Qualification Accredited

OCR
Oxford Cambridge and RSA

GCSE (9-1)

Specification

TWENTY FIRST CENTURY SCIENCE BIOLOGY B

J257

For first assessment in 2018

Version 3.3 (January 2024)

ocr.org.uk/gcsec21biology

Disclaimer

Specifications are updated over time. Whilst every effort is made to check all documents, there may be contradictions between published resources and the specification, therefore please use the information on the latest specification at all times. Where changes are made to specifications these will be indicated within the document, there will be a new version number indicated, and a summary of the changes. If you do notice a discrepancy between the specification and a resource please contact us at: resources.feedback@ocr.org.uk

We will inform centres about changes to specifications. We will also publish changes on our website. The latest version of our specifications will always be those on our website (ocr.org.uk) and these may differ from printed versions.

Registered office:
The Triangle Building
Shaftesbury Road
Cambridge
CB2 8EA

Contents

Support and Guidance

Introducing a new specification brings challenges for implementation and teaching, but it also opens up new opportunities. Our aim is to help you at every stage. We are working hard with teachers and other experts to bring you a package of practical support, resources and training.

Subject Advisors

OCR Subject Advisors provide information and support to centres including specification and non-exam assessment advice, updates on resource developments and a range of training opportunities.

Our Subject Advisors work with subject communities through a range of networks to ensure the sharing of ideas and expertise supporting teachers and students alike. They work with developers to help produce our specifications and the resources needed to support these qualifications during their development.

You can contact our Science Subject Advisors for specialist advice, guidance and support:

01223 553998

ScienceGCSE@ocr.org.uk

@OCR_Science

Teaching and learning resources

Our resources are designed to provide you with a range of teaching activities and suggestions that enable you to select the best activity, approach or context to support your teaching style and your particular students. The resources are a body of knowledge that will grow throughout the lifetime of the specification, they include:

- Delivery Guides
- Transition Guides
- Topic Exploration Packs
- Lesson Elements.

We also work with a number of leading publishers who publish textbooks and resources for our specifications. For more information on our publishing partners and their resources visit: ocr.org.uk/qualifications/gcse-and-a-level-reform/publishing-partners

Professional development

Our improved Professional Development Programme fulfils a range of needs through course selection, preparation for teaching, delivery and assessment. Whether you want to come to face-to-face events, look at our new digital training or search for training materials, you can find what you're looking for all in one place at the CPD Hub: cpdhub.ocr.org.uk

An introduction to new specifications

We run training events throughout the academic year that are designed to help prepare you for first teaching and support every stage of your delivery of the new qualifications.

To receive the latest information about the training we offer on GCSE and A Level, please register for email updates at: ocr.org.uk/updates

Assessment Preparation and Analysis Service

Along with subject-specific resources and tools, you'll also have access to a selection of generic resources that focus on skills development, professional guidance for teachers and results data analysis.

ExamBuilder

Enabling you to build, mark and assess tests from OCR exam questions and produce a complete mock GCSE or A Level exam. Find out more at **ocr.org.uk/exambuilder**

Subject Advisor Support

Our Subject Advisors provide you with access to specifications, high-quality teaching resources and assessment materials.

Practice Papers

Assess students' progress under formal examination conditions with question papers downloaded from a secure location, well-presented, easy-to-interpret mark schemes and commentary on marking and sample answers.

Skills Guides

These guides cover topics that could be relevant to a range of qualifications, for example communication, legislation and research.

Download the guides at **ocr.org.uk/skillsguides**

Active Results

Our free online results analysis service helps you review the performance of individual students or your whole cohort. For more details, please refer to **ocr.org.uk/activeresults**

1 Why choose an OCR GCSE (9–1) in Biology B (Twenty First Century Science)?

1

1a. Why choose an OCR qualification?

Choose OCR and you've got the reassurance that you're working with one of the UK's leading exam boards. Our new OCR GCSE (9–1) in Biology B (Twenty First Century Science) course has been developed in consultation with teachers, employers and Higher Education to provide learners with a qualification that's relevant to them and meets their needs.

We're part of the Cambridge Assessment Group, Europe's largest assessment agency and a department of the University of Cambridge. Cambridge Assessment plays a leading role in developing and delivering assessments throughout the world, operating in over 150 countries.

We work with a range of education providers, including schools, colleges, workplaces and other institutions in both the public and private sectors. Over 13 000 centres choose our A Levels, GCSEs and vocational qualifications including Cambridge Nationals and Cambridge Technicals.

Our Specifications

We believe in developing specifications that help you bring the subject to life and inspire your learners to achieve more.

We've created teacher-friendly specifications based on extensive research and engagement with the teaching community. They're designed to be straightforward and accessible so that you can tailor the delivery of the course to suit your needs. We aim to encourage learners to become responsible for their own learning, confident in discussing ideas, innovative and engaged.

We provide a range of support services designed to help you at every stage, from preparation through to the delivery of our specifications. This includes:

- A wide range of high-quality creative resources including:
  - Delivery Guides
  - Transition Guides
  - Topic Exploration Packs
  - Lesson Elements
  - . . . and much more.
- Access to Subject Advisors to support you through the transition and throughout the lifetime of the specification.
- CPD/Training for teachers to introduce the qualifications and prepare you for first teaching.
- Active Results – our free results analysis service to help you review the performance of individual learners or whole schools.
- ExamBuilder – our free online past papers service that enables you to build your own test papers from past OCR exam questions.

All GCSE (9–1) qualifications offered by OCR are accredited by Ofqual, the Regulator for qualifications offered in England. The accreditation number for OCR's GCSE (9–1) in Biology B (Twenty First Century Science) is QN601/8506/5.

1

1b. Why choose an OCR GCSE (9–1) in Biology B (Twenty First Century Science)?

We appreciate that one size doesn't fit all so we offer two suites of qualifications in each science:

Biology A (Gateway Science) – Provides a flexible approach to teaching. The specification is divided into topics, each covering different key concepts of biology. Teaching of practical skills is integrated with the theoretical topics and they are assessed through the written papers.

Biology B (Twenty First Century Science) – Learners study biology using a narrative-based approach. Ideas are introduced within relevant and interesting settings which help learners to anchor their conceptual knowledge of the range of biological topics required at GCSE level. Practical skills are embedded within the specification and learners are expected to carry out practical work in preparation for a written examination that will specifically test these skills.

Biology B (Twenty First Century Science) has been developed with the University of York Science Education Group (UYSEG) in conjunction with subject and teaching experts. Together we have aimed to produce a specification with up to date relevant content accompanied by a narrative to give context and an idea of the breadth of teaching required. Our new GCSE (9–1) in Biology B (Twenty First Century Science) qualification builds on our existing popular course. We've based the redevelopment of our GCSE (9–1) sciences on an understanding of what works well in centres large and small. We've undertaken a significant amount of consultation through our science forums (which include representatives from learned societies, HE, teaching and industry) and through focus groups with teachers.

The content is clear and logically laid out for both existing centres and those new to OCR, with assessment models that are straightforward to administer. We have worked closely with teachers to provide high quality support materials to guide you through the new qualifications.

Aims and learning outcomes

GCSE study in the sciences provides the foundation for understanding the material world. Scientific understanding is changing our lives and is vital to world's future prosperity, and all learners should be taught essential aspects of the knowledge, methods, process and uses of science. They should be helped to appreciate how the complex and diverse phenomena of the natural world can be described in terms of a small number of key ideas relating to the sciences which are both inter-linked, and are of universal application. These key ideas include:

- the use of conceptual models and theories to make sense of the observed diversity of natural phenomena
- the assumption that every effect has one or more cause
- that change is driven by differences between different objects and systems when they interact
- that many such interactions occur over a distance and over time without direct contact
- that science progresses through a cycle of hypothesis, practical experimentation, observation, theory development and review
- that quantitative analysis is a central element both of many theories and of scientific methods of inquiry.

The Twenty First Century Science suite will enable learners to:

- develop scientific knowledge and conceptual understanding through the specific disciplines of biology, chemistry and physics
- develop understanding of the nature, processes and methods of science, through different types of scientific enquiries that help them to answer scientific questions about the world around them
- develop and learn to apply observational, practical, modelling, enquiry and problem-solving skills, both in the laboratory, in the field and in other learning environments
- develop their ability to evaluate claims based on science through critical analysis of the methodology, evidence and conclusions, both qualitatively and quantitatively.

1

1c. What are the key features of this specification?

Building on research, and on the principles of *Beyond 2000*, the Twenty First Century Science suite was originally developed by the University of York Science Education Group (UYSEG), the Nuffield Foundation and OCR.

The 2016 suite continues to recognise the diversity of interests and future intentions of the learner population who take a science qualification at GCSE level. The specifications will prepare learners for progression to further study of science, whilst at the same time offering an engaging and satisfying course for those who choose not to study academic science further.

The Twenty First Century Science suite will:

- take opportunities to link science to issues relevant to all learners as citizens, and to the cultural aspects of science that are of value and interest to all
- develop learners' abilities to evaluate knowledge claims critically, by looking at the nature, quality and extent of the evidence, and at the arguments that link evidence to conclusions
- develop learners' understanding of the concepts and models that scientists use to explain natural phenomena
- develop learners' ability to plan and carry out practical investigations and their understanding of the role of experimental work in developing scientific explanations.

1d. How do I find out more information?

Whether new to our specifications, or continuing on from our legacy offerings, you can find more information on our webpages at www.ocr.org.uk

Visit our subject pages to find out more about the assessment package and resources available to support your teaching. The science team also release a termly newsletter *Science Spotlight* (despatched to centres and available from our subject pages).

If you are not already a registered OCR centre then you can find out more information on the benefits of becoming one at: www.ocr.org.uk

If you are not yet an approved centre and would like to become one go to: www.ocr.org.uk/approvals

Want to find out more?

You can contact the Science Subject Advisors:

Email: ScienceGCSE@ocr.org.uk,
Telephone: 01223 553998

Visit our Online Support Centre at support.ocr.org.uk

Check what CPD events are available:
www.cpdhub.ocr.org.uk

Follow us on Twitter:
https://twitter.com/ocr_science

2 The specification overview

2a. OCR's GCSE (9–1) in Biology B (Twenty First Century Science) (J257)

Learners are entered for either Foundation Tier (components 01 and 02) **or** Higher Tier (components 03 and 04) to be awarded the OCR GCSE (9–1) in Biology B (Twenty First Century Science).

2

Content Overview	Assessment Overview	
Foundation Tier, grades 1 to 5		
Content is split into eight teaching chapters: • Chapter B1: You and your genes • Chapter B2: Keeping healthy • Chapter B3: Living together – food and ecosystems • Chapter B4: Using food and controlling growth • Chapter B5: The human body – staying alive • Chapter B6: Life on Earth – past, present and future • Chapter B7: Ideas about Science • Chapter B8: Practical Skills Both papers assess content from all eight chapters.	Breadth in biology J257/01 90 marks 1 hour 45 minutes Written paper	**50%** of total GCSE
	Depth in biology J257/02 90 marks 1 hour 45 minutes Written paper	**50%** of total GCSE
Higher Tier, grades 4 to 9		
Content is split into eight teaching chapters: • Chapter B1: You and your genes • Chapter B2: Keeping healthy • Chapter B3: Living together – food and ecosystems • Chapter B4: Using food and controlling growth • Chapter B5: The human body – staying alive • Chapter B6: Life on Earth – past, present and future • Chapter B7: Ideas about Science • Chapter B8: Practical Skills Both papers assess content from all eight chapters.	Breadth in biology J257/03 90 marks 1 hour 45 minutes Written paper	**50%** of total GCSE
	Depth in biology J257/04 90 marks 1 hour 45 minutes Written paper	**50%** of total GCSE

2b. Content of GCSE (9–1) in Biology B (Twenty First Century Science) (J257)

2

Layout of specification content

The specification content is divided into eight chapters. The first six chapters describe the science content to be taught and assessed. The seventh chapter describes the *Ideas about Science* that should be taught, and will be assessed in contexts taken from any of the preceding chapters. The *Ideas about Science* cover the requirements of *Working Scientifically*. The final chapter describes the requirements for practical skills.

In the specification, the content that is assessable is presented in two columns: the teaching and learning narrative and the assessable learning outcomes. The narrative summarises the science story and provides context for the assessable learning outcomes thereby supporting the teaching of the specification. The assessable learning outcomes define the requirements for assessment and any contexts given in the narrative may also be assessed.

Within each chapter:

An overview summarises the science ideas included in the chapter, explaining why these ideas are relevant to learners living in the twenty first century and why it is desirable for learners to understand them.

Following the overview is a summary of the knowledge and understanding that learners should have gained from study at Key Stages 1 to 3. Some of these ideas are repeated in the content of the specification and while this material need not be retaught, it can be drawn upon to develop ideas at GCSE (9–1).

Learning at GCSE (9–1) is described in the tables that follow:

Teaching and learning narrative	**Assessable learning outcomes**	***Linked learning opportunities***
The teaching and learning narrative summarises the science story, including relevant *Ideas about Science* to provide contexts for the assessable learning outcomes. The narrative is intended to support teaching and learning. The requirements for assessment are defined by the assessable learning outcomes and any contexts given in the narrative may also be assessed.	The assessable learning outcomes set out the level of knowledge and understanding that learners are expected to demonstrate. The statements give guidance on the breadth and depth of learning. **Emboldened statements will only be assessed in Higher Tier papers.** The mathematical requirements in Appendix 5d are referenced by the prefix M to link the mathematical skills required to the areas of biology content where those mathematical skills could be linked to learning. Opportunities for carrying out practical activities are indicated throughout the specification and are referenced as *PAG1* to *PAG8* (Practical Activity Group, see Chapter 8). ⓘ *Advisory notes clarify the depth of cover required.*	The linked learning opportunities suggest ways to develop *Ideas about Science* and practical skills in context, and also highlight links to ideas in other chapters. Note, however, that *Ideas about Science* and practical skills may be taught, and will be assessed, in any context.

The Assessment Objectives in Section 3b make clear the range of ways in which learners will be required to demonstrate their knowledge and understanding in the assessments, and the Sample Assessment Materials (provided on the OCR website at www.ocr.org.uk) provide examples.

Biology key ideas

Biology is the science of living organisms (including animals, plants, fungi and microorganisms) and their interactions with each other and the environment. The study of biology involves collecting and interpreting information about the natural world to identify patterns and relate possible cause and effect. Biological information is used to help humans improve their own lives and strive to create a sustainable world for future generations.

Learners should be helped to understand how, through the ideas of biology, the complex and diverse phenomena of the natural world can be described in terms of a small number of key ideas which are of universal application, and which include:

- life processes depend on molecules whose structure is related to their function
- the fundamental units of living organisms are cells, which may be part of highly adapted structures including tissues, organs and organ systems, enabling living processes to be performed effectively
- living organisms may form populations of single species, communities of many species and ecosystems, interacting with each other, with the environment and with humans in many different ways
- living organisms are interdependent and show adaptations to their environment
- life on Earth is dependent on photosynthesis in which green plants and algae trap light from the Sun to fix carbon dioxide and combine it with hydrogen from water to make organic compounds and oxygen
- organic compounds are used as fuels in cellular respiration to allow the other chemical reactions necessary for life
- the chemicals in ecosystems are continually cycling through the natural world
- the characteristics of a living organism are influenced by its genome and its interaction with the environment
- evolution occurs by a process of natural selection and accounts both for biodiversity and how organisms are all related to varying degrees.

A summary of the content for the GCSE (9–1) Biology B (Twenty First Century Science) course is as follows:

Chapter B1: You and your genes	Chapter B2: Keeping healthy	Chapter B3: Living together – food and ecosystems
B1.1 What is the genome and what does it do? B1.2 How is genetic information inherited? B1.3 How can and should gene technology be used?	B2.1 What are the causes of disease? B2.2 How do organisms protect themselves against pathogens? B2.3 How can we prevent the spread of infections? B2.4 How can we identify the cause of an infection? *(separate science only)* B2.5 How can lifestyle, genes and the environment affect my health? B2.6 How can we treat disease?	B3.1 What happens during photosynthesis? B3.2 How do producers get the substances they need? B3.3 How are organisms in an ecosystem interdependent? B3.4 How are populations affected by conditions in an ecosystem?
Chapter B4: Using food and controlling growth	**Chapter B5: The human body – staying alive**	**Chapter B6: Life on Earth – past, present and future**
B4.1 What happens during cellular respiration? B4.2 How do we know about mitochondria and other cell structures? B4.3 How do organisms grow and develop? B4.4 How is plant growth controlled? *(separate science only)* B4.5 Should we use stem cells to treat damage and disease?	B5.1 How do substances get into, out of and around our bodies? B5.2 How does the nervous system help us respond to changes? B5.3 How do hormones control responses in the human body? B5.4 Why do we need to maintain a constant internal environment? B5.5 What role do hormones play in human reproduction? B5.6 What can happen when organs and control systems stop working?	B6.1 How was the theory of evolution developed? B6.2 How do sexual and asexual reproduction affect evolution? *(separate science only)* B6.3 How does our understanding of biology help us classify the diversity of organisms on Earth? B6.4 How is biodiversity threatened and how can we protect it?
Chapter B7: Ideas about Science		
IaS1 What needs to be considered when investigating a phenomenon scientifically? IaS2 What conclusions can we make from data? IaS3 How are scientific explanations developed? IaS4 How do science and technology impact society?		
Chapter B8: Practical Skills		

2c. Content of chapters B1 to B8

Chapter B1: You and your genes

Overview

The inheritance of genetic information from each generation to the next is a fundamental idea in science; it can help us answer questions about why we look the way we do, and build a foundation for later exploration of ideas about genetic diseases, cell division and growth, and evolution.

Topic B1.1 explores basic concepts of the genome and how it affects an organism's characteristics, through ideas about DNA and genes as the units of genetic information, the link between genes and proteins, and how the interaction between genes and the environment affects how an individual looks, develops and functions. Topic B1.2 explores inheritance by considering the effects of dominant and recessive alleles, the inheritance of characteristics, the principles of inheritance of single-gene characteristics and how sex is determined.

Understanding of the genome and emerging gene technologies are at the cutting edge of science, and they promise powerful applications to benefit present and future generations. But they also present ethical issues for individuals and society. Topic B1.3 explores some of the ideas people use to make decisions about applications of gene technology including genetic testing and genetic engineering.

Learning about genes and inheritance before GCSE (9–1)

From study at Key Stages 1 to 3 learners should:

- know that living things produce offspring of the same kind, but normally offspring vary and are not identical to their parents
- know that heredity is the process by which genetic information is transmitted from one generation to the next
- know that genetic information is stored in the nucleus
- understand a simple model of chromosomes, genes and DNA
- know about the part played by Watson, Crick, Wilkins and Franklin in the development of the DNA model
- know about sexual reproduction in animals, including the role of gametes and the process of fertilisation
- know about sexual and asexual reproduction in plants, including flower structures and the processes of pollination and fertilisation.

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.

B1.1 What is the genome and what does it do?

Teaching and learning narrative	Assessable learning outcomes *Learners will be required to:*
All organisms contain genetic material. Genetic material contains instructions that control how cells and organisms develop and function. Most of an organism's characteristics depend on these instructions and are modified by interaction with the environment. Genetic material in plant and animal cells is located in the nucleus, one of the main sub-cellular structures. In organisms whose cells do not have a nucleus (e.g. bacteria) the genetic material is located in the cytoplasm. All the genetic material of a cell is the organism's genome. In most organisms the genome is packaged into chromosomes. Chromosomes are long molecules of DNA. Genes are sections of this DNA. In the cells of plants and animals, chromosomes occur in pairs. The two chromosomes in a pair each carry the same genes. The two versions of each gene in the pair are called alleles, and can be the same or different. A different version of a gene is a genetic variant. The genotype of an organism is the combination of alleles it has for each gene; the phenotype is the characteristic that results from this combination and interaction with the environment. Genes tell a cell how to make proteins by joining together amino acids in a particular order.	1. a) explain how the nucleus and genetic material of eukaryotic cells (plants and animals) and the genetic material, including plasmids, of prokaryotic cells are related to cell functions b) describe how to use a light microscope to observe a variety of plant and animal cells *PAG1* 2. describe the genome as the entire genetic material of an organism 3. describe DNA as a polymer made up of nucleotides, forming two strands in a double helix 4. describe simply how the genome and its interaction with the environment influence the development of the phenotype of an organism, including the idea that most characteristics depend on instructions in the genome and are modified by interaction of the organism with its environment ⓘ *Learners are not expected to describe epigenetic effects* 5. explain the terms chromosome, gene, allele, variant, genotype and phenotype 6. explain the importance of amino acids in the synthesis of proteins, including the genome as instructions for the polymerisation of amino acids to make proteins

Linked learning opportunities

Practical work:
- use a microscope to look at a variety of plant and animal cells
- extract DNA from plant tissue

Specification links:
- principles of polymerisation, and DNA and proteins as examples of polymers (C4.2)

B1.1 What is the genome and what does it do?

Teaching and learning narrative	**Assessable learning outcomes** *Learners will be required to:*
DNA is a polymer in which the monomers are nucleotides. Each nucleotide includes one of four different bases (adenine, thymine, cytosine or guanine). **The order of bases in a genome is the genetic code. The genetic code is modelled using letters (A, T, C, G) to represent the bases (IaS3). The order (sequence) of bases in a gene is the code for protein synthesis.** **Each set of three nucleotides is the code for an amino acid. The properties of the protein that is made depend on which amino acids are present and their order.**	7. describe DNA as a polymer 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 *(separate science only)* **8. explain simply how the sequence of bases in DNA codes for the proteins made in protein synthesis, including the idea that each set of three nucleotides is the code for an amino acid** *(separate science only)* **9. recall a simple description of protein synthesis, in which:** • **a copy of a gene is made from messenger RNA (mRNA)** • **the mRNA travels to a ribosome in the cytoplasm** • **the ribosome joins amino acids together in an order determined by the mRNA** ⓘ ***Learners are not expected to recall details of transcription and translation*** *(separate science only)*
The order of bases in DNA can be changed if one or more nucleotides is deleted, inserted or substituted for a different nucleotide; these are mutations, and create genetic variants. **If the sequence of bases in a gene is changed by mutation, a protein made from it may function differently or not at all, though in some cases, the mutation won't have any effect.** **Some sections of DNA do not code for a protein, but they control whether particular genes are expressed, and therefore whether particular proteins are made. Thus, mutations in these sections can also affect phenotype by altering gene expression.**	**10. recall that all genetic variants arise from mutations** *(separate science only)* **11. describe how genetic variants in coding DNA may influence phenotype by altering the activity of a protein** *(separate science only)* **12. describe how genetic variants in non-coding DNA may influence phenotype by altering how genes are expressed** *(separate science only)*

Linked learning opportunities

Ideas about Science:

- using letters to model the genetic code (IaS3)

2

B1.2 How is genetic information inherited?

Teaching and learning narrative	Assessable learning outcomes *Learners will be required to:*
During sexual reproduction, each offspring inherits two alleles of each gene; one allele from each gamete. The two alleles can be two copies of the same genetic variant (homozygous) or different variants (heterozygous). A variant can be dominant or recessive, and the combination of alleles determines what effect the gene has.	1. explain the terms gamete, homozygous, heterozygous, dominant and recessive
	2. explain single gene inheritance, including dominant and recessive alleles and use of genetic diagrams
	3. predict the results of single gene crosses
Genetic diagrams such as family trees and Punnett squares can be used to model and predict outcomes of the inheritance of characteristics that are determined by a single gene (IaS3). However, most characteristics depend on the instructions in multiple genes and other parts of the genome.	4. use direct proportions and simple ratios in genetic crosses M1c
	5. use the concept of probability in predicting the outcome of genetic crosses M2e
Principles of inheritance of (single gene) characteristics were demonstrated in ideas developed by Gregor Mendel, using pea plants. Mendel's work illustrates how scientists develop explanations that account for data they have collected (IaS3). **Our understanding of genetics has developed greatly since Mendel did his work; we now know that most characteristics depend upon interactions between genetic variants in multiple parts of the genome. Today, scientists sequence whole genomes to investigate how genetic variants influence an organism's characteristics.**	6. recall that most phenotypic features are the result of multiple genes rather than single gene inheritance ⓘ *Learners are not expected to describe epistasis and its effects*
	7. describe the development of our understanding of genetics including the work of Mendel **and the modern-day use of genome sequencing** *(separate science only)*
A human individual's sex is determined by the inheritance of genes located on sex chromosomes; specifically, genes on the Y chromosome trigger the development of testes.	8. describe sex determination in humans

Linked learning opportunities

Practical work:

- microscopy of pollen tubes on agar (nuclei visible under high power)

Ideas about Science:

- use genetic diagrams (e.g. family trees and Punnett squares) to model and predict outcomes of single gene inheritance (IaS3)
- **distinguish data from explanatory ideas in an account of Mendel's work, and explain how Mendel's explanations accounted for the data he collected (IaS3)**

B1.3 How can and should gene technology be used?

Teaching and learning narrative	**Assessable learning outcomes** *Learners will be required to:*
Comparing the genomes of individuals with and without a disease can help to identify alleles associated with the disease. Once identified, we can test for these alleles in adults, children, fetuses and embryos, to investigate their risk of developing certain diseases. We can also assess the risk of adults passing these alleles to their offspring (including the identification of 'carriers' of recessive alleles). Genetic testing can also help doctors to prescribe the correct drugs to a patient ('personalised medicine'), by testing for alleles that affect how drugs will work in their body. Another application of gene technology is genetic engineering, in which the genome is modified to change an organism's characteristics. Genetic engineering has been used to introduce characteristics into organisms such as bacteria and plants that are useful to humans. Gene technology could help us provide for the needs of society by improving healthcare and producing food for the growing population. But with genetic testing we must also consider how the results will be used and by whom, and the risks of false positives/negatives and miscarriage (when sampling amniotic fluid). With genetic engineering there are concerns about the spread of inserted genes to other organisms, the need for long-term studies to check for adverse reactions, and moral concerns about modifying genomes (IaS4).	1. discuss the potential importance for medicine of our increasing understanding of the human genome, including the discovery of alleles associated with diseases and the genetic testing of individuals to inform family planning and healthcare 2. describe genetic engineering as a process which involves modifying the genome of an organism to introduce desirable characteristics **3. describe the main steps in the process of genetic engineering** **including:** • **isolating and replicating the required gene(s)** • **putting the gene(s) into a vector (e.g. a plasmid)** • **using the vector to insert the gene(s) into cells** • **selecting modified cells** 4. explain some of the possible benefits and risks, including practical and ethical considerations, of using gene technology in modern agriculture and medicine

Linked learning opportunities

Specification links:
- the involvement of genetic and other risk factors in the development of diseases such as cardiovascular disease, cancer and type 2 diabetes (B2.5)
- how can we treat disease? (B2.6)

Ideas about Science:
- genetic testing and genetic engineering as applications of science that have made a positive difference to people's lives (IaS4)
- discuss risks, benefits, ethical issues and regulation associated with gene technology (IaS4)

2

Chapter B2: Keeping healthy

Overview

Issues of risk, ethics and social responsibility related to disease prevention and treatment in humans and plants are often in the news. Understanding the science of health and disease enables us to consider the issues critically, and to explore possible answers.

In Topic B2.1, learners explore how different pathogens are spread and cause disease, with reference to some common communicable diseases of humans and plants, then in Topic B2.2 they consider how the immune system in humans and plants protects against infection.

Topic B2.3 looks at ways in which individuals and society can reduce the spread of diseases, linked to issues of risk and decision making, for example with regard to vaccination.

Topic B2.4 develops understanding of ways in which diseases can be identified in the lab and in the field, and how new technologies offer the potential to improve lives.

In Topics B2.4 and B2.5, the way that lifestyle, environmental and genetic factors affect the risk of developing non-communicable diseases is explored, with reference to ideas about health studies, sampling, correlation and cause. Finally, learners learn about ways of treating diseases in Topics B2.5 and B2.6 and explore issues related to the development and testing of new medicines.

Learning about health and disease before GCSE (9–1)

From study at Key Stages 1 to 3 learners should:

- appreciate that good hygiene helps humans keep healthy
- be able to identify and name the main parts of the human circulatory system, and describe the functions of the heart, blood vessels and blood
- appreciate the importance of bacteria in the human digestive system
- know that animals, including humans, need the right types and amount of nutrition, and that a healthy human diet includes carbohydrates, lipids (fats and oils), proteins, vitamins, minerals, dietary fibre and water
- recall some of the consequences of imbalances in the diet, including obesity, starvation and deficiency diseases
- recognise the impact of diet, exercise, drugs and lifestyle on the way their bodies function
- recall some of the effects of recreational drugs (including substance misuse) on behaviour, health and life processes.

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.

Learning about health and disease at GCSE (9–1)

B2.1 What are the causes of disease?

Teaching and learning narrative	Assessable learning outcomes *Learners will be required to:*
The health of most organisms will be compromised by disease during their lifetime. Physical and mental health can be compromised by disease caused by infection by a pathogen, an organism's genes, environment or lifestyle, or trauma. Disease damages host cells and impairs functions, causing symptoms. However, an unhealthy organism may not always show symptoms of disease, particularly during the 'incubation period' after infection with a pathogen. Some diseases are communicable: they are caused by infection with pathogenic bacteria, viruses, protists and fungi, and can be spread from organism to organism in bodily fluids, on surfaces, and in food and water. Other diseases are non-communicable: they are not caused by infection but are associated with genetic, environmental and lifestyle factors. Some common diseases illustrate different types of pathogen and common routes of spread and infection, including: In humans: influenza (viral), *Salmonella* food poisoning (bacterial), Athlete's foot (fungal), malaria (protist) and HIV (viral STI). In plants: tobacco mosaic virus (viral), ash dieback (fungal) and crown gall disease (bacterial).	1. describe the relationship between health and disease 2. describe different types of diseases (including communicable and non-communicable diseases) 3. explain how communicable diseases (caused by viruses, bacteria, protists and fungi) are spread in animals and plants 4. describe common human infections including influenza (viral), Salmonella (bacterial), Athlete's foot (fungal) and malaria (protist) and sexually transmitted infections in humans including HIV/AIDS (viral) 5. describe plant diseases including tobacco mosaic virus (viral), ash dieback (fungal) and crown gall disease (bacterial)

Linked learning opportunities

Practical work:
- model the spread of infection using liquids (where one is 'infected' with an invisible chemical that can be detected experimentally)
- culture and microscopy of swabs from different surfaces

B2.2 How do organisms protect themselves against pathogens?

Teaching and learning narrative	Assessable learning outcomes *Learners will be required to:*	*Linked learning opportunities*
Humans have physical, chemical and bacterial defences that make it difficult for pathogens to enter the blood. These include the skin and mucus, stomach acid, saliva, tears, and bacteria in the gut. Platelets help to seal wounds to reduce the chance of pathogens entering the blood. These defences are always present, and are not produced in response to a specific pathogen. Plants have physical defences against pathogens, including the leaf cuticle and cell wall.	1. describe non-specific defence systems of the human body against pathogens, including examples of physical, chemical and microbial defences 2. explain how platelets are adapted to their function in the blood 3. describe physical plant defences, including leaf cuticle and cell wall *(separate science only)*	
The immune system of the human body works to protect us against disease caused by pathogens. White blood cells destroy pathogens. White blood cells have receptors that recognise antigens on pathogens, to distinguish between non-self and self. Different types of white blood cell are adapted to either ingest and digest pathogens, or produce antibodies to disable them or tag them for attack by other white blood cells. An antibody is specific for (only recognises) a particular antigen. Once the body has made antibodies against a pathogen, memory cells stay in the body to make antibodies quickly upon re-infection (immunity).	4. explain the role of the immune system of the human body in defence against disease 5. explain how white blood cells are adapted to their functions in the blood, including what they do and how it helps protect against disease	
Plants do not have circulating immune cells or produce antibodies, but they have a simple immune system that protects them against pathogens. For example, plants can make antimicrobial substances in response to pathogens. The ability of plants to protect themselves against pathogens is important in human food security.	6. describe chemical plant defence responses, including antimicrobial substances *(separate science only)*	

B2.3 How can we prevent the spread of infections?

Teaching and learning narrative	Assessable learning outcomes *Learners will be required to:*
Reducing and preventing the spread of communicable diseases in animals and plants helps prevent loss of life, destruction of habitats and loss of food sources. For plants, strategies include regulating the movement of plant material, sourcing healthy plants and seeds, destroying infected plants, polyculture, crop rotation, and chemical and biological control. For animals, including humans, strategies include vaccination (to establish immunity), contraception, hygiene, sanitation, sterilising wounds, restricting travel, and destruction of infected animals. The likely effectiveness, benefits, risks and cost of each strategy must be considered, and an individual's right to decide balanced with what is best for society (IaS4).	1. explain how the spread of communicable diseases may be reduced or prevented in animals and plants, to include a minimum of one common human infection, one plant disease and sexually transmitted infections in humans including HIV/AIDS
	2. explain the use of vaccines in the prevention of disease, including the use of safe forms of pathogens and the need to vaccinate a large proportion of the population

Linked learning opportunities

Practical work:

- investigate microbial growth on different foods and surfaces in different conditions.

Ideas about Science:

- discuss risk and decision making in the context of disease prevention (IaS4)

B2.4 How can we identify the cause of an infection? *(separate science only)*

Teaching and learning narrative	Assessable learning outcomes *Learners will be required to:*	*Linked learning opportunities*
In order to decide upon a course of treatment for a communicable disease, it is important to identify the disease and the pathogen causing it. There are standard ways to do this, including observing symptoms and taking samples of tissue or body fluid for cell counting, culture, microscopy, staining, testing with antimicrobials, and genome analysis. In addition, isolation and reinfection can be used to identify plant pathogens. Correct identification relies on use of aseptic techniques to avoid contamination of samples.	1. a) describe ways in which diseases, including plant diseases, can be detected and identified, in the lab and in the field b) describe how to use a light microscope to observe microorganisms *PAG1* 2. describe and explain the aseptic techniques used in culturing organisms *PAG7* 3. calculate cross-sectional areas of bacterial cultures and of clear zones around antibiotic discs on agar jelly using πr^2 M5c *PAG7*	**Practical work:** • investigate the effect of antibiotic discs on growth of microorganisms on agar plates • practice aseptic techniques
Monoclonal antibodies can be produced in the laboratory, using cultured clones of a white blood cell to produce antibodies against a particular antigen. All the antibodies produced by the clones recognise the same antigen. **New technologies using monoclonal antibodies are providing diagnostic tests (e.g. for diseases) with greater sensitivity and specificity. These tests give faster and more accurate results, which enables decisions (e.g. about treatment) to be made more quickly and based on more accurate information (IaS4).**	**4. describe how monoclonal antibodies are produced** **including the following steps:** • **antigen injected into an animal** • **antibody-producing cells taken from animal** • **cells producing the correct antibody selected then cultured** **5. describe some of the ways in which monoclonal antibodies can be used in diagnostic tests**	**Ideas about Science:** • **use of monoclonal antibodies as a technological application of science that could make a significant differences to people's lives (IaS4)**

B2.5 How can lifestyle, genes and the environment affect health?

Teaching and learning narrative	**Assessable learning outcomes** *Learners will be required to:*
Whether or not a person develops a non-communicable disease depends on many factors, including the genetic variants they inherited, their environment and aspects of their lifestyle. The interaction of genetic and lifestyle factors can increase or decrease the risk.	1. a) describe how the interaction of genetic and lifestyle factors can increase or decrease the risk of developing non-communicable human diseases, including cardiovascular diseases, many forms of cancer, some lung and liver diseases and diseases influenced by nutrition, including type 2 diabetes b) describe how to practically investigate the effect of exercise on pulse rate and recovery rate *PAG6*
	2. use given data to explain the incidence of non-communicable diseases at local, national and global levels with reference to lifestyle factors, including exercise, diet, alcohol and smoking
	3. in the context of data related to the causes, spread, effects and treatment of disease: a) translate information between graphical and numerical forms M4a b) construct and interpret frequency tables and diagrams, bar charts and histograms M4a, M4c c) understand the principles of sampling as applied to scientific data M2d d) use a scatter diagram to identify a correlation between two variables M2g
Different types of disease can interact, such as when having a disease increases or decreases the risk of developing or contracting another.	4. describe interactions between different types of disease

Linked learning opportunities

Specification links:
- what causes cancer (B4.3)
- diseases caused by genes (B1.3)

Practical work:
- investigate the amounts of fat and sugar in foods/drinks
- measure blood pressure, recovery rate

Ideas about Science:
- discuss correlation, cause and risk in the context of non-communicable diseases (IaS3, IaS4)

B2.6 How can we treat disease?

Teaching and learning narrative	Assessable learning outcomes *Learners will be required to:*	*Linked learning opportunities*
Humans have developed medicines that can control or eliminate the cause of some diseases and/or reduce the length or severity of symptoms. Antibiotics are becoming less effective due to the appearance of antibiotic-resistant bacteria. For non-communicable diseases such as cardiovascular diseases, strategies that lower the risk of developing the disease have benefits compared to treatments administered later. Many factors need to be considered when prescribing treatments, including the likely effectiveness, risk of adverse reactions and the costs and benefits to the patient and others (IaS4).	1. explain the use of medicines, including antibiotics, in the treatment of disease 2. calculate cross-sectional areas of bacterial cultures and of clear zones around antibiotic discs on agar jelly using πr^2 M5c *PAG7* 3. evaluate some different treatments for cardiovascular disease, including lifestyle changes, medicines and surgery	**Specification links:** • 'personalised medicine' (B1.3) • antibiotic resistance in microorganisms (B6.1) **Ideas about Science:** • risk and decision making in the context of medicines and treatment (IaS4)
Studying the genomes and proteins of pathogens and host cells can suggest targets for new medicines. Large libraries of substances are screened for their ability to affect a target. It is unlikely that a perfect medicine will be found during screening, but substances are selected for modification and further tests. All new medicines have to be tested before they are made widely available. Preclinical testing, for safety and effectiveness, uses cultured human cells and animals. Clinical testing uses healthy human volunteers to test for safety, and humans with the disease to test for safety and effectiveness. 'Open-label', 'blind' and 'double-blind' trials can be used. There are ethical questions around using placebos in tests on people with a disease (IaS4).	4. describe the process of discovery and development of potential new medicines including preclinical and clinical testing	**Ideas about Science:** • ethics in the context of using placebos in clinical testing of new medicines (IaS4)

B2.6 How can we treat disease?

Some traditional treatments (e.g. radiotherapy and chemotherapy for cancer) cause adverse reactions. New technologies are enabling us to develop treatments that are more effective and have a lower risk of adverse reactions. For example, the specificity of monoclonal antibodies can be used to target cancer cells without damaging normal host cells.	**5. describe how monoclonal antibodies can be used to treat cancer** **including:** • **produce monoclonal antibodies specific to a cancer cell antigen** • **inject the antibodies into the blood** • **the antibodies bind to cancer cells, tagging them for attack by white blood cells** • **the antibodies can also be attached to a radioactive or toxic substance to deliver it to cancer cells** *(separate science only)*

Ideas about Science:

- use of monoclonal antibodies as a technological application of science that could make a difference to people's lives (IaS4)

Chapter B3: Living together – food and ecosystems

Overview

All living organisms depend on the ability of photosynthetic organisms to synthesise glucose from carbon dioxide and water in the presence of light, and on feeding relationships to transfer biomass through communities.

From study at earlier Key Stages, learners will be familiar with the reactants and products of photosynthesis, and the need for light in the process. In Topics B3.1 and B3.2 the context of photosynthesis is used to explore several fundamental concepts in biology, including enzyme action and the movement of substances by diffusion, osmosis and active transport.

Learners expand their knowledge of the interdependencies between organisms within ecosystems in Topic B3.3, through understanding of food webs, competition for resources, and the cycling of substances.

Finally, Topic B3.4 considers the effects that environmental changes and human activities can have on interacting populations within ecosystems.

Learning about food and ecosystems before GCSE (9–1)

From study at Key Stages 1 to 3 learners should:

- understand the similarities and differences between plant and animal cells
- know that some organisms make their own food using photosynthesis
- know that photosynthesis in plant cells occurs in the chloroplasts
- know the reactants in, and products of, photosynthesis, and be able to write a word summary
- know that photosynthesis requires light
- be familiar with the adaptations of leaves for photosynthesis, and the role of stomata in gas exchange
- know that water and minerals enter a plant through the roots
- know that molecules of a solute move through solvent, and through cell membranes, by diffusion
- know that animals obtain their food from plants (and other animals that ate plants)
- understand the difference between carnivores, herbivores and omnivores, and between producers and consumers
- know that individuals of the same type living in the same place make up a population, and that all the interacting populations in an ecosystem make up the community
- understand the use of food chains and food webs as models of the feeding relationships within a community
- appreciate the interdependence of organisms in a community, including food webs, the breakdown and cycling of substances, and animals as pollinators
- know that changes in an ecosystem can affect the survival of individuals and populations.

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.

Learning about food and ecosystems at GCSE (9–1)

B3.1 What happens during photosynthesis?

Teaching and learning narrative	**Assessable learning outcomes** *Learners will be required to:*	***Linked learning opportunities***
Producers make glucose using photosynthesis. Some of the glucose is used as the fuel for cellular respiration, some is converted into starch and then stored, and the rest is used to make lipids, proteins and other carbohydrates for growth. Photosynthesis involves many chemical reactions, but can be summarised in two main stages. The first stage requires light and chlorophyll (located in chloroplasts in plant cells) to split water molecules into hydrogen and oxygen. The hydrogen is transferred to the second stage, but the oxygen is released into the atmosphere as a waste product. The second stage combines carbon dioxide with hydrogen to make glucose.	1. a) describe the process of photosynthesis, including the inputs and outputs of the two mains stages and the requirement of light in the first stage, and describe photosynthesis as an endothermic process b) describe practical investigations into the requirements and products of photosynthesis *PAG5* 2. explain how chloroplasts in plant cells are related to photosynthesis	**Practical work:** • on a whole plant, wrap one leaf in foil, and enclose another leaf in a conical flask with a small amount of KOH (to remove CO_2); after 24h, test leaves for starch
The reactions in photosynthesis and many other biological processes are catalysed by enzymes. The lock and key model can be used to explain enzyme action. It can also be used to make predictions about the effect on the rate of enzyme-catalysed reactions when the substrate concentration, temperature and pH are changed (IaS3).	3. a) explain the mechanism of enzyme action including the active site, enzyme specificity and factors affecting the rate of enzyme-catalysed reactions, including substrate concentration, temperature and pH b) describe practical investigations into the effect of substrate concentration, temperature and pH on the rate of enzyme controlled reactions M2b, M2f, M4a, M4b, M4c *PAG4*	**Practical work:** • investigate effects of substrate concentration, temperature and pH on enzyme activity **Ideas about Science:** • lock and key model to explain and make predictions about enzyme activity (IaS3)

B3.1 What happens during photosynthesis?

Teaching and learning narrative	Assessable learning outcomes *Learners will be required to:*
Understanding of how factors affect enzyme activity helps to explain the effects of temperature and carbon dioxide concentration on the rate of photosynthesis. The effect of light intensity is explained by the need for light to bring about reactions in photosynthesis. **Light intensity is inversely proportional to the square of the distance from the light source (the inverse square law); this helps us explain why the rate of photosynthesis changes in the way that it does with distance from a point light source.**	4. a) explain the effect of temperature, light intensity and carbon dioxide concentration on the rate of photosynthesis b) describe practical investigations into the effect of environmental factors on the rate of photosynthesis *PAG5*
	5. use the inverse square law to explain changes in the rate of photosynthesis with distance from a light source
	6. explain the interaction of temperature, light intensity and carbon dioxide concentration in limiting the rate of photosynthesis, and use graphs depicting the effects
	7. in the context of the rate of photosynthesis: a) understand and use simple compound measures such as the rate of a reaction M1a, M1c b) translate information between graphical and numerical form M4a c) plot and draw appropriate graphs selecting appropriate scales for axes M4a, M4c d) extract and interpret information from graphs, charts and tables M2c

Linked learning opportunities

Practical work:

- investigate rate of photosynthesis by collecting gas or counting bubbles from pondweed
- use a datalogger to measure oxygen concentration, pH, temperature and light intensity over 24h for pondweed

B3.2 How do producers get the substances they need?

Teaching and learning narrative	Assessable learning outcomes *Learners will be required to:*
The ways in which photosynthetic organisms take in carbon dioxide and water for photosynthesis, and release the waste product oxygen, illustrate the principles of diffusion and osmosis. Generally, molecules move from a region of their higher concentration to a region of their lower concentration; the difference in concentration drives a change towards equal concentration. Carbon dioxide and oxygen molecules move by diffusion, through cell membranes in single-cellular (prokaryotic) producers, and through stomata and cell membranes in plants. Water molecules move by osmosis through cell membranes; projections from root cells (“root hairs”) of plants increase the surface area for osmosis. The way in which photosynthetic organisms take in nitrogen (to make proteins) illustrates the process of active transport. Producers get nitrogen from nitrate ions (NO_3^-). Molecules of water and gases can diffuse through partially-permeable cell membranes but nitrate ions cannot; producers use energy from molecules of ATP to transport nitrate ions through the cell membrane by active transport.	1. describe some of the substances transported into and out of photosynthetic organisms in terms of the requirements of those organisms, including oxygen, carbon dioxide, water and mineral ions
	2. a) explain how substances are transported into and out of cells through diffusion, osmosis and active transport b) describe practical investigations into the processes of diffusion and osmosis *PAG8* ⓘ *Learners are not expected to explain osmosis in terms of water potential*
	3. explain how the partially-permeable cell membranes of plant cells and prokaryotic cells are related to diffusion, osmosis and active transport
	4. explain how water and mineral ions are taken up by plants, relating the structure of the root hair cells to their function

Linked learning opportunities

Practical work:

- investigate diffusion using drops of ink in water and in agar in Petri dishes on graph paper
- investigate diffusion across a partially permeable membrane using starch suspension in dialysis tubing in a beaker of water; compare adding idione solution inside versus outside the tubing
- investigate the effect of solute concentration on osmosis using potato cylinders in sugar solution

B3.2 How do producers get the substances they need?

Teaching and learning narrative	Assessable learning outcomes *Learners will be required to:*	*Linked learning opportunities*
Plants do not have blood to transport substances around the organism; they have transport vessels formed from xylem and phloem. Water and ions (e.g. nitrate) in aqueous solution are moved through xylem from the roots and up the stem/trunk by transpiration, to replace water that evaporates from the plant surface and diffuses out of open stomata. Sugars are moved through phloem from photosynthetic to non-photosynthetic tissues by translocation. Sugars are loaded into phloem by active transport, then water moves into the concentrated solution by osmosis and pushes the substances along the tube. The rate of water uptake by a plant can be affected by environmental factors. Light intensity and temperature affect the rate of photosynthesis (and therefore the demand for water), while air movement and temperature affect the rate of water loss from aerial parts of the plant.	5. a) explain how the structure of the xylem and phloem are adapted to their functions in the plant b) describe how to use a light microscope to observe the structure of the xylem and phloem *PAG1*	**Practical work:** • use eosin stain to observe xylem in broad bean plant stem under hand lens and microscope • observe stomata (paint two thin layers of nail varnish onto a leaf, put clear tape over then peel off, stick to microscope slide)
	6. a) describe the processes of transpiration and translocation, including the structure and function of the stomata b) describe how to use a light microscope to observe the structure of stomata *PAG1* c) describe how to use a simple potometer *PAG6* ⓘ *Learners are not expected to describe transpiration in terms of tension or pressure, and are not expected to describe translocation in terms of water potential or hydrostatic pressure*	
	7. a) explain the effect of a variety of environmental factors on the rate of water uptake by a plant, to include light intensity, air movement, and temperature b) describe practical investigations into the effect of environmental factors on the rate of water uptake by a plant *PAG6*	
	8. in the context of water uptake by plants: a) use simple compound measures such as rate M1a, M1c b) carry out rate calculations M1a, M1c c) plot, draw and interpret appropriate graphs M4a, M4b, M4c, M4d d) calculate percentage gain and loss of mass M1c	

B3.3 How are organisms in an ecosystem interdependent?

Teaching and learning narrative	Assessable learning outcomes *Learners will be required to:*
Producers take in carbon and nitrogen compounds from their environment and use them (along with oxygen, hydrogen and other elements) to make small organic molecules including sugars, fatty acids, glycerol and amino acids. These small molecules are used to make larger organic molecules, such as long-chain carbohydrates, lipids and proteins. The larger molecules are used to build new structures (e.g. membranes, organelles). Consumers can only get their supply of carbon and nitrogen compounds by eating producers (or other consumers that ate producers) and digesting the biomass. This releases the small molecules so they can be absorbed and then used to build biomass in the consumer. The transfer of biomass between organisms is one way in which the populations in a community are interdependent, and can be modelled using a food web (IaS3). The amount of biomass present at each trophic level is not shown by a food web, but can be modelled using a pyramid of biomass (IaS3). The size of each population in a community is limited by predation and competition for food and other resources including space, water, light, shelter, mates, pollinators and seed dispersers.	1. a) explain the importance of sugars, fatty acids and glycerol, and amino acids in the synthesis and breakdown of carbohydrates, lipids and proteins b) describe the use of qualitative tests for biological molecules *PAG2*
	2. describe photosynthetic organisms as the main producers of food and therefore biomass for life on Earth
	3. describe some of the substances transported into organisms in terms of the requirements of those organisms, including dissolved food molecules
	4. describe different levels of organisation in an ecosystem from individual organisms to the whole ecosystem
	5. explain the importance of interdependence and competition in a community
	6. describe the differences between the trophic levels of organisms within an ecosystem *(separate science only)*
	7. describe pyramids of biomass and explain, with examples, how biomass is lost between the different trophic levels *(separate science only)*
	8. calculate the efficiency of biomass transfers between trophic levels and explain how this affects the number of organisms at each trophic level *(separate science only)* M1c

Linked learning opportunities

Practical work:

- investigate the breakdown of starch into sugars using amylase and test strips

Ideas about Science:

- use a food web as a model to explain interdependence in a community, identify limitations of the model, and use it to make predictions about the effects that a change in the ecosystem could have on the interacting populations (IaS3)
- pyramids of biomass as models of biomass transfer in a food chain (IaS3)

B3.3 How are organisms in an ecosystem interdependent?

Teaching and learning narrative	Assessable learning outcomes *Learners will be required to:*
Substances essential to life, including water and carbon, cycle through the biotic and abiotic components of ecosystems so that they can be used and reused by organisms. Water cycles through precipitation, food chains, transpiration, excretion, runoff, flow through streams/rivers/oceans, and evaporation. Carbon cycles through photosynthesis, food chains, cellular respiration, decomposition and combustion. Decomposition is catalysed by enzymes released by microorganisms. Rate of decomposition is affected by environmental factors: temperature affects enzymes and the rate of reactions; microorganisms need water to survive and many need oxygen for aerobic respiration. Landfill sites are often oxygen deficient, leading to an increase in anaerobic decomposition which produces methane – a gas with a much greater greenhouse effect than the carbon dioxide produced by aerobic decomposition.	9. recall that many different substances cycle through the abiotic and biotic components of an ecosystem, including carbon and water
	10. explain the importance of the carbon cycle and the water cycle to living organisms
	11. explain the role of microorganisms in the cycling of substances through an ecosystem
	12. calculate the percentage of mass, in the context of the use and cycling of substances in ecosystems M1c
	13. explain the effect of factors such as temperature and water content on rate of decomposition in aerobic and anaerobic environments *(separate science only)*
	14. calculate rate changes in the decay of biological material *(separate science only)* M1c

Linked learning opportunities

Practical work:

- culture microorganisms on starch agar, stain with iodine solution; clear areas beyond cultures show digestion by extracellular amylase

B3.4 How are populations affected by conditions in an ecosystem?

Teaching and learning narrative	**Assessable learning outcomes** *Learners will be required to:*
The distribution and abundance of organisms in an ecosystem depends on abiotic and biotic factors. The size of one or more populations in a community may be affected if the environmental conditions change, or if a new substance, competitor, predator or pathogen is introduced. A substance can bioaccumulate in a food chain to toxic concentration, and some can cause eutrophication (IaS4). A change in the size of a population will affect other populations in the same community. The distribution and abundance of organisms, and changing conditions, within an ecosystem can be investigated using techniques including: identification keys; transects and quadrats; capture, mark, release and recapture; sampling indicator species; and using instruments to measure abiotic factors such as temperature, light intensity, soil moisture and pH.	1. explain how some abiotic and biotic factors affect communities, including environmental conditions, toxic chemicals, availability of food and other resources, and the presence of predators and pathogens
	2. describe how to carry out a field investigation into the distribution and abundance of organisms in an ecosystem and explain how to determine their numbers in a given area M2d *PAG3*
	3. in the context of data related to organisms within a population: a) calculate arithmetic means M2b, M2f b) use fractions and percentages M1c c) plot and draw appropriate graphs selecting appropriate scales for the axes M4a, M4c d) extract and interpret information from charts, graphs and tables M2c

Linked learning opportunities

Practical work:

- investigate the distribution and abundance of organisms in an ecosystem

Ideas about Science:

- bioaccumulation and eutrophication as unintended impacts of human activity on the environment (IaS4)

2

Chapter B4: Using food and controlling growth

Overview

All living organisms depend on molecules of glucose obtained from photosynthesis (or from biomass obtained through food chains that start with photosynthetic organisms). The glucose is used for cellular respiration and in the synthesis of larger organic molecules used for growth.

From study at earlier Key Stages, learners will be familiar with the reactants and products of cellular respiration. In Topic B4.1 they explore how cellular respiration increases the amount of energy associated with cellular energy stores, in particular molecules of ATP that are essential for many life processes. In Topic B4.2 they consider briefly how we came to know what we do about organelles such as mitochondria, using the context of electron microscopy to illustrate the idea that some scientific explanations were only developed once a technological development made certain observations possible. Topic B4.3 links growth in multicellular organisms to the division of cells during the cell cycle, and explores the nature of stem cells and the role of cell differentiation. As a development of ideas, learners consider how cancer results from changes in DNA that cause a loss of control of cell division.

The role of plant hormones in controlling plant growth and environmental responses is explored in Topic B4.4, and these ideas applied to use of these hormones by humans to control plant growth to our advantage.

Finally, Topics B4.4 and B4.5 explore the question of whether stem cells should be used to regenerate tissue and treat disease.

Learning about cellular respiration and growth before GCSE (9–1)

From study at Key Stages 1 to 3 learners should:

- be familiar with the processes of aerobic and anaerobic respiration in living organisms, and fermentation in microorganisms, including word summaries of the reactions
- be able to recall the differences between aerobic and anaerobic respiration in terms of the reactants, products and implications for the organism
- be familiar with the tissues and organs of the human digestive system, including adaptations to function
- understand in simple terms that the human digestive system uses chemicals (including enzymes) to digest food
- appreciate the importance of bacteria in the human digestive system
- know how nutrients and water are transported within animals, including humans.

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.

Learning about cellular respiration and growth at GCSE (9–1)

B4.1 What happens during cellular respiration?

Teaching and learning narrative	**Assessable learning outcomes** *Learners will be required to:*
Consumers gain biomass from other organisms when they eat them. Some of this biomass is converted into molecules of glucose, the fuel for cellular respiration. Cellular respiration involves many chemical reactions and makes molecules of ATP. It occurs in the cytoplasm and mitochondria of animal and plant cells, and in the cytoplasm of microorganisms. ATP is required for processes that are essential for life, including breakdown and synthesis of molecules, active transport and muscle contraction. Aerobic respiration breaks down glucose and combines the breakdown products with oxygen, making water and carbon dioxide (a waste product). In conditions of low or no oxygen (such as in human cells during vigorous exercise, plant root cells in waterlogged soil and bacteria in puncture wounds) anaerobic respiration occurs. There is a partial breakdown of glucose, producing fewer molecules of ATP. In animal cells and some bacteria, this produces lactic acid (a waste product). In plants and some microorganisms, including yeast, it produces ethanol and carbon dioxide.	1. compare the processes of aerobic and anaerobic respiration, including conditions under which they occur, the inputs and outputs, and comparative yields of ATP 2. explain why cellular respiration occurs continuously in all living cells 3. explain how mitochondria in eukaryotic cells (plants and animals) are related to cellular respiration 4. describe cellular respiration as an exothermic process 5. a) describe practical investigations into the effect of different substrates on the rate of respiration in yeast *PAG5* b) carry out rate calculations for chemical reactions in the context of cellular respiration M1a, M1c

Linked learning opportunities

Practical work:

- investigate the amount of energy released from different foods, by burning them under a boiling tube of water where:
  energy (kJ) = mass of water (kg) x change in temperature (deg C) x 4.2 kJ/kg/deg C)
- investigate respiration in microorganisms by collecting CO_2 given off; which substrate works best?

B4.2 How do we know about mitochondria and other cell structures?

Teaching and learning narrative	Assessable learning outcomes *Learners will be required to:*	
Scientific progress often relies on technological developments which enable new observations to be made. The invention of the electron microscope enabled us to observe cell organelles such as mitochondria and chloroplasts at much higher magnification than had previously been possible with light microscopes, and thus to develop explanations about how their structures relate to their roles in cellular processes (IaS3).	1.	explain how electron microscopy has increased our understanding of sub-cellular structures
	2.	in the context of cells and sub-cellular structures: a) demonstrate an understanding of number, size and scale and the quantitative relationship between units M2a, M2h b) use estimations and explain when they should be used M1d **c) calculate with numbers written in standard form M1b**

Linked learning opportunities

Ideas about Science:

- explanations about the roles of cell organelles were developed from observations that could only be made using electron microscopy (IaS3)

B4.3 How do organisms grow and develop?

Teaching and learning narrative	Assessable learning outcomes *Learners will be required to:*
Growth of multicellular organisms involves an increase in the number of body cells. All new cells are created from existing cells when they divide. New body cells are created as part of the cell cycle. During interphase the cell grows larger, the numbers of organelles increase, and each chromosome is copied; then during mitosis the chromosome copies separate, the nucleus divides, and the cell divides to produce two new cells that are genetically identical to one another. Cancer is a non-communicable disease in humans caused by changes in a person's DNA. The changes cause a cell to divide many times by mitosis, which can create a tumour.	1. a) describe the role of the cell cycle in growth, including interphase and mitosis b) describe how to use a light microscope to observe stages of mitosis *PAG1* ⓘ *Learners are not expected to recall intermediate phases* 2. describe cancer as the result of changes in cells that lead to uncontrolled growth and division
Gametes are produced by meiosis, a different type of cell division. After interphase (during which the chromosome number has doubled), two meiotic divisions occur. Gametes contain half the number of chromosomes found in body cells (one chromosome from each pair). At fertilisation, maternal and paternal chromosomes pair up, so the zygote has the normal chromosome number.	3. explain the role of meiotic cell division in halving the chromosome number to form gametes, including the stages of interphase and two meiotic divisions ⓘ *Learners are not expected to recall intermediate phases*
A zygote divides by mitosis to form an embryo. All of the cells in an embryo are initially identical and unspecialised; these are embryonic stem cells, and can become specialised to form any type of cell (differentiation) by switching genes off and on. Most cells in a human embryo become specialised after the eight cell stage. However, some (adult stem cells) remain unspecialised and can become specialised later to become many, but not all, types of cells. In plants, only cells in meristems undergo mitosis, producing unspecialised cells that can develop into any kind of plant cell.	4. describe the function of stem cells in embryonic and adult animals and meristems in plants 5. explain the importance of cell differentiation, in which cells become specialised by switching genes off and on to form tissues with particular functions

Linked learning opportunities

Practical work:
- investigate mitosis using a microscope to look at stained cells from onion root tip

Specification links:
- factors that increase the risk of developing cancer (B2.5)

B4.4 How is plant growth controlled? *(separate science only)*

Teaching and learning narrative	Assessable learning outcomes *Learners will be required to:*
Plants are able to respond to their environment in different ways, e.g. phototropism in shoots and gravitropism in roots. These responses are controlled and coordinated by a group of plant hormones called auxins, and increase a plant's chances of survival. **Plants can also respond to environmental factors using other hormones. Gibberellins are involved in breaking seed dormancy (germination) in response to water, and bolting (production of flowers in an attempt to reproduce before death) in response to cold or lack of water. Ethene is involved in the ripening of fruit and dropping of leaves. Humans can exploit these responses and others such as triggering rooting in cuttings, by using plant hormones to trigger responses that are advantageous to us.**	1. a) 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 b) describe practical investigations into the role of auxin in phototropism *PAG6*
	2. describe some of the variety of effects of plant hormones, relating to gibberellins and ethene
	3. describe some of the different ways in which people use plant hormones to control plant growth

Linked learning opportunities

Practical work:

- investigate phototropism and the role of auxins in seedlings, using directional light sources and foil caps and rings

B4.5 Should we use stem cells to treat damage and disease?

Teaching and learning narrative	Assessable learning outcomes *Learners will be required to:*
Stem cells offer the potential to treat patients by replacing damaged tissues or cells. But the benefits must be weighed against risks and ethical concerns about the use and destruction of human embryos to collect embryonic stem cells. For these reasons, use of stem cells in research and medicine is subject to government regulation in many countries (IaS4).	1. discuss potential benefits, risks and ethical issues associated with the use of stem cells in medicine

Linked learning opportunities

Specification links:

- **stem cell therapy for neuron damage (B5.6)**

Ideas about Science:

- stem cell therapy as an application of science that could change lives (IaS4)
- risks, benefits and ethical issues associated with use of stem cells in medicine (IaS4)

2

2

Chapter B5: The human body – staying alive

Overview

From previous study, learners should appreciate that cells work together in multi-cellular organisms – in a hierarchy of cells, tissues, organs and systems – to support the functioning of each cell and of the organism as a whole. This chapter develops understanding of how cells and systems work together to support life in the human body.

In Topic B5.1, learners consider how the substances essential for chemical reactions are transported into, out of and around the human body, and why exchange surfaces are necessary. In Topics B5.2 and B5.3 they explore how the nervous and endocrine systems help the body to detect and respond to external and internal changes. Topic B5.4 illustrates the importance of maintaining a constant internal environment.

The essential role of hormones in human reproduction is explored in Topic B5.5, followed in Topic B5.6 by consideration of what can happen when certain structures and systems – including the regulation of blood sugar, structures in the eye and neurons in the nervous system – go wrong.

Learning about the human body before GCSE (9–1)

From study at Key Stages 1 to 3 learners should:

- appreciate the hierarchical organisation of multicellular organisms: from cells to tissues to organs to systems to organisms
- be able to identify, name, draw and label the basic parts of the human body
- have a basic understanding of the function of muscles
- be familiar with the tissues and organs of the human digestive system, including adaptations to function
- understand the basic structures and functions of the gas exchange system in humans, including adaptations to function
- understand the mechanism of breathing to move air in and out of the lungs, and be able to use a pressure model to explain the movement of gases
- understand, in outline, how nutrients and water are transported within animals, including humans
- be able to identify and name the main parts of the human circulatory system
- be familiar with the functions of the heart, blood vessels and blood
- know which part of the body is associated with each sense.

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.

Learning about the human body at GCSE (9–1)

B5.1 How do substances get into, out of and around our bodies?

Teaching and learning narrative	Assessable learning outcomes *Learners will be required to:*	*Linked learning opportunities*
Oxygen, water and molecules from food are essential for chemical reactions in cells in the human body, including cellular respiration and synthesis of biomass. Carbon dioxide and urea are waste products that need to be removed from cells before they reach toxic levels. Moving these substances into, around and out of the body depends upon interactions between the circulatory, gaseous exchange, digestive and excretory systems. Oxygen and carbon dioxide diffuse between blood in capillaries and air in alveoli. Water and dissolved food molecules are absorbed from the digestive system into blood in capillaries. Waste products including carbon dioxide and urea diffuse out of cells into the blood. Urea is filtered out of the blood by the kidneys into urine. Partially-permeable cell membranes regulate the movement of these substances; gases move across the membranes by diffusion, water by osmosis and other substances by active transport. The heart, blood vessels, red blood cells and plasma are adapted to transport substances around the body.	1. describe some of the substances transported into and out of the human body in terms of the requirements of cells, including oxygen, carbon dioxide, water, dissolved food molecules and urea 2. explain how the partially-permeable cell membranes of animal cells are related to diffusion, osmosis and active transport 3. describe the human circulatory system, including its relationships with the gaseous exchange system, the digestive system and the excretory system 4. explain how the structure of the heart is adapted to its function, including cardiac muscle, chambers and valves 5. explain how the structures of arteries, veins and capillaries are adapted to their functions, including differences in the vessel walls and the presence of valves 6. explain how red blood cells and plasma are adapted to their functions in the blood	**Practical work:** • dissect lamb's heart to observe atria, ventricles and valves • investigate valves in an arm vein (tourniquet around bicep; when veins become prominent, gently try to push blood in each direction)
To sustain all the living cells inside humans and other multi-cellular organisms, exchange surfaces increase the surface area:volume ratio, and the circulatory system moves substances around the body to decrease the distance they have to diffuse to and from cells.	7. explain the need for exchange surfaces and a transport system in multicellular organisms in terms of surface area:volume ratio 8. calculate surface area:volume ratios M1c, M5c	**Practical work:** • investigate the effect of surface area:volume ratio on diffusion of dye into agar cubes

B5.2 How does the nervous system help us respond to changes?

Teaching and learning narrative	Assessable learning outcomes *Learners will be required to:*	*Linked learning opportunities*
In order to survive, organisms need to detect and respond to changes in their external and internal environments. The highly adapted structures of the nervous system facilitate fast, short-lasting responses to stimuli. In a stimulated neuron, an electrical impulse passes along the axon. Most axons have a fatty sheath to increase impulse transmission speed. An impulse is transmitted from one neuron to another across a synapse by the release of transmitter substances, which diffuse across the gap and bind to receptors on the next neuron, stimulating it.	1. explain how the components of the nervous system work together to enable it to function, including sensory receptors, sensory neurons, the CNS, motor neurons and effectors 2. explain how the structures of nerve cells and synapses relate to their functions ⓘ Learners are not expected to explain nerve impulse transmission in terms of membrane potentials	
Reflexes provide rapid, involuntary responses without involving a processing centre, and are essential to the survival of many organisms. In some circumstances the brain can modify a reflex response via a neuron to the motor neuron of the reflex arc (e.g. to stop us dropping a hot object).	3. a) explain how the structure of a reflex arc, including the relay neuron, is related to its function b) describe practical investigations into reflex actions *PAG6*	
Research into the structure and function of the brain has huge potential impact for the ageing population. We know the brain is made of billions of neurons. We also know that different areas of the brain are important in different functions. **However, our ability to investigate and develop explanations about brain function remains limited. Most areas of the brain are concerned with many functions, but some functions can be mapped to particular areas using functional magnetic resonance imaging (fMRI), studies of patients with brain damage, and electrical stimulation (IaS3). There are ethical issues associated with studying brain damaged patients, including informed consent (IaS4).**	4. describe the structure and function of the brain and roles of the cerebral cortex (intelligence, memory, language and consciousness), cerebellum (conscious movement) and brain stem (regulation of heart and breathing rate) *(separate science only)* **5. explain some of the difficulties of investigating brain function** ***(separate science only)***	**Ideas about Science:** • **fMRI as a technological development that enabled observations that led to new scientific explanations (IaS3)** • **ethical issues around studying brain damaged patients (IaS4)**

B5.3 How do hormones control responses in the human body?

Teaching and learning narrative	Assessable learning outcomes *Learners will be required to:*	*Linked learning opportunities*
The endocrine system of humans and other animals uses hormones, secreted by glands and transported by the blood, to enable the body to respond to external and internal stimuli. Hormones bind to receptors on effectors, stimulating a response. The endocrine system provides slower, longer-lasting responses than the nervous system. **The production of hormones is regulated by negative feedback.**	1. describe the principles of hormonal coordination and control by the human endocrine system	
	2. explain the roles of thyroxine and adrenaline in the body, including thyroxine as an example of a negative feedback system	

B5.4 Why do we need to maintain a constant internal environment?

Teaching and learning narrative	Assessable learning outcomes *Learners will be required to:*
Cells, enzymes and life processes function only in certain conditions, and optimally when conditions are within a narrow range. The maintenance of a constant internal environment is homeostasis, and depends on receptors, nerves, hormones and (often antagonistic) effectors to counteract changes. The skin and muscles (including muscles in artery walls and hair follicles) work to control internal body temperature. **Maintenance of an ideal internal temperature depends on temperature receptors in the skin and hypothalamus, processing in the hypothalamus, responses such as sweating, hair erection, shivering, vasoconstriction and vasodilation, and negative feedback.** The kidneys filter water and urea from the blood into kidney tubules then reabsorb as much water as required, to maintain the water balance of the body. This helps to ensure the blood plasma is at the correct concentration to prevent the shrinking or bursting of cells due to osmosis. **Maintenance of an ideal water balance depends on receptors and processing in the hypothalamus, response by the pituitary gland (increased/decreased ADH production), and negative feedback.**	1. explain the importance of maintaining a constant internal environment in response to internal and external change
	2. a) describe the function of the skin in the control of body temperature, including changes to sweating, hair erection and blood flow b) describe practical investigations into temperature control of the body *PAG6* *(separate science only)*
	3. explain the response of the body to different temperature challenges, including receptors, processing, responses and negative feedback *(separate science only)*
	4. explain the effect on cells of osmotic changes in body fluids ⓘ *Learners are not expected to discuss water potential* *(separate science only)*
	5. describe the function of the kidneys in maintaining the water balance of the body, including filtering water and urea from the blood into kidney tubules then reabsorbing as much water as required *(separate science only)*
	6. describe the effect of ADH on the permeability of the kidney tubules *(separate science only)*
	7. explain the response of the body to different osmotic challenges, including receptors, processing, response, and negative feedback *(separate science only)*
	8. in the context of maintaining a constant internal environment: a) extract and interpret data from graphs, charts and tables M2c b) translate information between numerical and graphical forms M4a

Linked learning opportunities

Specification links:

- the effects of temperature on enzyme activity (B3.1)

Practical work:

- compare skin temperature and core body temperature under different conditions
- model the control of temperature by trying to keep a beaker of water at 40°C using just a Bunsen burner (single effector) compared to a Bunsen burner and ice (antagonistic effectors)

B5.5 What role do hormones play in human reproduction?

Teaching and learning narrative	Assessable learning outcomes *Learners will be required to:*	*Linked learning opportunities*
Hormones play a vital role in enabling sexual reproduction in humans: they regulate the menstrual cycle, including ovulation, in adult females. Without this process, sexual reproduction would not be possible.	1. describe the role of hormones in human reproduction, including the control of the menstrual cycle	
A number of hormones interact to control the menstrual cycle: • **FSH causes the ovaries to develop a follicle containing an egg, and produce oestrogen** • **oestrogen causes the uterus wall to thicken** • **LH causes the follicle to release the egg (ovulation)** • **the remains of the follicle secretes progesterone** • **progesterone prepares the lining of the uterus for implantation of a fertilised egg** • **oestrogen and progesterone stop the production of LH and FSH** • **as progesterone levels fall, the thickened uterus wall breaks down and is discharged (menstruation).**	**2. explain the interactions of FSH, LH, oestrogen and progesterone in the control of the menstrual cycle**	
The menstrual cycle can be controlled artificially by the administration of hormones, often as an oral pill. The hormones prevent ovulation, so can be used as a contraceptive, but they do not decrease the risk of sexual transmission of communicable diseases (IaS4).	3. explain the use of hormones in contraception and evaluate hormonal and non-hormonal methods of contraception	**Specification links:** • sexually transmitted disease (B2.1) **Ideas about Science:** • risk in the context of sex and contraception (IaS4)
Hormones can also be used to artificially manipulate the menstrual cycle as a treatment in certain cases of female infertility in which follicle development and ovulation do not occur successfully. The use of hormones to treat infertility is an example of an application of science that has made a significant positive difference to people's lives (IaS4).	**4. explain the use of hormones in modern reproductive technologies to treat infertility**	**Ideas about Science:** • **infertility treatment as an application of science that makes a positive difference to lives (IaS4)**

B5.6 What can happen when organs and control systems stop working?

Teaching and learning narrative	Assessable learning outcomes *Learners will be required to:*	*Linked learning opportunities*
Blood sugar level is controlled by insulin **and glucagon acting antagonistically**. Type 1 diabetes arises when the pancreas stops making insulin; blood sugar can be regulated using insulin injections. Type 2 diabetes develops when the body no longer responds to its own insulin or does not make enough insulin; blood sugar can be regulated using diet (high in complex carbohydrates), exercise and insulin injections.	1. explain how insulin controls the blood sugar level in the body **2. explain how glucagon and insulin work together to control the blood sugar level in the body** 3. compare type 1 and type 2 diabetes and explain how they can be treated	
The human eye is an important sense organ. Tissues in the eye are adapted to enable it to function. Damage or degradation of tissues and cells in the eye can impair sight. Ray diagrams can be used to model some of these problems and how they can be overcome (IaS3).	4. a) explain how the main structures of the eye are related to their functions, including the cornea, iris, lens, ciliary muscle and retina and to include the use of ray diagrams b) describe practical investigations into the response of the pupil in different light conditions *PAG6* *(separate science only)* 5. describe common defects of the eye, including short-sightedness, long-sightedness and cataracts, and explain how these problems may be overcome, including using ray diagrams to illustrate the effect of lenses *(separate science only)*	**Specification links**: • lenses and ray diagrams (P1.4) **Practical work**: • investigate the diameter of the pupil in different light conditions • investigate the focusing of light using lenses
Damage to neurons can lead to debilitating illness. Neurons, once differentiated, do not undergo mitosis, so cannot divide to replace lost neurons; this means damage to the nervous system can be difficult or impossible to treat. **Research into the use of stem cells to replace damaged cells of the nervous system offers the potential to improve the lives of people with nervous system injury and disease, but the ethics of stem cells use must also be considered (IaS4).**	**6. explain some of the limitations in treating damage and disease in the brain and other parts of the nervous system *(separate science only)***	**Specification links:** • Is it right to use stem cells in medicine? (B4.5) **Ideas about Science:** • stem cell therapy as an application of science that could change lives (IaS4)

Chapter B6: Life on Earth – past, present and future

Overview

The modern explanation of evolution by natural selection is one of the central ideas in biology. The historical development of the explanation and its journey to widespread acceptance in the science community illustrate key *Ideas about Science*.

Learners explore ideas about evolution in Key Stages 2 and 3, so by GCSE (9–1) they should be familiar with the concepts of variation (at phenotype level), adaptation, advantage, competition and natural selection. In Topic B6.1, learners begin to expand their understanding by linking variation to genetics, and the concept of evolution by natural selection is explored within the story of how the theory was developed, evaluated and modified by the scientific community. The topic considers the importance of evidence as the basis for widespread scientific acceptance of the theory, and probes reasons why some people may still not accept it.

The effects that sexual and asexual reproduction have on evolution are considered in Topic B6.2, followed by a brief examination in Topic B6.3 of the impact that developments in scientific understanding have had on the way we classify the diversity of life on Earth today.

Finally, in Topic B6.4 learners examine the impacts of human activities on the Earth's biodiversity, the tremendous importance of protecting it, issues that affect decision making, and ways in which our understanding of science can help us to interact positively with ecosystems so that biodiversity and ecosystem resources are conserved for the future.

Learning about evolution and biodiversity before GCSE (9–1)

From study at Key Stages 1 to 3 learners should:

- know that there are many different types of organisms living in many different environments, and that there are similarities and differences between all organisms
- recognise that living organisms can be grouped and classified in a variety of ways based on commonalities and differences
- be able to use classification keys
- recognise that living organisms have changed over time and that fossils provide information about organisms that lived millions of years ago
- appreciate that organisms live in habitats to which they are adapted
- recognise that organisms produce offspring of the same kind, but normally offspring vary and are not identical to their parents
- know that there is variation between individuals within a species, and that variation can be described as continuous or discontinuous
- understand that the variation means some organisms compete more successfully, resulting in natural selection
- appreciate that variation, adaptation, competition and natural selection result in the evolution of species
- understand that changes in the environment may leave organisms less well adapted to compete successfully and reproduce, which can lead to extinction
- be familiar with some of the reasons why it's important to protect and conserve biodiversity, and some ways of doing so.

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.

B6.1 How was the theory of evolution developed?

Teaching and learning narrative	Assessable learning outcomes *Learners will be required to:*	*Linked learning opportunities*
The modern theory of evolution by natural selection combines ideas about genes, variation, advantage and competition to explain how the inherited characteristics of a population can change over a number of generations. It includes the ideas that: Mutations in DNA create genetic variants, which may be inherited. Most genetic variants do not affect phenotype, but those that do may increase an organism's ability to survive in its environments and compete for resources (i.e. confer an advantage). Individuals with an advantage are more likely to reproduce; thus, by natural selection, the proportion of individuals possessing beneficial genetic variants increases in subsequent generations. A new species can arise if the organisms in a population evolve to be so different from their ancestors that they could no longer mate with them to produce fertile offspring. Speciation is more likely to occur when two populations of an organism are isolated.	1. state that there is usually extensive genetic variation within a population of a species 2. recall that genetic variants arise from mutations, and that most have no effect on the phenotype, some influence phenotype and a very few determine phenotype 3. explain how evolution occurs through natural selection of variants that give rise to phenotypes better suited to their environment 4. explain the importance of competition in a community, with regard to natural selection 5. describe evolution as a change in the inherited characteristics of a population over a number of generations through a process of natural selection which may result in the formation of new species	
Charles Darwin noticed that the selective breeding of plants and animals had produced new varieties with many beneficial characteristics, quite different to their wild ancestors. Most of what we eat, and our ability to feed the growing human population depends on selectively bred plants and animals. Darwin wondered whether a similar process of selection in nature could have created new species.	6. explain the impact of the selective breeding of food plants and domesticated animals	

B6.1 How was the theory of evolution developed?

Teaching and learning narrative	**Assessable learning outcomes** *Learners will be required to:*	***Linked learning opportunities***
The theory of evolution by natural selection was developed to explain observations made by Darwin, Wallace and other scientists, including: • the production of new varieties of plants and animals by selective breeding • fossils with similarities and differences to living species • the different characteristics shown by isolated populations of the same species living in different ecosystems. The development of the theory is an example of how scientists develop explanations. Darwin: made observations of the natural world; suggested natural selection to explain differences between fossils and living organisms, and between isolated populations; used ideas from Wallace and other scientists to improve his explanation; and shared his explanation with the scientific community (IaS3).	7. describe how fossils provide evidence for evolution 8. describe the work of Darwin and Wallace in the development of the theory of evolution by natural selection *(separate science only)*	**Ideas about Science:** • the theory of evolution by natural selection as an example of how scientific explanations are developed (IaS3)
The theory of evolution by natural selection illustrates how scientists continue to test a proposed explanation by making new observations and collecting new evidence, and how if the explanation is able to explain these it can become widely accepted by the scientific community (IaS3). For example, the spread of antibiotic resistance in bacteria can be explained by mutation, advantage and natural selection.	9. describe modern examples of evidence for evolution including antibiotic resistance in bacteria	**Ideas about Science:** • the theory of evolution by natural selection as a scientific explanation modified in light of new observations and ideas (IaS3)
Most scientists accept the modern theory of evolution because it is the best explanation for many of our observations of the natural world. However, some people do not accept it either because they are unaware of (or do not understand) the evidence, or because it does not fit with their beliefs (IaS4).	10. explain the impact of these ideas on modern biology and society *(separate science only)*	**Ideas about Science**: • reasons why different people do or do not accept an explanation (IaS4)

B6.2 How do sexual and asexual reproduction affect evolution? *(separate science only)*

Teaching and learning narrative	Assessable learning outcomes *Learners will be required to:*
The evolution of a population or species is affected by whether the individual organisms reproduce sexually or asexually. Sexual reproduction occurs at a slower rate than asexual reproduction, but provides genetic variation in the offspring.	1. explain some of the advantages and disadvantages of asexual and sexual reproduction in a range of organisms

Linked learning opportunities

B6.3 How does our understanding of biology help us classify the diversity of organisms on Earth?

Teaching and learning narrative	Assessable learning outcomes *Learners will be required to:*
The enormous diversity of organisms on Earth can be classified into groups on the basis of observed similarities and differences in their physical characteristics and, more recently, their DNA. We are more likely to classify species into the same group if there are lots of similarities in their genomes (i.e. if they have many genes, and genetic variants, in common). Genome analysis can also suggest whether different groups have a common ancestor, and how recently speciation occurred.	1. describe the impact of developments in biology on classification systems, including the use of DNA analysis to classify organisms

Linked learning opportunities

B6.4 How is biodiversity threatened and how can we protect it?

Teaching and learning narrative

The biodiversity of the Earth, or of a particular area, is the combination of the diversity of living organisms, the diversity of genes these organisms have, and the diversity of ecosystems.

The biodiversity of many areas is being reduced by activities related to increasing human population size, industrialisation and globalisation. Such interactions can result in ecosystems being damaged or destroyed, populations dying out, and species becoming extinct when conditions change more quickly than they can adapt. Humans can interact with ecosystems positively by using ecosystem resources in a sustainable way (at the same rate as they can be replaced), and by protecting and conserving biodiversity.

All organisms, including humans, depend on other organisms and the environment for their survival. Protecting and conserving biodiversity will help ensure we can continue to provide the human population with food, materials and medicines.

Biodiversity can be protected at different levels, including protection of individual species, protection of ecosystems, and control of activities that contribute to global climate change. Decisions about protecting and conserving biodiversity are affected by ecological, economic, moral and political issues (IaS4).

Assessable learning outcomes

Learners will be required to:

1.	describe both positive and negative human interactions within ecosystems and explain their impact on biodiversity
2.	**evaluate evidence for the impact of environmental changes on the distribution of organisms, with reference to water and atmospheric gases** ***(separate science only)***
3.	describe some of the biological factors affecting levels of food security including increasing human population, changing diets in wealthier populations, new pests and pathogens, environmental change, sustainability and cost of agricultural inputs *(separate science only)*
4.	explain some of the benefits and challenges of maintaining local and global biodiversity
5.	extract and interpret information related to biodiversity from charts, graphs and tables M2c, M4a
6.	describe and explain some possible biotechnological and agricultural solutions, including genetic modification, to the demands of the growing human population *(separate science only)*

Linked learning opportunities

Specification links:

- greenhouse gases and global warming (P1.3, C1.1)

Ideas about Science:

- the impacts of science on biodiversity, including negative impacts and potential solutions (IaS4)
- decision making in the context of the protection and conservation of biodiversity (IaS4)

Practical work:

- measure living and non-living indicators to assess the effect of pollution on organisms

2

Chapter B7: Ideas about Science

Overview

In order to make sense of the scientific ideas that learners encounter in lessons and in everyday life outside of school, they need an understanding of how science explanations are developed, the kinds of evidence and reasoning behind them, their strengths and limitations, and how far we can rely on them.

Learners also need opportunities to consider the impacts of science and technology on society, and how we respond individually and collectively to new ideas, artefacts and processes that science makes possible.

It is intended that the *Ideas about Science* will help learners understand how scientific knowledge is obtained, how to respond to science stories and issues in the world outside the classroom, and the impacts of scientific knowledge on society.

Note that:

- although particular *Ideas about Science* have been linked to particular contexts throughout the specification as examples, the assessable learning outcomes in this chapter should be developed, and will be assessed, in any context from chapters 1–6
- the assessable learning outcomes in this chapter will be assessed in all of the written examination papers
- terms associated with measurement and data analysis are used in accordance with their definitions in the Association of Science Education publication *The Language of Measurement* (2010).

Learning about How Science Works before GCSE (9–1)

From study at Key Stages 1 to 3 learners should:

- understand that science explanations are based on evidence and that as new evidence is gathered, explanations may change
- have devised and carried out scientific enquiries, in which they have selected the most appropriate techniques and equipment, collected and analysed data and drawn conclusions.

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.

IaS1 What needs to be considered when investigating a phenomenon scientifically?

Teaching and learning narrative	Assessable learning outcomes *Learners will be required to:*	*Linked learning opportunities*
The aim of science is to develop good explanations for natural phenomena. There is no single ‘scientific method’ that leads to good explanations, but scientists do have characteristic ways of working. In particular, scientific explanations are based on a cycle of collecting and analysing data. Usually, developing an explanation begins with proposing a hypothesis. A hypothesis is a tentative explanation for an observed phenomenon (“this happens because…”). The hypothesis is used to make a prediction about how, in a particular experimental context, a change in a factor will affect the outcome. A prediction can be presented in a variety of ways, for example in words or as a sketch graph. In order to test a prediction, and the hypothesis upon which it is based, it is necessary to plan an experimental strategy that enables data to be collected in a safe, accurate and repeatable way.	1. in given contexts use scientific theories and tentative explanations to develop and justify hypotheses and predictions 2. suggest appropriate apparatus, materials and techniques, justifying the choice with reference to the precision, accuracy and validity of the data that will be collected 3. recognise the importance of scientific quantities and understand how they are determined 4. identify factors that need to be controlled, and the ways in which they could be controlled 5. suggest an appropriate sample size and/or range of values to be measured and justify the suggestion M2d 6. plan experiments or devise procedures by constructing clear and logically sequenced strategies to: – make observations – produce or characterise a substance – test hypotheses – collect and check data – explore phenomena 7. identify hazards associated with the data collection and suggest ways of minimising the risk 8. use appropriate scientific vocabulary, terminology and definitions to communicate the rationale for an investigation and the methods used using diagrammatic, graphical, numerical and symbolic forms	

IaS2 What conclusions can we make from data?

Teaching and learning narrative	**Assessable learning outcomes** *Learners will be required to:*		*Linked learning opportunities*
The cycle of collecting, presenting and analysing data usually involves translating data from one form to another, mathematical processing, graphical display and analysis; only then can we begin to draw conclusions. A set of repeat measurements can be processed to calculate a range within which the true value probably lies and to give a best estimate of the value (mean). Displaying data graphically can help to show trends or patterns, and to assess the spread of repeated measurements. Mathematical comparisons between results and statistical methods can help with further analysis.	1.	present observations and other data using appropriate formats	
	2.	when processing data use SI units where appropriate (e.g. kg, g, mg; km, m, mm; kJ, J) and IUPAC chemical nomenclature unless inappropriate	
	3.	when processing data use prefixes (e.g. tera, giga, mega, kilo, centi, milli, micro and nano) and powers of ten for orders of magnitude	
	4.	be able to translate data from one form to another M2c, M4a	
	5.	when processing data interconvert units	
	6.	when processing data use an appropriate number of significant figures M2a	
	7.	when displaying data graphically select an appropriate graphical form, use appropriate axes and scales, plot data points correctly, draw an appropriate line of best fit, and indicate uncertainty (e.g. range bars) M2c, M4a, M4c	
	8.	when analysing data identify patterns/trends, use statistics (range and mean) and obtain values from a line on a graph (including gradient, interpolation and extrapolation) M2b, M2f, M2g, M4b, M4d	

IaS2 What conclusions can we make from data?

Teaching and learning narrative	Assessable learning outcomes *Learners will be required to:*	*Linked learning opportunities*
Data obtained must be evaluated critically before we can make conclusions based on the results. There could be many reasons why the quality (accuracy, precision, repeatability and reproducibility) of the data could be questioned, and a number of ways in which they could be improved. Data can never be relied on completely because observations may be incorrect and all measurements are subject to uncertainty (arising from the limitations of the measuring equipment and the person using it). A result that appears to be an outlier should be treated as data, unless there is a reason to reject it (e.g. measurement or recording error).	9. in a given context evaluate data in terms of accuracy, precision, repeatability and reproducibility, identify potential sources of random and systematic error, and discuss the decision to discard or retain an outlier 10. evaluate an experimental strategy, suggest improvements and explain why they would increase the quality (accuracy, precision, repeatability and reproducibility) of the data collected, and suggest further investigations	
Agreement between the collected data and the original prediction increases confidence in the tentative explanation (hypothesis) upon which the prediction is based, but does not prove that the explanation is correct. Disagreement between the data and the prediction indicates that one or other is wrong, and decreases our confidence in the explanation.	11. in a given context interpret observations and other data (presented in diagrammatic, graphical, symbolic or numerical form) to make inferences and to draw reasoned conclusions, using appropriate scientific vocabulary and terminology to communicate the scientific rationale for findings and conclusions 12. explain the extent to which data increase or decrease confidence in a prediction or hypothesis	

IaS3 How are scientific explanations developed?

Teaching and learning narrative	Assessable learning outcomes *Learners will be required to:*	*Linked learning opportunities*
Scientists often look for patterns in data as a means of identifying correlations that can suggest cause-effect links – for which an explanation might then be sought. The first step is to identify a correlation between a factor and an outcome. The factor may then be the cause, or one of the causes, of the outcome. In many situations, a factor may not always lead to the outcome, but increases the chance (or the risk) of it happening. In order to claim that the factor causes the outcome we need to identify a process or mechanism that might account for the observed correlation.	1. use ideas about correlation and cause to: a) identify a correlation in data presented as text, in a table, or as a graph M2g b) distinguish between a correlation and a cause-effect link c) suggest factors that might increase the chance of a particular outcome in a given situation, but do not invariably lead to it d) explain why individual cases do not provide convincing evidence for or against a correlation e) identify the presence (or absence) of a plausible mechanism as reasonable grounds for accepting (or rejecting) a claim that a factor is a cause of an outcome	**Considering correlation and cause:** risk factors for non-communicable diseases (B2.5)
Scientific explanations and theories do not 'emerge' automatically from data, and are separate from the data. Proposing an explanation involves creative thinking. Collecting sufficient data from which to develop an explanation often relies on technological developments that enable new observations to be made. As more evidence becomes available, a hypothesis may be modified and may eventually become an accepted explanation or theory. A scientific theory is a general explanation that applies to a large number of situations or examples (perhaps to all possible ones), which has been tested and used successfully, and is widely accepted by scientists. A scientific explanation of a specific event or phenomenon is often based on applying a scientific theory to the situation in question.	2. describe and explain examples of scientific methods and theories that have developed over time and how theories have been modified when new evidence became available	**Developing scientific explanations: Mendel's work on inheritance (B1.2);** the theory of evolution by natural selection (B6.1) Explanations that relied on technological development: roles of cell organelles (B4.2); brain function (B5.3); three domain model of classification (B6.3)

IaS3 How are scientific explanations developed?

Teaching and learning narrative	**Assessable learning outcomes** *Learners will be required to:*	***Linked learning opportunities***
Findings reported by an individual scientist or group are carefully checked by the scientific community before being accepted as scientific knowledge. Scientists are usually sceptical about claims based on results that cannot be reproduced by anyone else, and about unexpected findings until they have been repeated (by themselves) or reproduced (by someone else). Two (or more) scientists may legitimately draw different conclusions about the same data. A scientist's personal background, experience or interests may influence his/her judgements. An accepted scientific explanation is rarely abandoned just because new data disagree with it. It usually survives until a better explanation is available.	3. describe in broad outline the 'peer review' process, in which new scientific claims are evaluated by other scientists	
Models are used in science to help explain ideas and to test explanations. A model identifies features of a system and rules by which the features interact. It can be used to predict possible outcomes. Representational models use physical analogies or spatial representations to help visualise scientific explanations and mechanisms. Descriptive models are used to explain phenomena. Mathematical models use patterns in data of past events, along with known scientific relationships, to predict behaviour; often the calculations are complex and can be done more quickly by computer. Models can be used to investigate phenomena quickly and without ethical and practical limitations, but their usefulness is limited by how accurately the model represents the real world.	4. use a variety of models (including representational, spatial, descriptive, computational and mathematical models) to: – solve problems – make predictions – develop scientific explanations and understanding – identify limitations of models	**Examples of models*:*** letters (ATCG) for the genetic code (B1.1); Punnett squares for single-gene inheritance (B1.2); lock and key for enzyme action (B3.1); food webs **and pyramids of biomass** (B3.3); ray diagrams for focussing of light in the eye (B5.6); classification (B6.3)

IaS4 How do science and technology impact society?

Teaching and learning narrative	Assessable learning outcomes *Learners will be required to:*
Science and technology provide people with many things that they value, and which enhance their quality of life. However some applications of science can have unintended and undesirable impacts on the quality of life or the environment. Scientists can devise ways of reducing these impacts and of using natural resources in a sustainable way (at the same rate as they can be replaced). Everything we do carries a certain risk of accident or harm. New technologies and processes can introduce new risks. The size of a risk can be assessed by estimating its chance of occurring in a large sample, over a given period of time. To make a decision about a course of action, we need to take account of both the risks and benefits to the different individuals or groups involved. People are generally more willing to accept the risk associated with something they choose to do than something that is imposed, and to accept risks that have short-lived effects rather than long-lasting ones. **People's perception of the size of a particular risk may be different from the statistically estimated risk**. People tend to over-estimate the risk of unfamiliar things (like flying as compared with cycling), and of things whose effect is invisible or long-term (like ionising radiation). Some forms of scientific research, and some applications of scientific knowledge, have ethical implications. In discussions of ethical issues, a common argument is that the right decision is one which leads to the best outcome for the greatest number of people.	1. describe and explain examples of applications of science that have made significant positive differences to people's lives 2. identify examples of risks that have arisen from a new scientific or technological advance 3. for a given situation: a) identify risks and benefits to the different individuals and groups involved b) discuss a course of action, taking account of who benefits and who takes the risks c) suggest reasons for people's willingness to accept the risk **d) distinguish between perceived and calculated risk**

Linked learning opportunities

Positive applications of science: genetic engineering (B1.3); monoclonal antibodies (B2.3, B2.6); infertility treatment (B5.5); stem cell therapy (B4.7, **B5.6**); environmental conservation and sustainability (B6.4)

Unintended impacts: biodiversity loss (B6.4)

Considering risks, benefits and ethical issues: gene technology (B1.3); disease prevention (B2.4); risk factors for non-communicable diseases (B2.5); treatment options for disease (B2.6); placebos in clinical trials (B2.6); use of stem cells (B4.5, **B5.6**); studying brain damaged patients (B5.6); sex and contraception (B5.5); conservation of biodiversity (B6.4)

IaS4 How do science and technology impact society?

Teaching and learning narrative	Assessable learning outcomes *Learners will be required to:*	*Linked learning opportunities*
Scientists must communicate their work to a range of audiences, including the public, other scientists, and politicians, in ways that can be understood. This enables decision-making based on information about risks, benefits, costs and ethical issues.	4. suggest reasons why different decisions on the same issue might be appropriate in view of differences in personal, social, or economic or environmental context, and be able to make decisions based on the evaluation of evidence and arguments	
	5. distinguish questions that could in principle be answered using a scientific approach, from those that could not; where an ethical issue is involved clearly state what the issue is and summarise the different views that may be held	
	6. explain why scientists should communicate their work to a range of audiences	

2

Chapter B8: Practical skills

Compliance with the requirements for practical work

It is compulsory that learners complete at least *eight* practical activities.

OCR has split the requirements from the Department for Education 'GCSE subject content and assessment objectives' – Appendix 4 into eight Practical Activity Groups or PAGs.

The Practical Activity Groups allow centres flexibility in their choice of activity. Whether centres use OCR suggested practicals or centre-substituted practicals, they must ensure completion of at least eight practical activities and each learner *must* have had the opportunity to use all of the apparatus and techniques described in the following table of this chapter.

The table illustrates the apparatus and techniques required for each PAG and an example practical that may be used to contribute to the PAG. It should be noted that some apparatus and techniques can be used in more than one PAG. *It is therefore important that teachers take care to ensure that learners do have the opportunity to use all of the required apparatus and techniques during the course with the activities chosen by the centre.*

Within the specification there are a number of practicals, indicated as, for example, *PAG1*, that are described in the 'Assessable learning outcomes' column. These can count towards each PAG. We are expecting that centres will provide learners with opportunities to carry out a wide range of practical activities during the course. These can be the ones described in the specification or can be practicals that are devised by the centre. Activities can range from whole investigations to simple starters and plenaries.

It should be noted that the practicals described in the specification need to be covered in preparation for the questions in the written examinations that will assess practical skills. No less than 15% of the questions will assess practical skills. Learners also need to be prepared to answer questions using their knowledge and understanding of practical techniques and procedures in written papers.

Safety is an overriding requirement for all practical work. Centres are responsible for ensuring appropriate safety procedures are followed whenever their learners complete practical work.

Use and production of appropriate scientific diagrams to set up and record apparatus and procedures used in practical work is common to all science subjects and should be included wherever appropriate.

Revision of the requirements for practical work

OCR will review the practical activities detailed in Chapter B8 of this specification following any revision by the Secretary of State of the apparatus or techniques published specified in respect of the GCSE Biology B (Twenty First Century Science) qualification.

OCR will revise the practical activities if appropriate.

If any revision to the practical activities is made, OCR will produce an amended specification which will be published on the OCR website. OCR will then use the following methods to communicate the amendment to Centres: Notice to Centres sent to all Examinations Officers, e-alerts to Centres that have registered to teach the qualification and social media.

The following list includes opportunities for choice and use of appropriate laboratory apparatus for a variety of experimental problem-solving and/or enquiry based activities.

Practical Activity Group (PAG)	Apparatus and techniques that the practical must use or cover	Example of a practical activity (a range of practicals are included in the specification and Centres can devise their own activity)*
1 Microscopy	Use of appropriate apparatus, techniques and magnification, including microscopes, to make observations of biological specimens and produce labelled scientific drawings[7]	Investigate different magnification techniques to draw scientific diagrams from a number of biological specimens
	Use of appropriate apparatus to make and record a range of measurements accurately, including length, area, mass, time, temperature, volume of liquids and gases, and pH[1]	
2 Testing for biological molecules	Safe use of appropriate heating devices and techniques including use of a Bunsen burner and a water bath or electric heater[2]	Testing foods for the presence of biological molecules in a range of foods
	Use of appropriate techniques and qualitative reagents to identify biological molecules and processes in more complex and problem-solving contexts including continuous sampling in an investigation	
3 Sampling techniques	Application of appropriate sampling techniques to investigate the distribution and abundance of organisms in an ecosystem via direct use in the field (to include: biotic and abiotic factors)	Investigation the differences in habitats using ecological sampling techniques
	Use of appropriate apparatus to make and record a range of measurements accurately, including length, area, mass, time, temperature, volume of liquids and gases, and pH[1]	
4 Rates of enzyme-controlled reactions	Safe use of appropriate heating devices and techniques including use of a Bunsen burner and a water bath or electric heater[2]	Investigate the factors that can affect the rate of enzyme activity
	Use of appropriate apparatus and techniques for the observation and measurement of biological changes and/or processes[3]	
	Measurement of rates of reaction by a variety of methods including production of gas, uptake of water and colour change of indicator[5]	
	Use of appropriate apparatus to make and record a range of measurements accurately, including length, area, mass, time, temperature, volume of liquids and gases, and pH[1]	

Practical Activity Group (PAG)	Apparatus and techniques that the practical must use or cover	Example of a practical activity (a range of practicals are included in the specification and Centres can devise their own activity)*
5 Photosynthesis	Use of appropriate apparatus and techniques for the observation and measurement of biological changes and/or processes[3]	Investigate the factors that can affect the rate of photosynthesis on *Cabomba*
	Safe and ethical use of living organisms (plants or animals) to measure physiological functions and responses to the environment[4]	
	Measurement of rates of reaction by a variety of methods including production of gas, uptake of water and colour change of indicator[5]	
	Safe use of appropriate heating devices and techniques including use of a Bunsen burner and a water bath or electric heater[2]	
	Use of appropriate apparatus to make and record a range of measurements accurately, including length, area, mass, time, temperature, volume of liquids and gases, and pH[1]	
6 Physiology, responses respiration	Safe and ethical use of living organisms (plants or animals) to measure physiological functions and responses to the environment[4]	Investigate the effect of exercise on pulse rate/ventilation rate and recovery
	Safe use of appropriate heating devices and techniques including use of a Bunsen burner and a water bath or electric heater[2]	
7 Microbiological techniques	Use of appropriate apparatus and techniques for the observation and measurement of biological changes and/or processes[3]	Investigate the effectiveness of antimicrobial agents on the growth of a bacterial lawn
	Use of appropriate apparatus, techniques and magnification, including microscopes, to make observations of biological specimens and produce labelled scientific drawings[7]	
	Safe use of appropriate heating devices and techniques including use of a Bunsen burner and a water bath or electric heater[2]	
	Use of appropriate apparatus to make and record a range of measurements accurately, including length, area, mass, time, temperature, volume of liquids and gases, and pH[1]	
8 Transport in and out of cells	Use of appropriate apparatus and techniques for the observation and measurement of biological changes and/or processes[3]	Investigate the effect of different water potentials on the length and mass of potato chips
	Use of appropriate apparatus to make and record a range of measurements accurately, including length, area, mass, time, temperature, volume of liquids and gases, and pH[1]	

*** Centres are free to substitute alternative practical activities that also cover the apparatus and techniques from DfE: Biology, chemistry and physics GCSE subject content, July 2015 Appendix 4.**

[1, 2, 3, 4, 5, 7] These apparatus and techniques may be covered in any of the groups indicated. Numbers correspond to those used in DfE: Biology, chemistry and physics GCSE subject content, July 2015 Appendix 4.

Choice of activity

Centres can include additional apparatus and techniques within an activity beyond those listed as the minimum in the above tables. Learners *must* complete a *minimum* of eight practicals covering all the apparatus and techniques listed.

The apparatus and techniques can be covered:

(i) by using OCR suggested activities (provided as resources)
(ii) through activities devised by the Centre.

Centres can receive guidance on the suitability of their own practical activities through our free practical activity consultancy service.
E-mail: ScienceGCSE@ocr.org.uk

Where Centres devise their own practical activities to cover the apparatus and techniques listed above, the practical must cover all the requirements and be of a level of demand appropriate for GCSE. Each set of apparatus and techniques described in the middle column can be covered by more than one Centre devised practical activity e.g. "measurement of rates of reaction by a variety of methods including production of gas, uptake of water and colour change of indicator" could be split into two or more activities (rather than one).

2

NEA Centre Declaration Form: Practical Science Statement

Centres must provide a written **practical science statement** confirming that reasonable opportunities have been provided to all learners being submitted for entry within that year's set of assessments to undertake at least **eight** practical activities.

The practical science statement is contained within the NEA Centre Declaration Form which can be found on the OCR website at www.ocr.org.uk/formsfinder. By signing the form, the centre is confirming that they have taken reasonable steps to secure that each learner:

a) has completed the practical activities set by OCR as detailed in Chapter B8
b) has made a contemporaneous record of:
   (i) the work which the learner has undertaken during those practical activities, and
   (ii) the knowledge, skills and understanding which that learner has derived from those practical activities.

Centres should retain records confirming points (a) to (b) above as they may be requested as part of the JCQ inspection process. Centres must provide practical science opportunities for their learners. This does not go so far as to oblige centres to ensure that all of their learners take part in all of the practical science opportunities. There is always a risk that an individual learner may miss the arranged practical science work, for example because of illness. It could be costly for the centre to run additional practical science opportunities for the learner.

However, the opportunities to take part in the specified range of practical work must be given to all learners. Learners who do not take up the full range of opportunities may be disadvantaged as there will be questions on practical science in the GCSE (9–1) Biology B (Twenty First Century Science) assessment. Please see the JCQ publication *Instructions for conducting non-examination assessments* for further information.

Any failure by a centre to provide a practical science statement to OCR in a timely manner (by means of an NEA Centre Declaration Form) will be treated as malpractice and/or maladministration [under General Condition A8 (*Malpractice and maladministration*)].

2

2d. Prior knowledge, learning and progression

- Learners in England who are beginning a GCSE (9–1) course are likely to have followed a Key Stage 3 programme of study.
- There are no prior qualifications required in order for learners to enter for a GCSE (9–1) in Biology B (Twenty First Century Science).
- GCSEs (9–1) are qualifications that enable learners to progress to further qualifications, either Vocational or General.

There are a number of Science specifications at OCR. Find out more at www.ocr.org.uk

3 Assessment of GCSE (9–1) in Biology B (Twenty First Century Science)

3a. Forms of assessment

The GCSE (9–1) in Biology B (Twenty First Century Science) is a linear qualification with 100% external assessment.

OCR's GCSE (9–1) in Biology B (Twenty First Century Science) consists of four examined components that are externally assessed. Two are at Foundation Tier and two are at Higher Tier. Each component carries an equal weighting of 50% for that tier of the GCSE (9–1) qualification. Each component has a duration of 1 hour and 45 minutes.

3

Assessment approach

The assessment of the content of Biology B (Twenty First Century Science) is achieved using two components at each tier.

Breadth paper: this paper can assess content from across the whole specification. The paper will include short answer response questions. These will include structured questions, calculations and questions based on practical skills. Extended response questions are not found on the Breadth paper.

Depth paper: this paper can assess content from across the whole specification. The focus of the Depth paper is to allow learners to demonstrate their depth of understanding of specific aspects of the content. This will be achieved by the inclusion of some short answer response questions. These will include structured questions, calculations and questions based on practical skills. The paper will have at least two extended response questions, marked using Level of Response mark schemes, each with a total of 6 marks.

Breadth in biology (Components 01 and 03)

These components, one at Foundation Tier and one at Higher Tier, are each worth 90 marks and assess content from across all teaching chapters 1 to 8. Learners answer all the questions.

Depth in Biology (Components 02 and 04)

These components, one at Foundation Tier and one at Higher Tier, are each worth 90 marks and assess content from across all teaching chapters 1 to 8. Learners answer all the questions.

3b. Assessment objectives (AO)

There are three Assessment Objectives in OCR GCSE (9–1) in Biology B (Twenty First Century Science).

These are detailed in the table below:

Assessment Objectives		Weighting (%)	
		Higher	Foundation
AO1	**Demonstrate knowledge and understanding of:** • scientific ideas • scientific techniques and procedures	40%	40%
AO2	**Apply knowledge and understanding of:** • scientific ideas • scientific enquiry, techniques and procedures	40%	40%
AO3	**Analyse information and ideas to:** • interpret and evaluate • make judgements and draw conclusions • develop and improve experimental procedures	20%	20%

The Assessment Objectives are further broken down to Assessment Objective elements as shown in the table below.

Assessment Objective elements	
AO1	**Demonstrate knowledge and understanding of scientific ideas and scientific techniques and procedures.**
AO1.1	Demonstrate knowledge and understanding of scientific ideas.
AO1.2	Demonstrate knowledge and understanding of scientific techniques and procedures.
AO2	**Apply knowledge and understanding of scientific ideas and scientific enquiry, techniques and procedures.**
AO2.1	Apply knowledge and understanding of scientific ideas.
AO2.2	Apply knowledge and understanding of scientific enquiry, techniques and procedures.
AO3	**Analyse information and ideas to interpret and evaluate, make judgements and draw conclusions and develop and improve experimental procedures.**
AO3.1	Analyse information and ideas to interpret and evaluate.
AO3.1a	Analyse information and ideas to interpret.
AO3.1b	Analyse information and ideas to evaluate.
AO3.2	Analyse information and ideas to make judgements and draw conclusions.
AO3.2a	Analyse information and ideas to make judgements.

Assessment Objective elements	
AO3.2b	Analyse information and ideas to draw conclusions.
AO3.3	Analyse information and ideas to develop and improve experimental procedures.
AO3.3a	Analyse information and ideas to develop experimental procedures.
AO3.3b	Analyse information and ideas to improve experimental procedures.

AO weightings in OCR GCSE (9–1) in Biology B (Twenty First Century Science)

The relationship between the Assessment Objectives and the components are shown in the following table:

Component (Foundation Tier)	% of overall GCSE (9–1) in Biology B (Twenty First Century Science) (J257)			
	AO1	AO2	AO3	Total
Breadth in biology (Foundation Tier) J257/01	24	18	8	50
Depth in biology (Foundation Tier) J257/02	16	22	12	50
Total	40	40	20	100
Component (Higher Tier)	**AO1**	**AO2**	**AO3**	**Total**
Breadth in biology (Higher Tier) J257/03	24	18	8	50
Depth in biology (Higher Tier) J257/04	16	22	12	50
Total	40	40	20	100

3c. Command words

The key list of common command words used in our exams is listed below. The definitions are intended to provide guidance to teachers and students as to what a student will be expected to do when these words are used in examinations.

The exact response expected to a command word will be dependent on the context. At all times, we advise students to read the full question carefully to be sure of what they are being asked to do.

Command word	Definition
analyse	Separate information into components and identify their characteristics. Discuss the pros and cons of a topic or argument and make reasoned comment.
calculate	Generate a numerical answer, with workings shown.
choose	Select from a list or a number of alternatives.
classify	Assign to a category or group.
compare and contrast	Identify similarities and differences.
complete	Add words, numbers, labels or plots to complete a sentence, table, diagram or graph.

3

Command word	Definition
conclude	Make a decision after reasoning something out.
construct	Write out or draw the requested item, e.g. '…Construct a dot and cross diagram for sodium chloride…' or '…Construct a balanced equation for a specific reaction…'
convert	Change a defined item to another defined item, e.g. '…Convert your calculated answer in g to an answer in moles…'
deduce	Use your knowledge and/or supplied data to work something out, e.g. '…Deduce the empirical formula of compound **X** (using supplied data)…'
define	Use your knowledge to state the meaning of a given term, e.g. '…Define the term specific heat capacity…' or '…Define the term momentum…'
describe	Set out the facts or characteristics. The description of a process should address what happens, and when and/or where it happens. (Compare with 'Explain') For example, when asked to <u>describe</u> the change in rate of reaction seen on a graph, the expected response might be to describe whether the rate of reaction remains constant, or decreases or increases over time.
design	Plan and present ideas to show a layout / function / workings / object / system / process.
determine	Obtain a solution by following a set of procedures. Obtain a numerical value by carrying out a series of calculations. Also see 'Find' which is more commonly used for Foundation tier.
discuss	Give an account that addresses a range of ideas and arguments.
draw	Produce a diagram with sufficient detail and labels to illustrate the answer. (Compare with 'Sketch')
estimate	Assign an approximate value.
evaluate	Make a qualitative judgement taking into account different factors and using available knowledge / experience / evidence.
explain	Set out reasons and/or mechanisms to address why and/or how something happens. (Compare with 'Describe') For example, when asked to <u>explain</u> the change in rate of reaction seen on a graph, the expected response would suggest scientific reasons for any change seen, for example in terms of molecular collisions or enzymatic action.
find	Obtain a solution by following a set of procedures. Obtain a numerical value by carrying out a series of calculations. Also see 'Determine'. Find is more commonly used for Foundation tier.
give	A short answer is required without explanation (unless separately requested).
how	In what way?
identify	Recognise, list, name or otherwise characterise.
illustrate	Make clear by using examples or providing diagrams.
justify	Present a reasoned case for actions or decisions made.
label	Add names or other identifying words or symbols to a diagram.

Command word	Definition
measure	Establish a value using a suitable measuring instrument or technique.
name	Provide appropriate word(s) or term(s).
outline	Provide a description setting out the main characteristics / points.
plan	Consider, set out and communicate what is to be done.
plot	Translate data into a suitable graph or chart, with labelled axes.
predict	Make a judgement of an event or action that will or would happen in the future, as a result of knowledge, experience or evidence.
recall	Use your knowledge of the specification to remember a relevant key fact which needs to be used in the question.
select	Carefully choose as being the most suitable for a task or purpose.
show	Write down details, steps or calculations to prove a fact or answer.
sketch	Produce a simple, freehand drawing to illustrate the general point being conveyed. Detail is not required. (Compare with 'Draw') In the context of a graph, the general shape of the curve would be sufficient without plotting precise points. (Compare with 'Plot')
state or define	Express in precise terms the nature, state or meaning.
suggest	Give possible alternatives, produce an idea, put forward (for example) an idea or a plan for consideration.
use / using	The answer must be based on information given in the question.
what	A request for information, clarified by the context or question in which it is contained.
which	Identify an object, word or explanation.
why	For what reason?
write	Present the required information, e.g. '…Write balanced equations that represent the radioactive decay of...'

3d. Tiers

This scheme of assessment consists of two tiers: Foundation Tier and Higher Tier. Foundation Tier assesses grades 5 to 1 and Higher Tier assesses grades 9 to 4. An allowed grade 3 may be awarded on the Higher Tier option for learners who are a small number of marks below the grade 3/4 boundary. Learners must be entered for either the Foundation Tier or the Higher Tier.

3e. Total qualification time

Total qualification time (TQT) is the total amount of time, in hours, expected to be spent by a learner to achieve a qualification. It includes both guided learning hours and hours spent in preparation, study, and assessment. The total qualification time for GCSE Biology B is 140 hours. The total guided learning time is 120-140 hours.

3

3f. Qualification availability outside of England

This qualification is available in England. For Wales and Northern Ireland please check the Qualifications in Wales Portal (QIW) or the Northern Ireland Department of Education Performance Measures / Northern Ireland Entitlement Framework Qualifications Accreditation Number (NIEFQAN) list to see current availability.

3g. Language

This qualification is available in English only. All assessment materials are available in English only and all candidate work must be in English.

3h Assessment availability

There will be one examination series available each year in May/June to **all** learners.

All examined components must be taken in the same examination series at the end of the course.

This specification will be certificated from the June 2018 examination series onwards.

3i. Retaking the qualification

Learners can retake the qualification as many times as they wish.

They retake all components in the tier of entry of the qualification.

3j. Assessment of extended response

Extended response questions which are marked using a level of response mark scheme are included in the Depth in biology components (02 and 04). These are indicated in papers and mark schemes by an asterisk (*). Extended response questions provide learners with the opportunity to demonstrate their ability to construct and develop a sustained and coherent line of reasoning and marks for extended responses are integrated into the marking criteria.

3k. Synoptic assessment

Synoptic assessment tests the learners' understanding of the connections between different elements of the subject.

Synoptic assessment has been defined, for the purposes of this qualification, as allowing learners the opportunity to demonstrate the ability to draw together different areas of knowledge, skills and/or understanding from across the full course of study. The emphasis of synoptic assessment is to encourage the development of the understanding of Biology B (Twenty First Century Science) as a discipline. All papers contain an element of synoptic assessment.

Synoptic assessment requires learners to make and use connections within and between different areas of biology, for example by:

- applying knowledge and understanding of more than one area to a particular situation or context
- using knowledge and understanding or principles and concepts in planning experimental and investigative work and in the analysis and evaluation of data
- bringing together scientific knowledge and understanding from different areas of the subject and applying them.

3l. Calculating qualification results

A learner's overall qualification grade for OCR GCSE (9–1) in Biology B (Twenty First Century Science) will be calculated by adding together their marks from the two components taken to give their total weighted mark. This mark will then be compared to the qualification level grade boundaries for the entry option taken by the learner and for the relevant exam series to determine the learner's overall qualification grade.

4 Admin: what you need to know

The information in this section is designed to give an overview of the processes involved in administering this qualification so that you can speak to your exams officer. All of the following processes require you to submit something to OCR by a specific deadline.

More information about the processes and deadlines involved at each stage of the assessment cycle can be found in the Administration area of the OCR website.

OCR's *Admin overview* is available on the OCR website at https://www.ocr.org.uk/administration.

4a. Pre-assessment

Estimated entries

Estimated entries are your best projection of the number of learners who will be entered for a qualification in a particular series. Estimated entries should be submitted to OCR by the specified deadline. They are free and do not commit your centre in any way.

4

Final entries

Final entries provide OCR with detailed data for each learner, showing each assessment to be taken. It is essential that you use the correct entry code, considering the relevant entry rules.

Final entries must be submitted to OCR by the published deadlines or late entry fees will apply.

All learners taking a GCSE (9–1) in Biology B (Twenty First Century Science) must be entered for one of the following entry options:

Entry option		Components		
Entry code	**Title**	**Code**	**Title**	**Assessment type**
J257 F	Biology B (Twenty First Century Science) (Foundation Tier)	01	Breadth in biology Foundation Tier	External assessment
		02	Depth in biology Foundation Tier	External assessment
J257 H	Biology B (Twenty First Century Science) (Higher Tier)	03	Breadth in biology Higher Tier	External assessment
		04	Depth in biology Higher Tier	External assessment

Collecting evidence of student performance to ensure resilience in the qualifications system

Regulators have published guidance on collecting evidence of student performance as part of long-term contingency arrangements to improve the resilience of the qualifications system. You should review and consider this guidance when delivering this qualification to students at your centre.

For more detailed information on collecting evidence of student performance please visit our website at: https://www.ocr.org.uk/administration/general-qualifications/assessment/

4b. Special consideration

Special consideration is a post-assessment adjustment to marks or grades to reflect temporary injury, illness or other indisposition at the time the assessment was taken.

Detailed information about eligibility for special consideration can be found in the JCQ publication *A guide to the special consideration process*.

4c. External assessment arrangements

Regulations governing examination arrangements are contained in the JCQ *Instructions for conducting examinations*.

Learners are permitted to use a scientific or graphical calculator for components 01, 02, 03 and 04. Calculators are subject to the rules in the document *Instructions for Conducting Examinations* published annually by JCQ (www.jcq.org.uk).

Head of Centre Annual Declaration

The Head of Centre is required to provide a declaration to the JCQ as part of the annual NCN update, conducted in the autumn term, to confirm that the centre is meeting all the requirements detailed in the specification, including that they have provided all candidates with the opportunity to undertake the prescribed practical activities.

Any failure by a centre to provide the Head of Centre Annual Declaration will result in your centre status being suspended and could lead to the withdrawal of our approval for you to operate as a centre.

Private candidates

Private candidates may enter for OCR assessments.

A private candidate is someone who pursues a course of study independently but takes an examination or assessment at an approved examination centre. A private candidate may be a part-time student, someone taking a distance learning course, or someone being tutored privately. They must be based in the UK.

The GCSE Biology B (Twenty First Century Science) qualification requires learners to complete eight practical activities. These practical activities are an essential part of the course and will allow learners to develop skills for further study or employment as well as imparting important knowledge that is part of the specification.

There is no direct assessment of the practical skills part of the course. However, learners will need to have completed the activities to prepare fully for the written examinations as there will be questions that assess practical skills.

Private candidates need to contact OCR approved centres to establish whether they are prepared to host them as a private candidate. The centre may charge for this facility and OCR recommends that the arrangement is made early in the course.

Further guidance for private candidates may be found on the OCR website: https://www.ocr.org.uk.

4d. Results and certificates

Grade Scale

GCSE (9–1) qualifications are graded on the scale: 9–1, where 9 is the highest. Learners who fail to reach the minimum standard of 1 will be Unclassified (U).

Only subjects in which grades 9 to 1 are attained will be recorded on certificates.

Results

Results are released to centres and learners for information and to allow any queries to be resolved before certificates are issued.

Centres will have access to the following results information for each learner:

- the grade for the qualification
- the raw mark for each component
- the total weighted mark for the qualification.

The following supporting information will be available:

- raw mark grade boundaries for each component
- weighted mark grade boundaries for each entry option.

Until certificates are issued, results are deemed to be provisional and may be subject to amendment.

A learner's final results will be recorded on an OCR certificate. The qualification title will be shown on the certificate as 'OCR Level 1/Level 2 GCSE (9–1) in Biology B (Twenty First Century Science)'.

4e. Post-results services

A number of post-results services are available:

- **Review of results** – If you are not happy with the outcome of a learner's results, centres may request a review of marking.
- **Missing and incomplete results** – This service should be used if an individual subject result for a learner is missing, or the learner has been omitted entirely from the results supplied.
- **Access to scripts** – Centres can request access to marked scripts.

4f. Malpractice

Any breach of the regulations for the conduct of examinations and non-exam assessment may constitute malpractice (which includes maladministration) and must be reported to OCR as soon as it is detected. Detailed information on malpractice can be found in the JCQ publication *Suspected Malpractice in Examinations and Assessments: Policies and Procedures*.

5 Appendices

5a. Grade descriptors

Grade descriptors for GCSE (9–1) single science (biology, chemistry and physics) and combined science:

1. Grades 8 and 8–8

1.1 To achieve Grades 8 and 8–8 candidates will be able to:

- demonstrate relevant and comprehensive knowledge and understanding and apply these correctly to both familiar and unfamiliar contexts using accurate scientific terminology
- use a range of mathematical skills to perform complex scientific calculations
- critically analyse qualitative and quantitative data to draw logical, well-evidenced conclusions
- critically evaluate and refine methodologies, and judge the validity of scientific conclusions.

2. Grades 5 and 5–5

2.1 To achieve Grades 5 and 5–5 candidates will be able to:

- demonstrate mostly accurate and appropriate knowledge and understanding and apply these mostly correctly to familiar and unfamiliar contexts, using mostly accurate scientific terminology
- use appropriate mathematical skills to perform multi-step calculations
- analyse qualitative and quantitative data to draw plausible conclusions supported by some evidence
- evaluate methodologies to suggest improvements to experimental methods, and comment on scientific conclusions.

3. Grades 2 and 2–2

3.1 To achieve Grades 2 and 2–2 candidates will be able to:

- demonstrate some relevant scientific knowledge and understanding using limited scientific terminology
- perform basic calculations
- draw simple conclusions from qualitative or quantitative data
- make basic comments relating to experimental method.

5b. Overlap with other qualifications

There is a small degree of overlap between the content of this specification and those for GCSE (9–1) in Combined Science B (Twenty First Century Science), GCSE (9–1) in Chemistry B (Twenty First Century Science) and GCSE (9–1) in Physics B (Twenty First Century Science) courses. The links between the specifications may allow for some co-teaching, particularly in the area of working scientifically.

5c. Accessibility

Reasonable adjustments and access arrangements allow learners with special educational needs, disabilities or temporary injuries to access the assessment and show what they know and can do, without changing the demands of the assessment. Applications for these should be made before the examination series. Detailed information about eligibility for access arrangements can be found in the JCQ *Access Arrangements and Reasonable Adjustments.*

The GCSE (9–1) qualification and subject criteria have been reviewed in order to identify any feature which could disadvantage learners who share a protected Characteristic as defined by the Equality Act 2010. All reasonable steps have been taken to minimise any such disadvantage.

5d. Units in science

It is expected that learners will show understanding of the biological quantities and corresponding units, SI base units and derived units listed below. They will be able to use them in qualitative work and calculations. These units and their associated quantities are dimensionally independent.

SI base units		
Physical quantity	**Unit**	**Unit**
Length	Metre	m
Mass	kilogram	kg
Time	second	s
Temperature	kelvin	K
Current	Ampere	A
Amount of a substance	mole	mol

SI derived units		
Physical quantity	**Unit(s)**	**Unit(s)**
Area	squared metre	m^2
Volume	cubic metre; litre; cubic decimetre	m^3; *l*; dm^3
Density	kilogram per cubic metre	kg/m^3
Temperature	degree Celsius	°C
Pressure	Pascal	Pa
Specific heat capacity	joule per kilogram per degree Celsius	J/kg°C
Specific latent heat	joule per kilogram	J/kg
Speed	metre per second	m/s
Force	Newton	N
Gravitational field strength	newton per kilogram	N/kg
Acceleration	metre per squared second	m/s^2
Frequency	hertz	Hz
Energy	joule	J
Power	watt	W
Electric charge	coulomb	C
Electric potential difference	volt	V
Electric resistance	ohm	Ω
Magnetic flux density	tesla	T

5e. Mathematical skills

The mathematical skills required for the GCSE (9–1) in biology (B), chemistry (C), physics (P) and combined science (CS) are shown in the table below.

	Mathematical skills	Subject			
M1	Arithmetic and numerical computation				
a	Recognise and use expressions in decimal form	B	C	P	CS
b	Recognise expressions in standard form	B	C	P	CS
c	Use ratios, fractions and percentages	B	C	P	CS
d	Make estimates of the results of simple calculations, without using a calculator	B	C	P	CS
M2	Handling data				
a	Use an appropriate number of significant figures	B	C	P	CS
b	Find arithmetic means	B	C	P	CS
c	Construct and interpret frequency tables and diagrams, bar charts and histograms	B	C	P	CS
d	Understand the principles of sampling as applied to scientific data	B			CS
e	Understand simple probability	B			CS
f	Understand the terms mean, mode and median	B		P	CS
g	Use a scatter diagram to identify a correlation between two variables	B		P	CS
h	Make order of magnitude calculations	B	C	P	CS
M3	**Algebra**				
a	Understand and use the symbols: =, <, <<, >>, >, ∝ , ~	B	C	P	CS
b	Change the subject of an equation		C	P	CS
c	Substitute numerical values into algebraic equations using appropriate units for physical quantities		C	P	CS
d	Solve simple algebraic equations	B		P	CS
M4	**Graphs**				
a	Translate information between graphical and numeric form	B	C	P	CS
b	Understand that y=mx+c represents a linear relationship	B	C	P	CS
c	Plot two variables from experimental or other data	B	C	P	CS
d	Determine the slope and intercept of a linear graph	B	C	P	CS
e	Draw and use the slope of a tangent to a curve as a measure of rate of change		C	P	CS
f	Understand the physical significance of area between a curve and the x-axis and measure it by counting squares as appropriate			P	CS
M5	**Geometry and trigonometry**				
a	Use angular measures in degrees			P	CS
b	Visualise and represent 2D and 3D forms including two dimensional representations of 3D objects		C	P	CS
c	Calculate areas of triangles and rectangles, surface areas and volumes of cubes.	B	C	P	CS

5f. Mathematical skills requirement

In order to be able to develop their skills, knowledge and understanding in GCSE (9–1) in Biology B (Twenty First Century Science), learners need to have been taught, and to have acquired competence in, the appropriate areas of mathematics relevant to the subject as indicated in the table of coverage below.

The questions and tasks used to target mathematical skills will be at a level of demand that is appropriate to GCSE (9–1) Biology.

In the Foundation Tier question papers, the questions that assess mathematical skills will not be of a lower demand than that which is expected of learners at Key Stage 3, as outlined in the Department for Education's document "Mathematics programme of study: key stage 3".

In the Higher Tier question papers, the questions that assess mathematical skills will not be lower demand than that of questions and tasks in the assessment for the Foundation Tier in a GCSE qualification in Mathematics.

The assessment of quantitative skills would include at least 10% GCSE (or above) mathematical skills at the appropriate tier for biology.

These skills will be applied in the context of the relevant biology.

This list of examples is not exhaustive and is not limited to GCSE examples. These skills could be developed in other areas of specification content from those indicated.

	Mathematical skills	Specification reference
M1	**Arithmetic and numerical computation**	
a	Recognise and use expressions in decimal form	3.1.7a, 3.2.8a, 3.2.8b, 4.1.5b
b	Recognise and use expressions in standard form	4.2.2c
c	Use ratios, fractions and percentages	1.2.4, 3.1.7a, 3.2.8a, 3.2.8b, 3.2.8d, 3.3.8, 3.3.12, 3.3.14, 3.4.3b, 4.1.5b, 5.1.8
d	Make estimates of the results of simple calculations, without using a calculator	4.2.2b
M2	**Handling data**	
a	Use an appropriate number of significant figures	4.2.2a, IaS2.6
b	Find arithmetic means	3.1.3b, 3.4.3a, IaS2.1b, IaS2.8
c	Construct and interpret frequency tables and diagrams, bar charts and histograms	3.1.7d, 3.4.3d, 5.4.8a, 6.4.5, IaS2.4, IaS2.7
d	Understand the principles of sampling as applied to scientific data	2.5.3c, 3.4.2, IaS1.5
e	Understand simple probability	1.2.5

	Mathematical skills	Specification reference
f	Understand the terms mean, mode and median	3.1.3b, 3.4.3a, IaS2.8
g	Use a scatter diagram to identify a correlation between two variables	2.5.3d, IaS2.8, IaS3.1a
h	Make order of magnitude calculations	4.2.2a
M3	**Algebra**	
a	Understand and use the symbols: =, <, <<, >>, >, ∝ , ~	No direct specification references but statements will be assessed
d	Solve simple algebraic equations	
M4	**Graphs**	
a	Translate information between graphical and numeric form	2.5.3a, 2.5.3b, 3.1.3b, 3.1.7b, 3.1.7c, 3.2.8c, 3.4.3c, 5.4.8b, 6.4.5, IaS2.4, IaS2.7
b	Understand that y=mx+c represents a linear relationship	3.1.3b, 3.2.8c, IaS2.8
c	Plot two variables from experimental or other data	2.5.3b, 3.1.3b, 3.1.7c, 3.2.8c, 3.4.3c, IaS2.7
d	Determine the slope and intercept of a linear graph	3.2.8c, IaS2.8
M5	**Geometry and trigonometry**	
c	Calculate areas of triangles and rectangles, surface areas and volumes of cubes.	2.4.3, 2.6.2, 5.1.8

[1] These, and other CLEAPSS® publications, are on the CLEAPSS® Science Publications website www.cleapss.org.uk. Note that CLEAPSS® publications are only available to members. For more information about CLEAPSS® go to www.cleapss.org.uk.

5g. Health and Safety

In UK law, health and safety is primarily the responsibility of the employer. In a school or college the employer could be a local education authority, the governing body or board of trustees. Employees (teachers/lecturers, technicians etc.) have a legal duty to cooperate with their employer on health and safety matters. Various regulations, but especially the COSHH Regulations 2002 (as amended) and the Management of Health and Safety at Work Regulations 1999, require that before any activity involving a hazardous procedure or harmful microorganisms is carried out, or hazardous chemicals are used or made, the employer must carry out a risk assessment. A useful summary of the requirements for risk assessment in school or college science can be found at: https://www.ase.org.uk

For members, the CLEAPSS® guide, *PS90*, *Making and recording risk assessments in school science*[1] offers appropriate advice.

Most education employers have adopted nationally available publications as the basis for their Model Risk Assessments.

Where an employer has adopted model risk assessments an individual school or college then has to review them, to see if there is a need to modify or adapt them in some way to suit the particular conditions of the establishment.

Such adaptations might include a reduced scale of working, deciding that the fume cupboard provision was inadequate or the skills of the learners were insufficient to attempt particular activities safely. The significant findings of such risk assessment should then be recorded in a "*point of use text* ", for example on schemes of work, published teachers guides, work sheets, etc. There is no specific legal requirement that detailed risk assessment forms should be completed for each practical activity, although a minority of employers may require this.

Where project work or investigations, sometimes linked to work-related activities, are included in specifications this may well lead to the use of novel procedures, chemicals or microorganisms, which are not covered by the employer's model risk assessments. The employer should have given guidance on how to proceed in such cases. Often, for members, it will involve contacting CLEAPSS®.

Summary of updates

Date	Version	Section	Title of section	Change
December 2017	2	Multiple		Changes to generic wording and OCR website links throughout the specification. No changes have been made to any assessment requirements.
April 2018	2.1	i) Front cover ii) 4d	i) Disclaimer ii) Results and certificates: Results	i) Addition of Disclaimer ii) Amend to Certification Titling
May 2018	2.2	2c and 4c	Practical Science Statement, Revision of the requirements for practical work and Head of Centre Declaration	Update in line with new NEA Centre Declaration form and clarification of PAG alternatives
December 2018	3	i) 3b ii) 3c	i) Assessment Objectives (AO) ii) Command words	i) Addition of Assessment Objective elements and ii) Command words
January 2020	3.1	1d 4e	How do I find out more information? Post-results services	Remove link to Social forum and replace with link for Online Support Centre Amend Enquiries about results to review of results
				Update to specification covers to meet digital accessibility standards
June 2023	3.2	3	Assessment of GCSE (9–1) in Biology B (Twenty First Century Science)	Insertion of new section 3e. Total qualification time
January 2024	3.3	3f, 3g 4a Checklist	Qualification availability, Language Pre-assessment	Inclusion of disclaimer regarding language and availability Update to include resilience guidance Inclusion of Teach Cambridge

YOUR CHECKLIST

Our aim is to provide you with all the information and support you need to deliver our specifications.

- ☐ Bookmark OCR website for all the latest information and news on GCSE (9-1) Twenty First Century Science Biology B
- ☐ Sign up for Teach Cambridge: our personalised and secure website that provides teachers with access to all planning, teaching and assessment support materials
- ☐ Be among the first to hear about support materials and resources as they become available – register for Twenty First Century Science Biology B updates
- ☐ Find out about our professional development
- ☐ View our range of skills guides for use across subjects and qualifications
- ☐ Discover our new online past paper service
- ☐ Learn more about Active Results
- ☐ Visit our Online Support Centre

Download high-quality, exciting and innovative GCSE (9-1) Twenty First Century Science Biology B resources from ocr.org.uk/gcsec21biology

Resources and support for our GCSE (9-1) Twenty First Century Science Biology B qualification, developed through collaboration between our Biology Subject Advisors, teachers and other subject experts, are available from our website. You can also contact our Biology Subject Advisors who can give you specialist advice, guidance and support.

Contact the team at:

01223 553998

science@ocr.org.uk

@OCR_Science

To stay up to date with all the relevant news about our qualifications, register for email updates at **ocr.org.uk/updates**

Visit our Online Support Centre at **support.ocr.org.uk**

follow us on

facebook.com/ocrexams

linkedin.com/company/ocr

@OCRexams

youtube.com/ocrexams