological factors affecting levels of food security	increasing human population, changing diets in wealthier populations, new pests and pathogens, environmental change, sustainability and cost of agricultural inputs	M2b, M2f		
B6.2b ☑	describe and explain some possible agricultural solutions to the demands of the growing human population	increased use of hydroponics, biological control, gene technology, fertilisers and pesticides		WS1.1c	
B6.2c	explain the impact of the selective breeding of food plants and domesticated animals		M1c, M2c, M4a	WS1.1c	Research into the Rothamsted Research Broadbalk experiment.
B6.2d	describe genetic engineering as a process which involves modifying the genome of an organism to introduce desirable characteristics				
B6.2e	**describe the main steps in the process of genetic engineering**	**restriction enzymes, sticky ends, vectors e.g. plasmids, ligase, host bacteria and selection using antibiotic resistance markers**			Produce a storyboard of the processes for genetic engineering.
B6.2f ☑	explain some of the possible benefits and risks of using gene technology in modern agriculture	practical and ethical considerations		WS1.1c, WS1.1d, WS1.1e, WS1.1f, WS1.1g, WS1.1h, WS1.3i	Research into the advantages and disadvantages of selective breeding and genetic engineering.
B6.2g	describe and explain some possible biotechnological solutions to the demands of the growing human population	genetic modification	M1c, M2c, M4a	WS1.1c, WS1.1g	Research into the growth of GM crops or livestock.

B6.3 Monitoring and maintaining health

Summary
Diseases affect the health of populations of both humans and plants. Scientists are constantly on the lookout for ways of preventing and combating disease. The prevention of disease in plants is important so that we are able to grow healthy plants enabling us to feed ourselves and enhance our environment. The understanding of how disease is spread, how our bodies defend themselves against disease and how immunity is achieved is essential to enable us to combat potentially fatal diseases spreading throughout whole populations. Non-communicable diseases also have an impact on the health of the population. The prevention of these diseases is frequently discussed in the media, with advice being given to us on how to reduce our risk of contracting these diseases through our life-style choices and discussion of new technologies.

Underlying knowledge and understanding
Learners should be familiar with the effects of 'recreational' drugs (including substance misuse) on behaviour, health and life processes, the impact of exercise, asthma and smoking on the gas exchange system and the consequences of imbalances in the diet, including obesity, starvation and deficiency diseases.

Common misconceptions
Research has shown that learners tend to view all micro-organisms as being non-beneficial. They tend to consider health as just physical and do not consider mental health. Learners also confuse which diseases are inherited and which are caught. They see cancer as a genetic disease.

Tiering
Statements shown in **bold** type will only be tested in the Higher Tier papers. All other statements will be assessed in both Foundation and Higher Tier papers.

Reference	Mathematical learning outcomes	Mathematical skills
BM6.3i	translate information between graphical and numerical forms	M4a
BM6.3ii	construct and interpret frequency tables and diagrams, bar charts and histograms	M2c
BM6.3iii	understand the principles of sampling as applied to scientific data	M2d
BM6.3iv	use a scatter diagram to identify a correlation between two variables	M2g
BM6.3v ☑	calculate cross-sectional areas of bacterial cultures and clear agar jelly using πr^2	M5c

Topic content			Opportunities to cover:		Practical suggestions
Learning outcomes		To include	Maths	Working scientifically	
B6.3a	describe the relationship between health and disease				
B6.3b	describe different types of diseases	communicable and non-communicable diseases			
B6.3c	describe the interactions between different types of disease	HIV and tuberculosis; HPV and cervical cancer	M4a		
B6.3d	explain how communicable diseases (caused by viruses, bacteria, protists and fungi) are spread in animals and plants	scientific quantities, number of pathogens, number of infected cases, estimating number of cases	M2c, M2g	WS1.4b	
B6.3e	explain how the spread of communicable diseases may be reduced or prevented in animals and plants	detection of the antigen, DNA testing, visual identification of the disease	M2c	WS1.4b	
B6.3f	describe a minimum of one common human infection, one plant disease and sexually transmitted infections in humans including HIV/AIDS	plant diseases: virus tobacco mosaic virus TMV, fungal *Erysiphe graminis* barley powdery mildew, bacterial *Agrobacterium tumafaciens* crown gall disease			
B6.3g ☑	describe physical plant defence responses to disease	leaf cuticle, cell wall			
B6.3h ☑	describe chemical plant defence responses	antimicrobial substances			
B6.3i ☑	**describe different ways plant diseases can be detected and identified, in the lab and in the field**	**the laboratory detection of the DNA or antigen from the disease causing organism. The field diagnosis by observation and microscopy**			
B6.3j	explain how white blood cells and platelets are adapted to their defence functions in the blood				

Learning outcomes		To include	Maths	Working scientifically	Practical suggestions
B6.3k	describe the non-specific defence systems of the human body against pathogens				
B6.3l	explain the role of the immune system of the human body in defence against disease				
B6.3m ☑	**describe how monoclonal antibodies are produced**			WS1.1d	
B6.3n ☑	**describe some of the ways in which monoclonal antibodies can be used**	**their role in detecting antigens in pregnancy testing, detection of diseases (prostate cancer) and potentially treating disease (targeting cancer cells)**			
B6.3o	explain the use of vaccines and medicines in the prevention and treatment of disease	antibiotics, antivirals and antiseptics		WS1.1g, WS1.1h	Research into whether children should be routinely vaccinated?
B6.3p ☑	explain the aseptic techniques used in culturing organisms	use of alcohol, flaming, autoclaving of glassware and growth media, and measures used to stop contaminants falling onto/into the growth media (e.g. working around a Bunsen burner)	M3d, M5c	WS1.1h, WS1.2c, WS2a, WS2b, WS2c, WS2d	Investigation into growth bacterial cultures using aseptic techniques. (PAG B1, PAG B7)
B6.3q	describe the processes of discovery and development of potential new medicines	preclinical and clinical testing	M2d, M3d, M5c	WS1.1d, WS2a, WS2b, WS2c, WS2d	Investigation into growth bacterial cultures using aseptic techniques. (PAG B1, PAG B7)
B6.3r	recall that many non-communicable human diseases are caused by the interaction of a number of factors	cardiovascular diseases, many forms of cancer, some lung (bronchitis) and liver (cirrhosis) diseases and diseases influenced by nutrition, including type 2 diabetes			
B6.3s	evaluate some different treatments for cardiovascular disease	lifestyle, medical and surgical	M2g		

Learning outcomes		To include	Maths	Working scientifically	Practical suggestions
B6.3t	analyse the effect of lifestyle factors on the incidence of non-communicable diseases at local, national and global levels	lifestyle factors to include exercise, diet, alcohol and smoking	M2c, M2d, M4a		
B6.3u	describe cancer as the result of changes in cells that lead to uncontrolled growth and division				
B6.3v	discuss potential benefits and risks associated with the use of stem cells in medicine	tissue transplantation and rejection		WS1.1c, WS1.1d, WS1.1e, WS1.1f, WS1.1g, WS1.1h, WS1.1j	
B6.3w	explain some of the possible benefits and risks of using gene technology in medicine	practical and ethical considerations		WS1.1c, WS1.1d, WS1.1e, WS1.1j	
B6.3x	discuss the potential importance for medicine of our increasing understanding of the human genome	the ideas of predicting the likelihood of diseases occurring and their treatment by drugs which are targeted to genomes		WS1.1c, WS1.1d, WS1.1j	