OCR
RECOGNISING ACHIEVEMENT

TWENTY FIRST CENTURY SCIENCE SUITE

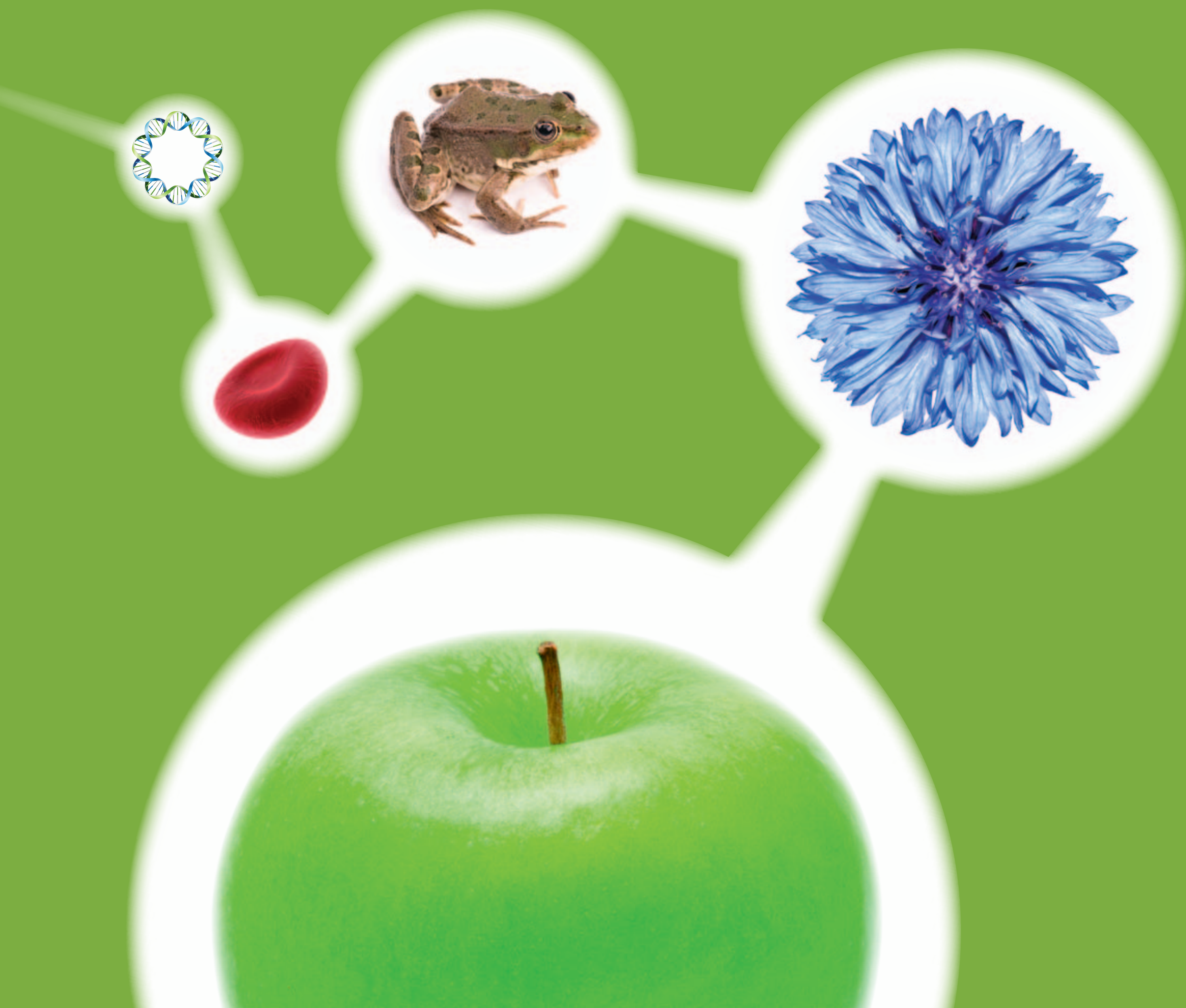
GCSE BIOLOGY A

ACCREDITED SPECIFICATION

J243

VERSION 1

MARCH 2011



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- Our **clear and sensible assessment** approach means that exam papers and requirements are clearly presented and sensibly structured for you and your students.
- **Pathways for choice** – we have the broadest range of science qualifications and our GCSEs provide an ideal foundation for students to progress to more advanced studies and science-related careers.
- **Working in partnership to support you** – together with teachers we've developed a range of practical help and support to save you time. We provide everything you need to teach our specifications with confidence and ensure your students get as much as possible from our qualifications.
- **A personal service** – as well as providing you with lots of support resources, we're also here to help you with specialist advice, guidance and support for those times when you simply need a more individual service.

HERE'S HOW TO CONTACT US FOR SPECIALIST ADVICE:

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Email: science@ocr.org.uk

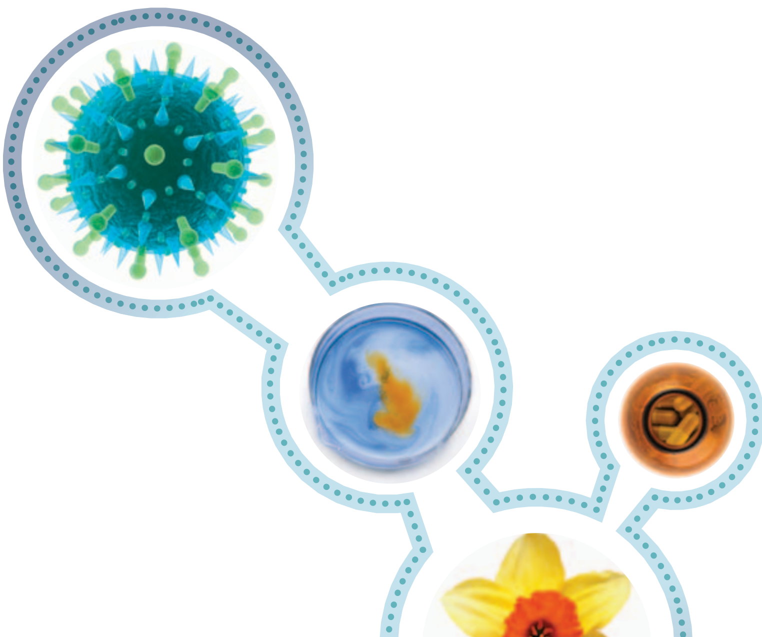
Online: http://answers.ocr.org.uk

Fax: 01223 552627

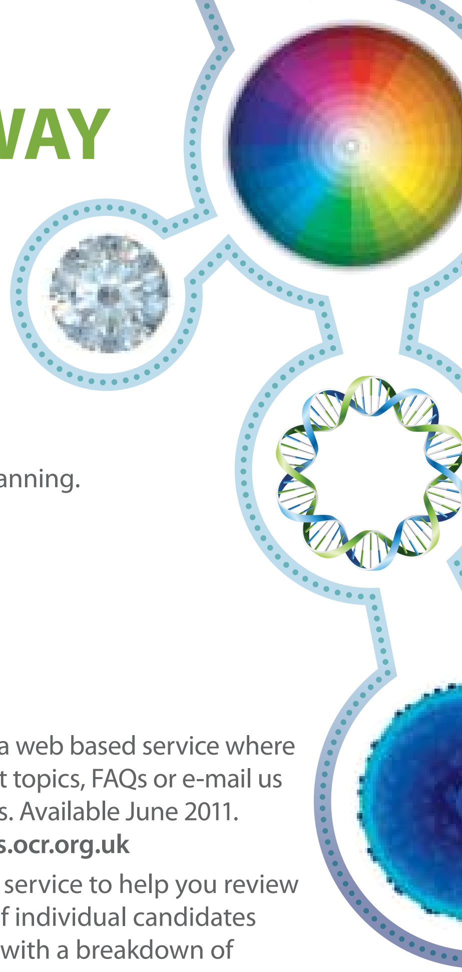
Post: Customer Contact Centre, OCR, Progress House, Westwood Business Park, Coventry CV4 8JQ

DON'T FORGET

– you can download a copy of this specification and all our support materials at **www.gcse-science.com**



SUPPORTING YOU ALL THE WAY



Our aim is to help you at every stage and we work in close consultation with teachers and other experts, to provide a practical package of high quality resources and support.

Our support materials are designed to save you time while you prepare for and teach our new specifications. In response to what you have told us we are offering detailed guidance on key topics, controlled assessment and curriculum planning.

Our essential FREE support includes:

Materials

- Specimen assessment materials and mark schemes
- Guide to controlled assessment
- Sample controlled assessment material
- Exemplar candidate work
- Teacher's handbook
- Sample schemes of work and lesson plans
- Guide to curriculum planning
- Frequently asked questions
- Past papers.

You can access all of our support at:
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Training

Our FREE GCSE Science Get Started events

- include useful information about our specifications direct from the experts
- are designed to assist you in preparing to teach
- provide you with an opportunity to speak face-to-face with our team.

We're also developing online support and training for those unable to get away from school.

Go to **www.ocr.org.uk/science2011/training** for full details and to book your place.

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Join our social network at **www.social.ocr.org.uk** where you can start discussions, ask questions and upload resources.

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- **Answers @ OCR –** a web based service where you can browse hot topics, FAQs or e-mail us with your questions. Available June 2011. Visit **http://answers.ocr.org.uk**
- **Active Results** – a service to help you review the performance of individual candidates or a whole school, with a breakdown of results by question and topic.
- **Local cluster support networks** – supported by OCR, you can join our local clusters of centres who offer each other mutual support.

Endorsed publisher partner materials

We're working closely with our publisher partner Oxford University Press to ensure effective delivery of endorsed materials when you need them.
Find out more at:
www.twentyfirstcenturyscience.org

WHAT TO DO NEXT

1) Sign up to teach – let us know you will be teaching this specification to ensure you receive all the support and examination materials you need. Simply complete the online form at **www.ocr.org.uk/science/signup**

2) Become an approved OCR centre – if your centre is completely new to OCR and has not previously used us for any examinations, visit **www.ocr.org.uk/centreapproval** to become an approved OCR centre.

TWENTY FIRST CENTURY SCIENCE SUITE

Science today – for scientists of tomorrow

Explore the science that underpins day-to-day life. Enthuse and motivate students using a mix of teaching strategies.

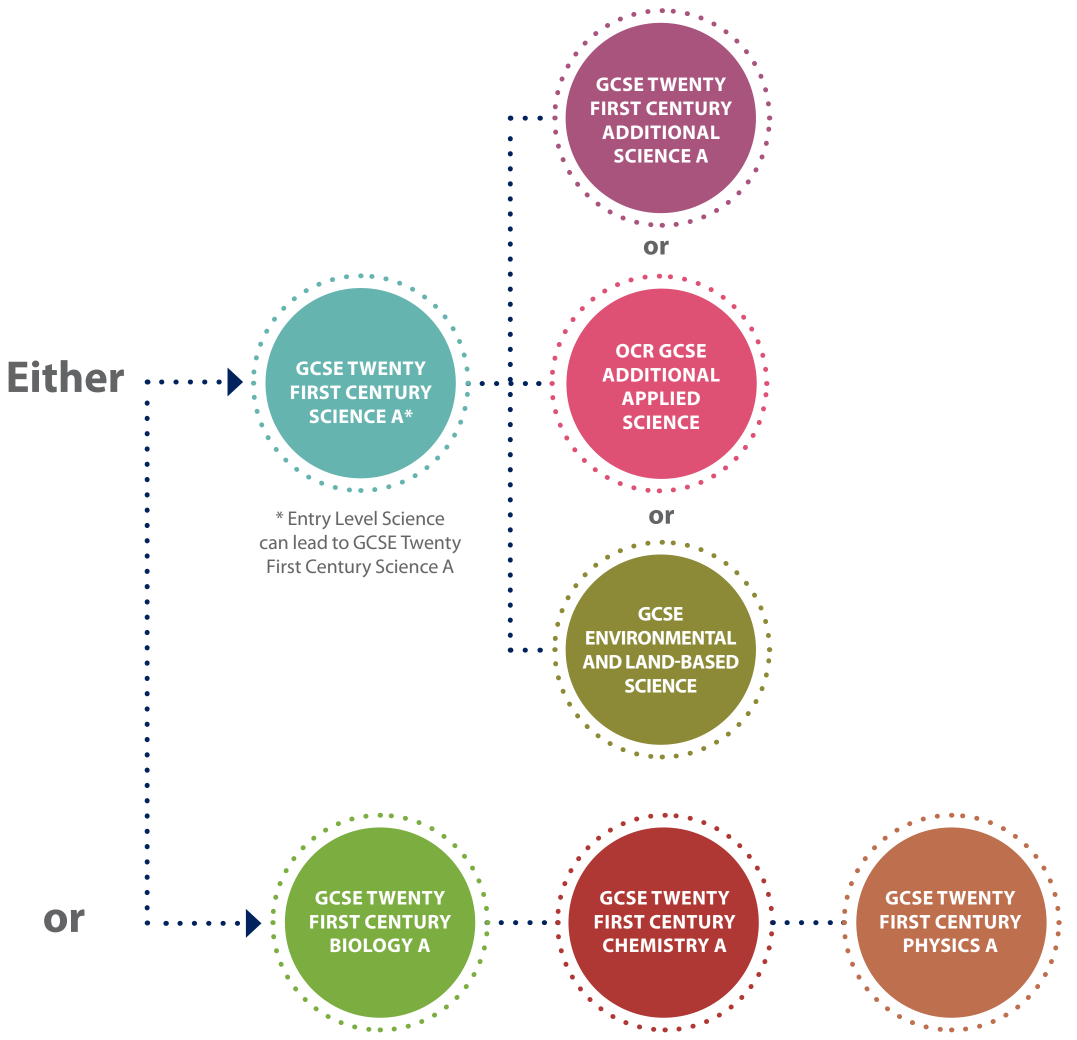
Our Twenty First Century Science suite:

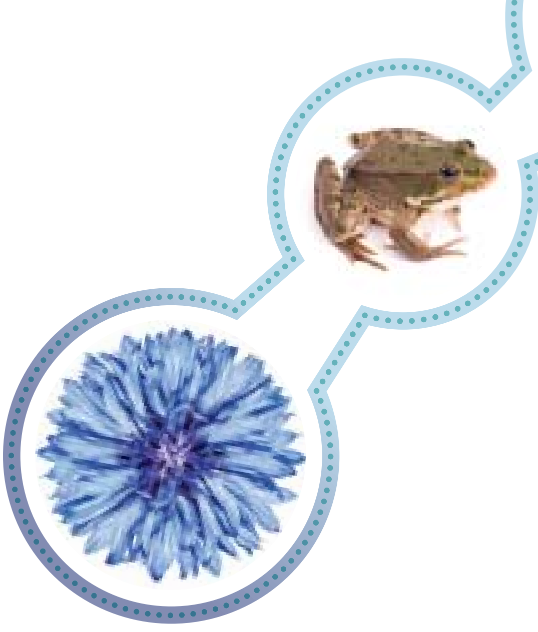
- is engaging to study and motivating for you to teach
- will help your students engage with the course rather than just study it
- gives you the flexibility to choose a delivery style to engage students.

KEY FEATURES

- **Flexible assessments**, which can be arranged to suit your centre and your students – unit exams will be available twice a year, in January and June.
- An **ideal foundation** for students to progress to more-advanced studies and science-related careers.
- A well regarded and proven **concept led** teaching approach to science.

POSSIBLE GCSE COMBINATIONS





GCSE BIOLOGY A

KEY FEATURES

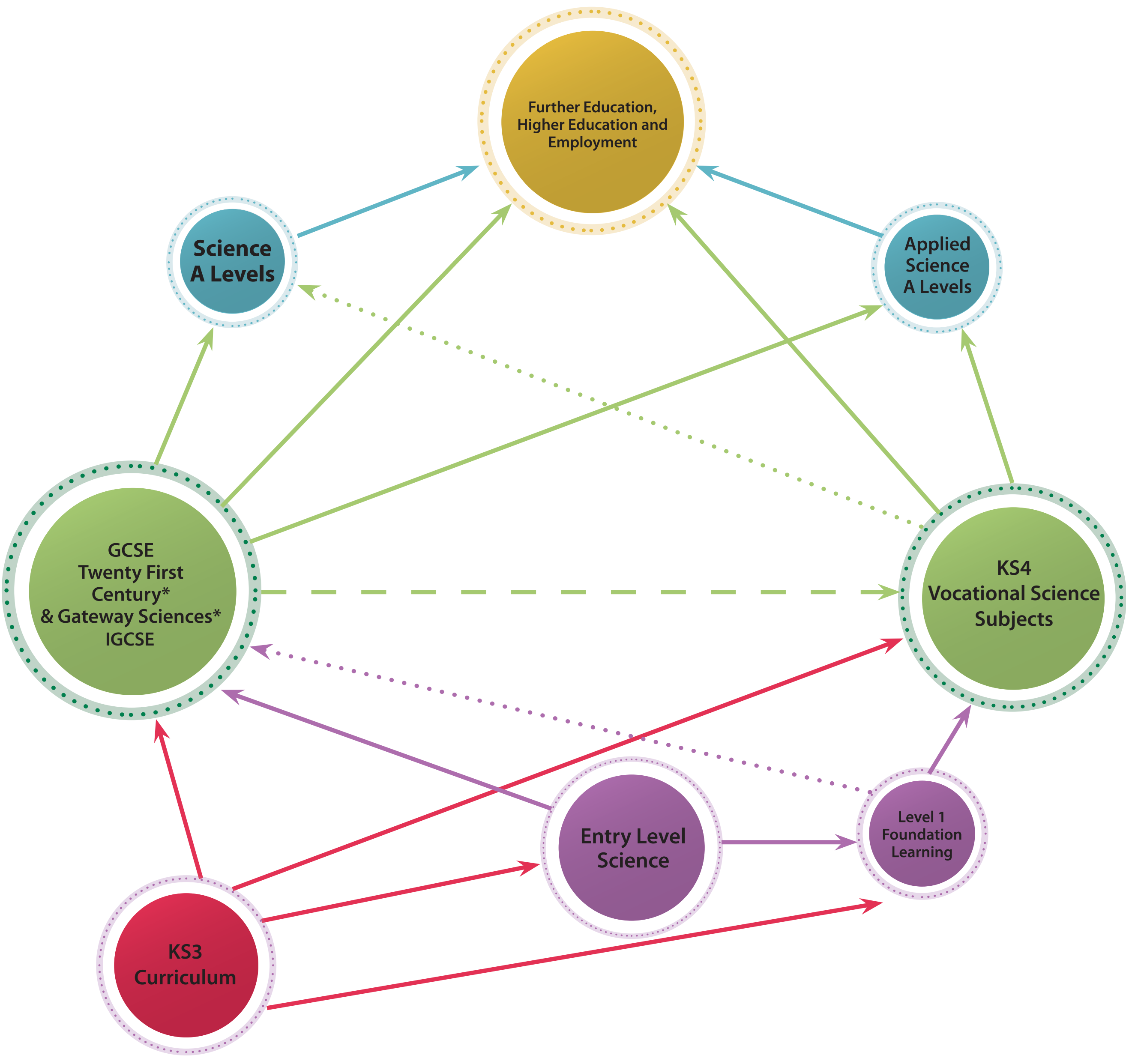
GCSE Biology A provides the opportunity to:

- develop interest in, and enthusiasm for, biology
- develop a critical approach to scientific evidence and methods
- acquire and apply skills, knowledge and understanding of how science works and its essential role in society
- acquire scientific skills, knowledge and understanding necessary for progression to further learning.

GCSE Biology A provides distinctive and relevant experience for students who wish to progress to Level 3 qualifications.

COURSE OVERVIEW	ASSESSMENT OVERVIEW		
UNIT A161 Module B1: You and your genes Module B2: Keeping healthy Module B3: Life on Earth	60 marks 1 hour written paper	**25%** of total GCSE	Three written exams, assessed externally by OCR, each of which: • is offered in Foundation and Higher Tiers • uses both objective style and free response questions (there is no choice of questions) • assesses the quality of written communication
UNIT A162 Module B4: The processes of life Module B5: Growth and development Module B6: Brain and mind	60 marks 1 hour written paper	**25%** of total GCSE	
UNIT A163 Module B7: Further biology	60 marks 1 hour written paper	**25%** of total GCSE	
UNIT A164 Controlled assessment	64 marks Approx 4.5–6 hours	**25%** of total GCSE	Comprises a Practical Investigation from a choice set by OCR Assessed by teachers, internally standardised and externally moderated by OCR Assesses the quality of written communication

PROGRESSION PATHWAYS IN SCIENCE



This could be a progression route along a particular curriculum pathway. (Stage, not age pathways)

This could be a progression route however students would require additional support.

Alternative qualification options

* Offered as
Science, Additional Science, Biology, Chemistry and Physics.

Contents

Contents

1 Introduction to the Twenty First Century Science suite

The Twenty First Century Science suite comprises five specifications which share a similar approach to teaching and learning, utilise common materials, use a consistent style of examination questions and have a common approach to skills assessment.

The qualifications available as part of this suite are:

- GCSE Science A
- GCSE Additional Science A
- GCSE Biology A
- GCSE Chemistry A
- GCSE Physics A.

GCSE Science A (J241)	which emphasises scientific literacy – the knowledge and understanding which candidates need to engage, as informed citizens, with science-based issues. As with other courses in the suite, this qualification uses contemporary, relevant contexts of interest to candidates, which can be approached through a range of teaching and learning activities.
GCSE Additional Science A (J242)	which is a concept-led course developed to meet the needs of candidates seeking a deeper understanding of basic scientific ideas. The course focuses on scientific explanations and models, and gives candidates an insight into how scientists develop scientific understanding of ourselves and the world we inhabit.
GCSE Biology A (J243)	each of which provides an opportunity for further developing an understanding of science explanations, how science works and the study of elements of applied science, with particular relevance to professional scientists.
GCSE Chemistry A (J244)	
GCSE Physics A (J245)	

The suite emphasises explanations, theories and modelling in science along with the implications of science for society. Strong emphasis is placed on the active involvement of candidates in the learning process and each specification encourages a wide range of teaching and learning activities.

The suite is supported by the Nuffield Foundation Curriculum Programme and The University of York Science Education Group, and by resources published by Oxford University Press.

In addition, an Additional Applied Science course (J251) is available. This can be used in conjunction with Science A as an alternative route to two science GCSEs, for candidates not following GCSE Additional Science A.

2 Introduction to GCSE Biology A

2.1 Overview of OCR GCSE Biology A

Unit A161: ***Modules B1, B2, B3***

This is a tiered unit offered in Foundation and Higher Tiers.	Written paper 1 hour 60 marks 25% of the qualification Candidates answer all questions. The unit uses both objective style and free response questions.

+

Unit A162: ***Modules B4, B5, B6***

This is a tiered unit offered in Foundation and Higher Tiers.	Written paper 1 hour 60 marks 25% of the qualification Candidates answer all questions. The unit uses both objective style and free response questions.

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Unit A163: ***Module B7***

This is a tiered unit offered in Foundation and Higher Tiers.	Written paper 1 hour 60 marks 25% of the qualification Candidates answer all questions. The unit uses both objective style and free response questions.

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Unit A164: ***Controlled assessment***

This unit is not tiered.	Controlled assessment Approximately 4.5–6 hours 64 marks 25% of the qualification

2.2 What is new in OCR GCSE Biology A?

	What stays the same?	What changes?
Structure	• The course can be taught as modular or linear. • Four units, comprising three externally assessed units and one internally assessed unit. • Externally assessed units are tiered – Foundation and Higher Tier.	• All four units have equal weightings of 25%. • Controlled assessment replaces coursework. • No 'Ideas in Context' paper, and no pre-release material for externally assessed units.
Content	• Content is divided into seven modules. • Module B7 is equivalent in length to any three modules from B1–B6.	• New Module B4, 'The processes of life', replaces 'Homeostasis'. • Module B7, 'Further biology', updated and includes aspects of the original Modules B4 and B7.
Assessment	• The internally assessed unit is based on a Practical Investigation. • Modules are externally assessed within written examination papers. • Ideas about Science (How Science Works) are written into the specification content. • January and June assessments are available for written papers. • Controlled assessment is available in June series only.	• New terminal and re-sit rules apply to science GCSEs. • There will be a choice of controlled assessment tasks set by OCR, each valid for entry in a single examination series. • The controlled assessment for Biology will be based on a Practical Investigation only. • Controlled assessment is worth 25%, and will be simpler to mark and administer. • Ideas about Science are associated with all units. • Quality of written communication (QWC) will be assessed in all units. • Externally assessed papers are each 1 hour long, with a total of 60 marks divided between objective (worth 40%) and free response style questions.

2.3 Guided learning hours

GCSE Biology A requires 120–140 guided learning hours in total.

Content of GCSE Biology A

3.1 Summary of content

A module defines the required teaching and learning outcomes.

The specification content is displayed as seven modules. The titles of these seven modules are listed below.

Modules B1 – B6 are designed to be taught in approximately **half a term each**, in 10% of the candidates' curriculum time. Module B7 is designed to be taught in approximately **one and a half terms** at 10% curriculum time.

Module B1: You and your genes	Module B2: Keeping healthy	Module B3: Life on Earth
• What are genes and how do they affect the way that organisms develop? • Why can people look like their parents, brothers and sisters, but not be identical to them? • How can and should genetic information be used? How can we use our knowledge of genes to prevent disease? • How is a clone made?	• How do our bodies resist infection? • What are vaccines and antibiotics and how do they work? • What factors increase the risk of heart disease? • How do our bodies keep a healthy water balance?	• Systems in balance – how do different species depend on each other? • How has life on Earth evolved? • What is the importance of biodiversity?
Module B4: The processes of life	**Module B5: Growth and development**	**Module B6: Brain and mind**
• How do chemical reactions take place in living things? • How do plants make food? • How do living organisms obtain energy?	• How do organisms develop? • How does an organism produce new cells? • How do genes control growth and development within the cell?	• How do animals respond to changes in their environment? • How is information passed through the nervous system? • Can reflex responses be learned? • How do humans develop more complex behaviour?
Module B7: Further Biology		
• Peak performance – movement and exercise • Peak performance – circulation	• Peak performance – energy balance • What can we learn from natural ecosystems?	• New technologies

3.2 Layout of specification content

The specification content is divided into seven modules assessed across three units. Three modules (B1 – B3), together with their associated Ideas about Science (see Appendix B), are assessed in Unit A161. The next three modules (B4 – B6) and their associated Ideas about Science are assessed in Unit A162. Module B7 is assessed in Unit A163, together with **any** of the Ideas about Science from Appendix B.

A summary of each unit precedes the modules that are assessed within that unit, indicating the modules and the associated Ideas about Science that can be assessed.

Each module starts with an overview that explains the background to the module and identifies:

- for Modules B1 – B3:
  - issues for citizens that are likely to be uppermost in their minds when considering the module topic, whatever their understanding of science
  - questions about the topic that science can help to address, which could reasonably be asked of a scientifically literate person.
- for Modules B4 – B7:
  - a summary of the topics
- opportunities for mathematics
- opportunities for practical work
- opportunities for ICT.

Following the module overview, the Ideas about Science that can be introduced or developed in the module are outlined. Finally, the module content is presented in detail.

Within the detailed content of each module, several notations are used to give teachers additional information about the assessment. The table below summarises these notations.

Notation	Explanation
Bold	**These content statements will only be assessed on Higher Tier papers.**
ⓘ	*Advisory notes for teachers to clarify depth of cover required.*

3.3 Summary of Biology A Unit A161: *Modules B1, B2, B3*

Unit A161 is the first unit for GCSE Biology A. It assesses the content of Modules B1, B2 and B3 together with their associated Ideas about Science.

The modules in Unit A161 offer students the chance to develop the scientific literacy needed by active and informed citizens in a modern democratic society where science and technology play key roles in shaping our lives. The course content has a clear focus on scientific literacy. Teachers can use a wide range of teaching and learning styles, challenging students to consider critically the issues and choices raised by technology and science. Students will appreciate what science has to say about people, the environment and the Universe.

Ideas about Science in Unit A161

Modules B1, B2 and B3 present learning opportunities for a number of the Ideas about Science. The start of each module details the particular Ideas about Science that can be introduced or developed within the contexts covered in the module. Specific examples of contexts within which Ideas about Science can be taught are given in the OCR scheme of work for GCSE Biology A (published separately).

However, it is not intended that understanding and application of these Ideas about Science should be limited to the context in which they are taught; they should be applicable to any appropriate scientific context.

Accordingly, questions in Unit A161 can assess any of the Ideas about Science linked to Modules B1, B2 and B3, and these Ideas about Science may be assessed in the context of any of the learning outcomes covered in the three modules.

In summary, the Ideas about Science that can be assessed in Unit A161, within any of the scientific contexts introduced by Modules B1, B2 and B3, are:

Cause-effect explanations
IaS 2.3 – 2.7
Developing scientific explanations
IaS 3.1 – 3.4
The scientific community
IaS 4.1 – 4.4
Risk
IaS 5.1 – 5.7
Making decisions about science and technology
IaS 6.1 – 6.6

3.3.1 Module B1: You and your genes

Overview

The inheritance of detailed information from each generation to the next is a fundamental story in science. For each of us, inheritance also raises questions about our own development. In this module, candidates learn basic concepts of inheritance: genes as units of inheritance, the interplay between genes and environment, and sexual reproduction as a source of variation.

These concepts are sufficiently detailed for candidates to make sense of related ideas in other GCSE Science modules. More complex ideas, such as mechanisms for protein synthesis and cell division, are not required; these are covered in later modules.

Throughout the module, candidates are introduced to genetic technologies that open up new possibilities for individuals and society. In doing so, they present significant ethical issues for citizens. Candidates explore some of the ideas people use to make ethical decisions. This enables them to engage with issues which regularly appear in the media, such as genetic testing and cloning research.

Some of the issues covered in this module may be very sensitive for candidates.

Issues for citizens	Questions that science may help to answer
How do my genes affect my appearance, my body, and my health? How and why do people find out about their genes? What decisions do people make with this information? Can we change our genes, and should this be allowed? What is cloning, and should it be allowed?	What are genes and how do they affect the way that organisms develop? Why can people look like their parents, brothers or sisters, but not be identical to them? How can and should genetic information be used? How can we use our knowledge of genes to prevent disease? How can we use our knowledge of genes to improve treatment of disease? What are stem cells, and why could they be useful in treating some diseases?

Opportunities for mathematics

This module offers opportunities to develop mathematics skills. For example:

- carry out calculations using experimental data, including finding the mean and the range
- use ideas of ratios in the context of inheritance
- plot, draw and interpret graphs and charts from candidates' own and secondary data
- use ideas about probability in the context of risk.

Opportunities for practical work

This module offers opportunities for practical work in teaching and learning. For example:

- clone plant materials
- model fertilisation to illustrate the random nature of allele distribution in sex
- role play to discuss the ethics of genetic testing
- internet research to investigate regulation associated with genetic information
- activity to decide if permission should be granted for embryo selection
- decision-making activity to consider different viewpoints on using embryonic stem cells.

Opportunities for ICT

This module offers opportunities to illustrate the use of ICT in science. For example:

- use of the internet to disseminate scientific findings about health issues to the public.

Use of ICT in teaching and learning can include:

- animated journey through a cell to illustrate the relationship between the nucleus, chromosomes and genes
- interactive models of genetic crosses
- video clips of media reports highlighting ethical and regulatory issues.

Module B1: You and your genes – Ideas about Science		
Module B1 provides opportunities to develop candidates' understanding of these Ideas about Science		
6	**Making decisions about science and technology**	
	Candidates should understand that:	A candidate who understands this can, for example:
6.3	• in many areas of scientific work, the development and application of scientific knowledge are subject to official regulations.	• in contexts where this is appropriate, show awareness of, **and discuss**, the official regulation of scientific research and the application of scientific knowledge.
6.4	• some questions, such as those involving values, cannot be answered by science.	• distinguish questions which could in principle be answered using a scientific approach, from those which could not.
6.5	• some forms of scientific research, and some applications of scientific knowledge, have ethical implications. People may disagree about what should be done (or permitted).	• where an ethical issue is involved: – say clearly what this issue is – summarise different views that may be held.
6.6	• in discussions of ethical issues, one common argument is that the right decision is one which leads to the best outcome for the greatest number of people involved. Another is that certain actions are considered right or wrong whatever the consequences.	• in a given context, identify, **and develop**, arguments based on the ideas that: – the right decision is the one which leads to the best outcome for the greatest number of people involved – certain actions are considered right or wrong whatever the consequences.

Module B1: You and your genes

B1.1 What are genes and how do they affect the way that organisms develop?

1. recall that instructions to control how an organism develops and functions are found in the nucleus of its cells and are called genes
2. recall that genes are instructions for a cell that describe how to make proteins
3. recall that proteins may be structural (eg collagen) or functional (eg enzymes such as amylase)
4. recall that genes are sections of very long DNA molecules that make up chromosomes in the nuclei of cells
5. understand that some characteristics are determined by genes (eg dimples), some are determined by environmental factors (eg scars), and some are determined by a combination of genes and the environment (eg weight)
6. understand that many characteristics are determined by several genes working together (eg eye colour).

Module B1: You and your genes

B1.2 Why can people look like their parents, brothers and sisters, but not be identical to them?

1. recall that body cells contain pairs of chromosomes and that sex cells contain only one chromosome from each pair
2. understand that chromosomes in a pair carry the same genes in the same place, but that there may be different versions of genes called alleles
3. recall that an individual usually has two alleles for each gene
4. recall that in an individual the two alleles of each gene can be the same **(homozygous)** or different **(heterozygous)**
5. understand that during sexual reproduction genes from both parents come together and produce variation in the offspring
6. understand that offspring have some similarities to their parents because of the combination of maternal and paternal alleles in the fertilised egg
7. understand that different offspring from the same parents can differ from each other because they inherit a different combination of maternal and paternal alleles
8. understand that an allele can be dominant or recessive, and that:
    a. an individual with one or both dominant alleles (in a pair of alleles) will show the associated dominant characteristic
    b. an individual with one recessive allele (in a pair of alleles) will not show the associated recessive characteristic
    c. an individual with both recessive alleles (in a pair of alleles) will show the associated recessive characteristic
9. recall that human males have XY sex chromosomes and females have XX sex chromosomes
10. **understand that the sex-determining gene on the Y chromosome triggers the development of testes, and that in the absence of a Y chromosome ovaries develop**
11. use and interpret genetic diagrams (family trees and Punnett squares) showing:
    a. the inheritance of single gene characteristics with a dominant and recessive allele
    b. the inheritance of sex chromosomes
12. **understand that the term genotype describes the genetic make-up of an organism (the combination of alleles), and the term phenotype describes the observable characteristics that the organism has.**

Module B1: You and your genes

B1.3 How can and should genetic information be used? How can we use our knowledge of genes to prevent disease?

1. understand that a small number of disorders are caused by faulty alleles of a single gene, including Huntington's disease and cystic fibrosis
2. recall that disorders may be caused by dominant alleles (eg Huntington's disease) or recessive alleles (eg cystic fibrosis)
3. recall the symptoms of Huntington's disease and cystic fibrosis, to include:
   a. Huntington's disease – late onset, tremor, clumsiness, memory loss, inability to concentrate, mood changes
   b. cystic fibrosis – thick mucus, difficulty breathing, chest infections, difficulty in digesting food
4. understand that a person with one recessive allele (in a pair of alleles) will not show the symptoms of the disorder, but is a carrier and can pass the recessive allele to their children
5. interpret through genetic diagrams (family trees and Punnett squares) the inheritance of a single gene disorder, including the risk of a child being a carrier
6. describe uses of genetic testing for screening adults, children and embryos, limited to:
   a. testing embryos for embryo selection **(pre-implantation genetic diagnosis)**
   b. predictive testing for genetic diseases
   c. testing an individual before prescribing drugs
7. understand that testing adults and fetuses for alleles that cause genetic disorders has implications that need to be considered, including:
   a. risk of miscarriage as a result of cell sampling for the genetic test
   b. using results that may not be accurate, including false positives and false negatives
   c. whether or not to have children at all
   d. whether or not a pregnancy should be terminated
   e. whether other members of the family should be informed
8. **understand the implications of testing embryos for embryo selection prior to implantation**
9. understand the implications of the use of genetic testing by others (for example, for genetic screening programmes by employers and insurance companies).

Module B1: You and your genes

B1.4 How is a clone made?

1. understand that bacteria, plants and some animals can reproduce asexually to form clones (individuals with identical genes)
2. understand that any differences between clones are likely to be due only to environmental factors
3. understand that clones of plants occur naturally when plants produce bulbs or runners
4. understand that clones of animals occur:
   a. naturally, when cells of an embryo separate (identical twins)
   b. artificially, when the nucleus from an adult body cell is transferred to an empty unfertilised egg cell
5. understand that there are different types of stem cells:
   a. adult stem cells which are unspecialised cells that can develop into many, but not all, types of cells
   b. embryonic stem cells which are unspecialised cells that can develop into any type of cell
6. understand that, as a result of being unspecialised, stem cells from embryos and adults offer the potential to treat some illnesses
7. understand that the majority of cells of multicellular organisms become specialised during the early development of the organism.

3.3.2 Module B2: Keeping healthy

Overview

Keeping healthy involves maintaining a healthy lifestyle, avoiding infection, and using medication when necessary. This module illustrates these principles through prevention of infectious diseases and heart disease.

Candidates learn about the immune system and how vaccines work to prevent infection. They also learn about the increase of 'superbugs', and how correct use of antibiotics can help to reduce their prevalence. The module explores how new drugs are developed, including the stages of testing for safety and effectiveness. Candidates also consider the causes of heart disease and how individuals can minimise this risk. They also learn about maintaining a constant internal environment, illustrated through an understanding of how our body keeps a healthy water balance.

In the contexts of vaccination policy and the study of clinical trials, candidates explore ideas of correlation and cause, and how peer review by the scientific community strengthens the confidence in scientific claims. They also consider particular ethical issues arising in modern medicine, for example the right of individual choice versus social policy, illustrated through vaccination policy.

Issues for citizens	Questions that science may help to answer
Why do I catch some diseases but not others? Why are we encouraged to have vaccinations? Why should we always finish a course of antibiotics? How do drug companies make sure a new drug is as safe as possible? How can my lifestyle affect my health?	How do our bodies resist infection? What are vaccines and antibiotics and how do they work? How are new drugs developed and tested? What factors increase the risk of heart disease? How do our bodies keep a healthy water balance?

Opportunities for mathematics

This module offers opportunities to develop mathematics skills. For example:

- develop a sense of scale in the context of microorganisms
- carry out calculations using experimental data, including finding the mean and the range
- plot, draw and interpret graphs and charts from candidates' own and secondary data
- extract information from charts, graphs and tables including data from epidemiological studies
- use ideas about correlation in the context of health risk factors
- use ideas about probability in the context of risk.

Opportunities for practical work

This module offers opportunities for practical work in teaching and learning. For example:

- demonstrate the rapid spread of an infection through a population using ‘contaminated’ hand contact
- role play discussion of the ethical questions arising from the need to have a high take-up of vaccination to establish effective herd immunity
- antibiotic action practical activity to demonstrate that different antibiotics have different activity against particular bacteria
- monitor blood pressure
- heart dissection.

Opportunities for ICT

This module offers opportunities to illustrate the use of ICT in science. For example:

- storing and displaying magnified images from microscopes
- storing and displaying data from studies of factors which may, or may not, cause disease
- modelling control systems which involve negative feedback.

Use of ICT in teaching and learning can include:

- animations to illustrate immune responses
- animations to illustrate development of antibiotic-resistant bacterial populations
- video clips to illustrate smallpox vaccination programmes
- video clips of interviews with patients who have heart disease
- video clips illustrating how epidemiological research is carried out and reported.

Module B2: Keeping healthy – Ideas about Science

Module B2 provides opportunities to develop candidates' understanding of these Ideas about Science

2	Cause-effect explanations Candidates should understand that:	A candidate who understands this can, for example:
2.3	• if an outcome occurs when a specific factor is present, but does not when it is absent, or if an outcome variable increases (or decreases) steadily as an input variable increases, we say that there is a correlation between the two.	• suggest and explain an example from everyday life of a correlation between a factor and an outcome • identify where a correlation exists when data are presented as text, as a graph, or in a table. ⓘ *Examples may include both positive and negative correlations, but candidates will not be expected to know these terms.*
2.4	• a correlation between a factor and an outcome does not necessarily mean that the factor causes the outcome; both might, for example, be caused by some other factor.	• use the ideas of correlation and cause when discussing data and show awareness that a correlation does not necessarily indicate a causal link • identify, and suggest from everyday experience, examples of correlations between a factor and an outcome where the factor is (or is not) a plausible cause of the outcome • explain why an observed correlation between a given factor and outcome does not necessarily mean that the factor causes the outcome.
2.5	• in some situations, a factor alters the chance (or probability) of an outcome, but does not invariably lead to it. We also call this a correlation.	• suggest factors that might increase the chance of a particular outcome in a given situation, but do not invariably lead to it • explain why individual cases do not provide convincing evidence for or against a correlation.
2.6	• to investigate a claim that a factor increases the chance (or probability) of an outcome, scientists compare samples (eg groups of people) that are matched on as many other factors as possible, or are chosen randomly so that other factors are equally likely in both samples. The larger the samples, the more confident we can be about any conclusions drawn.	• discuss whether given data suggest that a given factor does/does not increase the chance of a given outcome • evaluate critically the design of a study to test if a given factor increases the chance of a given outcome, by commenting on sample size and how well the samples are matched.
2.7	• **even when there is evidence that a factor is correlated with an outcome, scientists are unlikely to accept that it is a cause of the outcome, unless they can think of a plausible mechanism linking the two.**	• **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.**

4	**The scientific community**	
	Candidates should understand that:	A candidate who understands this can, for example:
4.1	• scientists report their claims to other scientists through conferences and journals. Scientific claims are only accepted once they have been evaluated critically by other scientists.	• describe in broad outline the 'peer review' process, in which new scientific claims are evaluated by other scientists • recognise that there is less confidence in new scientific claims that have not yet been evaluated by the scientific community than there is in well-established ones.
4.2	• scientists are usually sceptical about claims that cannot be repeated by anyone else, and about unexpected findings until they have been replicated (by themselves) or reproduced (by someone else).	• identify the fact that a finding has not been reproduced by another scientist as a reason for questioning a scientific claim • explain why scientists see this as important.

5	Risk Candidates should understand that:	A candidate who understands this can, for example:
5.1	• everything we do carries a certain risk of accident or harm. Nothing is risk free. New technologies and processes based on scientific advances often introduce new risks.	• explain why it is impossible for anything to be completely safe • identify examples of risks which arise from a new scientific or technological advance • suggest ways of reducing a given risk.
5.2	• we can sometimes assess the size of a risk by measuring its chance of occurring in a large sample, over a given period of time.	• interpret and discuss information on the size of risks, presented in different ways.
5.3	• to make a decision about a particular risk, we need to take account both of the chance of it happening and the consequences if it did.	• discuss a given risk, taking account of both the chance of it occurring and the consequences if it did.
5.4	• to make a decision about a course of action, we need to take account of both its risks and benefits, to the different individuals or groups involved.	• identify risks and benefits in a given situation, to the different individuals and groups involved • discuss a course of action, with reference to its risks and benefits, taking account of who benefits and who takes the risks • suggest benefits of activities that are known to have risk.
5.5	• 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.	• offer reasons for people's willingness (or reluctance) to accept the risk of a given activity.
5.6	• **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).**	• **distinguish between perceived and calculated risk, when discussing personal choices** • **suggest reasons for given examples of differences between perceived and measured risk.**
5.7	• governments and public bodies may have to assess what level of risk is acceptable in a particular situation. This decision may be controversial, especially if those most at risk are not those who benefit.	• discuss the public regulation of risk, **and explain why it may in some situations be controversial**.

6	Making decisions about science and technology Candidates should understand that:	A candidate who understands this can, for example:
6.4	• some questions, such as those involving values, cannot be answered by science.	• distinguish questions which could in principle be answered using a scientific approach, from those which could not.
6.5	• some forms of scientific research, and some applications of scientific knowledge, have ethical implications. People may disagree about what should be done (or permitted).	• where an ethical issue is involved: – say clearly what this issue is – summarise different views that may be held.
6.6	• in discussions of ethical issues, one common argument is that the right decision is one which leads to the best outcome for the greatest number of people involved. Another is that certain actions are considered right or wrong whatever the consequences.	• in a given context, identify, **and develop**, arguments based on the ideas that: – the right decision is the one which leads to the best outcome for the greatest number of people involved – certain actions are considered right or wrong whatever the consequences.

Module B2: Keeping healthy

B2.1 How do our bodies resist infection?

1. understand that symptoms of an infectious disease are caused by damage done to cells by microorganisms or the poisons (toxins) they produce
2. understand why, in suitable conditions such as those inside a human body, microorganisms (eg bacteria and viruses) can reproduce rapidly to produce very large numbers
3. calculate the population growth of microorganisms given appropriate data
4. understand that white blood cells are part of the body's immune system and can destroy microorganisms by engulfing and digesting them or by producing antibodies
5. understand that antibodies recognise microorganisms by the antigens that they carry on their surface, that different microorganisms have different antigens, and that a different antibody is therefore needed to recognise each different type of microorganism
6. understand that once the body has made the antibody to recognise a particular microorganism, memory cells can make that antibody again very quickly, therefore protecting against that particular microorganism in the future (immunity).

Module B2: Keeping healthy

B2.2 What are vaccines and antibiotics and how do they work?

1. understand that vaccinations provide protection from microorganisms by establishing memory cells that produce antibodies quickly on reinfection
2. understand that a vaccine usually contains a safe form of a disease-causing microorganism
3. **understand why, to prevent epidemics of infectious diseases, it is necessary to vaccinate a high percentage of a population**
4. understand that vaccines and drugs (medicines) can never be completely risk-free, since individuals have varying degrees of side effects to them
5. understand that due to genetic differences, people react differently to drugs and vaccines
6. understand that chemicals called antimicrobials can be used to kill, **or inhibit**, bacteria, fungi and viruses
7. recall that antibiotics are a type of antimicrobial that are effective against bacteria but not viruses
8. understand that over a period of time bacteria and fungi may become resistant to antimicrobials
9. **understand that random changes (mutations) in the genes of these microorganisms sometimes lead to varieties which are less affected by antimicrobials**
10. understand that to reduce antibiotic resistance we should only use antibiotics when necessary and always complete the course
11. understand that new drugs and vaccines are first tested for safety and effectiveness using animals and human cells grown in the laboratory
12. recall that human trials may then be carried out:
    a. on healthy volunteers to test for safety
    b. on people with the illness to test for safety and effectiveness
13. **describe and explain the use of 'open-label', 'blind' and 'double-blind' human trials in the testing of a new medical treatment**
14. **understand the importance of long-term human trials**
15. understand the ethical issues related to using placebos in human trials.

Module B2: Keeping healthy

B2.3 What factors increase the risk of heart disease?

1. describe the role of the heart as a double pump in the circulatory system
2. understand why heart muscle cells need their own blood supply
3. understand how the structure of arteries, veins and capillaries is related to their function
4. understand that heart rate can be measured by recording the pulse rate
5. understand that blood pressure measurements record the pressure of the blood on the walls of the artery
6. understand that a blood pressure measurement is given as two numbers, the higher value when the heart is contracting and the lower value when the heart is relaxed
7. understand that 'normal' measurements for factors such as heart rate and blood pressure are given within a range because individuals vary
8. understand how fatty deposits in the blood vessels supplying the heart muscle can produce a 'heart attack'
9. understand that heart disease is usually caused by lifestyle factors and/or genetic factors
10. understand that lifestyle factors that can increase the risk of heart disease include:
    a. poor diet
    b. stress
    c. cigarette smoking
    d. misuse of drugs
11. understand that regular moderate exercise reduces the risk of developing heart disease
12. relate differences in lifestyle factors in the UK and non-industrialised countries to the prevalence of heart disease
13. understand how factors that can increase the risk of heart disease are identified via epidemiological and large scale genetics studies
14. assess levels of heart disease risk, and actions that could be taken to reduce risk, when provided with lifestyle and genetic data
15. understand that high blood pressure increases the risk of heart disease
16. understand that the misuse of drugs (eg Ecstasy, cannabis, nicotine and alcohol) can have an adverse effect on health, including heart rate and blood pressure, increasing the risk of a heart attack.

Module B2: Keeping healthy

B2.4 How do our bodies keep a healthy water balance?

1. understand that nervous and hormonal communication systems are involved in maintaining a constant internal environment (homeostasis)
2. understand that automatic control systems throughout the body maintain a range of factors at steady levels and that this is required for cells to function properly
3. recall that these control systems have:
   a. receptors to detect changes in the environment
   b. processing centres to receive information and coordinate responses automatically
   c. effectors to produce the response
4. **understand the principle of negative feedback**
5. **understand that negative feedback between the effector and the receptor of a control system reverses any changes to the system's steady state**
6. understand that a balanced water level is important for maintaining the concentration of cell contents at the correct level for cell activity
7. understand that water levels are controlled by balancing gains from drinks, food and respiration and losses through sweating, breathing, faeces and the excretion of urine
8. understand that the kidneys play a vital role in balancing levels of water, waste and other chemicals in the blood

   ⓘ *Candidates are not expected to recall details of kidney structure*
9. understand that the kidneys balance water levels by producing dilute or concentrated urine as a response to concentration of blood plasma, which is affected by external temperature, exercise level and intake of fluids and salt
10. **understand that concentration of urine is controlled by a hormone called ADH, which is released into the bloodstream by the pituitary gland**
11. **understand how ADH secretion is controlled by negative feedback**
12. understand that alcohol results in the production of a greater volume of more dilute urine, **due to ADH suppression**, which can lead to dehydration and adverse effects on health
13. understand that the drug Ecstasy results in a smaller volume of less dilute urine, **due to increased ADH production**.

3.3.3 Module B3: Life on Earth

Overview

Debate about theories for the evolution of life on Earth often features in the media and popular culture. Candidates consider different explanations for evolution. These contexts illustrate how explanations arise and become accepted, and the role of the scientific community in this process. Natural selection is introduced as the mechanism for evolution.

Biodiversity is recognised as an important natural resource, which is increasingly threatened by human activity. Candidates consider how ecosystems are in balance and how living organisms are dependent on their environment and each other for survival. The extinction of species is a growing concern often featured in the media. Candidates consider causes of extinction and whether extinctions should be a global concern.

The need for sustainability is frequently referred to in the press. Candidates are introduced to what this really means and how maintaining biodiversity is one of the keys to sustainability. Specific examples are used to show how sustainability can be increased.

Issues for citizens	Questions that science may help to answer
Why do some species survive whereas others do not survive? Is evolution 'just a theory'? Where do new species come from? Why do some species become extinct, and does it matter?	How do different species depend on their environment and each other? How have scientists developed explanations of evolution? How does evolution work? What is the importance of biodiversity?

Opportunities for mathematics

This module offers opportunities to develop mathematics skills. For example:

- carry out calculations using experimental data, including finding the mean and the range
- carry out calculations using fractions and percentages for energy transfer
- plot, draw and interpret graphs and charts from candidates' own and secondary data
- extract information from charts, graphs and tables
- use ideas about correlation in the context of climate change.

Opportunities for practical work

This module offers opportunities for practical work in teaching and learning. For example:

- investigate adaptation in plants and animals
- eco-column practical investigation of food webs
- fieldwork to investigate biodiversity and environmental change in local habitats
- investigate the changes in nitrogen in an establishing aquarium over three weeks
- calculate an ecological 'footprint' that measures how great an impact an individual's lifestyle has on the environment.

Opportunities for ICT

This module offers opportunities to illustrate the use of ICT in science. For example:

- recording and displaying the results of DNA analysis
- monitoring and recording human and animal behaviour.

Use of ICT in teaching and learning can include:

- video clips to illustrate varied ecosystems
- use of the internet to research endangered plants or animals
- presentation to show how understanding of evolution develops as new evidence is discovered.

Module B3: Life on Earth – Ideas about Science

Module B3 provides opportunities to develop candidates' understanding of these Ideas about Science

3	Developing scientific explanations Candidates should understand that:	A candidate who understands this can, for example:
3.1	• scientific hypotheses, explanations and theories are not simply summaries of the available data. They are based on data but are distinct from them.	• in a given account of scientific work, identify statements which report data and statements of explanatory ideas (hypotheses, explanations, theories) • recognise that an explanation may be incorrect even if the data agree with it.
3.2	• an explanation cannot simply be deduced from data, but has to be thought up creatively to account for the data.	• identify where creative thinking is involved in the development of an explanation.
3.3	• a scientific explanation should account for most (ideally all) of the data already known. It may explain a range of phenomena not previously thought to be linked. It should also enable predictions to be made about new situations or examples.	• recognise data or observations that are accounted for by, or conflict with, an explanation • give good reasons for accepting or rejecting a proposed scientific explanation • identify the better of two given scientific explanations for a phenomenon, and give reasons for the choice.
3.4	• scientific explanations are tested by comparing predictions based on them with data from observations or experiments.	• draw valid conclusions about the implications of given data for a given scientific explanation, in particular: – understand that agreement between a prediction and an observation increases confidence in the explanation on which the prediction is based but does not prove it is correct – understand that disagreement between a prediction and an observation indicates that one or the other is wrong, and decreases our confidence in the explanation on which the prediction is based.

4	The scientific community	
	Candidates should understand that:	A candidate who understands this can, for example:
4.3	• if explanations cannot be deduced from the available data, 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 judgments.	• show awareness that the same data might be interpreted, quite reasonably, in more than one way • suggest plausible reasons why scientists in a given situation disagree(d).
4.4	• an accepted scientific explanation is rarely abandoned just because some new data disagree with its predictions. It usually survives until a better explanation is available.	• discuss the likely consequences of new data that disagree with the predictions of an accepted explanation • **suggest reasons why scientists should not give up an accepted explanation immediately if new data appear to conflict with it.**
6	**Making decisions about science and technology**	
	Candidates should understand that:	A candidate who understands this can, for example:
6.1	• science-based technology provides people with many things that they value, and which enhance the quality of life. Some applications of science can, however, have unintended and undesirable impacts on the quality of life or the environment. Benefits need to be weighed against costs.	• in a particular context, identify the groups affected and the main benefits and costs of a course of action for each group • **suggest reasons why different decisions on the same issue might be appropriate in view of differences in social and economic context.**
6.2	• scientists may identify unintended impacts of human activity (including population growth) on the environment. They can sometimes help us to devise ways of mitigating this impact and of using natural resources in a more sustainable way.	• identify, and suggest, examples of unintended impacts of human activity on the environment • explain the idea of sustainability, and apply it to specific situations • use data (for example, from a Life Cycle Assessment) to compare the sustainability of alternative products or processes.

Module B3: Life on Earth

B3.1 Systems in balance – how do different species depend on each other?

1. understand that a species is a group of organisms that can breed together to produce fertile offspring
2. understand that adaptation of living organisms to their environment increases the species' chance of survival by making it more likely that individuals will survive to reproduce
3. recall, and recognise when given relevant data, examples of how different organisms are adapted to their environment, and explain how the adaptations increase the organism's chance of surviving to successfully reproduce
4. understand that living organisms are dependent on the environment and other species for their survival
5. understand that there is competition for resources between different species of animals or plants in the same habitat
6. relate changes affecting one species in a food web to the impact on other species that are part of the same food web
7. **explain the interdependence of living organisms by using food webs**
8. understand that a change in the environment may cause a species to become extinct, for example, if:
   a. the environmental conditions change beyond its ability to adapt
   b. a new species that is a competitor, predator or disease organism of that species is introduced
   c. another species (animal, plant or microorganism) in its food web becomes extinct
9. understand that nearly all organisms are ultimately dependent on energy from the Sun
10. recall that plants absorb a small percentage of the Sun's energy for the process of photosynthesis
11. recall that this absorbed energy is stored in the chemicals which make up the plants' cells
12. understand that energy is transferred between organisms in an ecosystem:
    a. when organisms are eaten
    b. when dead organisms and waste materials are fed on by decay organisms (decomposers **and detritivores**)
13. explain how energy passes out of a food chain at each stage via heat, waste products and uneaten parts, limiting the length of food chains
14. calculate from given data the percentage efficiency of energy transfer at different stages of a food chain
15. understand how carbon is recycled through the environment to include the processes of combustion, respiration, photosynthesis and decomposition
16. understand the importance of the role of microorganisms in the carbon cycle

B3.1 Systems in balance – how do different species depend on each other?

17. understand how nitrogen is recycled through the environment in the processes of:

    a. nitrogen fixation to form nitrogen compounds including nitrates

    b. conversion of nitrogen compounds to protein in plants and animals

    c. transfer of nitrogen compounds through food chains

    d. excretion, death and decay of plants and animals resulting in release of nitrates into the soil

    e. uptake of nitrates by plants

    f. denitrification

    ⓘ *Foundation tier candidates are not expected to recall details of conversion of atmospheric nitrogen to nitrates, or nitrates to atmospheric nitrogen*

18. understand the importance of the role of microorganisms in the nitrogen cycle, including decomposition, **nitrogen fixation and denitrification**

19. interpret simple diagrams of the carbon cycle and nitrogen cycle

    ⓘ *Foundation tier candidates are not expected to recall nitrogen fixation or denitrification*

20. understand how environmental change can be measured using non-living indicators, including nitrate levels, temperature and carbon dioxide levels

21. understand how climate and environmental change can be measured using living indicators, including phytoplankton, lichens and aquatic river organisms such as mayfly nymphs

22. interpret data obtained from living and non-living indicators to investigate environmental change.

Module B3: Life on Earth

B3.2 How has life on Earth evolved?

1. recall that life on Earth began approximately 3500 million years ago
2. understand that life on Earth (including species that are now extinct) evolved from very simple living things
3. understand that there is variation between individuals of the same species and that some of this variation is genetic so can be passed on to offspring
4. understand that genetic variation is the result of changes that occur in genes (mutations)
5. understand that mutated genes in sex cells can be passed on to offspring and may occasionally produce new characteristics
6. understand the process of natural selection in terms of the effects of genetic variation and competition on survival and reproduction, leading to an increase in the number of individuals displaying beneficial characteristics in later generations
7. describe the similarities and differences between natural selection and selective breeding
8. interpret data on changes in a species in terms of natural selection
9. understand how the combined effect of mutations, environmental changes, natural selection and isolation can produce new species in the process of evolution
10. understand that evidence for evolution is provided by the fossil record and from analysis of similarities and differences in the DNA of organisms
11. understand that Darwin's theory of evolution by natural selection was the result of many observations and creative thought and why it is a better scientific explanation than Lamarck's (eg fits with advances in understanding of genetics, no evidence or mechanism for inheritance of acquired characteristics).

Module B3: Life on Earth

B3.3 What is the importance of biodiversity?

1. understand that organisms are classified into groups according to similarities and differences in characteristics including:
   a. physical features (eg flowers in flowering plants and the skeleton in vertebrates)
   b. DNA
   ⓘ *Candidates will not be expected to give examples of characteristics of particular taxonomic groups*
2. understand that organisms are classified at different levels, and that these levels can be arranged in an order progressing from large groups containing many organisms with a small number of characteristics in common (eg kingdom) to smaller groups containing fewer organisms with more characteristics in common (eg species)
   ⓘ *Candidates will not be expected to recall the names of taxa other than kingdom and species*
3. understand that the classification of living and fossil organisms can help to:
   a. make sense of the enormous diversity of organisms on Earth
   b. show the evolutionary relationships between organisms
4. understand that biodiversity refers to the variety of life on Earth including:
   a. the number of different species
   b. the range of different types of organisms, eg plants, animals and microorganisms
   c. the genetic variation within species
5. understand why biodiversity is important for the future development of food crops and medicines
6. understand that the rate of extinction of species is increasing and why this is likely to be due to human activity
7. understand that maintaining biodiversity to ensure the conservation of different species is one of the keys to sustainability
8. understand that sustainability means meeting the needs of people today without damaging the Earth for future generations
9. understand that large-scale monoculture crop production is not sustainable because it does not maintain biodiversity
10. describe and explain how sustainability can be improved, for example in the use of packaging materials, by considering the materials used, energy used and pollution created
11. understand why it is preferable to decrease the use of some materials, including packaging materials, even when they are biodegradable, because of:
    a. use of energy in their production and transport
    b. slow decomposition in oxygen deficient landfill sites.

3.4 Summary of Biology A Unit A162: *Modules B4, B5, B6*

Unit A162 is the second unit for GCSE Biology A. It assesses the content of Modules B4, B5 and B6 together with their associated Ideas about Science. Any of IaS1 (Data: their importance and limitations) and IaS2 (Cause-effect explanations) can also be assessed in this unit.

The modules in Unit A162 give emphasis and space to fundamental ideas in the sciences, ensure that appropriate skills are developed in preparation for further study, and provide a stimulating bridge to advanced level studies in science. The emphasis of the unit is on 'science for the scientist' and those aspects of 'How Science Works' that relate to the process of science.

Ideas about Science in Unit A162

Modules B4, B5 and B6 present learning opportunities for a number of the Ideas about Science. The start of each module details the particular Ideas about Science that can be introduced or developed within the contexts covered in the module. Specific examples of contexts within which Ideas about Science can be taught are given in the OCR scheme of work for GCSE Biology A (published separately).

However, it is not intended that understanding and application of Ideas about Science should be limited to the context in which they are taught; they should be applicable to any appropriate scientific context.

Accordingly, questions in Unit A162 can assess any of the Ideas about Science linked to Modules B4, B5 and B6, as well as IaS1 (Data: their importance and limitations) and IaS2 (Cause-effect explanations). These Ideas about Science may be assessed in the context of any of the learning outcomes covered in the three modules.

In summary, the Ideas about Science that can be assessed in Unit A162, within any of the scientific contexts introduced by Modules B4, B5 and B6, are:

Data: their importance and limitations
IaS 1.1 – 1.6
Cause-effect explanations
IaS 2.1 – 2.7
Developing scientific explanations
IaS 3.1 – 3.4
Making decisions about science and technology
IaS 6.5, 6.6

3.4.1 Module B4: The processes of life

Overview

Biological processes that take place in cells involve chemical reactions catalysed by enzymes. Photosynthesis and respiration are examples of these processes, and these reactions take place in specialised structures within cells. The conditions for optimum enzyme action require temperature and pH to be controlled. Anaerobic respiration of microorganisms and yeast provides humans with useful products, including biogas, bread and alcohol.

The first topic considers some of the most fundamental chemical reactions that occur within cells and highlights the crucial role that enzymes play in these processes. The highly specific nature of enzymes is explored, along with sensitivity of enzymes to their environment. The lock and key model provides an accessible example of how models and analogy can enhance understanding of scientific processes.

The second topic focuses in more detail on photosynthesis and the processes plants utilise to take in and transport water and nutrients, necessary to produce the complex molecules required for plant growth.

The processes of plant growth are also fundamental to providing the glucose and complex sugars that many animal and microbial life forms depend upon for respiration. Respiration is explored in more detail in the third topic.

Topics	
B4.1	How do chemical reactions take place in living things?
Reactions in cells; role of enzymes.	
B4.2	How do plants make food?
Photosynthesis; cell structures for photosynthesis; limiting factors.	
B4.3	How do living organisms obtain energy?
Aerobic respiration; anaerobic respiration; cell structures for respiration.	

Opportunities for mathematics

This module offers opportunities to develop mathematics skills. For example:

- carry out calculations using experimental data, including finding the mean and the range
- carry out calculations using fractions and percentages
- plot, draw and interpret graphs and charts from candidates' own and secondary data
- use ideas about correlation.

Opportunities for practical work

This module offers opportunities for practical work in teaching and learning. For example:

- investigate how seed beetles are able to sense their surroundings
- investigate the effects of an enzyme on biological processes
- investigate the factors affecting photosynthesis
- use microscopes to look carefully at the structure of leaves
- investigate rates of diffusion in different media
- investigate the effect of solute concentration on potato cell water balance
- use soil tests to compare soils and composts
- use field work to investigate factors affecting the species of plants in different environmental conditions
- investigate the energy content of different foods
- use data logging to track temperature changes during respiration in peas
- investigate anaerobic respiration in yeast.

Opportunities for ICT

This module offers opportunities to illustrate the use of ICT in science. For example:

- molecular modelling to develop explanations of enzyme action.

Use of ICT in teaching and learning can include:

- animations to explain enzyme action and the effect of temperature on enzyme activity
- animations of diffusion, osmosis and active transport.

Module B4: The processes of life – Ideas about Science

Module B4 provides opportunities to develop candidates' understanding of these Ideas about Science

1	Data: their importance and limitations Candidates should understand that:	A candidate who understands this can, for example:
1.1	• data are crucial to science. The search for explanations starts from data; and data are collected to test proposed explanations.	• use data rather than opinion if asked to justify an explanation • outline how a proposed scientific explanation has been (or might be) tested, referring appropriately to the role of data.
1.2	• we can never be sure that a measurement tells us the true value of the quantity being measured.	• suggest reasons why a given measurement may not be the true value of the quantity being measured.
1.3	• if we make several measurements of any quantity, these are likely to vary.	• suggest reasons why several measurements of the same quantity may give different values • when asked to evaluate data, make reference to its repeatability **and/or reproducibility**.
1.4	• the mean of several repeat measurements is a good estimate of the true value of the quantity being measured.	• calculate the mean of a set of repeated measurements • from a set of repeated measurements of a quantity, use the mean as the best estimate of the true value • explain why repeating measurements leads to a better estimate of the quantity.
1.5	• from a set of repeated measurements of a quantity, it is possible to estimate a range within which the true value probably lies.	• from a set of repeated measurements of a quantity, make a sensible suggestion about the range within which the true value probably lies **and explain this** • **when discussing the evidence that a quantity measured under two different conditions has (or has not) changed, make appropriate reference both to the difference in means and to the variation within each set of measurements.**
1.6	• if a measurement lies well outside the range within which the others in a set of repeats lie, or is off a graph line on which the others lie, this is a sign that it may be incorrect. If possible, it should be checked. If not, it should be used unless there is a specific reason to doubt its accuracy.	• identify any outliers in a set of data • treat an outlier as data unless there is a reason for doubting its accuracy • **discuss and defend the decision to discard or to retain an outlier.**

2	Cause-effect explanations Candidates should understand that:	A candidate who understands this can, for example:
2.1	• it is often useful to think about processes in terms of factors which may affect an outcome (or input variables which may affect an outcome variable).	• in a given context, identify the outcome and factors that may affect it • in a given context, suggest how an outcome might alter when a factor is changed.
2.2	• to investigate the relationship between a factor and an outcome, it is important to control all the other factors which we think might affect the outcome (a so-called 'fair test').	• identify, in a plan for an investigation of the effect of a factor on an outcome, the fact that other factors are controlled as a positive design feature, or the fact that they are not as a design flaw • explain why it is necessary to control all the factors that might affect the outcome other than the one being investigated.

Module B4: The processes of life

B4.1 How do chemical reactions take place in living things?

1. understand that the basic processes of life carried out by all living things depend on chemical reactions within cells that require energy released by respiration
2. understand the role of photosynthesis in making food molecules and energy available to living organisms through food chains
3. describe photosynthesis as a series of chemical reactions that use energy from sunlight to build large food molecules in plant cells and some microorganisms (eg phytoplankton)
4. describe respiration as a series of chemical reactions that release energy by breaking down large food molecules in all living cells
5. recall that enzymes are proteins that speed up chemical reactions
6. recall that cells make enzymes according to the instructions carried in genes
7. understand that molecules have to be the correct shape to fit into the active site of the enzyme (the lock and key model)
8. understand that enzymes need a specific constant temperature to work at their optimum, and that they permanently stop working (**denature**) if the temperature is too high
9. **explain that enzyme activity at different temperatures is a balance between:**
   - **a. increased rates of reaction as temperature increases**
   - **b. changes to the active site at higher temperatures, including denaturing**
   - ⓘ *Candidates are not expected to explain why rates of reaction increase with temperature*
10. recall that an enzyme works at its optimum at a specific pH
11. **explain the effect of pH on enzyme activity in terms of changes to the shape of the active site.**

Module B4: The processes of life

4.2 How do plants make food?

1. recall the names of the reactants and products of photosynthesis, and use the word equation:

   light energy
   carbon dioxide + water → glucose + oxygen

2. **recall the formulae of the reactants and products of photosynthesis, and use the symbol equation:**

   light energy
   $$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$$

3. recall the main stages of photosynthesis:
   a. light energy absorbed by the green chemical chlorophyll
   b. energy used to bring about the reaction between carbon dioxide and water to produce glucose (a sugar)
   c. oxygen produced as a waste product

4. recall that glucose may be:
   a. converted into chemicals needed for growth of plant cells, for example cellulose, protein and chlorophyll
   b. converted into starch for storage
   c. used in respiration to release energy

5. recall the structure of a typical plant cell, limited to chloroplasts, cell membrane, nucleus, cytoplasm, mitochondria, vacuole and cell wall

6. understand the functions of the structures in a typical plant cell that have a role in photosynthesis, including:
   a. chloroplasts contain chlorophyll and the enzymes for the reactions in photosynthesis
   b. cell membrane allows gases and water to pass in and out of the cell freely while presenting a barrier to other chemicals
   c. nucleus contains DNA which carries the genetic code for making enzymes and other proteins used in the chemical reactions of photosynthesis
   d. cytoplasm where the enzymes and other proteins are made

7. recall that minerals taken up by plant roots are used to make some chemicals needed by cells, including nitrogen from nitrates to make proteins

8. understand that diffusion is the passive overall movement of molecules from a region of their higher concentration to a region of their lower concentration

9. recall that the movement of oxygen and carbon dioxide in and out of leaves during photosynthesis occurs by diffusion

4.2 How do plants make food?

10. understand that osmosis (a specific case of diffusion) is the overall movement of water from a dilute to a more concentrated solution through a partially permeable membrane

11. recall that the movement of water into plant roots occurs by osmosis

12. understand that active transport is the overall movement of chemicals across a cell membrane requiring energy from respiration

13. recall that active transport is used in the absorption of nitrates by plant roots

14. understand that the rate of photosynthesis may be limited by:

    a. temperature

    b. carbon dioxide

    c. light intensity

15. interpret data on factors limiting the rate of photosynthesis

16. describe and explain techniques used in fieldwork to investigate the effect of light on plants, including:

    a. using a light meter

    b. using a quadrat

    c. using an identification key

17. understand how to take a transect.

Module B4: The processes of life

B4.3 How do living organisms obtain energy?

1. understand that all living organisms require energy released by respiration for some chemical reactions in cells, including chemical reactions involved in:
   a. movement
   b. synthesis of large molecules
   c. active transport
2. understand that synthesis of large molecules includes:
   a. synthesis of polymers required by plant cells such as starch and cellulose from glucose in plant cells
   b. synthesis of amino acids from glucose and nitrates, and then proteins from amino acids in plant, animal and microbial cells
3. recall that aerobic respiration takes place in animal and plant cells and some microorganisms, and requires oxygen
4. recall the names of the reactants and products of aerobic respiration and use the word equation:

   glucose + oxygen → carbon dioxide + water (+ energy released)

5. **recall the formulae of the reactants and products of aerobic respiration and use the symbol equation:**

   $$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$$

6. recall that anaerobic respiration takes place in animal, plant and some microbial cells in conditions of low oxygen or absence of oxygen, to include:
   a. plant roots in waterlogged soil
   b. bacteria in puncture wounds
   c. human cells during vigorous exercise
7. recall the names of the reactants and products of anaerobic respiration in animal cells and some bacteria, and use the word equation:

   glucose → lactic acid (+ energy released)

8. recall the names of the reactants and products of anaerobic respiration in plant cells and some microorganisms including yeast, and use the word equation:

   glucose → ethanol + carbon dioxide (+ energy released)

9. understand that aerobic respiration releases more energy per glucose molecule than anaerobic respiration

B4.3 How do living organisms obtain energy?

10. recall the structure of typical animal and microbial cells (bacteria and yeast) limited to:
    a. nucleus
    b. cytoplasm
    c. cell membrane
    d. mitochondria (for animal and yeast cells)
    e. cell wall (for yeast and bacterial cells)
    f. circular DNA molecule (for bacterial cells)
11. understand the functions of the structures in animal, plant, bacteria and yeast cells that have a role in respiration, including:
    a. mitochondria contain enzymes for the reactions in aerobic respiration (in animals, plants and yeast)
    b. cell membrane allows gases and water to pass in and out of the cell freely while presenting a barrier to other chemicals
    c. nucleus or circular DNA in bacteria contains DNA which carries the genetic code for making enzymes used in the chemical reactions of respiration
    d. cytoplasm where enzymes are made and which contains the enzymes used in anaerobic respiration
12. describe examples of the applications of the anaerobic respiration of microorganisms, including the production of biogas and fermentation in bread making and alcohol production.

3.4.2 Module B5: Growth and development

Overview

Genetic technologies are at the cutting edge of contemporary science. Research into proteomics, stem cell technology and cellular growth control is at the forefront of modern medical science. Knowledge and understanding of these areas promise powerful applications to benefit both present and future generations.

The first topic explains plant and animal development, comparing and contrasting the development of unspecialised cells. The ability of plant meristems to regenerate whole plants is considered, including the effect of plant hormones on their development.

The second topic looks at how the structure of DNA allows cells to be accurately copied. Key stages in the cell cycle are identified, and cell division by mitosis and meiosis compared.

The final topic describes the process of protein synthesis, following the one-gene-one-protein hypothesis.

Topics	
B5.1	How do organisms develop?
Embryo development; cell specialisation in plants and animals; plant growth responses.	
B5.2	How does an organism produce new cells?
Main processes of the cell cycle; comparisons of mitosis and meiosis.	
B5.3	How do genes control growth and development within the cell?
Structure of genetic code and mechanism for protein synthesis.	

Opportunities for mathematics

This module offers opportunities to develop mathematics skills. For example:

- develop a sense of scale in the context of DNA, cells and plants
- carry out calculations using fractions and percentages
- plot, draw and interpret graphs and charts from candidates' own and secondary data.

Opportunities for practical work

This module offers opportunities for practical work in teaching and learning. For example:

- use microscopes to look at a variety of plant and animal cells
- dissect and draw a broad bean
- take plant cuttings and investigate the effects of using hormone rooting powder
- investigate the effects of phototropism
- view germinating pollen
- extract DNA from plants.

Opportunities for ICT

This module offers opportunities to illustrate the use of ICT in science. For example:

- imaging cells and observing their growth and development.

Use of ICT in teaching and learning can include:

- animations to illustrate DNA structure, replication, and protein synthesis
- animations to illustrate cell division
- video clips to show stages in human development.

Module B5: Growth and development – Ideas about Science

Module B5 provides opportunities to develop candidates' understanding of these Ideas about Science

	3 Developing scientific explanations Candidates should understand that:	A candidate who understands this can, for example:
3.1	• scientific hypotheses, explanations and theories are not simply summaries of the available data. They are based on data but are distinct from them.	• in a given account of scientific work, identify statements which report data and statements of explanatory ideas (hypotheses, explanations, theories) • recognise that an explanation may be incorrect even if the data agree with it.
3.2	• an explanation cannot simply be deduced from data, but has to be thought up creatively to account for the data.	• identify where creative thinking is involved in the development of an explanation.
3.3	• a scientific explanation should account for most (ideally all) of the data already known. It may explain a range of phenomena not previously thought to be linked. It should also enable predictions to be made about new situations or examples.	• recognise data or observations that are accounted for by, or conflict with, an explanation • give good reasons for accepting or rejecting a proposed scientific explanation • identify the better of two given scientific explanations for a phenomenon, and give reasons for the choice.
3.4	• scientific explanations are tested by comparing predictions based on them with data from observations or experiments.	• draw valid conclusions about the implications of given data for a given scientific explanation, in particular: – understand that agreement between a prediction and an observation increases confidence in the explanation on which the prediction is based but does not prove it is correct – understand that disagreement between a prediction and an observation indicates that one or the other is wrong, and decreases our confidence in the explanation on which the prediction is based.

Module B5: Growth and development

B5.1 How do organisms develop?

1. recall that cells in multicellular organisms can be specialised to do particular jobs
2. recall that groups of specialised cells are called tissues, and groups of tissues form organs
3. recall that a fertilised egg cell (zygote) divides by mitosis to form an embryo
4. recall that in a human embryo up to (and including) the eight cell stage, all the cells are identical (embryonic stem cells) and could produce any type of cell required by the organism
5. understand that after the eight cell stage, most of the embryo cells become specialised and form different types of tissue
6. understand that some cells (adult stem cells) remain unspecialised and can become specialised at a later stage to become many, but not all, types of cell required by the organism
7. understand that in plants, only cells within special regions called meristems are mitotically active
8. understand that the new cells produced from plant meristems are unspecialised and can develop into any kind of plant cell
9. understand that unspecialised plant cells can become specialised to form different types of tissue (including xylem and phloem) within organs (including flowers, leaves, stems and roots)
10. understand that the presence of meristems (as sources of unspecialised cells) allows the production of clones of a plant from cuttings, and that this may be done to reproduce a plant with desirable features
11. understand that a cut stem from a plant can develop roots and then grow into a complete plant which is a clone of the parent, and that rooting can be promoted by the presence of plant hormones (**auxins**)
12. understand that the growth and development of plants is also affected by the environment, eg phototropism
13. understand how phototropism increases the plant's chance of survival
14. **explain phototropism in terms of the effect of light on the distribution of auxin in a shoot tip.**

Module B5: Growth and development

B5.2 How does an organism produce new cells?

1. recall that cell division by mitosis produces two new cells that are genetically identical to each other and to the parent cell
2. describe the main processes of the cell cycle:
   a. cell growth during which:
      - numbers of organelles increase
      - the chromosomes are copied when the two strands of each DNA molecule separate and new strands form alongside them

   b. mitosis during which:
      - copies of the chromosomes separate
      - the nucleus divides

   ⓘ *Candidates are not expected to recall intermediate stages of mitosis*
3. recall that meiosis is a type of cell division that produces gametes
4. understand why, in meiosis, it is important that the cells produced only contain half the chromosome number of the parent cell

   ⓘ *Candidates are not expected to recall intermediate stages of meiosis*
5. understand that a zygote contains a set of chromosomes from each parent.

Module B5: Growth and development

B5.3 How do genes control growth and development within the cell?

1. recall that DNA has a double helix structure

2. recall that both strands of the DNA molecule are made up of four different bases which always pair up in the same way: A with T, and C with G

3. understand that the order of bases in a gene is the genetic code for the production of a protein

4. **explain how the order of bases in a gene is the code for building up amino acids in the correct order to make a particular protein**

   ⓘ *Candidates are not expected to recall details of nucleotide structure, transcription or translation*

5. recall that the genetic code is in the cell nucleus of animal and plant cells but proteins are produced in the cell cytoplasm

6. understand that genes do not leave the nucleus but a copy of the gene (**messenger RNA**) is produced to carry the genetic code to the cytoplasm

7. understand that although all body cells in an organism contain the same genes, many genes in a particular cell are not active (switched off) because the cell only produces the specific proteins it needs

8. understand that in specialised cells only the genes needed for the cell can be switched on, but in embryonic stem cells any gene can be switched on during development to produce any type of specialised cell

9. understand that adult stem cells and embryonic stem cells have the potential to produce cells needed to replace damaged tissues

10. understand that ethical decisions need to be taken when using embryonic stem cells and that this work is subject to Government regulation

11. **understand that, in carefully controlled conditions of mammalian cloning, it is possible to reactivate (switch on) inactive genes in the nucleus of a body cell to form cells of all tissue types.**

3.4.3 Module B6: Brain and mind

Overview

How the human brain functions remains largely unknown. Neuroscience is an area at the frontier of medical research, and has huge potential impact for an ageing population.

This module begins by looking at how, in order to survive, simple organisms respond to changes in their environment. The nervous system of multicellular animals is also considered.

The second topic considers how information is transmitted from receptor cells to effector cells, including a simple description of chemical transmission across synapses. The effects of drugs on synapses in the brain are explored (for example, Ecstasy).

Simple, conditioned and modified reflexes are introduced in the third topic, with reference to survival and adaptation.

The fourth topic takes a closer look at the brain, and how some neuron pathways become 'preferred' while other potential pathways remain available to allow for adaptation to new situations. This topic illustrates specialised areas of the brain, identifies methods scientists have used to map the cerebral cortex and introduces a basic understanding of memory.

Topics	
B6.1	How do animals respond to changes in their environment?
Co-ordination of responses to stimuli via the central nervous system.	
B6.2	How is information passed through the nervous system?
Structure of neurons; transmission of electrical impulses, including synapses; effects of Ecstasy on synapse action.	
B6.3	What can we learn through conditioning?
Simple reflex actions for survival; mechanism of a reflex arc; conditioned reflexes.	
B6.4	How do humans develop more complex behaviour?
Formation of neuron pathways and learning through repetition; mapping brain function; models for understanding memory.	

Opportunities for mathematics

This module offers opportunities to develop mathematics skills. For example:

- carry out calculations using experimental data, including finding the mean and the range
- plot, draw and interpret graphs and charts from candidates' own and secondary data.

Opportunities for practical work

This module offers opportunities for practical work in teaching and learning. For example:

- investigate reflex behaviour of woodlice
- look at microscope slides of neurons
- research reflex behaviour in newborn babies and in other animals
- investigate receptor cells on the tongue
- measure the speed at which a nerve impulse travels
- investigate factors that affect reaction times
- measure the touch sensitivity of different areas of the body
- make a presentation about Pavlov and his work on conditioned reflexes
- investigate how practice of a skill improves performance
- investigate pupils' own learning
- investigate whether woodlice have a memory.

Opportunities for ICT

This module offers opportunities to illustrate the use of ICT in science. For example:

- observe and digitally record human and animal behaviour
- log, record and display physiological data.

Use of ICT in teaching and learning can include:

- video clips to illustrate patterns in the behaviour of living things
- animations to explain synapse function and the effects of drugs on synapses
- interactive animations on brain function
- using the internet to research behaviour and memory.

Module B6: Brain and mind – Ideas about Science

Module B6 provides opportunities to develop candidates' understanding of these Ideas about Science

6	**Making decisions about science and technology** Candidates should understand that:	A candidate who understands this can, for example:
6.5	• some forms of scientific research, and some applications of scientific knowledge, have ethical implications. People may disagree about what should be done (or permitted).	• where an ethical issue is involved: – say clearly what this issue is – summarise different views that may be held.
6.6	• in discussions of ethical issues, one common argument is that the right decision is one which leads to the best outcome for the greatest number of people involved. Another is that certain actions are considered right or wrong whatever the consequences.	• in a given context, identify, **and develop**, arguments based on the ideas that: – the right decision is the one which leads to the best outcome for the greatest number of people involved – certain actions are considered right or wrong whatever the consequences.

Module B6: Brain and mind

B6.1 How do animals respond to changes in their environment?

1. recall that a stimulus is a change in the environment of an organism
2. understand that simple reflexes produce rapid involuntary responses to stimuli
3. understand that the simplest animals rely on reflex actions for the majority of their behaviour
4. understand that these reflex actions help to ensure that the simplest animals respond to a stimulus in a way that is most likely to result in their survival, to include finding food and sheltering from predators
5. recall examples of simple reflexes in humans, to include newborn reflexes (eg stepping, grasping, sucking), pupil reflex, knee jerk and dropping a hot object
6. understand that nervous co-ordination, including simple reflexes, requires:
   a. receptors to detect stimuli
   b. processing centres to receive information and coordinate responses
   c. effectors to produce the response
7. understand that receptors and effectors can form part of complex organs, for example:
   a. light receptor cells in the retina of the eye
   b. hormone secreting cells in a gland
   c. muscle cells in a muscle
8. understand that nervous systems use electrical impulses for fast, short-lived responses including simple reflexes
9. recall that hormones are chemicals that are produced in glands, travel in the blood and bring about slower, longer-lasting responses, eg insulin and oestrogen
10. recall that the development of nervous and hormonal communication systems depended on the evolution of multicellular organisms.

Module B6: Brain and mind

B6.2 How is information passed through the nervous system?

1. recall that nervous systems are made up of neurons (nerve cells) linking receptor cells (eg in eyes, ears and skin) to effector cells (in muscles/glands)
2. recall that neurons transmit electrical impulses when stimulated
3. recall that an axon is a long extension of the cytoplasm in a neuron and is surrounded by cell membrane
4. understand that some axons are surrounded by a fatty sheath, which insulates the neuron from neighbouring cells and increases the speed of transmission of a nerve impulse
5. recall that in humans and other vertebrates the central nervous system (CNS) is made up of the spinal cord and brain
6. recall that in the mammalian nervous system the CNS (brain and spinal cord) is connected to the body via the peripheral nervous system (PNS) (sensory and motor neurons)
7. understand that the CNS coordinates an animal's responses via:
   a. sensory neurons carrying impulses from receptors to the CNS
   b. motor neurons carrying impulses from the CNS to effectors
8. understand that within the CNS, impulses are passed from sensory neurons to motor neurons through relay neurons
9. describe the nervous pathway of a spinal reflex arc to include receptor, sensory neuron, relay neuron, spinal cord, motor neuron and effector
10. **understand that this arrangement of neurons into a fixed pathway allows reflex responses to be automatic and so very rapid, since no processing of information is required**
11. recall that there are gaps between adjacent neurons called synapses and that impulses are transmitted across them
12. **understand that at a synapse an impulse triggers the release of chemicals (transmitter substances) from the first neuron into the synapse, which diffuse across and bind to receptor molecules on the membrane of the next neuron**
13. **understand that only specific chemicals bind to the receptor molecules, initiating a nerve impulse in the next neuron**
14. recall that some toxins and drugs, including Ecstasy, beta blockers and Prozac, affect the transmission of impulses across synapses
15. **understand that Ecstasy (MDMA) blocks the sites in the brain's synapses where the transmitter substance, serotonin, is removed**
16. **understand that the effects of Ecstasy on the nervous system are due to the subsequent increase in serotonin concentration**
17. recall that the cerebral cortex is the part of our brain most concerned with intelligence, memory, language and consciousness
18. understand that scientists can map the regions of the brain to particular functions (including studies of patients with brain damage, studies in which different parts of the brain are stimulated electrically, and brain scans such as MRI, showing brain structure and activity).

Module B6: Brain and mind

B6.3 Can reflex responses be learned?

1. understand that a reflex response to a new stimulus can be learned by introducing the secondary (new) stimulus in association with the primary stimulus, and that this is called conditioning
2. describe and explain two examples of conditioning, including Pavlov's dogs
3. **understand that in a conditioned reflex the final response (eg salivation) has no direct connection to the secondary stimulus (eg ringing of a bell)**
4. **understand that conditioned reflexes are a form of simple learning that can increase an animal's chance of survival**
5. **recall that in some circumstances the brain can modify a reflex response via a neuron to the motor neuron of the reflex arc, for example keeping hold of a hot object.**

Module B6: Brain and mind

B6.4 How do humans develop more complex behaviour?

1. understand that the evolution of a larger brain gave early humans a better chance of survival
2. recall that mammals have a complex brain of billions of neurons that allows learning by experience, including social behaviour
3. understand that during development the interaction between mammals and their environment results in neuron pathways forming in the brain
4. understand that learning is the result of experience where:
   a. certain pathways in the brain become more likely to transmit impulses than others
   b. new neuron pathways form and other neuron pathways are lost
5. understand that this is why some skills may be learnt through repetition
6. **understand that the variety of potential pathways in the brain makes it possible for the animal to adapt to new situations**
7. **understand the implications of evidence suggesting that children may only acquire some skills at a particular age, to include language development in feral children**
8. describe memory as the storage and retrieval of information
9. recall that memory can be divided into short-term memory and long-term memory
10. understand that humans are more likely to remember information if:
    a. they can see a pattern in it (or impose a pattern on it)
    b. there is repetition of the information, especially over an extended period of time
    c. there is a strong stimulus associated with it, including colour, light, smell, or sound
11. understand how models can be used to describe memory (including the multi-store model) to include short-term memory, long-term memory, repetition, storage, retrieval and forgetting
12. understand that models are limited in explaining how memory works.

3.5 Summary of Biology A Unit A163: *Module B7*

Unit A163 is the third unit for GCSE Biology A. It assesses the content of Module B7 together with **any** of the Ideas about Science.

Unit A163 includes additional content to enhance progression and to give a greater understanding of the subjects concerned. This unit continues the emphasis on ‘science for the scientist’ in preparation for further study, and provides a stimulating bridge to advanced level studies in science.

Ideas about Science in Unit A163

Module B7 presents learning opportunities for a number of the Ideas about Science. The start of the module details the particular Ideas about Science that can be introduced or developed within the contexts covered in the module. Specific examples of contexts within which Ideas about Science can be taught are given in the OCR scheme of work for GCSE Biology A (published separately).

However, it is not intended that understanding and application of Ideas about Science should be limited to the context in which they are taught; they should be applicable to any appropriate scientific context.

Accordingly, questions in Unit A163 can assess any of the Ideas about Science (summarised in Appendix B), and these Ideas about Science may be assessed in the context of any of the learning outcomes covered in Module B7.

In summary, the Ideas about Science that can be assessed in Unit A163, within **any** of the scientific contexts introduced by Module B7, are:

Data: their importance and limitations
IaS 1.1 – 1.6
Cause-effect explanations
IaS 2.1 – 2.7
Developing scientific explanations
IaS 3.1 – 3.4
The scientific community
IaS 4.1 – 4.4
Risk
IaS 5.1 – 5.7
Making decisions about science and technology
IaS 6.1 – 6.6

3.5.1 Module B7: Further Biology

Overview

More than ever before, Biology in the Twenty First Century is at the forefront of science. In this module, candidates draw together and develop their understanding of some of the major science explanations they have studied during Modules B1 – B3 (Unit A161) and Modules B4 – B6 (Unit A162). Throughout Module B7 candidates have opportunities to employ Ideas about Science from IaS1 (Data: their importance and limitations), IaS5 (Risk), and IaS6 (Making decisions about science and technology).

Medicine and health, and production of food and other resources such as fuels are important areas involving biological sciences. In 'Peak performance' pupils learn more about how human bodies work and how to keep fit and healthy.

Humans cannot live without consideration of their place in the natural world. We are part of the natural world and dependent on it for our survival. In 'What can we learn from natural ecosystems?' pupils find out how the natural world provides humans with a model for sustainable systems.

In 'New technologies' pupils discover more about the fast-moving world of modern biological techniques. Many of these have implications for human food production and production of medicines and other useful products.

Topics
B7.1 Peak performance – movement and exercise
Skeletal system; health and fitness.
B7.2 Peak performance – circulation
Components of blood; the circulatory system.
B7.3 Peak performance – energy balance
Maintaining constant body temperature and blood sugar; diabetes.
B7.4 What can we learn from natural ecosystems?
Closed loop systems; sustainability.
B7.5 New technologies
DNA technology; genetic modification; nanotechnology; stem cells.

Opportunities for mathematics

This module offers opportunities to develop mathematics skills. For example:

- develop a sense of scale in the context of DNA, cells, organs, organisms and ecosystems
- develop a sense of scale in the context of nanotechnology
- carry out calculations using experimental data on heart rate and recovery period after exercise
- carry out calculations to find the percentage increase in measured values including muscle length and heart rate
- use ideas of proportion in the context of gel electrophoresis of DNA fragments
- plot, draw, and interpret graphs and charts from candidates' own and secondary data in the context of seed germination, injury recovery times, body mass index, and enzyme activity
- use ideas about correlation in the context of blood sugar and insulin levels
- use ideas about uncertainty and probability in the context of the risks and benefits of genetically modified organisms
- use the equation for calculating BMI including appropriate units for physical quantities.

Opportunities for practical work

This module offers opportunities for practical work in teaching and learning. For example:

- find out how muscles and bones enable humans and other animals to move, both by self-observation and by dissecting a chicken wing
- investigate the physiology of fitness
- investigate the energy content of oil from different seeds
- investigate the role of microorganisms in recycling
- investigate the effect of temperature on enzyme activity
- investigate the conditions required for seed germination
- heart dissection
- model an ecosystem on a small scale
- use a model to investigate the role of blood in maintaining a constant body temperature.

Opportunities for ICT

This module offers opportunities to illustrate the use of ICT in science. For example:

- log, store and display data for analysis and evaluation
- the integral role of ICT in DNA technologies
- animations of movement at a joint
- animations of the heart
- animations of valves in veins
- investigate the structures in a chicken leg

Use of ICT in teaching and learning can include:

- video clips of physiotherapy
- video clips showing behaviour of living things in response to extreme temperatures
- a data logger to monitor body temperature over 12 or 24 hours
- video clips of Easter Island
- video clips of Masai people
- video clips of biodigester in use
- video clips of desert
- animations of genetic modification
- animations to illustrate the change in surface area as material is divided up
- using the internet to research new technologies.

Module B7: Further Biology – Ideas about Science

Module B7 provides opportunities to develop candidates' understanding of these Ideas about Science

1	**Data: their importance and limitations**	
	Candidates should understand that:	A candidate who understands this can, for example:
1.1	• data are crucial to science. The search for explanations starts from data; and data are collected to test proposed explanations.	• use data rather than opinion if asked to justify an explanation • outline how a proposed scientific explanation has been (or might be) tested, referring appropriately to the role of data.
1.2	• we can never be sure that a measurement tells us the true value of the quantity being measured.	• suggest reasons why a given measurement may not be the true value of the quantity being measured.
1.3	• if we make several measurements of any quantity, these are likely to vary.	• suggest reasons why several measurements of the same quantity may give different values • when asked to evaluate data, make reference to its repeatability **and/or reproducibility**.
1.4	• the mean of several repeat measurements is a good estimate of the true value of the quantity being measured.	• calculate the mean of a set of repeated measurements • from a set of repeated measurements of a quantity, use the mean as the best estimate of the true value • explain why repeating measurements leads to a better estimate of the quantity.
1.5	• from a set of repeated measurements of a quantity, it is possible to estimate a range within which the true value probably lies.	• from a set of repeated measurements of a quantity, make a sensible suggestion about the range within which the true value probably lies **and explain this** • **when discussing the evidence that a quantity measured under two different conditions has (or has not) changed, make appropriate reference both to the difference in means and to the variation within each set of measurements.**
1.6	• if a measurement lies well outside the range within which the others in a set of repeats lie, or is off a graph line on which the others lie, this is a sign that it may be incorrect. If possible, it should be checked. If not, it should be used unless there is a specific reason to doubt its accuracy.	• identify any outliers in a set of data • treat an outlier as data unless there is a reason for doubting its accuracy • **discuss and defend the decision to discard or to retain an outlier.**

2	Cause-effect explanations Candidates should understand that:	A candidate who understands this can, for example:
2.3	• if an outcome occurs when a specific factor is present, but does not when it is absent, or if an outcome variable increases (or decreases) steadily as an input variable increases, we say that there is a correlation between the two.	• suggest and explain an example from everyday life of a correlation between a factor and an outcome • identify where a correlation exists when data are presented as text, as a graph, or in a table. ⓘ *Examples may include both positive and negative correlations, but candidates will not be expected to know these terms.*
2.4	• a correlation between a factor and an outcome does not necessarily mean that the factor causes the outcome; both might, for example, be caused by some other factor.	• use the ideas of correlation and cause when discussing data and show awareness that a correlation does not necessarily indicate a causal link • identify, and suggest from everyday experience, examples of correlations between a factor and an outcome where the factor is (or is not) a plausible cause of the outcome • explain why an observed correlation between a given factor and outcome does not necessarily mean that the factor causes the outcome.
2.5	• in some situations, a factor alters the chance (or probability) of an outcome, but does not invariably lead to it. We also call this a correlation.	• suggest factors that might increase the chance of a particular outcome in a given situation, but do not invariably lead to it • explain why individual cases do not provide convincing evidence for or against a correlation.

3	Developing scientific explanations Candidates should understand that:	A candidate who understands this can, for example:
3.4	• scientific explanations are tested by comparing predictions based on them with data from observations or experiments.	• draw valid conclusions about the implications of given data for a given scientific explanation, in particular: – understand that agreement between a prediction and an observation increases confidence in the explanation on which the prediction is based but does not prove it is correct – understand that disagreement between a prediction and an observation indicates that one or the other is wrong, and decreases our confidence in the explanation on which the prediction is based.

5	Risk	
	Candidates should understand that:	A candidate who understands this can, for example:
5.1	• everything we do carries a certain risk of accident or harm. Nothing is risk free. New technologies and processes based on scientific advances often introduce new risks.	• explain why it is impossible for anything to be completely safe • identify examples of risks which arise from a new scientific or technological advance • suggest ways of reducing a given risk.
5.2	• we can sometimes assess the size of a risk by measuring its chance of occurring in a large sample, over a given period of time.	• interpret and discuss information on the size of risks, presented in different ways.
5.3	• to make a decision about a particular risk, we need to take account both of the chance of it happening and the consequences if it did.	• discuss a given risk, taking account of both the chance of it occurring and the consequences if it did.
6	**Making decisions about science and technology**	
	Candidates should understand that:	A candidate who understands this can, for example:
6.1	• science-based technology provides people with many things that they value, and which enhance the quality of life. Some applications of science can, however, have unintended and undesirable impacts on the quality of life or the environment. Benefits need to be weighed against costs.	• in a particular context, identify the groups affected and the main benefits and costs of a course of action for each group • **suggest reasons why different decisions on the same issue might be appropriate in view of differences in social and economic context.**
6.2	• scientists may identify unintended impacts of human activity (including population growth) on the environment. They can sometimes help us to devise ways of mitigating this impact and of using natural resources in a more sustainable way.	• identify, and suggest, examples of unintended impacts of human activity on the environment • explain the idea of sustainability, and apply it to specific situations • use data (for example, from a Life Cycle Assessment) to compare the sustainability of alternative products or processes.
6.3	• in many areas of scientific work, the development and application of scientific knowledge are subject to official regulations.	• in contexts where this is appropriate, show awareness of, **and discuss**, the official regulation of scientific research and the application of scientific knowledge.
6.4	• some questions, such as those involving values, cannot be answered by science.	• distinguish questions which could in principle be answered using a scientific approach, from those which could not.

6	Making decisions about science and technology	
	Candidates should understand that:	A candidate who understands this can, for example:
6.5	• some forms of scientific research, and some applications of scientific knowledge, have ethical implications. People may disagree about what should be done (or permitted).	• where an ethical issue is involved: – say clearly what this issue is – summarise different views that may be held.
6.6	• in discussions of ethical issues, one common argument is that the right decision is one which leads to the best outcome for the greatest number of people involved. Another is that certain actions are considered right or wrong whatever the consequences.	• in a given context, identify, **and develop**, arguments based on the ideas that: – the right decision is the one which leads to the best outcome for the greatest number of people involved – certain actions are considered right or wrong whatever the consequences.

Module B7: Further Biology

B7.1 Peak performance – movement and exercise

1. understand that the internal skeleton of vertebrates is needed for support and movement
2. understand that muscles can only move bones at a joint by contraction, and thus operate in antagonistic pairs
3. recall the structure and function of the components of a joint, to include:
    a. smooth layer of cartilage and synovial fluid to reduce friction between bones
    b. elastic ligaments to stabilise joints while allowing movement
    c. tendons to transmit the forces between muscle and bones
4. understand how the specific properties of ligaments, cartilage and tendons enable them to function effectively
5. explain why certain factors in a person's medical or lifestyle history need to be disclosed before an exercise regime is started (for example: symptoms, current medication, alcohol and tobacco consumption, level of physical activity, family medical history and previous treatments)
6. interpret data obtained when monitoring a person during and after exercise, including change in heart rate, change in blood pressure and the recovery period
7. use proportion of body fat and body mass index (BMI) as measurements of fitness
8. use the equation:

$$\text{BMI} = \frac{\text{body mass (kg)}}{[\text{height (m)}]^2}$$

9. **understand that any assessment of progress needs to take into account the accuracy of the monitoring technique and the repeatability of the data obtained**
10. recall common injuries that can be caused by excessive exercise, to include sprains, dislocations, and torn ligaments or tendons
11. recall symptoms and basic treatments for a sprain
12. describe the role of the physiotherapist in treatment of skeletal-muscular injury.

Module B7: Further Biology

B7.2 Peak performance – circulation

1. explain what is meant by a double circulatory system
2. understand that the blood carries glucose molecules and oxygen to the muscles, and waste products such as carbon dioxide away from muscles
3. relate the components of the blood to their functions, including:
   a. red blood cells – transport oxygen
   b. white blood cells – fighting infections
   c. platelets – blood clotting at injury sites
   d. plasma – transporting nutrients (eg glucose and amino acids), antibodies, hormones and waste (carbon dioxide and urea)
4. understand how red blood cells are adapted to their function, limited to:
   a. packed with haemoglobin (to bind oxygen)
   b. no nucleus (more space for haemoglobin)
   c. biconcave shape (increased surface area for oxygen exchange)
5. describe and name the main structures and blood vessels of the heart including the left and right atria and ventricles, vena cava, aorta, pulmonary vein, pulmonary artery, coronary arteries and valves
6. describe the function of valves in the heart and veins
7. **understand how tissue fluid is formed in capillary beds and that it assists the exchange of chemicals by diffusion between capillaries and tissues, to include oxygen, carbon dioxide, glucose and urea.**

Module B7: Further Biology

B7.3 Peak performance – energy balance

1. understand that to maintain a constant body temperature, heat gained (including heat released during respiration) is balanced by heat lost
2. recall that temperature receptors in the skin detect external temperature
3. recall that temperature receptors in the brain (**hypothalamus**) detect the temperature of the blood
4. understand that the brain (**hypothalamus**) acts as a processing centre, receiving information from the temperature receptors, and sending instructions to trigger the effectors automatically
5. recall that effectors include sweat glands and muscles
6. understand that at high body temperatures:
    a. more sweat is produced by sweat glands which cools the body when it evaporates
    b. blood vessels supplying the capillaries of the skin dilate (vasodilation) allowing more blood to flow through skin capillaries which increases heat loss
7. explain how exercise produces increased sweating, and can produce dehydration, which may lead to reduced sweating and further increase of core body temperature
8. understand that at low body temperatures:
    a. the increased rate of respiration stimulated when muscles contract rapidly (shivering) results in some of the energy transferred in respiration warming the surrounding tissues
    b. blood vessels supplying the capillaries of the skin constrict (vasoconstriction) restricting blood flow through skin capillaries which reduces heat loss
9. **understand that some effectors work antagonistically, which allows a more sensitive and controlled response**
10. understand that high levels of sugar, common in some processed foods, are quickly absorbed into the blood stream, causing a rapid rise in the blood sugar level
11. recall that there are two types of diabetes (type 1 and type 2), and that it is particularly late-onset diabetes (type 2) which is more likely to arise because of poor diet or obesity
12. understand that type 1 diabetes arises when the pancreas stops producing enough of the hormone, insulin, but that type 2 diabetes develops when the body no longer responds to its own insulin or does not make enough insulin
13. recall that type 1 diabetes is controlled by insulin injections and that type 2 diabetes can be controlled by diet and exercise
14. explain how a diet high in fibre and complex carbohydrates can help to maintain a constant blood sugar level
15. interpret data on risks associated with an unhealthy lifestyle (limited to poor diet and lack of exercise), including obesity, heart disease, diabetes and some cancers.

Module B7: Further Biology

B7.4 What can we learn from natural ecosystems?

1. recall that a perfect closed loop system is a system that has no waste because the output from one part of the system becomes the input to another part
2. understand that an ecosystem is a type of closed loop system since most waste materials are not lost but are used as food or reactants
3. name examples of waste products in natural ecosystems, to include oxygen (from photosynthesis), carbon dioxide (from respiration), and dead organic matter such as fallen petals, leaves and fruits, and faeces
4. understand how these waste products may become food or reactants for animals, plants and microorganisms in the ecosystem, including the role of the digestive enzymes of microorganisms
5. interpret closed loop system diagrams and data on the storage and movement of chemicals through an ecosystem, including water, carbon, nitrogen and oxygen

   ⓘ *Candidates will not be expected to recall details of the nutrient cycles*
6. understand that no ecosystem is a perfect closed loop system since some output is always lost, eg migration of organisms and loss of nutrients transferred by air or water
7. understand that in stable ecosystems, including rainforests, the output (losses) is balanced by gains
8. understand why the production of large quantities of reproductive structures, including eggs, sperm, pollen, flowers and fruit, is a necessary strategy for successful reproduction
9. understand that, in stable ecosystems, the production of large quantities of these reproductive structures is not wasteful, since the surplus is recycled in the ecosystem
10. recall that vegetation in stable ecosystems, such as rain forests, prevents soil erosion and extremes of temperature, and promotes cloud formation
11. understand that vegetation reduces soil erosion since foliage protects the soil from direct rainfall and roots help to bind the soil together
12. understand that humans depend on natural ecosystems to provide ‘ecosystem services’, for example providing clean air, water, soil, mineral nutrients, pollination, fish and game
13. understand that human systems are not closed loop systems because some waste leaves the system, including non-recycled waste from households, agriculture and industry, and emissions from burning fossil fuels
14. understand that some non-recycled waste can build up to harmful levels, **including bioaccumulation in food chains**
15. understand that human activity can unbalance natural ecosystems by altering the inputs and outputs, and that this leads to change
16. **describe and explain the process of eutrophication**
17. describe the environmental impact of removing biomass from natural closed loop systems for human use, to include unsustainable timber harvesting and fishing

B7.4 What can we learn from natural ecosystems?

18. explain the impact of replacing vegetation in natural ecosystems with agricultural crops and livestock, to include the loss of biodiversity, silting of rivers and desertification
19. understand that the use of natural resources by humans can only be sustainable if used at a rate at which they can be replaced
20. understand why the use of crude oil does not fulfil the requirements of a closed loop system, including:
    a. crude oil takes millions of years to form from the decay of dead organisms
    b. energy released from burning crude oil originated from the Sun when these organisms were alive ('fossil sunlight energy')
21. recall and understand solutions to allow sustainable harvesting of natural resources such as timber and fish, including the use of quotas and restocking/replanting
22. describe the role of sunlight as a sustainable source of energy for natural ecosystems and sustainable agriculture
23. understand the tensions between conserving natural ecosystems and the needs of local human communities.

Module B7: Further Biology

B7.5 New technologies

1. recall the features of bacteria that make them ideal for industrial and genetic processes to include:
   a. rapid reproduction
   b. presence of plasmids
   c. simple biochemistry
   d. ability to make complex molecules
   e. lack of ethical concerns in their culture
2. understand that bacteria and fungi can be grown on a large scale (fermentation) to include production of:
   a. antibiotics and other medicines
   b. single-cell protein
   c. enzymes for food processing, for example chymosin as a vegetarian substitute for rennet
   d. enzymes for commercial products, such as washing powders and to make biofuels
3. recall that genetic modification is where a gene from one organism is transferred to another and continues to work
4. recall the main steps in genetic modification as:
   a. isolating and replicating the required gene
   b. putting the gene into a suitable vector (virus or plasmid)
   c. using the vector to insert the gene into a new cell
   d. selecting the modified individuals
5. recall examples of the application of genetic modification, to include:
   a. bacterial synthesis of medicines, for example insulin
   b. herbicide resistance in crop plants
6. **understand and explain the use of DNA technology in genetic testing, to include:**
   a. isolation of a DNA sample from white blood cells
   b. production of a gene probe labelled with a fluorescent chemical
   c. addition of the labelled gene probe (marker) to the DNA sample
   d. use of UV to detect the marker and therefore indicate the position of the gene or the presence of a specific allele in the DNA sample
7. recall that nanotechnology involves structures that are about the same size as some molecules
8. describe the application of nanotechnology in the food industry, including food packaging which can increase shelf life and detect contaminants
9. describe applications of stem cell technology in tissue and organ culture, including the treatment of leukaemia and the potential to treat spinal cord injuries
10. describe the role of biomedical engineering in pacemakers and the replacement of faulty heart valves.

4 Assessment of GCSE Biology A

4.1 Overview of the assessment in GCSE Biology A

GCSE Biology A J243	
Unit A161: *Modules B1, B2, B3*	
25% of the total GCSE 1 hr written paper 60 marks	This question paper: • is offered in Foundation and Higher Tiers • assesses Modules B1, B2 and B3 • uses both objective style and free response questions (there is no choice of questions) • assesses the quality of written communication.
Unit A162: *Modules B4, B5, B6*	
25% of the total GCSE 1 hr written paper 60 marks	This question paper: • is offered in Foundation and Higher Tiers • assesses Modules B4, B5 and B6 • uses both objective style and free response questions (there is no choice of questions) • assesses the quality of written communication.
Unit A163: *Module B7*	
25% of the total GCSE 1 hr written paper 60 marks	This question paper: • is offered in Foundation and Higher Tiers • assesses Module B7 • uses both objective style and free response questions (there is no choice of questions) • assesses the quality of written communication.
Unit A164: *Controlled assessment*	
25% of the total GCSE Controlled assessment Approximately 4.5–6 hours 64 marks	This unit: • comprises a Practical Investigation • is assessed by teachers, internally standardised and then externally moderated by OCR • assesses the quality of written communication.

4.2 Tiers

All written papers are offered in one of two tiers: Foundation Tier and Higher Tier. Foundation Tier papers assess grades G to C and Higher Tier papers assess Grades D to A*. An allowed grade E may be awarded on the Higher Tier components.

In Units A161, A162 and A163, candidates are entered for an option in either the Foundation Tier or the Higher Tier. Unit A164 (controlled assessment) is not tiered.

Candidates may enter for either the Foundation Tier or Higher Tier in each of the externally assessed units. So a candidate may take, for example, A161/F and A162/H.

4.3 Assessment objectives (AOs)

Candidates are expected to demonstrate their ability to:

AO1	recall, select and communicate their knowledge and understanding of biology
AO2	apply skills, knowledge and understanding of biology in practical and other contexts
AO3	analyse and evaluate evidence, make reasoned judgements and draw conclusions based on evidence.

4.3.1 AO weightings – GCSE Biology A

The relationship between the units and the assessment objectives of the scheme of assessment is shown in the following grid:

Unit	% of GCSE			Total
	AO1	AO2	AO3	
Units A161–A163	30	34	11	75
Unit A164: Controlled assessment	2	5	18	25
Total	**32**	**39**	**29**	**100**

4.4 Grading and awarding grades

GCSE results are awarded on the scale A* to G. Units are awarded a* to g. Grades are indicated on certificates. However, results for candidates who fail to achieve the minimum grade (G or g) will be recorded as *unclassified* (U or u) and this is **not** certificated.

GCSEs are unitised schemes. Candidates can take units across several different series provided the terminal rules are satisfied. They can also re-sit units.

When working out candidates' overall grades OCR needs to be able to compare performance on the same unit in different series when different grade boundaries have been set, and between different units. OCR uses a Uniform Mark Scale to enable this to be done.

A candidate's uniform mark for each unit is calculated from the candidate's raw marks on that unit. The raw mark boundary marks are converted to the equivalent uniform mark boundary. Marks between grade boundaries are converted on a pro rata basis.

When unit results are issued, the candidate's unit grade and uniform mark are given. The uniform mark is shown out of the maximum uniform mark for the unit, eg 60/100.

The uniform mark grade boundaries for each of the assessments are shown below:

(GCSE) Unit Weighting	Maximum Unit Uniform Mark	Unit Grade								
		a*	a	b	c	d	e	f	g	u
25%	100	90	80	70	60	50	40	30	20	0

The written papers will have a total weighting of 75% and controlled assessment a weighting of 25%.

Higher tier candidates who fail to gain a 'd' grade may achieve an "allowed e". Higher tier candidates who miss the allowed grade 'e' will be given a uniform mark in the range f–u but will be graded as 'u'.

Candidate's uniform marks for each unit will be combined to give a total uniform mark for the specification. The candidate's overall grade will be determined by the total uniform mark.

The following table shows the minimum total mark for each overall grade:

Qualification	Max Uniform Mark	Qualification Grade								
		A*	A	B	C	D	E	F	G	U
J243	400	360	320	280	240	200	160	120	80	0

A candidate's uniform mark for each paper will be combined with the uniform mark for the controlled assessment to give a total uniform mark for the specification. The candidate's grade will be determined by the total uniform mark.

4.5 Grade descriptions

Grade descriptions are provided to give a general indication of the standards of achievement likely to have been shown by candidates awarded particular grades. The descriptions must be interpreted in relation to the content in the specification; they are not designed to define that content. The grade awarded will depend in practice upon the extent to which the candidate has met the assessment objectives overall. Shortcomings in some aspects of the assessment may be balanced by better performance in others.

The grade descriptors have been produced by the regulatory authorities in collaboration with the awarding bodies.

4.5.1 Grade F

Candidates recall, select and communicate limited knowledge and understanding of biology. They recognise simple inter-relationships between biology and society. They show a limited understanding that scientific advances may have ethical implications, benefits and risks. They use limited scientific and technical knowledge, terminology and conventions, showing some understanding of scale in terms of time, size and space.

They apply skills, including limited communication, mathematical, technical and observational skills, knowledge and understanding in practical and some other contexts. They recognise and use hypotheses, evidence and explanations and can explain straightforward models of phenomena, events and processes. They use a limited range of methods, sources of information and data to address straightforward scientific questions, problems and hypotheses.

Candidates interpret and evaluate limited quantitative and qualitative data and information from a narrow range of sources. They can draw elementary conclusions having collected limited evidence.

4.5.2 Grade C

Candidates recall, select and communicate secure knowledge and understanding of biology. They demonstrate understanding of the nature of biology and its principles and applications and the relationship between biology and society. They understand that scientific advances may have ethical implications, benefits and risks. They use scientific and technical knowledge, terminology and conventions appropriately, showing understanding of scale in terms of time, size and space.

They apply appropriate skills, including communication, mathematical, technical and observational skills, knowledge and understanding in a range of practical and other contexts. They show understanding of the relationships between hypotheses, evidence, theories and explanations and use models, including mathematical models, to describe abstract ideas, phenomena, events and processes. They use a range of appropriate methods, sources of information and data, applying their skills to address scientific questions, solve problems and test hypotheses.

Candidates analyse, interpret and evaluate a range of quantitative and qualitative data and information. They understand the limitations of evidence and use evidence and information to develop arguments with supporting explanations. They draw conclusions based on the available evidence.

4.5.3 Grade A

Candidates recall, select and communicate precise knowledge and detailed understanding of biology. They demonstrate a comprehensive understanding of the nature of biology, its principles and applications and the relationship between biology and society. They understand the relationships between scientific advances, their ethical implications and the benefits and risks associated with them. They use scientific and technical knowledge, terminology and conventions appropriately and consistently, showing a detailed understanding of scale in terms of time, size and space.

They apply appropriate skills, including communication, mathematical, technical and observational skills, knowledge and understanding effectively in a wide range of practical and other contexts. They show a comprehensive understanding of the relationships between hypotheses, evidence, theories and explanations and make effective use of models, including mathematical models, to explain abstract ideas, phenomena, events and processes. They use a wide range of appropriate methods, sources of information and data consistently, applying relevant skills to address scientific questions, solve problems and test hypotheses.

Candidates analyse, interpret and critically evaluate a broad range of quantitative and qualitative data and information. They evaluate information systematically to develop arguments and explanations taking account of the limitations of the available evidence. They make reasoned judgments consistently and draw detailed, evidence-based conclusions.

4.6 Quality of written communication

Quality of written communication (QWC) is assessed in all units and is integrated into the marking criteria.

Candidates are expected to:

- ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
- present information in a form that suits its purpose
- use a suitable structure and style of writing.

Questions assessing quality of written communication will be indicated by the icon of a pencil (✏).

Controlled assessment in GCSE Biology A

This section provides general guidance on controlled assessment: what controlled assessment tasks are, when and how they are available, how to plan and manage controlled assessment and what controls must be applied throughout the process. More specific guidance and support is provided in the *Guide to controlled assessment for GCSE Twenty First Century Science*, which will be available on the OCR website from Spring 2011.

5.1 Introduction to controlled assessment tasks

All controlled assessment tasks are set by OCR and will be available for submission only in June examination series. Each year a choice of two tasks will be offered, based on Modules B1 – B7; one of these two tasks will be based on Modules B4 – B6.

Each task will be valid for submission in a single examination series only, but may be undertaken at any point between release of the task by OCR and the examination series for which the task must be submitted. Centres must ensure that candidates undertake a task that is valid for submission in the year in which the candidate intends to submit it. The series in which each task can be submitted will be clearly marked on the front cover of the task. Tasks will not be valid for submission in any examination series other than that indicated.

Every year, two new controlled assessment tasks will be made available on OCR Interchange from 1 June, two years ahead of the examination series for which the tasks are to be submitted. These will be removed upon expiry. Guidance on how to access controlled assessment tasks from OCR Interchange is available on the OCR website: www.ocr.org.uk.

It is not necessary for all candidates from a centre to carry out the same task from the choice of two provided. Staff at each centre can choose whether:

- all candidates from the centre complete the same task
- all candidates in any teaching group carry out the same task, but different groups use different tasks
- candidates complete tasks on an individual basis.

The number of tasks attempted is at the discretion of the centre, but the results of only one complete task may be submitted.

5.2 Nature of controlled assessment tasks

5.2.1 Introduction to skills assessment

The controlled assessment for GCSE Biology A comprises one element: a practical investigation.

Investigations are central to the nature of science as an evidence-based activity and practical investigations provide an effective and valid assessment instrument for a course which is both a basis for further studies and for possible future careers in science. The ability of a candidate to formulate a hypothesis and to explain patterns in results will be related to their knowledge and understanding of the topic.

Controlled assessment tasks for GCSE Biology A practical investigations require candidates to:

- develop hypotheses and plan practical ways to test them including risk assessment
- manage risks when carrying out practical work
- collect, process, analyse and interpret primary and secondary data including the use of appropriate technology to draw evidence-based conclusions
- review methodology to assess fitness for purpose
- review hypotheses in the light of outcomes.

Practical investigations therefore draw together the skills of predicting and planning, and collecting, interpreting, evaluating and reviewing primary and secondary data within the context of a whole investigation. Candidates should be familiar with these requirements before starting any controlled assessment task.

It is expected that candidates will be involved in a variety of practical work during the course that will prepare them for this assessment. This should include developing their abilities to handle equipment and carry out practical procedures safely, illustrating science principles with real experiences and learning how to carry out and evaluate investigations.

In addition, candidates' abilities to devise and evaluate suitable methods, to decide on suitable data ranges and to offer explanations will be closely linked to their understanding of some Ideas about Science, particularly:

- IaS1: Data: their importance and limitations
- IaS2: Cause-effect explanations
- IaS3: Developing scientific explanations
- IaS5: Risk.

Candidates should be encouraged to use ideas and vocabulary related to these Ideas about Science in their reports and it is therefore important that candidates are familiar with these ideas before attempting the investigation. Ideas about Science are detailed in Appendix B.

The tasks to be used for the controlled assessment that are set by OCR will be presented in a way which leaves some freedom for each centre to vary the approach as appropriate, to allow for candidates of different abilities and interests, or for differences in the materials, equipment and facilities at different centres.

The tasks provided will be open-ended and investigative in nature. The information provided with each task will include:

- *Information for candidates (1)*: an introduction to the topic of the investigation, to be issued to candidates at the start of the task, placing the work into an appropriate wider context
- *Information for candidates (2)*: secondary data for analysis, to be issued to candidates only on completion of the data collection part of their practical investigation
- *Information for teachers*: an overview of the investigation including notes on possible approaches and assessment issues and guidance for technicians.

At the start of a controlled assessment, candidates will use the information provided to plan how to collect data, including any preliminary work required, and to develop a testable hypothesis before carrying out the investigation. After collecting primary data and interpreting and evaluating the results, candidates will be expected to engage with relevant secondary data to develop and evaluate their conclusions further and review their original hypothesis. Sources of secondary data can include experimental results from other candidates in the class or school, as well as text books and web sites on the internet. In addition, OCR will provide some secondary data relevant to the task set for each practical investigation.

The completed work will be presented for assessment as a written report.

5.2.2 Summary of tasks in Unit A164

Assessment Task	Task Marks	Weighting
Practical investigation	64	25%

5.3 Planning and managing controlled assessment

Controlled assessment tasks will be available up to two years ahead of the examination series for which they are valid, to allow planning time. It is anticipated that candidates will spend a total of about 4.5–6 hours in producing the work for this unit. Candidates should be allowed sufficient time to complete the task.

When supervising tasks, teachers are expected to:

- exercise continuing supervision of work in order to monitor progress and to prevent plagiarism
- provide guidance on the use of information from other sources to ensure that confidentiality and intellectual property rights are maintained
- exercise continuing supervision of practical work to ensure essential compliance with Health and Safety requirements
- ensure that the work is completed in accordance with the specification requirements and can be assessed in accordance with the specified marking criteria and procedures.

Teachers must not provide templates, model answers or feedback on drafts. Candidates must produce their own individual responses to each stage and work independently to produce the report on the final stage (Analysis, evaluation and review).

Suggested steps and timings are included below, with guidance on regulatory controls at each stage of the process. Teachers must ensure that control requirements indicated below are met throughout the process.

5.3.1 Research and planning, and collecting data

- Strategy: research and planning **1.5 – 2 hours**

  In the research and planning stage, a limited level of control is required. This means that candidates can undertake this part of the process without direct teacher supervision and away from the centre, as required. This may also include collection of secondary data where this informs the planning of the work. Candidates are also able to work in collaboration during this stage. During the research phase candidates can be given support and guidance. Teachers can explain the task, advise on how the task could be approached, advise on resources and alert the candidate to key things that must be included in their final piece of work. However, each candidate must develop their own individual response.

- Collecting data **1.5 – 2 hours**

  In the data collection stage, a limited level of control is required. Candidates will carry out practical work under direct teacher supervision to collect primary data. They may work in collaboration during this stage but all candidates must be actively involved and develop their own, individual response in determining how best to collect and record primary data.

  Secondary data may also be collected during this stage to support or extend the conclusions to the investigation. However, it is not permitted to base the assessment solely on secondary data or (computer) simulations, or on data recorded by candidates whilst watching demonstrations.

  The OCR-provided secondary data, *Information for candidates (2)*, should be given to candidates **only** after collection of primary data is completed. This can be used in addition to secondary data collection by the candidate, if appropriate. Time should be allowed for further collection of secondary data following the issue of *Information for candidates (2)*.

5.3.2 Analysis, evaluation and review

- Analysis, evaluation and review **1.5 – 2 hours**

  The report for this stage is produced in the centre under conditions of high control, which means that candidates work individually to complete their reports under direct teacher supervision. Teachers must be able to authenticate the work and there must be acknowledgement and referencing of any sources used. If writing up is carried out over several sessions, work must be collected in between each session, including any electronic data storage such as USB memory sticks and rewritable CDs.

5.3.3 Presentation of the final piece of work

Candidates must observe certain procedures in the production of controlled assessment tasks.

- Tables, graphs and spreadsheets may be produced using appropriate ICT. These should be inserted into the final report at the appropriate place.
- Any copied material must be suitably acknowledged.
- Quotations must be clearly marked and a reference provided wherever possible.
- Work submitted for moderation by OCR must be marked with the:
  - centre number
  - centre name
  - candidate number
  - candidate name
  - unit code and title
  - controlled assessment task title.

Work submitted on paper for moderation must be secured by treasury tags. Work submitted in digital format (CD or online) must be in a suitable file structure as detailed in Appendix A at the end of this specification.

5.4 Marking and moderating controlled assessment

All controlled assessment tasks are marked by centre assessor(s) using OCR marking criteria and guidance.

This corresponds to a medium level of control.

5.4.1 Applying the marking criteria

The starting point for marking the tasks is the marking criteria (see section 5.4.5 Marking criteria for controlled assessment tasks). These identify levels of performance for the skills, knowledge and understanding that the candidate is required to demonstrate. Guidance for each specific task will be provided in the *Information for teachers* for each task. Before the start of the course, and for use at INSET training events, OCR will provide exemplification through real or simulated candidate work which will help to clarify the level of achievement that assessors should be looking for when awarding marks.

5.4.2 Using the hierarchical marking criteria

A standard method of marking is used for the controlled assessment tasks for Twenty First Century Science GCSE Biology A, based on a grid of hierarchical marking criteria. The marking criteria indicate levels of response and are generic, so can be used for marking any OCR-issued practical investigation. They define the performance for the skills, knowledge and understanding that the candidate is expected to demonstrate at each level. For each task set by OCR, more specific guidance will also be given in the *Information for teachers* on applying the marking criteria in the context of the task.

Candidates' progress through a task is assessed in five strands, each of which corresponds to a different type of performance by the candidate. Three of the five strands include two different aspects of the work. Thus, marking is based on a total of 8 aspects, each of which is shown as a different row in the grid of marking criteria.

For each aspect, a hierarchical set of four marking criteria shows typical performance for candidates working at 1–2, 3–4, 5–6 and 7–8 marks. This provides a level of response mark scheme where achievement is divided into four non-overlapping bands, each covering a range of two marks.

Award of marks in each row of the grid is based on the professional judgement of the teacher and is hierarchical. This means that each of the criteria is considered in turn, working up from the lowest band to the highest band that is fully matched by the candidate's performance. Once a band has been reached which is not fully matched by the work seen, no higher bands can be considered.

Within each two-mark band, the higher mark is available where the performance fully matches the criterion for that mark band (and all preceding, lower mark bands). The lower mark is awarded where the candidate has partially, but not fully, matched this criterion and has exceeded the criteria in the preceding, lower mark bands.

Where there is no evidence of engagement with an aspect of the work, or if the response is not sufficient to merit award of one mark, a mark of zero is awarded for the aspect.

This method of marking can be used even where there is wide variation in performance between different aspects of the work. Weak performance on one aspect need not limit marks in other aspects.

In Strand A, two alternative routes to credit are provided. One row of criteria is used for investigations where the candidate uses graphical display or charts to reveal patterns in the data. The other row is used where the candidate has used statistical or algebraic methods to identify patterns. Only the row which gives the highest mark is counted.

The level awarded in each aspect is recorded on a marking grid, which also serves as a cover sheet if the work is called for moderation.

The total for the assessment is the sum of all the aspect marks, giving a maximum possible mark of 64.

5.4.3 Annotation of candidates' work

Each piece of internally assessed work should show how the marks have been awarded in relation to the marking criteria.

The writing of comments on candidates' work provides a means of dialogue and feedback between teacher and candidate and a means of communication between teachers during internal standardisation.

5.4.4 Overview of marking criteria for controlled assessment tasks

The five strands in the marking criteria are designed to match five main stages in the investigation. However, candidates do not always follow this sequence strictly when writing their investigation reports, and positive achievement should be credited in the appropriate strand wherever it is found in the report.

Strand	Aspect	Notes
S strategy	S(a) – formulating a hypothesis or prediction	Candidates review factors that might affect their results (this may include preliminary tests of these effects) and use their scientific knowledge to choose an effect to study, based on a prediction or testable hypothesis (IaS3). Responses in this aspect will be in extended writing and should be assessed for quality of written communication of the content.
	S(b) – design of techniques and choice of equipment	Candidates test different experimental methods or apparatus, and justify the choices they make (IaS1). They show awareness of safe working practices and the hazards associated with materials (IaS1–3, IaS5). At the highest level, a full risk assessment is included.
C collecting data	C – range and quality of primary data	Candidates make decisions about the amount of data to be collected, the range of values covered, and effective checking for reproducibility (IaS1).
A analysis	A – revealing patterns in data	To allow access to a wider range of activities, this strand has two alternative sets of criteria. One is for the quality of graphical display. The alternative row can be used to award credit for statistical or numerical analysis of data, eg species distribution surveys.
E evaluation	E(a) – evaluation of apparatus and procedures	Candidates show awareness of any limitations imposed by the apparatus or techniques used and suggest improvements to the method.
	E(b) – evaluation of primary data	Candidates consider carefully the reproducibility of their data, recognise outliers and treat them appropriately (IaS1).
R review	R(a) – collection and use of secondary data	Candidates collect secondary data, which can be considered together with their own primary data, to give a broader basis for confirmation, adaptation or extension of the initial hypothesis or prediction.
	R(b) – reviewing confidence in the hypothesis	Candidates make an overall review of the evidence in relation to the underlying scientific theory and consider how well it supports the hypothesis, and what extra work might help to improve confidence in the hypothesis (IaS2 and IaS3). Quality of written communication should be taken into account in assessing this aspect of the work.

5.4.5 Marking criteria for controlled assessment tasks

Marking criteria are to be applied hierarchically (see section 5.4.2).

Strand/ Aspect	0	1 – 2 marks	3 – 4 marks	5 – 6 marks	7 – 8 marks	AO
S a	*	Make a prediction to test, but without any justification. The response may be simplistic, with frequent errors of spelling, punctuation or grammar and have little or no use of scientific vocabulary.	Suggest a testable prediction and justify it by reference to common sense or previous experience. Some relevant scientific terms are used, but spelling, punctuation and grammar are of variable quality.	Consider major factors and refer to scientific knowledge to make a testable hypothesis about how one factor will affect the outcome. Information is effectively organised with generally sound spelling, punctuation and grammar. Specialist terms are used appropriately.	After consideration of all relevant factors, select one and propose a testable hypothesis and quantitative prediction about how it will affect the outcomes. The report is comprehensive, relevant and logically sequenced, with full and effective use of relevant scientific terminology. There are few, if any, grammatical errors.	AO1: 2 marks AO2: 4 marks AO3: 2 marks
S b	*	Follow a given technique, but with very limited precision or accuracy. Make an appropriate comment about safe working.	Select and use basic equipment to collect a limited amount of data. Correctly identify hazards associated with the procedures used.	Select and use techniques and equipment appropriate for the range of data required, and explain the ranges chosen. Identify any significant risks and suggest some precautions.	Justify the choice of equipment and technique to achieve data which is precise and valid. Complete a full and appropriate risk assessment, identifying ways of minimising risks associated with the work.	AO2: 4 marks AO3: 4 marks
C	*	Record a very limited amount of data (eg isolated individual data points with no clear pattern), covering only part of the range of relevant cases/situations, with no checking for repeatability. Data is generally of low quality.	Record an adequate amount or range of data, allowing some errors in units or labelling, and with little checking for repeatability. Data is of variable quality, with some operator error apparent.	Collect and correctly record data to cover the range of relevant cases/situations, with regular repeats or checks for repeatability. Data is of generally good quality.	Choose an appropriate range of values to test across the range, with regular repeats and appropriate handling of any outliers. Checks or preliminary work are included to confirm or adapt the range and number of measurements to ensure data of high quality.	AO1: 1 mark AO2: 3 marks AO3: 4 marks

Strand/ Aspect	0	1 – 2 marks	3 – 4 marks	5 – 6 marks	7 – 8 marks	AO
A	*	Display limited numbers of results in tables, charts or graphs, using given axes and scales.	Construct simple charts or graphs to display data in an appropriate way, allowing some errors in scaling or plotting.	Correctly select scales and axes and plot data for a graph, including an appropriate line of best fit, or construct complex charts or diagrams eg species distribution maps.	Indicate the spread of data (eg through scatter graphs or range bars) or give clear keys for displays involving multiple data-sets.	AO3: 8 marks
		Select individual results as a basis for conclusions.	Carry out simple calculations eg correct calculation of averages from repeated readings.	Use mathematical comparisons between results to support a conclusion.	Use complex processing to reveal patterns in the data eg statistical methods, use of inverse relationships, or calculation of gradient of graphs.	
E a	*	Make relevant comments about problems encountered whilst collecting the data.	Describe the limitations imposed by the techniques and equipment used.	Suggest (in outline) improvements to apparatus or techniques, or alternative ways to collect the data; or explain why the method used gives data of sufficient quality to allow a conclusion.	Describe in detail improvements to the apparatus or techniques, or alternative ways to collect the data, and explain why they would be an improvement; or explain fully why no further improvement could reasonably be achieved.	AO3: 8 marks
E b	*	Make a claim for accuracy or repeatability, but without appropriate reference to the data.	Correctly identify individual results which are beyond the range of experimental error (are outliers), or justify a claim that there are no outliers.	Use the general pattern of results or degree of scatter between repeats as a basis for assessing accuracy and repeatability and explain how this assessment is made.	Consider critically the repeatability of the evidence, accounting for any outliers.	AO3: 8 marks
R a	*	Compare own experimental results with at least one piece of secondary data and make basic comments on similarities and/ or differences. Secondary data collected is limited in amount and not always relevant to the investigation.	Identify in detail similarities and differences between the secondary data and primary data. Secondary data collected is relevant to the investigation and sources are referenced, although these may be incomplete.	Describe and explain the extent to which the secondary data supports, extends and/ or undermines the primary data, and identify any areas of incompleteness. A range of relevant secondary data is collected from several fully referenced sources.	Assess the levels of confidence that can be placed on the available data, and explain the reasons for making these assessments. Comment on the importance of any similarities or differences.	AO1: 1 mark AO2: 1 mark AO3: 6 marks

Strand/ Aspect	0	1 – 2 marks	3 – 4 marks	5 – 6 marks	7 – 8 marks	AO
R b	*	Correctly state whether or not the original prediction or hypothesis is supported, with reference only to common sense or previous experience. The response is simplistic, with frequent errors in spelling, punctuation or grammar and has little or no use of scientific vocabulary.	Comment on whether trends or correlations in the data support the prediction or hypothesis and suggest why by reference to appropriate science. Some relevant scientific terms are used correctly, but spelling, punctuation and grammar are of variable quality.	Explain the extent to which the hypothesis can account for the pattern(s) shown in the data. Use relevant science knowledge to conclude whether the hypothesis has been supported or to suggest how it should be modified to account for the data more completely. Information is organised effectively with generally sound spelling, punctuation and grammar. Specialist terms are used appropriately.	Give a detailed account of what extra data could be collected to increase confidence in the hypothesis. The report is comprehensive, relevant and logically sequenced, with full and effective use of relevant scientific terminology. There are few, if any, grammatical errors.	AO1: 2 marks A03: 6 marks

* No response, or response not sufficient for award of 1 mark

5.4.6 Assessment objectives (AOs)

Each of the aspects to be assessed addresses one or more of the assessment objectives and these are shown in the marking criteria. The overall balance is shown in the table below:

Assessment Objective	TOTAL
AO1: Recall, select and communicate their knowledge and understanding of biology	6
AO2: Apply skills, knowledge and understanding of biology in practical and other contexts	12
AO3: Analyse and evaluate evidence, make reasoned judgments and draw conclusions based on evidence	46
TOTAL	64

5.4.7 Authentication of work

Teachers must be confident that the work they mark is the candidate's own. This does not mean that a candidate must be supervised throughout the completion of all work but the teacher must exercise sufficient supervision, or introduce sufficient checks, to be in a position to judge the authenticity of the candidate's work.

Wherever possible, the teacher should discuss work-in-progress with candidates. This will not only ensure that work is underway in a planned and timely manner but will also provide opportunities for assessors to check authenticity of the work and provide general feedback.

Candidates must not plagiarise. Plagiarism is the submission of another's work as one's own and/or failure to acknowledge the source correctly. Plagiarism is considered to be malpractice and could lead to the candidate being disqualified. Plagiarism sometimes occurs innocently when candidates are unaware of the need to reference or acknowledge their sources. It is therefore important that centres ensure that candidates understand that the work they submit must be their own and that they understand the meaning of plagiarism and what penalties may be applied. Candidates may refer to research, quotations or evidence but they must list their sources. The rewards from acknowledging sources, and the credit they will gain from doing so, should be emphasised to candidates as well as the potential risks of failing to acknowledge such material.

Both candidates and teachers must declare that the work is the candidate's own:

- **Each candidate** must sign a declaration before submitting their work to their teacher. A candidate authentication statement that can be used is available to download from the OCR website. These statements should be retained within the centre until all enquiries about results, malpractice and appeals issues have been resolved. **A mark of zero must be recorded if a candidate cannot confirm the authenticity of their work.**
- **Teachers** are required to declare that the work submitted for internal assessment is the candidate's own work by sending the moderator a centre authentication form (CCS160) for each unit at the same time as the marks. If a centre fails to provide evidence of authentication, **we will set the mark for that candidate(s) to Pending (Q) for that component until authentication can be provided.**

5.5 Internal standardisation

It is important that all internal assessors of this controlled assessment work to common standards. Centres must ensure that the internal standardisation of marks across assessors and teaching groups takes place using an appropriate procedure.

This can be done in a number of ways. In the first year, reference material and OCR training meetings will provide a basis for centres' own standardisation. In subsequent years, this, or centres' own archive material, may be used. Centres are advised to hold preliminary meetings of staff involved to compare standards through cross-marking a small sample of work. After most marking has been completed, a further meeting at which work is exchanged and discussed will enable final adjustments to be made.

5.6 Submitting marks and authentication

All work for controlled assessment is marked by the teacher and internally standardised by the centre. Marks are then submitted to OCR **and** your moderator: refer to the OCR website for submission dates of the marks to OCR.

There should be clear evidence that work has been attempted and some work produced. If a candidate submits no work for an internally assessed component, then the candidate should be indicated as being absent from that component. If a candidate completes any work at all for an internally assessed component, then the work should be assessed according to the internal assessment objectives and marking instructions and the appropriate mark awarded, which may be zero.

The centre authentication form (CCS160) must be sent to the moderator with the marks.

5.7 Submitting samples of candidate work

5.7.1 Sample requests

Once you have submitted your marks, your exams officer will receive an email requesting a moderation sample. Samples will include work from across the range of attainment of the candidates' work.

The sample of work which is presented to the moderator for moderation must show how the marks have been awarded in relation to the marking criteria defined in Section 5.4.5. Each candidate's work should have a cover sheet attached to it with a summary of the marks awarded for the task.

When making your entries, the entry option specifies how the sample for each unit is to be submitted. For each of these units, all candidate work must be submitted using the **same entry option**. It is not possible for centres to offer both options for a unit within the same series. You can choose different options for different units. Please see the Section 8.2.1 for entry codes.

5.7.2 Submitting moderation samples via post

The sample of candidate work must be posted to the moderator within three days of receiving the request. You should use one of the labels provided to send the candidate work.

We would advise you to keep evidence of work submitted to the moderator, eg copies of written work or photographs of practical work. You should also obtain a certificate of posting for all work that is posted to the moderator.

5.7.3 Submitting the moderation samples via the OCR Repository

The OCR Repository, which is accessed via Interchange, is a system which has been created to enable centres to submit candidate work electronically for moderation. It allows centres to upload work for several candidates at once but does not function as an e-portfolio for candidates.

The OCR GCSE Biology A Unit A164 can be submitted via the OCR Repository.

Once you receive your sample request, you should upload the work to the OCR Repository within three days of receiving the request. Instructions for how to upload files to OCR using the OCR Repository can be found on the OCR website and in the *Guide to controlled assessment for GCSE Twenty First Century Science*, which will be available on the OCR website from Spring 2011.

It is the centre's responsibility to ensure that any work submitted to OCR electronically is virus-free.

5.8 External moderation

The purpose of moderation is to ensure that the standard of the award of marks for work is the same for each centre and that each teacher has applied the standards appropriately across the range of candidates within the centre.

At this stage, if necessary, centres may be required to provide an additional sample of candidate work (if marks are found to be in the wrong order) or carry out some re-marking. If you receive such a request, please ensure that you respond as quickly as possible to ensure that your candidates' results are not delayed.

6.1 Free support and training from OCR

OCR recognises that the introduction of the new specifications and controlled assessment will bring challenges for implementation and teaching.

Working in close consultation with teachers, publishers and other experts, centres can expect a high level of support, services and resources for OCR qualifications.

Essential FREE support materials including:

- New OCR GCSE Sciences website www.gcse-science.com to access information and support materials quickly and easily
- Specimen assessment materials and mark schemes
- Guide to controlled assessment
- Sample controlled assessment materials
- Exemplar candidate work
- Teacher's handbook
- Sample schemes of work and lesson plans
- Guide to curriculum planning
- Frequently asked questions

Essential FREE support services including:

- Free INSET training – for information visit www.gcse-science.com
- Interchange – a completely secure, free website to help centres reduce administrative tasks at exam time
- E-alerts – register now for regular updates at www.ocr.org.uk/2011signup
- Active Results – detailed item level analysis of candidate results

6.2 OCR endorsed resources

OCR works with publishers to ensure centres can access a choice of quality, 'Official Publisher Partner' and 'Approved publication,' resources, endorsed by OCR for use with individual specifications.

You can be confident that resources branded with 'Official Publisher Partner' or 'Approved publication' logos have undergone OCR's thorough quality assurance process and are endorsed for use with the relevant specification.

These endorsements do not mean that the materials are the only suitable resources available or necessary to achieve an OCR qualification. All responsibility for the content of the published resources rests with the publisher.

6.2.1 Publisher partner

OCR RECOGNISING ACHIEVEMENT OXFORD UNIVERSITY PRESS Official Publisher Partnership

We have been working closely with Oxford University Press, our publisher partner for OCR GCSE Twenty First Century Science 2011, to help ensure their new resources match the new specifications and are available when you need them.

Oxford University Press is working with our science team, the Nuffield Foundation and University of York Science Education Group to publish new editions of the popular Twenty First Century Science resources. These resources are lively, engaging and make science relevant to every student.

The second editions of these resources are packed with up-to-date science together with the familiar topics you enjoy teaching, step by step guidance for answering all types of exam questions (including extended response questions) and support for the new controlled assessment.

To order an Evaluation Pack, or for further details, please visit the Oxford University Press website at www.oxfordsecondary.co.uk/twentyfirstcenturyscience.

6.2.2 Endorsed publishers

Approved publication OCR RECOGNISING ACHIEVEMENT

Other endorsed resources available for this specification include OCR GCSE Twenty First Century Science from Collins.

Collins is working with a team of experienced authors to provide resources which will help you deliver the new OCR GCSE Twenty First Century Science specifications. The Science, Additional Science and Separate Science components build on each other so your department can buy as needed and use them with all students taking different 2011 GCSE science routes.

Reduce planning time – the student books, teacher packs, homework activities, interactive books and assessment package are fully integrated and matched to the Collins GCSE Twenty First Century Science scheme of work so you can get started straight away.

For further details and to order an Evaluation Pack visit www.collinseducation.com/gcsescience2011.

6.3 Training

6.3.1 Get Ready... introducing the new specification

A series of FREE half-day training events are being run from mid-September 2010, to give you an overview of the new specification.

6.3.2 Get Started...towards successful delivery of the new specification

These events will run until December 2011 and will look at the new specification in more depth, with emphasis on first delivery:

- Visit www.ocr.org.uk/training/ for more details.

6.4 OCR support services

6.4.1 Active Results

Active Results is available to all centres offering the OCR GCSE Biology A specification.

activeresults

Active Results is a free results analysis service to help teachers review the performance of individual candidates or whole schools.

Devised specifically for the UK market, data can be analysed using filters on several categories such as gender and other demographic information, as well as providing breakdowns of results by question and topic.

Active Results allows you to look in greater detail at your results:

- richer and more granular data will be made available to centres, including question-level data available from e-marking
- you can identify the strengths and weaknesses of individual candidates and your centre's cohort as a whole
- our systems have been developed in close consultation with teachers so that the technology delivers what you need.

Further information on Active Results can be found on the OCR website.

6.4.2 OCR Interchange

OCR Interchange has been developed to help you to carry out day-to-day administration functions online, quickly and easily. The site allows you to register and enter candidates online. In addition, you can gain immediate and free access to candidate information at your convenience. Sign up at https://interchange.ocr.org.uk.

7 Access to GCSE Biology A

7.1 Disability Discrimination Act (DDA) information relating to GCSE Biology A

GCSEs often require assessment of a broad range of competencies. This is because they are general qualifications and, as such, prepare candidates for a wide range of occupations and higher level courses.

The revised GCSE qualifications and subject criteria were reviewed by the regulators to identify whether any of the competencies required by the subject presented a potential barrier to any disabled candidates. If this was the case, the situation was reviewed again to ensure that such competencies were included only where essential to the subject. The findings of this process were discussed with disability groups and with disabled people.

Reasonable adjustments are made for disabled candidates in order to enable them to access the assessments and to demonstrate what they know and can do. For this reason, very few candidates will have a complete barrier to the assessment. Information on reasonable adjustments is found in *Regulations and Guidance Relating to Candidates who are Eligible for Adjustments in Examinations* produced by the Joint Council www.jcq.org.uk.

Candidates who are unable to access part of the assessment, even after exploring all possibilities through reasonable adjustments, may still be able to receive an award based on the parts of the assessment they have taken.

The access arrangements permissible for use in this specification are in line with QCDA's GCSE subject criteria equalities review and are as follows:

	Yes/No	Type of Assessment
Readers	Yes	All assessments
Scribers	Yes	All assessments
Practical assistants	Yes	All controlled assessments. The practical assistant may assist with assessed practical tasks under instruction from the candidate.
Word processors	Yes	All assessments
Transcripts	Yes	All assessments
BSL interpreters	Yes	All assessments
Oral language modifiers	Yes	All assessments
MQ papers	Yes	All assessments
Extra time	Yes	All assessments

7.2 Arrangements for candidates with particular requirements

All candidates with a demonstrable need may be eligible for access arrangements to enable them to show what they know and can do. The criteria for eligibility for access arrangements can be found in the JCQ document *Access Arrangements, Reasonable Adjustments and Special Consideration.*

Candidates who have been fully prepared for the assessment but who have been affected by adverse circumstances beyond their control at the time of the examination may be eligible for special consideration. Centres should consult the JCQ document *Access Arrangements, Reasonable Adjustments and Special Consideration.*

Administration of GCSE Biology A 8

8.1 Availability of assessment

There are two examination series each year, in January and June. GCSE Biology A units will be assessed from January 2012. Assessment availability and unit weighting can be summarised as follows:

	Unit A161 (25%)	Unit A162 (25%)	Unit A163 (25%)	Unit A164 (25%)	Certification availability
January 2012	✓				–
June 2012	✓	✓			–
January 2013	✓	✓			–
June 2013	✓	✓	✓	✓	✓*
January 2014	✓	✓	✓		✓*
June 2014	✓	✓	✓	✓	✓*

GCSE certification is available for the first time in June 2013 for GCSE Biology A, and each January and June thereafter.

*Centres are reminded that at least 40% of the assessment must be taken in the examination series in which the qualification is certificated. This can be any combination of assessment units, including written papers and controlled assessment units.

8.2 Making entries

Centres must be registered with OCR in order to make any entries, including estimated entries. We recommend that centres apply to OCR to become a registered centre well in advance of making their first entries.

Submitting entries accurately and on time is critical to the successful delivery of OCR's services to centres. Entries received after the advertised deadlines can ultimately jeopardise the final production and delivery of results. Therefore, please make sure that you are aware of the entry deadlines, which are available on the OCR website.

8.2.1 Making unit entries

Centres must have made an entry for a unit in order for OCR to supply the appropriate forms and/or moderator details for controlled assessment.

It is essential that unit entry codes are quoted in all correspondence with OCR.

Unit entry code	Component code	Assessment method	Unit titles
A161 F	01	Written paper	Unit A161 (Modules B1, B2 and B3) (Foundation Tier)
A161 H	02	Written paper	Unit A161 (Modules B1, B2 and B3) (Higher Tier)
A162 F	01	Written paper	Unit A162 (Modules B4, B5 and B6) (Foundation Tier)
A162 H	02	Written paper	Unit A162 (Modules B4, B5 and B6) (Higher Tier)
A163 F	01	Written paper	Unit A163 (Module B7) (Foundation Tier)
A163 H	02	Written paper	Unit A163 (Module B7) (Higher Tier)

Controlled assessment unit

For the controlled assessment Unit A164, candidates must be entered for either the OCR Repository option or the postal moderation option. Centres must enter all of their candidates for ONE of the options. It is not possible for centres to offer both components within the same series.

Unit entry code	Component code	Assessment method	Unit titles
A164 A	01	Moderated via OCR Repository	Controlled assessment
A164 B	02	Moderated via postal moderation	Controlled assessment

8.2.2 Qualification entries

Candidates must enter for qualification certification separately from unit assessment(s). If a certification entry is **not** made, no overall grade can be awarded.

Candidates may enter for:

- GCSE certification code J243.

A candidate who has completed all the units required for the qualification must enter for certification in the same examination series in which the terminal rules are satisfied.

GCSE certification is available for the first time in June 2013 for GCSE Biology A, and each January and June thereafter.

8.3 Terminal rule

Candidates must take at least 40% of the overall assessment in the same series they enter for the qualification certification.

Guidance on the terminal rule can be found on the OCR website.

8.4 Unit and qualification re-sits

Candidates may re-sit each unit once before entering for certification for a GCSE. The better result for each unit will count towards the final qualification, **provided that the terminal rule is satisfied.**

However, candidates may enter for the qualification an unlimited number of times.

Please refer to the Admin Guide on the OCR website for more information.

8.5 Enquiries about results

Under certain circumstances, a centre may wish to query the result issued to one or more candidates. Enquiries about results for GCSE units must be made immediately following the series in which the relevant unit was taken (by the Enquiries about Results deadline).

Please refer to the JCQ *Post-Results Services* booklet and the OCR Admin Guide for further guidance about action on the release of results. Copies of the latest versions of these documents can be obtained from the OCR website.

8.6 Shelf-life of units

Individual unit results, prior to certification of the qualification, have a shelf-life limited only by that of the qualification.

8.7 Prohibited qualifications and classification code

Every specification is assigned a national classification code indicating the subject area to which it belongs. The classification code for this specification is 1010.

Centres should be aware that candidates who enter for more than one GCSE qualification with the same classification code will have only one grade (the highest) counted for the purpose of the School and College Performance Tables.

Centres may wish to advise candidates that, if they take two specifications with the same classification code, schools and colleges are very likely to take the view that they have achieved only one of the two GCSEs. The same view may be taken if candidates take two GCSE specifications that have different classification codes but have significant overlap of content. Candidates who have any doubts about their subject combinations should seek advice, for example from their centre or the institution to which they wish to progress.

9 Other information about GCSE Biology A

9.1 Overlap with other qualifications

This specification has been developed alongside GCSE Science A, GCSE Additional Science A, GCSE Chemistry A, GCSE Physics A and GCSE Additional Applied Science.

Modules 1–3 of this specification are also included in GCSE Science A. Modules 4–6 of this specification are also included in GCSE Additional Science A.

Aspects of the controlled assessment of skills are common across GCSE Additional Science A, GCSE Biology A, GCSE Chemistry A and GCSE Physics A.

9.2 Progression from this qualification

GCSE qualifications are general qualifications which enable candidates to progress either directly to employment, or to proceed to further qualifications.

Progression to further study from GCSE will depend upon the number and nature of the grades achieved. Broadly, candidates who are awarded mainly Grades D to G at GCSE could either strengthen their base through further study of qualifications at Level 1 within the National Qualifications Framework or could proceed to Level 2. Candidates who are awarded mainly Grades A* to C at GCSE would be well prepared for study at Level 3 within the National Qualifications Framework.

9.3 Avoidance of bias

OCR has taken great care in preparation of this specification and assessment materials to avoid bias of any kind.

9.4 Code of Practice/Common criteria requirements/Subject criteria

This specification complies in all respects with the current GCSE, GCE, Principal Learning and Project Code of Practice as available on the Ofqual website, *The Statutory Regulation of External Qualifications 2004*, and the subject criteria for GCSE Biology.

9.5 Language

This specification and associated assessment materials are in English only.

9.6 Spiritual, moral, ethical, social, legislative, economic and cultural issues

This specification offers opportunities which can contribute to an understanding of these issues.

The table below gives some examples which could be used when teaching the course.

Issue	Opportunities for teaching the issues during the course
Moral issues The commitment of scientists to publish their findings and subject their ideas to testing by others.	Practical investigation: reviewing the strategy and procedures. B3: Study of scientists' reactions to competing explanations to account for evidence relating to evolution of life on Earth.
Ethical issues The ethical implications of selected scientific issues.	B1: Ethical issues arising from implications of modern genetic technologies. B2: Ethical issues arising from vaccination policy.
Social issues Risk and the factors which decide the level of risk people are willing to accept in different circumstances.	B2: Assessing the risks associated with vaccination and the reaction of different people to these risks.
Economic issues The range of factors which have to be considered when weighing the costs and benefits of scientific activity.	B1: Evaluating the costs and benefits associated with biotechnologies.
Cultural issues Scientific explanations which give insight into the local and global environment.	B2: Vaccination policy, for different diseases, and in different countries.

9.7 Sustainable development, health and safety considerations and European developments, consistent with international agreements

This specification supports these issues, consistent with current EU agreements, as outlined below.

The specification incorporates specific modules on health and welfare and on the environment within its content. These modules encourage candidates to develop environmental responsibility based upon a sound understanding of the principle of sustainable development.

9.8 Key Skills

This specification provides opportunities for the development of the Key Skills of *Communication, Application of Number, Information Technology, Working with Others, Improving Own Learning and Performance and Problem Solving* at Levels 1 and/or 2. However, the extent to which this evidence fulfils the Key Skills criteria at these levels will be totally dependent on the style of teaching and learning adopted for each unit.

The following table indicates where opportunities may exist for at least some coverage of the various Key Skills criteria at Levels 1 and/or 2 for each unit.

Unit	C		AoN		IT		WwO		IoLP		PS	
	1	2	1	2	1	2	1	2	1	2	1	2
A161	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
A162	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
A163	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
A164	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Detailed opportunities for generating Key Skills evidence through this specification are posted on the OCR website (www.ocr.org.uk). A summary document for Key Skills Coordinators showing ways in which opportunities for Key Skills arise within GCSE courses has been published.

9.9 ICT

In order to play a full part in modern society, candidates need to be confident and effective users of ICT. This specification provides candidates with a wide range of appropriate opportunities to use ICT in order to further their study of biology.

Opportunities for ICT include:

- using videos clips to provide the context for topics studied and to illustrate the practical importance of the scientific ideas
- gathering information from the internet and CD-ROMs
- gathering data using sensors linked to data-loggers or directly to computers
- using spreadsheets and other software to process data
- using animations and simulations to visualise scientific ideas
- using modelling software to explore theories
- using software to present ideas and information on paper and on screen.

Particular opportunities for the use of ICT appear in the introductions to each of the modules.

9.10 Citizenship

From September 2002, the National Curriculum for England at Key Stage 4 includes a mandatory programme of study for Citizenship.

GCSE Biology A is designed as a science education for future citizens which not only covers aspects of the Citizenship programme of study but also extends beyond that programme by dealing with important aspects of science which all people encounter in their everyday lives.

A Appendix A: Guidance for the production of electronic controlled assessment

Structure for evidence

A controlled assessment portfolio is a collection of folders and files containing the candidate's evidence. Folders should be organised in a structured way so that the evidence can be accessed easily by a teacher or moderator. This structure is commonly known as a folder tree. It would be helpful if the location of particular evidence is made clear by naming each file and folder appropriately and by use of an index called 'Home Page'.

There should be a top level folder detailing the candidate's centre number, candidate number, surname and forename, together with the unit code A164, so that the portfolio is clearly identified as the work of one candidate.

Each candidate produces an assignment for controlled assessment. The evidence should be contained within a separate folder within the portfolio. This folder may contain separate files.

Each candidate's controlled assessment portfolio should be stored in a secure area on the centre's network. Prior to submitting the controlled assessment portfolio to OCR, the centre should add a folder to the folder tree containing controlled assessment and summary forms.

Data formats for evidence

In order to minimise software and hardware compatibility issues it will be necessary to save candidates' work using an appropriate file format.

Candidates must use formats appropriate to the evidence that they are providing and appropriate to viewing for assessment and moderation. Open file formats or proprietary formats for which a downloadable reader or player is available are acceptable. Where this is not available, the file format is not acceptable.

Electronic controlled assessment is designed to give candidates an opportunity to demonstrate what they know, understand and can do using current technology. Candidates do not gain marks for using more sophisticated formats or for using a range of formats. A candidate who chooses to use only word documents will not be disadvantaged by that choice.

Evidence submitted is likely to be in the form of word processed documents, PowerPoint presentations, digital photos and digital video.

To ensure compatibility, all files submitted must be in the formats listed below. Where new formats become available that might be acceptable, OCR will provide further guidance. OCR advises against changing the file format that the document was originally created in. It is the centre's responsibility to ensure that the electronic portfolios submitted for moderation are accessible to the moderator and fully represent the evidence available for each candidate.

Accepted file formats

A

Movie formats for digital video evidence
MPEG (*.mpg)
QuickTime movie (*.mov)
Macromedia Shockwave (*.aam)
Macromedia Shockwave (*.dcr)
Flash (*.swf)
Windows Media File (*.wmf)
MPEG Video Layer 4 (*.mp4)

Audio or sound formats
MPEG Audio Layer 3 (*.mp3)

Graphics formats including photographic evidence
JPEG (*.jpg)
Graphics file (*.pcx)
MS bitmap (*.bmp)
GIF images (*.gif)

Animation formats
Macromedia Flash (*.fla)

Structured markup formats
XML (*.xml)

Text formats
Comma Separated Values (.csv)
PDF (.pdf)
Rich text format (.rtf)
Text document (.txt)

Microsoft Office suite
PowerPoint (.ppt)
Word (.doc)
Excel (.xls)
Visio (.vsd)
Project (.mpp)

B Appendix B: Ideas about Science

This specifications within the Twenty First Century Science suite are unique in having interpreted and extrapolated the principals of ‘How Science Works’ into a series of ‘Ideas about Science’. It is intended that the Ideas about Science will ensure students understand how scientific knowledge is obtained, how it is reported in the world outside the classroom, and the impacts of scientific knowledge on society.

GCSE Biology A aims to develop students’ understanding of the Ideas about Science alongside their growing understanding of scientific ideas and explanations of the behaviour of the natural world.

Why are Ideas about Science important?

In order to make sense of the scientific ideas that students encounter in lessons and read or hear about outside of school, they need to develop an understanding of science itself – of how scientific knowledge is obtained, the kinds of evidence and reasoning behind it, its strengths and limitations, and how far we can therefore rely on it. They also need opportunities to reflect on the impacts of scientific knowledge on society, and how we respond individually and collectively to the new ideas, artefacts and processes that science makes possible.

Reports of scientific claims, inventions and discoveries are prolific in the media of the twenty first century, and an understanding of the Ideas about Science will ensure that students are well-equipped to critically evaluate the science stories they read and hear.

The kind of understanding of science that we would wish students to have by the end of their school science education might be summarised as follows:

How science works

The aim of science is to find explanations for the behaviour of the material world. There is no single ‘method of science’ that leads automatically to scientific knowledge. Scientists do, however, have characteristic ways of working. In particular, data from observations and measurements are of central importance. All data, however, have to be interpreted, and this is influenced by the ideas we bring to it. Scientific explanations do not ‘emerge’ automatically from data. Proposing an explanation involves creative thinking. So, it is quite possible (and may be quite reasonable) for different people to arrive at different explanations for the same data.

Causes and effects

Scientists often look for cause-effect explanations. 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.

Theories, explanations and predictions

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 theory might propose a model involving objects (and their behaviour) that cannot be observed directly, to account for what we observe. Or it might define quantities and ways of measuring them, and state some mathematical relationships between them.

A scientific explanation of a specific event or phenomenon is often based on applying a scientific theory (or theories) to the situation in question.

A proposed scientific explanation (whether it is a very general scientific theory or a more specific explanation) is tested by comparing predictions based on it with observations or measurements. If these agree, it increases our confidence that the explanation might be correct. This can never be conclusively proved, but accumulating evidence can bring us to the point where it is hard to imagine any other possible explanation. If prediction and data disagree, then one or the other must be wrong. Data can never be relied on completely because observations may be incorrect and all measurements are subject to uncertainty, arising from the inevitable limitations of the measuring equipment or the person using it. If we believe the data are accurate, then the prediction must be wrong, lowering our confidence in the proposed explanation.

Science and scientists

The scientific community has established robust procedures for testing and checking the claims of individual scientists, and reaching an agreed view. Scientists report their findings to other scientists at conferences and in peer-reviewed journals. Claims are not accepted until they have survived the critical scrutiny of the scientific community. In some areas of enquiry, it has proved possible to eliminate all the explanations we can think of but one – which then becomes the accepted explanation (until, if ever, a better one is proposed).

Where possible, scientists choose to study simple situations in order to gain understanding. This, however, can make it difficult to apply this understanding to complex, real-world situations. So there can be legitimate disagreements about scientific explanations of particular phenomena or events, even though there is no dispute about the fundamental scientific knowledge involved.

Science and society

The application of scientific knowledge, in new technologies, materials and devices, greatly enhances our lives, but can also have unintended and undesirable side-effects. Often we need to weigh up the benefits against the disadvantages – and also consider who gains and who loses. An application of science may have social, economic and political implications, and sometimes also ethical ones. Personal and social decisions require an understanding of the science involved, but also involve knowledge and values that go beyond science.

How can Ideas about Science be developed in teaching?

Within this Appendix all of the Ideas about Science are listed together, in an order that shows clearly how they relate to one another and build up the understanding of science that we would like students to develop.

In addition to this Appendix, specific Ideas about Science are identified at the start of each module within the specification, to indicate that there are good opportunities within the content of the module to introduce and develop them. The OCR scheme of work for GCSE Biology A (published separately) will also highlight teaching opportunities for specific Ideas about Science.

What are the Ideas about Science?

The following pages set out in detail the Ideas about Science and what candidates should be able to do to demonstrate their understanding of them. The statements in the left-hand column specify the understandings candidates are expected to develop; the entries in the right-hand column are suggestions about some of the ways in which evidence of their understanding can be demonstrated.

B

1 Data: their importance and limitations

Data are the starting point for scientific enquiry – and the means of testing scientific explanations. But data can never be trusted completely, and scientists need ways of evaluating how good their data are.

	Candidates should understand that:	A candidate who understands this can, for example:
1.1	• data are crucial to science. The search for explanations starts from data; and data are collected to test proposed explanations.	• use data rather than opinion if asked to justify an explanation • outline how a proposed scientific explanation has been (or might be) tested, referring appropriately to the role of data.
1.2	• we can never be sure that a measurement tells us the true value of the quantity being measured.	• suggest reasons why a given measurement may not be the true value of the quantity being measured.
1.3	• if we make several measurements of any quantity, these are likely to vary.	• suggest reasons why several measurements of the same quantity may give different values • when asked to evaluate data, make reference to its repeatability **and/or reproducibility**.
1.4	• the mean of several repeat measurements is a good estimate of the true value of the quantity being measured.	• calculate the mean of a set of repeated measurements • from a set of repeated measurements of a quantity, use the mean as the best estimate of the true value • explain why repeating measurements leads to a better estimate of the quantity.
1.5	• from a set of repeated measurements of a quantity, it is possible to estimate a range within which the true value probably lies.	• from a set of repeated measurements of a quantity, make a sensible suggestion about the range within which the true value probably lies **and explain this** • **when discussing the evidence that a quantity measured under two different conditions has (or has not) changed, make appropriate reference both to the difference in means and to the variation within each set of measurements.**
1.6	• if a measurement lies well outside the range within which the others in a set of repeats lie, or is off a graph line on which the others lie, this is a sign that it may be incorrect. If possible, it should be checked. If not, it should be used unless there is a specific reason to doubt its accuracy.	• identify any outliers in a set of data • treat an outlier as data unless there is a reason for doubting its accuracy • **discuss and defend the decision to discard or to retain an outlier.**

2 Cause-effect explanations

Scientists look for patterns in data, as a means of identifying correlations that might suggest possible cause-effect links – for which an explanation might then be sought.

	Candidates should understand that:	A candidate who understands this can, for example:
2.1	• it is often useful to think about processes in terms of factors which may affect an outcome (or input variables which may affect an outcome variable).	• in a given context, identify the outcome and factors that may affect it • in a given context, suggest how an outcome might alter when a factor is changed.
2.2	• to investigate the relationship between a factor and an outcome, it is important to control all the other factors which we think might affect the outcome (a so-called 'fair test').	• identify, in a plan for an investigation of the effect of a factor on an outcome, the fact that other factors are controlled as a positive design feature, or the fact that they are not as a design flaw • explain why it is necessary to control all the factors that might affect the outcome other than the one being investigated.
2.3	• if an outcome occurs when a specific factor is present, but does not when it is absent, or if an outcome variable increases (or decreases) steadily as an input variable increases, we say that there is a correlation between the two.	• suggest and explain an example from everyday life of a correlation between a factor and an outcome • identify where a correlation exists when data are presented as text, as a graph, or in a table. ⓘ *Examples may include both positive and negative correlations, but candidates will not be expected to know these terms.*
2.4	• a correlation between a factor and an outcome does not necessarily mean that the factor causes the outcome; both might, for example, be caused by some other factor.	• use the ideas of correlation and cause when discussing data and show awareness that a correlation does not necessarily indicate a causal link • identify, and suggest from everyday experience, examples of correlations between a factor and an outcome where the factor is (or is not) a plausible cause of the outcome • explain why an observed correlation between a given factor and outcome does not necessarily mean that the factor causes the outcome.
2.5	• in some situations, a factor alters the chance (or probability) of an outcome, but does not invariably lead to it. We also call this a correlation.	• suggest factors that might increase the chance of a particular outcome in a given situation, but do not invariably lead to it • explain why individual cases do not provide convincing evidence for or against a correlation.

	Candidates should understand that:	A candidate who understands this can, for example:
2.6	• to investigate a claim that a factor increases the chance (or probability) of an outcome, scientists compare samples (eg groups of people) that are matched on as many other factors as possible, or are chosen randomly so that other factors are equally likely in both samples. The larger the samples, the more confident we can be about any conclusions drawn.	• discuss whether given data suggest that a given factor does/does not increase the chance of a given outcome • evaluate critically the design of a study to test if a given factor increases the chance of a given outcome, by commenting on sample size and how well the samples are matched.
2.7	• **even when there is evidence that a factor is correlated with an outcome, scientists are unlikely to accept that it is a cause of the outcome, unless they can think of a plausible mechanism linking the two.**	• **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.**

3 Developing scientific explanations

The aim of science is to develop good explanations for natural phenomena. Initially, an explanation is a hypothesis that might account for the available data. As more evidence becomes available, it may become an accepted explanation or theory. Scientific explanations and theories do not 'emerge' automatically from data, and cannot be deduced from the data. Proposing an explanation or theory involves creative thinking. It can then be tested – by comparing its predictions with data from observations or measurements.

	Candidates should understand that:	A candidate who understands this can, for example:
3.1	• scientific hypotheses, explanations and theories are not simply summaries of the available data. They are based on data but are distinct from them.	• in a given account of scientific work, identify statements which report data and statements of explanatory ideas (hypotheses, explanations, theories) • recognise that an explanation may be incorrect even if the data agree with it.
3.2	• an explanation cannot simply be deduced from data, but has to be thought up creatively to account for the data.	• identify where creative thinking is involved in the development of an explanation.
3.3	• a scientific explanation should account for most (ideally all) of the data already known. It may explain a range of phenomena not previously thought to be linked. It should also enable predictions to be made about new situations or examples.	• recognise data or observations that are accounted for by, or conflict with, an explanation • give good reasons for accepting or rejecting a proposed scientific explanation • identify the better of two given scientific explanations for a phenomenon, and give reasons for the choice.
3.4	• scientific explanations are tested by comparing predictions based on them with data from observations or experiments.	• draw valid conclusions about the implications of given data for a given scientific explanation, in particular: — understand that agreement between a prediction and an observation increases confidence in the explanation on which the prediction is based but does not prove it is correct — understand that disagreement between a prediction and an observation indicates that one or the other is wrong, and decreases our confidence in the explanation on which the prediction is based.

4 The scientific community

Findings reported by an individual scientist or group are carefully checked by the scientific community before being accepted as scientific knowledge.

	Candidates should understand that:	A candidate who understands this can, for example:
4.1	• scientists report their claims to other scientists through conferences and journals. Scientific claims are only accepted once they have been evaluated critically by other scientists.	• describe in broad outline the 'peer review' process, in which new scientific claims are evaluated by other scientists • recognise that there is less confidence in new scientific claims that have not yet been evaluated by the scientific community than there is in well-established ones.
4.2	• scientists are usually sceptical about claims that cannot be repeated by anyone else, and about unexpected findings until they have been replicated (by themselves) or reproduced (by someone else).	• identify the fact that a finding has not been reproduced by another scientist as a reason for questioning a scientific claim • explain why scientists see this as important.
4.3	• if explanations cannot be deduced from the available data, 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 judgments.	• show awareness that the same data might be interpreted, quite reasonably, in more than one way • suggest plausible reasons why scientists in a given situation disagree(d).
4.4	• an accepted scientific explanation is rarely abandoned just because some new data disagree with its predictions. It usually survives until a better explanation is available.	• discuss the likely consequences of new data that disagree with the predictions of an accepted explanation • **suggest reasons why scientists should not give up an accepted explanation immediately if new data appear to conflict with it.**

5 Risk

Every activity involves some risk. Assessing and comparing the risks of an activity, and relating these to the benefits we gain from it, are important in decision making.

	Candidates should understand that:	A candidate who understands this can, for example:
5.1	• everything we do carries a certain risk of accident or harm. Nothing is risk free. New technologies and processes based on scientific advances often introduce new risks.	• explain why it is impossible for anything to be completely safe • identify examples of risks which arise from a new scientific or technological advance • suggest ways of reducing a given risk.
5.2	• we can sometimes assess the size of a risk by measuring its chance of occurring in a large sample, over a given period of time.	• interpret and discuss information on the size of risks, presented in different ways.
5.3	• to make a decision about a particular risk, we need to take account both of the chance of it happening and the consequences if it did.	• discuss a given risk, taking account of both the chance of it occurring and the consequences if it did.
5.4	• to make a decision about a course of action, we need to take account of both its risks and benefits, to the different individuals or groups involved.	• identify risks and benefits in a given situation, to the different individuals and groups involved • discuss a course of action, with reference to its risks and benefits, taking account of who benefits and who takes the risks • suggest benefits of activities that are known to have risk.
5.5	• 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.	• offer reasons for people's willingness (or reluctance) to accept the risk of a given activity.
5.6	• **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).**	• **distinguish between perceived and calculated risk, when discussing personal choices** • **suggest reasons for given examples of differences between perceived and measured risk.**
5.7	• governments and public bodies may have to assess what level of risk is acceptable in a particular situation. This decision may be controversial, especially if those most at risk are not those who benefit.	• discuss the public regulation of risk, **and explain why it may in some situations be controversial.**

6 Making decisions about science and technology

To make sound decisions about the applications of scientific knowledge, we have to weigh up the benefits and costs of new processes and devices. Sometimes these decisions also raise ethical issues. Society has developed ways of managing these issues, though new developments can pose new challenges to these.

	Candidates should understand that:	A candidate who understands this can, for example:
6.1	• science-based technology provides people with many things that they value, and which enhance the quality of life. Some applications of science can, however, have unintended and undesirable impacts on the quality of life or the environment. Benefits need to be weighed against costs.	• in a particular context, identify the groups affected and the main benefits and costs of a course of action for each group • **suggest reasons why different decisions on the same issue might be appropriate in view of differences in social and economic context.**
6.2	• scientists may identify unintended impacts of human activity (including population growth) on the environment. They can sometimes help us to devise ways of mitigating this impact and of using natural resources in a more sustainable way.	• identify, and suggest, examples of unintended impacts of human activity on the environment • explain the idea of sustainability, and apply it to specific situations • use data (for example, from a Life Cycle Assessment) to compare the sustainability of alternative products or processes.
6.3	• in many areas of scientific work, the development and application of scientific knowledge are subject to official regulations.	• in contexts where this is appropriate, show awareness of, **and discuss**, the official regulation of scientific research and the application of scientific knowledge.
6.4	• some questions, such as those involving values, cannot be answered by science.	• distinguish questions which could in principle be answered using a scientific approach, from those which could not.
6.5	• some forms of scientific research, and some applications of scientific knowledge, have ethical implications. People may disagree about what should be done (or permitted).	• where an ethical issue is involved: — say clearly what this issue is — summarise different views that may be held.
6.6	• in discussions of ethical issues, one common argument is that the right decision is one which leads to the best outcome for the greatest number of people involved. Another is that certain actions are considered right or wrong whatever the consequences.	• in a given context, identify, **and develop**, arguments based on the ideas that: — the right decision is the one which leads to the best outcome for the greatest number of people involved — certain actions are considered right or wrong whatever the consequences.

Appendix C: Mathematics skills for GCSE science qualifications

Candidates are permitted to use calculators in all assessments.

Candidates should be able to:

- understand number size and scale and the quantitative relationship between units
- understand when and how to use estimation
- carry out calculations involving +, – , ×, ÷, either singly or in combination, decimals, fractions, percentages and positive whole number powers
- provide answers to calculations to an appropriate number of significant figures
- understand and use the symbols =, <, >, ~
- understand and use direct proportion and simple ratios
- calculate arithmetic means
- understand and use common measures and simple compound measures such as speed
- plot and draw graphs (line graphs, bar charts, pie charts, scatter graphs, histograms), selecting appropriate scales for the axes
- substitute numerical values into simple formulae and equations using appropriate units
- translate information between graphical and numeric form
- extract and interpret information from charts, graphs and tables
- understand the idea of probability
- calculate area, perimeters and volumes of simple shapes.

In addition, higher tier candidates should be able to

- **interpret, order and calculate with numbers written in standard form**
- **carry out calculations involving negative powers (only –1 for rate)**
- **change the subject of an equation**
- **understand and use inverse proportion**
- **understand and use percentiles and deciles.**

D Appendix D: Physical quantities and units

It is expected that candidates will show an understanding of the physical quantities and corresponding SI units listed below, and will be able to use them in quantitative work and calculations. Whenever they are required for such questions, units will be provided and, where necessary, explained.

Fundamental physical quantities

Physical quantity	Unit(s)
length	metre (m); kilometre (km); centimetre (cm); millimetre (mm); nanometre (nm)
mass	kilogram (kg); gram (g); milligram (mg)
time	second (s); millisecond (ms) ; year (a); million years (Ma); billion years (Ga)
temperature	degree Celsius (°C); kelvin (K)
current	ampere (A); milliampere (mA)

Derived physical quantities and units

Physical quantity	Unit(s)
area	cm^2; m^2
volume	cm^3; dm^3; m^3; litre (l); millilitre (ml)
density	kg/m^3; g/cm^3
speed, velocity	m/s; km/h
acceleration	m/s^2
momentum	kg m/s
force	newton (N)
pressure	N/m^2; pascal (Pa)
gravitational field strength	N/kg
energy	joule (J); kilojoule (kJ); megajoule (MJ); kilowatt hour (kWh); megawatt hour (MWh)
power	watt (W); kilowatt (kW); megawatt (MW)
frequency	hertz (Hz); kilohertz (kHz)
information	bytes (B); kilobytes (kB); megabytes (MB)
potential difference	volt (V)
resistance	ohm (Ω)
radiation dose	sievert (Sv)
distance (in astronomy)	light-year (ly); parsec (pc)
power of a lens	dioptre (D)

Prefixes for units			
nano (n)	one thousand millionth	0.000000001	× 10^{-9}
micro (μ)	one millionth	0.000001	× 10^{-6}
milli (m)	one thousandth	0.001	× 10^{-3}
kilo (k)	× one thousand	1000	× 10^{3}
mega (M)	× one million	1 000 000	× 10^{6}
giga (G)	× one thousand million	1 000 000 000	× 10^{9}
tera (T)	× one million million	1 000 000 000 000	× 10^{12}

E Appendix E: Health and safety

In UK law, health and safety is the responsibility of the employer. For most establishments entering candidates for GCSE, this is likely to be the local education authority or the governing body. Employees, ie teachers and lecturers, have a duty to cooperate with their employer on health and safety matters. Various regulations, but especially the COSHH Regulations 2002 and the Management of Health and Safety at Work Regulations 1999, require that before any activity involving a hazardous procedure or harmful micro-organisms is carried out, or hazardous chemicals are used or made, the employer must provide a risk assessment.

For members, the CLEAPSS® guide, *Managing Risk Assessment in Science** offers detailed advice. Most education employers have adopted a range of nationally available publications as the basis for their Model Risk Assessments. Those commonly used include:

Safety in Science Education, DfEE, 1996, HMSO, ISBN 0 11 270915 X.

Topics in Safety, 3rd edition, 2001, ASE ISBN 0 86357 316 9;

Safeguards in the School Laboratory, 11th edition, 2006, ASE ISBN 978 0 86357 408 5;

CLEAPSS® *Hazcards,* 2007 edition and later updates*;

CLEAPSS® *Laboratory Handbook**;

Hazardous Chemicals, A Manual for Science Education, 1997, SSERC Limited ISBN 0 9531776 0 2.

Where an employer has adopted these or other publications as the basis of their 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 candidates were insufficient to attempt particular activities safely. The significant findings of such risk assessment should then be recorded, 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, although a few employers require this.

Where project work or individual investigations, sometimes linked to work-related activities, are included in specifications this may well lead to the use of novel procedures, chemicals or micro-organisms, 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® (or, in Scotland, SSERC).

*These, and other CLEAPSS® publications, are on the CLEAPSS® Science Publications CD-ROM issued annually to members. Note that CLEAPSS® publications are only available to members. For more information about CLEAPSS® go to www.cleapss.org.uk. In Scotland, SSERC (www.sserc.org.uk) has a similar role to CLEAPSS® and there are some reciprocal arrangements.

YOUR CHECKLIST

OUR AIM IS TO PROVIDE YOU WITH ALL THE INFORMATION AND SUPPORT YOU NEED TO DELIVER OUR SPECIFICATIONS.

- ✓ Bookmark **www.gcse-science.com**
- ✓ Be among the first to hear about support materials and resources as they become available. Register for email updates at **www.ocr.org.uk/updates**
- ✓ Book your INSET training place online at **www.ocr.org.uk/eventbooker**
- ✓ Find out about controlled assessment support at **www.ocr.org.uk/science2011/support**
- ✓ Learn more about Active Results at **www.ocr.org.uk/activeresults**
- ✓ Join our social network community for teachers at **www.social.ocr.org.uk**

NEED MORE HELP?

Here's how to contact us for specialist advice

Phone: 01223 553998

Email: science@ocr.org.uk

Online: http://answers.ocr.org.uk

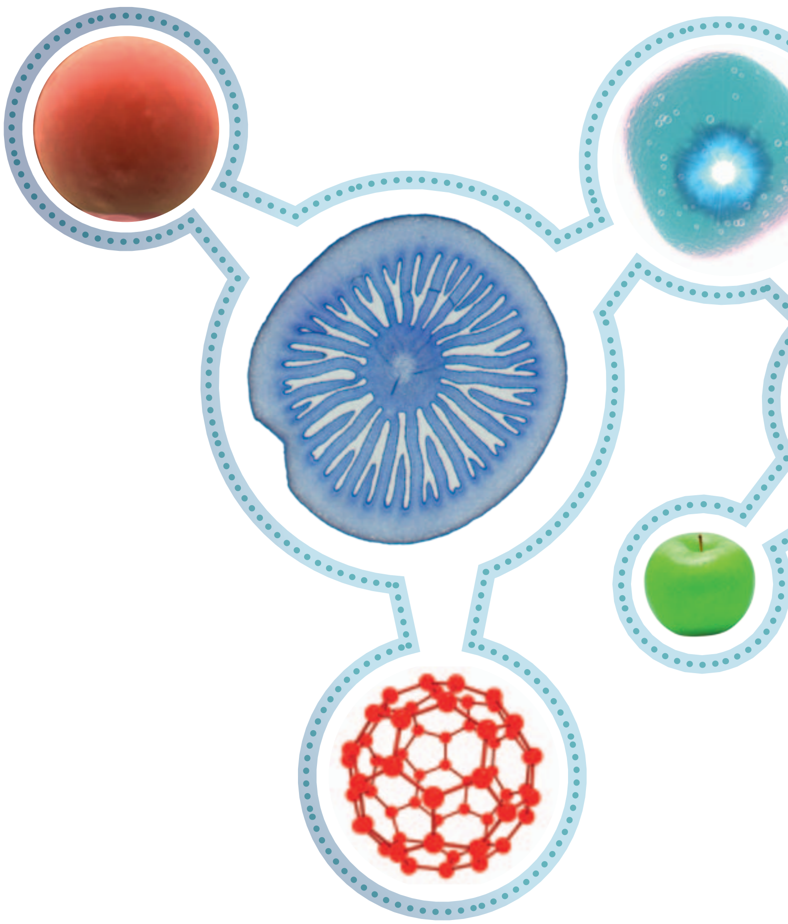
Fax: 01223 552627

Post: Customer Contact Centre, OCR, Progress House, Westwood Business Park, Coventry CV4 8JQ

WHAT TO DO NEXT

1) Sign up to teach – let us know you will be teaching this specification to ensure you receive all the support and examination materials you need. Simply complete the online form at **www.ocr.org.uk/science/signup**

2) Become an approved OCR centre – if your centre is completely new to OCR and has not previously used us for any examinations, visit **www.ocr.org.uk/centreapproval** to become an approved OCR centre.



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