GCSE

Biology A

Twenty First Century Science Suite

OCR GCSE in Biology A J633

Foreword to the Third Edition

This Third Edition of the OCR GCSE Biology A specification reflects the change to the style of questions used in Units 1 & 2 (A221 and A222) from January 2010 (see page 44). In addition there are clarifications to the wording of the specification on pages 25, 39, 44, 49, 51, 52, 53, 63, 64, 65 and 71.

Vertical black lines indicate a significant change to the previous printed version.

specification

version 3 – September 2009

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Contents

Vertical black lines indicate a significant change to the previous printed version.

The majority of changes are to the formatting in Section 3, (the replacement of bullet points with alphabetical labels). These changes can be found on pages 11, 12, 15, 16, 17, 20, 21, 22, 24, 25, 26, 27, 29, 32, 37, 38, 39, 40, 42 and 43. This change is intended to make it simpler to reference the content of the specification.

Changes to the wording of the specification can be found on pages 25, 39, 44, 49, 51, 52, 53, 63, 64, 65 and 71.

1 About this Qualification

1.1 About the Twenty First Century Science Suite

The Twenty First Century Science Suite comprises six specifications which share common material, use a similar style of examination questions and have a common approach to skills assessment. The qualifications available as part of this suite are:

GCSE Science A (J630)	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 (J631)	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 Additional Applied Science A (J632)	which meets the needs of candidates who wish to develop their scientific understanding through authentic, work related contexts. The course focuses on procedural and technical knowledge that underpins the work of practitioners of science and gives candidates an insight into what is involved in being a practitioner of science.
GCSE Biology A (J633) **GCSE Chemistry A (J634)** **GCSE Physics A (J635)**	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.

This suite is supported by the Nuffield Curriculum Centre and The University of York Science Education Group.

1.2 About this Biology Specification

This booklet contains OCR's GCSE specification in Biology for teaching from September 2006 and first certification in June 2008.

This specification aims to provide candidates with the scientific understanding needed to progress to further studies of biology, should they choose to undertake them. Candidates should gain an insight into:

- what is involved in being a practitioner of science;
- how scientists develop scientific understanding of ourselves and the world we inhabit;
- how these understandings can be applied to the benefit of humanity.

Candidates must have a broad understanding of the scientific ideas that provide a conceptual foundation for further studies of science. These are referred to as 'Science Explanations'. But, candidates also need to be able to reflect on scientific knowledge itself, the practices that have produced it, the kinds of reasoning that are used in developing a scientific argument, and on the issues that arise when scientific knowledge is put to practical use. These are referred to as 'Ideas about Science' (IaS). This specification provides a combination of these two essential elements.

This specification comprises seven teaching modules which are assessed through four units. Candidates take Units 1, 2 and 3 **and** either Unit 4 **or** 5.

Unit	Unit Code	Title	Duration	Weighting	Total Mark
1	A221	Biology A Unit 1 – modules B1, B2, B3	40 mins	16.7%	42
2	A222	Biology A Unit 2 – modules B4, B5, B6	40 mins	16.7%	42
3	A223	Biology A Unit 3 – Ideas in Context plus B7	60 mins	33.3%	55
4	A229	Biology A Unit 4 – Practical Data Analysis and Case Study	-	33.3%	40
5	A230	Biology A Unit 5 – Practical Investigation	-	33.3%	40

1.3 Qualification Titles and Levels

This qualification is shown on a certificate as OCR GCSE in Biology.

This qualification is approved by the regulatory authority, QCA, as part of the National Qualifications Framework.

Candidates who gain grades G to D will have achieved an award at Foundation Level (Level 1 of the National Qualifications Framework).

Candidates who gain grades C to A* will have achieved an award at Intermediate Level (Level 2 of the National Qualifications Framework).

1.4 Aims

The aims of this GCSE specification are to encourage candidates to:

- acquire a systematic body of scientific knowledge, and the skills needed to apply this in new and changing situations in a range of domestic, industrial and environmental contexts;
- acquire an understanding of scientific ideas, how they develop, the factors which may affect their development and their power and limitations;
- plan and carry out investigative tasks, considering and evaluating critically their own data and that obtained from other sources, and using ICT where appropriate;
- use electronic (internet, CD ROMs, databases, simulations etc.) and/or more traditional sources or information (books, magazines, leaflets etc.) to research and plan an investigation;
- select, organise and present information clearly and logically, using appropriate scientific terms and conventions, and using ICT where appropriate;
- interpret and evaluate scientific data from a variety of sources.

1.5 Prior Learning/Attainment

Candidates who are taking courses leading to this qualification at Key Stage 4 should normally have followed the corresponding Key Stage 3 programme of study within the National Curriculum.

Other candidates entering this course should have achieved a general educational level equivalent to National Curriculum Level 3, or a distinction at Entry Level within the National Qualifications Framework.

2 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 B1-6 are designed to be taught in approximately half a term, 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

- 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?
- What are stem cells, and why could they be useful in treating some diseases?

Module B2: Keeping Healthy

- How do our bodies resist infection?
- What are vaccines and how do they work?
- What are antibiotics, and why can they become less effective? How are new drugs developed and tested?
- What factors increase the risk of heart disease?

Module B3: Life on Earth

- How did life on Earth begin and evolve?
- How have scientists developed explanations of evolution?
- How did humans evolve? How are our nervous systems organised?
- Why do some species become extinct, and does it matter? What is the importance of biodiversity?

Module B4: Homeostasis

- What is homeostasis?
- Why is homeostasis important for a cell?
- How is our body temperature kept constant?
- How does the body control water balance?

Module B5: Growth and Development

- How does an organism produce new cells?
- How do genes control growth and development within the cell?
- How do new organisms develop from a single cell?

Module B6: Brain and Mind

- How do organisms respond to changes in their environment?
- How is information passed through the nervous system?
- What are reflex actions?
- How do humans develop more complex behaviour?
- What do we know about the way in which the brain co-ordinates our senses?
- How do drugs affect our nervous systems?

Module B7: Further Biology

- Living organisms are interdependent
- Photosynthesis
- Heterotrophic nutrition
- New technologies
- Respiration
- Circulation
- Skeletal system.

3 Content

Layout of Module Content

The specification content of modules B1, B2 and B3 is based on a set of Science Explanations and the Ideas about Science (see Appendices F and G). The presentation of the content of these modules recognises these ideas about science in the overview page. The typical layout is shown here.

Issues for citizens	Questions that science may help to answer
e.g. How do my genes affect my appearance, my body, and my health?	e.g. What are genes and how do they affect the way that living organisms develop?
Science Explanations	Ideas about Science
e.g. SE8 The gene theory of inheritance	e.g. IaS 6.4-6.7 Making decisions about science and technology

The overview identifies:

- issues for citizens which are likely to be uppermost in the minds of citizens 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;
- those Science Explanations and Ideas about Science which are introduced or further developed in the module.

Modules B4, B5, B6 and B7 also begin with an overview page, which outlines the content of the module.

Some symbols and fonts are provided to give teachers additional information, expressed in abbreviated form, about the way in which the content is linked to other parts of the specification, and the table below summarises this information.

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

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, gene therapy and cloning research.

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?	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 and why do people find out about their genes? What decisions do people make with this information?	How can and should genetic information be used?
Can we change our genes, and should this be allowed?	How can we use our knowledge of genes to prevent disease?
What is cloning, and should it be allowed?	What are stem cells, and why could they be useful in treating some diseases?
Science Explanations	**Ideas about Science**
SE6b Cells as the basic units of living things. SE8 The gene theory of inheritance.	IaS 6.4-6.7 Making decisions about science and technology.

ICT Opportunities

This module offers opportunities for illustrating the use of ICT in science. For example:

- the 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, genes and DNA, and a simple explanation of protein synthesis.
- interactive animation of genetic crosses;
- video clips of relevant media reports.

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 for how an organism develops are found in the nucleus of its cells;
2. understand that genes are instructions for a cell that describe how to make proteins, **which may be structural or enzymes;**
3. understand that genes are sections of very long DNA molecules that make up chromosomes in the nuclei of cells.

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

1. recall that sex cells have only one copy of each chromosome;
2. understand that the occurrence of chromosomes (and hence genes) in pairs relates to their origin from each parent's sex cells;
3. recall that chromosomes in a pair carry the same genes in the same place, but that there are different versions of genes called alleles;
4. understand that a person may have two alleles the same or two different alleles for any gene;
5. interpret (through family trees or genetic diagrams) the inheritance of normal single gene characteristics with a dominant and recessive allele;
6. understand that offspring may have some similarity to their parents because of the combination of maternal and paternal alleles in the fertilised egg;
7. understand why different offspring from the same parents can differ from each other;
8. recall that human males have sex chromosomes XY and females have sex chromosomes XX;
9. **recall that sex of a human embryo is determined by a gene on the Y chromosome;**
10. **understand the link between this gene and the development of sex organs into either ovaries or testes.**

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 most characteristics are determined by several genes working together, for example, height;
2. understand that most characteristics are also affected by environmental factors, for example, lifestyle factors contributing to disease;
3. recall that a small number of disorders are caused by alleles of a single gene, limited to Huntington's disorder and cystic fibrosis;
4. recall the symptoms of Huntington's disorder and cystic fibrosis;
5. understand why a person with one recessive allele will not show the associated characteristic, but is a carrier and can pass the allele to their children;
6. interpret (through family trees or genetic diagrams) the inheritance of a single gene disorder, including the risk of a child being a carrier;
7. understand the implications of testing adults and fetuses for alleles which cause genetic disease, for example:
    a. whether or not to have children at all;
    b. whether or not a pregnancy should be terminated.
8. understand the implications of testing embryos for embryo selection (**pre-implantation genetic diagnosis**);
9. **understand the implications of the use of genetic testing by others, (for example, for genetic screening programmes, by employers and insurance companies);**
10. understand that gene therapy may make it possible to treat certain genetic diseases;
11. In the context of genetic testing (when provided with additional information about the reliability and risks of genetic tests) or gene therapy, be able to:
    a. distinguish questions which could be addressed using a scientific approach, from questions which could not;
    b. say clearly what the issue is;
    c. summarise different views that may be held;
    d. identify and develop arguments based on the ideas that:
        - the right decision is the one which leads to the best outcome for the majority of people involved;
        - certain actions are never justified because they are unnatural or wrong;
12. **in the context of use of genetic testing by others, can:**
    a. **distinguish what can be done (technical feasibility), from what should be done (values);**
    b. **explain why different courses of action may be taken in different social and environmental contexts**

MODULE B1: YOU AND YOUR GENES

B1.4 What are stem cells, and why could they be useful in treating some diseases?

1. recall that bacteria, plants and some animals can reproduce asexually to form clones (with identical genes to their parent);
2. understand that any differences between clones are likely to be due only to environmental factors;
3. understand how 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;**
4. recall that embryonic stem cells are unspecialised cells that can develop into any type of cell;
5. understand that there is the potential to use stem cells to treat some illnesses;
6. recall that the cells of multicellular organisms become specialised during the early development of the organism;
7. in the context of cloning embryos to produce large numbers of stem cells to treat illnesses, can:
   a. say clearly what the issue is;
   b. summarise different views that may be held;
   c. identify and develop arguments based on the ideas that:
      - the right decision is the one which leads to the best outcome for the majority of people involved;
      - certain actions are never justified because they are unnatural or wrong.

MODULE B2: KEEPING HEALTHY – OVERVIEW

Keeping healthy involves maintaining a healthy lifestyle, practicing good hygiene to avoid 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. They consider the causes of heart disease, and how individuals can minimise this risk. The module explores how new drugs are developed, including the stages of testing for safety and efficiency. Candidates also learn about the increase of ‘superbugs’, and how correct use of antibiotics can help to reduce their prevalence.

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 reliability of 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?	How do our bodies resist infection?
Why are we encouraged to have vaccinations?	What are vaccines and how do they work?
Why won’t the doctor give me an antibiotic when I catch a cold? What are ‘superbugs’?	What are antibiotics and why can they become less effective?
How do drug companies make sure a new drug is as safe as possible?	How are new drugs developed and tested?
How can my lifestyle affect my health?	What factors increase the risk of heart disease?

Science Explanations	Ideas about Science
SE7c Maintenance of life. SE10 The germ theory of disease.	IaS 2.3 – 2.7 Correlation and cause. IaS 4.1 – 4.2 Scientific community. IaS 6.5-6.7 Making decisions about science and technology.

ICT Opportunities

This module offers opportunities for illustrating 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.

Use of ICT in teaching and learning can include:

- animation to illustrate immune response;
- animation 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 of illustrating how epidemiological research is carried out and reported.

MODULE B2: KEEPING HEALTHY

B2.1 How do our bodies resist infection?

1. recall that there are natural barriers to reduce the risk of harmful microorganisms entering the body (limited to the skin, chemicals in tears, sweat and stomach acid);
2. understand that in suitable conditions (such as inside the body) these microorganisms can reproduce rapidly;
3. understand that symptoms of a disease are caused by damage done to cells by the microorganisms or the poisons (toxins) they produce;
4. recall that our bodies have immune systems to defend themselves against the invading microorganisms;
5. understand that white blood cells can destroy microorganisms by engulfing and digesting them, or by producing antibodies;
6. understand that a different antibody is needed to recognise each different type of microorganism;
7. understand that once the body has made the antibody to recognise a particular microorganism, it can make that antibody again very quickly, therefore protecting against that particular microorganism.

MODULE B2: KEEPING HEALTHY

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

1. understand that microorganisms may enter the body and cause illness before the immune system can destroy them;
2. understand that vaccinations provide protection from microorganisms by establishing antibodies before infection;
3. recall that a vaccination contains a usually safe form of a disease-causing microorganism;
4. understand that vaccination can never be completely safe, since individuals have varying degrees of side effects from a vaccine;
5. **understand why, to prevent epidemics of infectious diseases, it is necessary to vaccinate a high percentage of a population;**
6. understand that there is a conflict between a person's right to decide about vaccination for themselves or their children, and what is of benefit to society as a whole;
7. understand that new vaccines against influenza have to be developed regularly because the virus changes very quickly;
8. **understand that it is difficult to develop an effective vaccine against the HIV virus (which causes AIDS) because the virus damages the immune system and has a high mutation rate;**
9. with respect to vaccination policy can:
   a. say clearly what the issue is;
   b. summarise different views that may be held;
   c. distinguish what can be done (technical feasibility) from what should be done (values);
   d. explain why different courses of action may be taken in different social and economic contexts;
   e. identify, and develop, arguments based on the ideas that:
      - the right decision is the one which leads to the best outcome for the majority of people involved;
      - certain actions are never justified because they are unnatural or wrong.

MODULE B2: KEEPING HEALTHY

B2.3 What are antibiotics, and why can they become less effective? How are new drugs developed and tested?

1. recall that we can kill bacteria and fungi, but not viruses, using chemicals called antibiotics;
2. recall that over a period of time bacteria and fungi may become resistant to antibiotics;
3. **understand that random changes (mutations) in the genes of these microorganisms sometimes lead to varieties which are less affected by the antibiotic;**
4. understand that to reduce antibiotic resistance we should only use antibiotics when necessary and always complete the course;
5. recall that new drugs are first tested for safety and effectiveness using human cells grown in the laboratory and animals;
6. 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.
7. **describe and explain the use of 'blind' or 'double-blind' human trials in the testing of a new medical treatment;**
8. **understand why placebos are not commonly used in human trials.**

MODULE B2: KEEPING HEALTHY

B2.4 What factors increase the risk of heart disease?

1. understand why heart muscle cells need their own blood supply;
2. explain how the structure of arteries and veins is related to their function;
3. understand how fatty deposits in the blood vessels supplying the heart muscle can produce a 'heart attack';
4. recall that heart disease is usually caused by lifestyle factors and/or genetic factors, not microorganisms;
5. recall that these lifestyle factors include poor diet, stress, cigarette smoking, excessive alcohol intake;
6. understand that heart disease is more common in the UK than in non-industrialised countries;
7. recall that regular moderate exercise reduces the risk of developing heart disease;
8. in the context of how lifestyle factors that can increase the risk of heart disease are identified via epidemiological studies:

   a. can give an example from everyday life of a correlation between a factor and an outcome;
   b. uses the ideas of correlation and cause appropriately;
   c. can explain why a correlation between a factor and an outcome does not necessarily mean that one causes the other, and give an example to illustrate this;
   d. can suggest factors that might increase the chance of an outcome but not invariably lead to it;
   e. can explain that individual cases do not provide convincing evidence for or against a correlation;
   f. can evaluate the design for a study to test whether or not a factor increases the chance of an outcome, by commenting on sample size and how well the samples are matched;
   g. can use data to develop an argument that a factor does/does not increase the chance of an outcome;
   h. can identify the presence (or absence) of a plausible mechanism as significant for the acceptance (or rejection) of a claimed causal link;
   i. can describe in broad outline the 'peer review' process, in which new scientific claims are evaluated by other scientists;
   j. can recognise that new scientific claims which have not yet been evaluated by the scientific community are less reliable than well-established ones;
   k. can identify absence of replication as a reason for questioning a scientific claim;
   l. can explain why scientists regard it as important that a scientific claim can be replicated by other scientists.

MODULE B3: LIFE ON EARTH – OVERVIEW

Theories for the origin of life on Earth often feature in the media and popular culture. Candidates consider different explanations for life on Earth, and its subsequent 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.

Evolution of multicellular organisms has led to complex body communication systems, both nervous and hormonal. Through the context of human evolution, candidates consider implications of data for given theories.

Living organisms are dependent on their environment and each other for survival. Biodiversity is recognised as an important natural resource, which is increasingly threatened by human activity. Candidates consider causes of extinction, and whether extinctions should be a global concern.

Issues for citizens	Questions that science may help to answer
Where did life on Earth come from?	How did life on Earth begin and evolve?
Is evolution 'just a theory'?	How have scientists developed explanations of evolution?
How do some species survive? Why do some species become extinct, and does it matter?	How did humans evolve? How are our nervous systems organised? What is the importance of biodiversity?

Science Explanations	Ideas about Science
SE4b,c The interdependence of living things. SE7e Maintenance of life. SE9 The theory of evolution by natural selection.	IaS 3 Developing explanations. IaS 4.3 – 4.4 The scientific community.

ICT Opportunities

This module offers opportunities for illustrating 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;
- 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

B3.1 How did life on Earth begin and evolve?

1. recall that the many different species of living things on Earth (and many species that are now extinct) evolved from very simple living things;
2. recall that life on Earth began about 3500 million years ago;
3. understand that evidence for evolution is provided by fossils and from analysis of similarities and differences in DNA of organisms;
4. recall that the first living things developed from molecules that could copy themselves;
5. understand that these molecules were produced by the conditions on Earth at that time, or may have come from elsewhere;
6. recall that evolution happens due to natural selection;
7. understand the process of natural selection in terms of variation, competition, increased chance of survival and reproduction, and increased number of individuals displaying certain characteristics in later generations;
8. understand that variation is caused by both environment and genes, but only genetic variation can be passed on;
9. explain the difference between natural selection and selective breeding;
10. **interpret data on changes in a species in terms of natural selection;**
11. **recall that changes can occur in genes (mutations);**
12. **understand that mutated genes in sex cells can be passed on to offspring and may occasionally produce new characteristics;**
13. **understand that the combined effect of mutations, environmental changes and natural selection can produce new species;**
14. understand that if the conditions on Earth had, at any stage, been different from what they actually were, evolution by natural selection could have produced different results.

MODULE B3: LIFE ON EARTH

B3.2 How have scientists developed explanations of evolution?

1. when provided with information about alternative views on the origin of life on Earth, or the evolutionary process:
   a. can identify statements which are data and statements which are (all or part of) an explanation;
   b. can recognise data or observations that are accounted for by, (or conflict with), an explanation;
   c. can identify imagination and creativity in the development of an explanation;
   d. can justify accepting or rejecting a proposed explanation on the grounds that it:
      - accounts for observations;
      - **and/or provides an explanation that links things previously thought to be unrelated;**
   e. can identify a scientific question for which there is not yet an agreed answer **and suggest a reason why;**
   f. can suggest plausible reasons why scientists involved in a scientific event or issue disagree(d);
   g. can suggest reasons for scientists' reluctance to give up an accepted explanation when new data appear to conflict with it.

MODULE B3: LIFE ON EARTH

B3.3 How did humans evolve? How are our nervous systems organised?

1. recall that the evolution of multicellular organisms has led to nervous and hormonal communication systems;
2. recall that sensor (receptor) cells detect stimuli and effector cells produce responses to stimuli;
3. recall that nervous systems are made up of nerve cells (neurons) linking receptor cells (e.g. in eyes, ears and skin) to effector cells (in muscles/glands);
4. recall that in humans and other vertebrates the nervous system is coordinated by a central nervous system (spinal cord and brain);
5. understand that nervous systems use electrical impulses for fast, short-lived responses;
6. recall that hormones are chemicals which travel in the blood and bring about slower, longer-lasting responses;
7. recall two examples, in humans, of each of nervous and hormonal communication;
8. **recall that nervous and hormonal communication systems are involved in maintaining a constant internal environment (homeostasis);**
9. recall that the evolution of a larger brain gave some early humans a better chance of survival;
10. understand human evolution in terms of a common ancestor, divergence of hominid species, extinction of all but one of these species;
11. when provided with additional information about human evolution, can draw valid conclusions about the implications of given data for a given theory, for example:
    a. recognises that an observation that agrees with a prediction (derived from an explanation) increases confidence in the explanation **but does not prove it is correct;**
    b. recognises that an observation that disagrees with a prediction (derived from an explanation) indicates that either the observation or the prediction is wrong, **and that this may decrease our confidence in the explanation.**

MODULE B3: LIFE ON EARTH

B3.4 Why do some species become extinct, and does it matter? What is the importance of biodiversity?

1. understand that living organisms are dependent on the environment and other species for their survival;
2. understand that there is competition for resources between different species of animals or plants in the same habitat;
3. relate changes affecting one species in a food web to the impact on other species that are part of the same food web;
4. understand that a rapid change in the environment may cause a species to become extinct, for example, if:
   a. the environmental conditions change;
   b. a new species that is a competitor, predator or disease organism of that species is introduced;
   c. another organism in its food web becomes extinct;
5. understand that species have become extinct (or are in danger of becoming extinct) and that this is likely to be due to human activity;
6. recall two examples of modern extinctions caused by direct human activity, and two caused by indirect human activity;
7. explain why maintaining biodiversity is an important part of using the environment in a sustainable way;
8. understand that biodiversity may be important for the future development of food crops and medicines.

MODULE B4: HOMEOSTASIS – OVERVIEW

Extreme environments hold a fascination for human beings, and people continue to push their bodies to the furthest limits of endurance. For some individuals, e.g. premature babies or patients with kidney disease, their homeostatic mechanisms must be artificially supported. These contemporary topics provide engaging contexts for the coherent study of homeostasis.

This module looks at the importance of homeostasis for individual cells and whole organisms and the effects of disrupting homeostasis. A general understanding of homeostasis is developed in the first topic, through an analogy with control mechanisms in artificial systems. This understanding is applied at cell level in the second topic, which focuses on movement of molecules in and out of cells, and enzyme function. The remaining two topics look in detail at temperature control and water balance in the whole organism.

Topics
B4.1 What is homeostasis?
Modelling of homeostasis mechanisms by an artificial system; principle of negative feedback.
B4.2 Why is homeostasis important for a cell?
Transport into and out of cells; enzyme function.
B4.3 How is our body temperature kept constant?
Detection of temperature change; co-ordination by the brain; responses to fall or rise in body temperature.
B4.4 How does the body control water balance?
Kidney function for excretion and water balance.

ICT Opportunities

This module offers opportunities for illustrating the use of ICT in science. For example:

- modelling control systems which involve negative feedback;
- molecular modelling to develop explanations of enzyme action.

Use of ICT in teaching and learning can include:

- animation to explain enzyme action and the effect of temperature on enzyme activity;
- a data logger to monitor body temperature over 12 or 24 hours;
- animation to explore kidney function;
- the internet to research symptoms and treatments of hypothermia and heatstroke.

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MODULE B4: HOMEOSTASIS

B4.1 What is homeostasis?

1. recall that homeostasis is the maintenance of a constant internal environment;
2. understand that automatic control systems throughout the body maintain a range of factors at steady levels, which are required for cells to function properly (limited to temperature and water);
3. understand that strenuous exercise, survival in hot or cold climates: **scuba-diving** and **mountain climbing** affect homeostasis (temperature, **blood oxygen levels**, hydration and **salt levels**);
4. understand how artificial systems, such as the temperature control system in an incubator, are similar to body control systems;
5. understand that artificial and body systems have:
   a. receptors to detect stimuli;
   b. processing centres to receive information and coordinate responses;
   c. effectors which produce the response automatically;
6. **understand the principle of negative feedback;**
7. **recall that negative feedback between the effector and the receptor of a control system reverses any changes to the systems steady state;**
8. **understand that some effectors work antagonistically, which allows a more sensitive response**.

MODULE B4: HOMEOSTASIS

B4.2 Why is homeostasis important for a cell?

1. understand that diffusion is the passive overall movement of molecules from a region of their high concentration to a region of their low concentration;
2. 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;
3. recall some examples of chemicals, such as O_2, CO_2 and dissolved food, which move in/out of cells by diffusion;
4. **understand that some chemicals (for example, glucose) are also moved by active transport;**
5. **understand that if excess water moves into animal cells by osmosis the cell membrane may rupture and if too much water moves out of cells they are unable to function correctly;**
6. recall that enzymes are proteins that speed up chemical reactions in cells;
7. recall that enzymes need a specific constant temperature to work at their optimum;
8. explain how, at low temperatures, small increases in temperature increase the frequency of collisions between an enzyme and other molecules, so the rate of reaction increases;
9. recall that at higher temperatures enzymes stop working (denature);
10. understand that only molecules with the correct shape can fit into the enzyme. This is known as the lock and key model;
11. **recall that enzymes have a small part called the active site where certain molecules bind to the enzyme and the reaction occurs;**
12. **understand that the shape of the active site can be changed by heating above a certain temperature or altering the pH, so that the molecules can no longer fit and the reaction cannot happen.**

MODULE B4: HOMEOSTASIS

B4.3 How is our body temperature kept constant?

1. recall that energy gain and loss must be balanced in order to maintain a constant body temperature;
2. recall that body extremities tend to be cooler than the core body temperature, and that energy is transferred from the blood to the tissues when blood reaches cooler parts;
3. recall that temperature receptors in the skin detect external temperature;
4. recall that temperature receptors in the brain (**hypothalamus**) detect the temperature of the blood;
5. understand that the brain (**hypothalamus**) acts as a processing centre, receiving information from the temperature receptors, and triggering the effectors automatically;
6. recall that effectors include sweat glands and muscles;
7. 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 energy loss;
8. recall that heat stroke is an uncontrolled increase in body temperature;
9. recall the common causes, symptoms and initial treatment of heat stroke;
10. explain how exposure to very hot temperatures produces increased sweating, and can produce dehydration, which may lead to reduced sweating and further increase of core body temperature;
11. understand that when core body temperature becomes too high the normal mechanisms for controlling body temperature break down;
12. 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 energy loss;
13. recall that hypothermia is when core body temperature falls below 35^{o}C;
14. recall the cause, symptoms and initial treatment of hypothermia;
15. understand that in hypothermia body heat cannot be replaced as fast as it is being lost.

MODULE B4: HOMEOSTASIS

B4.4 How does the body control water balance?

1. recall that water is gained from drinks, food and respiration and is lost through sweating, breathing, faeces and the excretion of urine;
2. understand that a balanced water level is important for maintaining the concentration of cell contents at the correct level for cell activity;
3. describe how the kidneys play a vital role in removing waste urea from the blood and in balancing levels of other chemicals in the blood by:
   a. filtering small molecules from the blood to form urine (water, salt and urea);
   b. reabsorbing all the sugar;
   c. reabsorbing as much salt as the body requires;
   d. reabsorbing as much water as the body requires;
   e. excreting the remaining urine, which is stored in the bladder;

ⓘ Candidates are not expected to recall details of kidney structure;

4. understand that the kidneys balance water levels by producing dilute or concentrated urine as a response to concentration of blood plasma, which varies with external temperature, exercise level, intake of fluids and salt;
5. **recall that concentration of urine is controlled by a hormone called ADH, which is released into the bloodstream by the pituitary gland;**
6. **understand how ADH secretion is controlled by negative feedback;**
7. understand that alcohol results in a greater volume of more dilute urine, **due to ADH suppression**, which can lead to dehydration;
8. understand that the drug Ecstasy results in a smaller volume of less dilute urine, **due to increased ADH production**.

MODULE B5: GROWTH AND DEVELOPMENT – OVERVIEW

Genetic technologies are at the cutting edge of contemporary science. Research into proteinomics, 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 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 second topic describes the process of protein synthesis, following the one-gene-one-protein hypothesis.

The final 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.

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

ICT Opportunities

This module offers opportunities for illustrating 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:

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

MODULE B5: GROWTH AND DEVELOPMENT

B5.1 How does an organism produce new cells?

1. recall that DNA has a double helix structure;
2. understand that cell division by mitosis produces two new cells identical to each other and to the parent cell;
3. 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 cell divides;

ⓘ Candidates are not expected to recall intermediate stages of mitosis.

4. recall that meiosis is a type of cell division that produces gametes;
5. understand why, in meiosis, it is important that the cells produced only contain half the chromosome number of the parent cell;
6. understand that a zygote contains a set of chromosomes from each parent.

ⓘ Candidates are not expected to recall intermediate stages of meiosis.

B5.2 How do genes control growth and development within the cell?

1. recall that the genetic code is in the cell nucleus but proteins are produced in the cell cytoplasm;
2. understand that genes do not leave the nucleus but a copy of the gene is produced to carry the genetic code to the cytoplasm;
3. recall that both strands of the DNA molecule are made up of four different bases, which always pair up in the same way;
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.

MODULE B5: GROWTH AND DEVELOPMENT

B5.3 How do new organisms develop from a single cell?

1. recall that the zygote divides by mitosis to form an embryo;
2. understand that in a human embryo, up to the eight cell stage, all the cells are identical and could produce any sort of cell required by the organism (embryonic stem cells);
3. understand that after this point, the cells become specialised and form different types of tissue;
4. understand that although body cells in an organism contain the same genes, many genes in a particular cell are not active because it only produces the specific proteins it needs;
5. **understand that, in carefully controlled conditions of mammalian cloning, it is possible to reactivate inactive genes in the nucleus of a body cell to form cells of all tissue types;**
6. **understand that adult and embryonic stem cells have the potential to produce cells needed to replace damaged tissues;**
7. recall that new cells in plants specialise into cells of roots, leaves or flowers;
8. understand that unlike animal cells, some plant cells remain unspecialised and can develop into any type of plant cell;
9. relate the presence of these unspecialised cells to the production of clones of a plant with desirable features, from cuttings;
10. recall that unlike animals, most plants continue to grow in height and width throughout their lives;
11. understand that plant meristems divide to produce cells that result in increased height, length of roots, and girth of the plant;
12. understand that, if the hormonal conditions in their environment are changed, unspecialised plant cells can develop into a range of other tissues (to include xylem and phloem) or organs (to include leaves, roots and flowers);
13. describe how cut stems from a plant can develop roots in the presence of plant hormones **(auxins)** and grow into a complete plant which is a clone of the parent;
14. understand how phototropism increases the plant’s chance of survival;
15. **explain phototropism in terms of the effect of light on the distribution of auxin in a shoot tip.**

MODULE B6: BRAIN AND MIND – OVERVIEW

How the human brain functions remains largely unknown. Neuroscience is an area at the frontiers of medical research, and has huge potential impact for an aging 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. Simple, learnt 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 neuron pathways become ‘preferred’ although potential pathways are available to allow for adaptation to new situations. The fifth topic illustrates specialised areas of the brain, methods scientists have used to map the cerebral cortex and introduces a basic understanding of memory. Finally the effects of drugs on synapses in the brain are explored (for example, Ecstasy).

Topics	
B6.1	How do organisms 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 motor neurons; transmission of electrical impulses, including synapses.	
B6.3	What are reflex actions?
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.	
B6.5	What do we know about the way in which the brain co-ordinates our senses?
Mapping brain function; models for understanding memory.	
B6.6	How do drugs affect our nervous systems?
Effects of Ecstasy on synapse action.	

ICT Opportunities

This module offers opportunities for illustrating the use of ICT in science. For example:

- observing and recording human and animal behaviour;
- logging, recording and displaying physiological data.

Use of ICT for teaching and learning can include:

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

MODULE B6: BRAIN AND MIND

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

1. recall that a stimulus is a change in the environment of an organism;
2. understand that animals respond to stimuli in order to keep themselves in favourable conditions;
3. understand that the central nervous system (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;
4. 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;
5. recall that in the mammalian nervous system the CNS (brain and spinal cord) is connected to the body via the peripheral nervous system (sensory and motor neurons).

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

1. recall that neurons transmit electrical impulses when stimulated;
2. recall that in motor neurons the cytoplasm forms a long fibre surrounded by a cell membrane called an axon;
3. 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;
4. recall that there are gaps between adjacent neurons called synapses;
5. **understand that at the end of a sensory neuron an impulse triggers the release of chemicals into the synapse, which diffuse across and bind to receptor molecules on the membrane of a motor neuron;**
6. **understand that the receptor molecules only bind to specific chemicals, initiating a nerve impulse in the motor neuron.**

MODULE B6: BRAIN AND MIND

B6.3 What are reflex actions?

1. recall that simple reflexes produce rapid involuntary responses;
2. understand the nervous pathway of a reflex arc;
3. understand that simple reflexes ensure that an animal will respond to a stimulus in a way that is most likely to result in its survival, to include finding food, sheltering from predators, and finding a mate;
4. understand that simple animals rely on reflex actions for the majority of their behaviour;
5. understand that the disadvantage of this simple behaviour is that these animals have difficulty responding to new situations;
6. recall examples of simple reflexes in humans, to include newborn reflexes, pupil reflex;
7. **understand that a reflex response to a new stimulus can be learned by introducing a secondary stimulus in association with the primary stimulus, e.g. Pavlov's dogs (conditioned reflex action);**
8. **understand that in a conditioned reflex the final response has no direct connection to the stimulus;**
9. **understand that some conditioned reflexes increase the animal's chances of survival, e.g. rejection by birds of caterpillars with particular colouring;**
10. **recall that in some circumstances the brain can modify a reflex response via a neuron to the motor neuron of the reflex arc, to include keeping hold of a hot dinner plate.**

B6.4 How do humans develop more complex behaviour?

1. recall that mammals have a complex brain of billions of neurons that allows learning by experience, including social behaviour;
2. understand that during development the interaction between mammals and their environment results in neuron pathways forming in the brain;
3. understand learning as the result of experience where certain pathways in the brain will become more likely to transmit impulses than others;
4. understand that this is why some skills may be learnt through repetition;
5. understand that the variety of potential pathways in the brain makes it possible for the animal to adapt to new situations;
6. **understand that there is evidence to suggest that children may only acquire some skills at a particular age, to include language development in feral children.**

MODULE B6: BRAIN AND MIND

B6.5 What do we know about the way in which the brain co-ordinates our senses?

1. recall that the cerebral cortex is the part of our brain most concerned with intelligence, memory, language and consciousness;
2. recall that a variety of methods have been used by scientists to map the regions of the cortex (including studies of patients with brain damage, studies in which different parts of the brain are stimulated electrically and, more recently, MRI brain scans);
3. describe memory as the storage and retrieval of information;
4. understand that verbal memory can be divided into short-term memory and long-term memory;
5. **understand that humans are more likely to remember information if they can see a pattern in it (or impose a pattern on it), if there is repetition of the information, especially over an extended period of time, or if there is a strong stimulus associated with it, including colour, light, smell, sound;**
6. understand that scientists have produced models for memory but so far none of these has been able to provide an adequate explanation.

B6.6 How do drugs affect our nervous systems?

1. recall that some drugs and toxins affect the transmission of impulses across synapses;
2. **understand that Ecstasy (MDMA) blocks the sites in the brain’s synapses where the chemical serotonin is removed;**
3. **understand that the mood-enhancing effects of Ecstasy are due to the subsequent increase in serotonin concentration.**

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 GCSE Science and GCSE Additional Science. Throughout the module candidates have opportunities to employ Ideas about Science from IaS1 Data and their limitations, IaS5 Risk, and IaS6 Making decisions about science and technology.

An explanation of energy flow through ecosystems extends candidates' knowledge and understanding of the interdependence of organisms. Candidates learn more about autotrophic and heterotrophic nutrition, exploring a range of nutritional interactions, including parasitism. Sickle-cell anaemia provides a useful context to draw together explanations of gene theory and evolution.

In earlier modules, candidates have considered some of the ethical implications for genetic testing. Here they learn more about the science behind this application, and also other new genetic technologies, including genetic modification and large-scale growth of microorganisms to produce, for example, antibiotics, single-cell protein and hormones. They also consider the economic, social and ethical implications for the release of genetically modified organisms.

Candidates consider their own energy requirements, learning more about respiration and their own physiology (circulatory and skeletal systems). This also provides an opportunity to consider the application of science by those practitioners who work to improve people's health and fitness.

Topics
B7.1 Living organisms are interdependent
Energy flow through ecosystems; soil.
B7.2 Photosynthesis
Importance of photosynthesis in the food chain.
B7.3 Heterotrophic nutrition
Symbiosis and commensalism; parasites.
B7.4 New technologies
DNA technologies; social, ethical and economic implications.
B7.5 Respiration
Respiration and exercise.
B7.6 Circulation
Components of blood; blood types; the circulation system.
B7.7 Skeletal systems
Skeletal system; health and fitness.

ICT Opportunities

This module offers opportunities for illustrating the use of ICT in science. For example:

- logging, storing and displaying data for analysis and evaluation;
- the integral role of ICT in DNA technologies.

Use of ICT in teaching and learning can include:

- video clips to illustrate patterns in the behaviour of living things;
- the internet to research.

MODULE B7: FURTHER BIOLOGY

B7.1 Living organisms are interdependent.

1. understand that all organisms are ultimately dependent on energy from the Sun;
2. recall that plants absorb a small percentage of this energy for the process of photosynthesis;
3. recall that this energy is stored in the chemicals which make up the plants' cells;
4. distinguish between autotrophs and heterotrophs in an ecosystem;
5. explain how 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;
6. draw and interpret pyramids of number and biomass to illustrate feeding relationships in a food chain;
7. explain the advantages of using each type of pyramid;
8. 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;
9. calculate from given data the percentage efficiency of energy transfer at different stages of a food chain;
10. recall that soil is composed of:
    a. biomass (living organisms and decaying material);
    b. inorganic material;
    c. air;
    d. water (with dissolved mineral ions);
11. calculate percentage water and biomass in soil samples (IaS1.4, 1.5, 1.6).

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MODULE B7: FURTHER BIOLOGY

B7.2 Photosynthesis.

1. recall the equation for photosynthesis:

$$\text{carbon dioxide} + \text{water} \xrightarrow{\text{light energy}} \text{glucose} + \text{oxygen}$$

2. recall the main stages of photosynthesis:
   a. light energy absorbed by the green chemical chlorophyll;
   b. energy used to rearrange the atoms of carbon dioxide and water to produce glucose (a sugar);
   c. oxygen produced as a waste product;
3. recall that this glucose may be:
   a. converted into chemicals needed for growth of plant cells, for example, cellulose, protein, chlorophyll;
   b. converted into starch for storage;
   c. used in respiration to release energy;
4. **understand that starch is a better storage molecule than glucose because it is insoluble and has little effect on the osmotic balance of the cell;**
5. **interpret data on the levels of carbon dioxide and oxygen exchanged between a plant and the surrounding atmosphere during a 24 hour period, including the compensation point;**
6. recall that the energy released by respiration may be used to synthesise polymers required by the plant cell, to include:
   a. glucose to starch and cellulose;
   b. glucose and nitrates to amino acids and then to proteins;
7. **understand that plant roots absorb nitrates by active transport;**
8. understand that rate of photosynthesis may be limited by low levels of:
   a. temperature;
   b. carbon dioxide;
   c. light intensity;
9. **interpret data on limiting factors;**
10. understand the limitations of data measuring rate of photosynthesis (IaS1.1, 1.2, 1.3);
11. understand that most scientists agree that human activity is causing an increased level of atmospheric carbon dioxide.

MODULE B7: FURTHER BIOLOGY

B7.3 Heterotrophic nutrition

1. recognise examples of symbiosis and commensalism;
2. recall parasitism as a close association between two organisms of different species which is beneficial to one (the parasite) and harmful to the other (the host);
3. recall two parasites and explain how specific features enable them to be successful;
4. understand the importance of parasites:
   a. as causes of human diseases, including malaria;
   b. for their impact on food production (both plants and animals);
5. understand that the evolution of a parasite is thought to be closely linked to that of its host;
6. **recall the symptoms of sickle-cell anaemia, caused by a faulty recessive allele;**
7. **understand that carriers of the sickle-cell allele have some protection from malaria;**
8. **understand how natural selection has resulted in an increased frequency of the sickle-cell allele in certain populations.**

MODULE B7: FURTHER BIOLOGY

B7.4 New technologies

1. recall the structure of bacteria, limited to:
   a. cell wall;
   b. cell membrane;
   c. circular DNA chromosome;
   d. DNA plasmid;
2. recall that bacteria and fungi can be grown on a large scale (fermentation) to include:
   a. production of antibiotics;
   b. production of single-cell protein;
   c. enzymes for food manufacture, for example, rennin;
3. recall the main steps in genetic modification as:
   a. isolating and replicating the required gene;
   b. transferring the gene into a new cell;
   c. use of a vector (virus or plasmid);
4. recall that genetic modification includes:
   a. bacterial synthesis of drugs and hormones, for example, insulin;
   b. disease resistance in crop plants;
5. understand that there are economic, social and ethical implications for the release of genetically modified organisms (IaS5.1, **5.5**, 6.3, **6.6**);
6. explain the use of DNA technology in genetic testing:
   a. isolating DNA from white blood cells;
   b. production of gene probe;
   c. use of UV or autoradiography to locate gene probe;

MODULE B7: FURTHER BIOLOGY

B7.5 Respiration

1. recall that energy is released from food chemicals in the process of respiration;
2. recall that aerobic respiration requires oxygen;
3. recall the equation for aerobic respiration:

   glucose + oxygen → carbon dioxide + water (+ energy released)
4. **understand that energy released during respiration is used to synthesise a chemical called ATP;**
5. **understand that ATP can be referred to as the "energy currency" of living things;**
6. recall that muscle tissue contracts when provided with energy (**ATP**) from respiration;
7. recall that during exercise, respiration in muscle cells increases to provide additional energy for movement;
8. understand that muscle cells require a faster supply of oxygen and glucose, and removal of carbon dioxide;
9. understand that this need is met by increasing heart and breathing rates;
10. understand that 'normal' measurements for factors such as heart rate and blood pressure are given within a range, and that individuals vary (IaS1.6);
11. recall the word equation for anaerobic respiration in human body cells:

    glucose → lactic acid (+ energy released)
12. recall that anaerobic respiration takes place in muscle cells when there is a shortage of oxygen and leads to a build up of lactic acid in muscles;
13. **recall that oxygen is needed to break down the lactic acid, referred to as the 'oxygen debt';**
14. **recall that aerobic respiration releases more energy per glucose molecule than anaerobic respiration;**
15. **understand that anaerobic respiration may be advantageous to human beings and other organisms in certain conditions.**

MODULE B7: FURTHER BIOLOGY

B7.6 Circulation

1. recall the components of blood and their functions:
   a. red blood cells – transporting oxygen;
   b. white blood cells – fighting infection;
   c. platelets – blood clotting at injury sites;
2. recall that the ABO blood type system describes:
   a. antigens on the surface of red blood cells;
   b. antibodies in blood plasma;
3. understand that, for blood transfusions, the donor and recipient must be matched to avoid clotting;
4. interpret compatibility data for the ABO system;
5. **recall that ABO blood type is determined by a single gene with three alleles, A, B and O;**
6. **recall that A and B are co-dominant, and that O is recessive to both;**
7. **draw and interpret genetic diagrams illustrating the inheritance of ABO blood type;**
8. describe the main structures and blood vessels of the heart;
9. explain what is meant by a double circulatory system;
10. describe the function of valves in the heart and veins;
11. recall that tissue fluid is formed as blood passes through capillary beds;
12. understand that this assists the exchange of chemicals by diffusion between capillaries and tissues, to include oxygen, carbon dioxide, glucose and urea.

MODULE B7: FURTHER BIOLOGY

B7.7 Skeletal system

1. recall that vertebrates have an internal skeleton for support and movement;
2. describe the relationship between bones, ligaments, muscles and tendons;
3. understand that muscles can only move bones at a joint by contraction, and thus operate in antagonistic pairs;
4. recall the outline structure of a joint to include:
   a. smooth layer of cartilage to prevent the bones rubbing together;
   b. synovial fluid which is oily and helps joint movement;
5. understand how the specific properties of ligaments, cartilage and tendons enable them to function effectively;
6. recall factors in a person's medical or lifestyle history that should be disclosed before treatment begins or an exercise regime is started (for example, symptoms, current medication, alcohol or tobacco consumption, level of physical activity, family medical history, previous treatments);
7. understand why this information is needed;
8. understand the advantages of regular contact between health or fitness practitioners and their patients or clients;
9. **understand why personal medical or fitness information must be recorded, stored and made available to other people on the health or fitness practitioner team;**
10. understand that treatments often have side effects and that these are weighed against the benefits gained;
11. understand that there is often more than one way to achieve an agreed target (enhanced fitness, cure, recovery, rehabilitation);
12. describe briefly one example of monitoring a person's progress (a) during treatment or fitness training (b) after this is complete;
13. understand why accurate record-keeping during treatment or fitness training is essential;
14. **understand that any assessment of progress needs to take into account the accuracy of the monitoring technique and the reliability of the data obtained;**
15. recall two examples of reasons for modifying a programme before it has been completed;
16. recall common injuries that can be caused by excessive exercise, to include sprains, dislocations, torn ligaments or tendons;
17. recall symptoms and basic treatments for a sprain;
18. describe the role of the physiotherapist in treatment of skeletal-muscular injury;
19. describe a set of exercises to treat one such injury.

4 Scheme of Assessment

4.1 Units of Assessment

GCSE Biology (J633)	
Unit 1: Biology A Unit 1 – modules B1, B2, B3 (A221)	
16.7% of the total GCSE marks 40 minutes written paper 42 marks	This question paper: • is offered in Foundation and Higher Tiers; • focuses on B1, B2, B3; • assesses knowledge and understanding of the specification content and application of that knowledge and understanding; • uses both objective style and free response questions (there is no choice of questions).
Unit 2: Biology A Unit 2 – modules B4, B5, B6 (A222)	
16.7% of the total GCSE marks 40 minutes written paper 42 marks	This question paper: • is offered in Foundation and Higher Tiers; • focuses on B4, B5, B6; • assesses knowledge and understanding of the specification content and application of that knowledge and understanding; • uses both objective style and free response questions (there is no choice of questions).
Unit 3: Biology A Unit 3 – Ideas in Context plus B7 (A223)	
33.3% of the total GCSE marks 60 minutes written paper 55 marks	This question paper: • is offered in Foundation and Higher Tiers; • assesses knowledge and understanding of the specification content and application of that knowledge and understanding; • may draw on any of the Ideas About Science in Appendix F; • uses structured questions throughout (there is no choice of questions); • incorporates pre-release material which provides the context for question 1; • starts with a question normally based on one or two of modules B1-B6. The modules can be identified from the pre-release material; • continues with questions focused on the content of B7 Further Biology; • includes some marks for communication skills.

Unit 4: Biology A Unit 4 – Practical Data Analysis and Case Study (A229)	
33.3% of the total GCSE marks skills assessment 40 marks (16 + 24)	• This skills assessment unit comprises two elements: the critical analysis of primary data and a case study of a topical (scientific) issue. • Opportunities for both elements should arise naturally during the course. • This unit is assessed by teachers, internally standardised and then externally moderated by OCR.
Unit 5: Biology A Unit 5 – Practical Investigation (A230)	
33.3% of the total GCSE marks skills assessment 40 marks	• This unit comprises five strands, which together are used to assess a complete investigative task. • This unit is assessed by teachers, internally standardised and then externally moderated by OCR.

4.2 Unit Options

Candidates take Units 1, 2 and 3 and either Unit 4 or Unit 5.

4.3 Tiers

Units 1, 2 and 3 are set 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. Candidates are entered for either the Foundation Tier or the Higher Tier using option codes F and H.

Units 4 and 5 (skills assessment) are not tiered. Candidates enter either A229, Practical Data Analysis task plus a Case Study, or A230, Practical Investigation.

Candidates may enter Units 1, 2, and 3 at different tiers, so for example, a candidate may take A221F, A222F and A223H.

4.4 Assessment Availability

There are two examination series each year, in January and June.

	Unit 1 (A221)	Unit 2 (A222)	Unit 3 (A223)	Unit 4 (A229)	Unit 5 (A230)
January 2007	-	-	-	-	-
June 2007	✓	-	-	-	-
January 2008	✓	✓	-	-	-
June 2008	✓	✓	✓	✓	✓

After June 2008, Units A221 and A222 will be available in the January and June series. The Biology Ideas in Context paper (Unit A223), and skills assessment (Units A229 and A230), will only be available in the June series.

The Foundation and Higher tier papers covering the same unit will be timetabled on the same day, and will commence at the same time. The papers timetabled simultaneously will contain common questions, or part questions, targeting the overlapping grades C and D.

4.5 Assessment Objectives

The Assessment Objectives describe the intellectual and practical skills which candidates should be able to demonstrate, in the context of the prescribed content. Candidates should demonstrate communication skills, including ICT, using scientific conventions (including chemical equations) and mathematical language (including formulae).

Assessment Objective 1 (AO1): Knowledge and understanding of science and how science works

Candidates should be able to:

- demonstrate knowledge and understanding of the scientific facts, concepts techniques and terminology in the specification;
- show understanding of how scientific evidence is collected and its relationship with scientific explanations and theories;
- show understanding of how scientific knowledge and ideas change over time and how these changes are validated.

Assessment Objective 2 (AO2): Application of skills knowledge and understanding

Candidates should be able to:

- apply concepts, develop arguments or draw conclusions related to familiar and unfamiliar situations;
- plan a scientific task, such as a practical procedure, testing an idea, answering a question or solving a problem;
- show understanding of how decisions about science and technology are made in different situations, including contemporary situations and those raising ethical issues;
- evaluate the impact of scientific developments or processes on individuals, communities or the environment.

Assessment Objective 3 (AO3): Practical, enquiry and data-handling skills

Candidates should be able to:

- carry out practical tasks safely and skillfully;
- evaluate the methods they use when collecting first-hand and secondary data;
- analyse and interpret qualitative and quantitative data from different sources;
- consider the validity and reliability of data in presenting and justifying conclusions.

4.5.1 Weighting of Assessment Objectives

All figures given are for guidance only and have a tolerance of ±3%.

Assessment Objectives	Weighting
AO1: Knowledge and understanding	30.0%
AO2: Application of knowledge and understanding, analysis and evaluation	40.6%
AO3: Enquiry	29.3%

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

	Weighting of Assessment Objectives by Unit			
	AO1	AO2	AO3	Total
Unit 1 (A221), Unit 2 (A222)	15%	16.3%	2.0%	33.3%
Unit 3 (A223)	13%	18.3%	2.0%	33.3%
Unit 4 (A229), Unit 5 (A230)	2%	6%	25.3%	33.3%
Overall	30%	40.6%	29.3%	100%

4.6 Quality of Written Communication

In the question papers, differentiation is achieved by the use of two tiers of entry, by setting questions which are designed to assess candidates at their appropriate level of attainment, and which are intended to allow all candidates to demonstrate what they know, understand and can do. In skills assessment, differentiation is by task and by outcome. Candidates undertake tasks that allow them to display positive achievement.

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.

Candidates' quality of written communication will be assessed in the Ideas in Context paper (A223) and in the Case Study (A229) or Practical Investigation (A230).

5 Skills Assessment

5.1 Nature of Skills Assessment

Rationale

The skills assessment accounts for 33.3% of the marks for this specification. There is some choice of the material that is presented for assessment. However it is hoped that candidates have opportunities to develop their skills in all aspects of the tasks described here and then present the highest scoring piece of work.

All internally assessed coursework must be set in a context appropriate to the qualification in which it is to be used. For example, coursework to be credited towards GCSE Biology must be set in a context drawn from the Biology specification or closely related to it.

Skills assessment should arise naturally out of teaching, so that it can be assessed by teachers, internally standardised and then externally moderated by OCR. Candidates are required to submit work for either Unit 4 (A229) or Unit 5 (A230).

Practical Data analysis and Case study (Unit 4, A229)

The Unit 4 skills assessment comprises two elements: the critical analysis of primary data, and a Case Study on a topical (scientific) issue.

First-hand experience of the problems of collecting valid and reliable data can give candidates a better sense of what the difficulties really are, a 'feel' for how great they are in specific cases, and provide a context for beginning to understand how to tackle and perhaps overcome them. Analysis and interpretation of data teaches how scientists use experimental evidence to develop and test theories. Evaluation of procedures and data shows how the reliability of scientific findings can be assessed.

The Case Study is designed to motivate candidates and give them an insight into how science is reported to the public, and how they can explore the validity of underlying research and claims or recommendations based on the research. Centres should note that marks for both elements of Unit 4 (A229) must be submitted in the same examination session.

Element 1: Data Analysis: Marks submitted out of 16

Candidates either singly or collaboratively take part in a practical procedure in order to collect primary data. Candidates are assessed on their ability to analyse and evaluate the data collected and the limitations of the techniques used. It is not essential for candidates to collect all of the data which is to be used in this exercise. Their own first hand data may be supplemented with extra data from other candidates or classes, demonstrations or other sources.

Marks are awarded for two strands, Interpretation (Strand I) and Evaluation (Strand E). The two marks which make up the assessment total for this element of skills assessment must both come from the same activity.

Element 2: Case Study Marks submitted out of 24

This assignment should arise naturally from work on the course or from an issue that arises while candidates are following the course. It should be related to an aspect of science that involves an element of controversy, in terms either of the interpretation of evidence, or of the acceptability of some new development. Topics for study should be selected by candidates in discussion with teachers, and should be seen as an extension or consolidation of studies undertaken as a normal part of the course. The work should be capable of being completed within approximately 4-6 hours over a period of time, for example, one lesson per week for half a term, with some non-contact time.

Practical Investigation (Unit 5, A230)

The use of practical investigations to assess skills in science was based on research in a number of centres, particularly the University of Durham. For more than 10 years, it has formed the basis of coursework assessment for National Curriculum science.

Investigations require the drawing together of skills in planning, collecting data, interpreting data and evaluation. They provide an effective and valid assessment instrument for a course which is seen as a basis for further studies and possible future careers in science. However, the regulations used at Key Stage 4 over the past 5-year cycle have been constructed in a way which has restricted the variety of work attempted and has led to rather mechanical ‘criterion matching’, rather than genuine open-ended work.

For this specification, the basic structure of investigations is retained, but the emphasis on prediction is removed, allowing a much wider range of activities and approaches. A different marking style has been developed, drawing more on the professional judgment of teachers.

The task aims to motivate candidates and help them to appreciate the importance of having a clear and manageable question, to learn how to choose equipment and use it appropriately, and to design suitable apparatus for making observations and measurements. First-hand experience of the problems of collecting valid and reliable data can give candidates a better sense of what the difficulties really are, and a 'feel' for how great they are in specific cases, and provide a context for beginning to understand how to tackle and perhaps overcome these.

Candidates are required to complete one single practical investigation. The Investigation, accounts for 33% of the marks for this specification. It is assessed by teachers, internally standardised, and then externally moderated.

Within this science suite, investigative work is designed to have a broad definition. In addition to confirming the predicted effect of a variable on a system over a range, the definition also includes more speculative investigation of systems where no clear prediction can be made in advance, e.g. where there is little relevant explanatory theory available in the course, or where the experimental material is likely to be variable, for example in surveys of distribution of species. It also includes tasks which involve determining the consistency of measurements e.g. comparing the characteristics of different artefacts, obtaining evidence for the ‘normal’ variation in respiratory peak flow-rates of an individual, etc.

The initial stimulus for an investigation should arise from class teaching or discussion which ensures that candidates are aware of suitable practical techniques and have some relevant background theoretical knowledge.

This unit of assessment is based on complete, first-hand practical investigations. Candidates may complete as many investigations as they wish during the course. The final mark will be the total for the highest-scoring single piece of work assessed. It is not permitted to aggregate together marks taken from different investigations. Where appropriate, first-hand data collected by the candidate may be supplemented by secondary data from other sources. In such cases, credit for collecting data should be based on the overall quality of all the data obtained or selected.

Marks are awarded for 5 strands of the investigation, with each strand marked on a scale of 0 – 8.

5.2 Marking Internally Assessed Work

Arrival at Strand Marks

The method of marking the skills assessment is the same across this Science suite.

The award of marks is based on the professional judgement of the science teacher, working within a framework of descriptions of performance. Within each strand, each line in the marking grids represents a different aspect of performance. For each of these, a series of four descriptions of performance illustrates what might be expected for candidates working at different levels.

Marking decisions should be recorded on marking grids. A master copy is provided in the skills assessment guidance booklet. The completed grid serves as a cover-sheet for the work if it is required for moderation.

Candidates may not always report their work in a particular order. So, evidence of achievement in a strand may be located almost anywhere in the work. Thus, it is necessary to look at the whole piece of work for evidence of each strand in turn.

Within any one strand, each aspect should be considered in turn. There must be clear evidence in a candidate's work to support the lower marks in an aspect before higher ones can be matched. A tick on the grid should be used to indicate the performance statement that best matches the work.

Where the maximum mark is 8, intermediate marks 1, 3, 5 or 7 can be used where performance exceeds that required by one statement, but does not adequately match that required by the next higher statement (e.g. if the work significantly exceeds what is required for 4 marks, but does not reach the standard for 6, then the tick should be placed on the dividing line between the 4 and 6 mark boxes).

Where a decision is based partly on the teacher' observation of the candidate at work, the work should be annotated to record this at an appropriate point.

In some cases, in order to allow credit for the widest possible variety of activities, an aspect of performance is represented by two (or more) rows of mark descriptors separated by dashed lines. In such cases, where a row is not relevant or appropriate for a particular activity, it should be left blank and excluded from the 'best-fit' marking judgement and the more appropriate alternative row(s) used.

When each aspect of the performance within a strand has been assessed in this way, the pattern of achievement is interpreted by a 'best-fit' judgement to give a mark for that strand.

This method of marking can be applied even where there is a wide variation between performance in different aspects. Thus, weak performance in one aspect need not depress marks too far if other aspects show better performance.

Recording and submitting marks

Skills Assessment Forms will be provided for centres to record marks submitted for moderation. The final mark should be submitted to OCR on form MS1 by **15th May** in the year of entry. These forms are produced and dispatched at the relevant time, based on entry information provided by the Centre.

All assessed work which has contributed to candidates' final totals must be available for moderation.

Unit 4 (A229), Element 1: Practical Data Analysis (13.3%)

Marking Criteria – Practical Data Analysis

There are two strands in this element; Interpreting Data and Evaluation. The descriptors for each strand are identical to those found in the Unit 5 Practical Investigation (A230).

Strand I: Interpreting Data

Candidates are expected to be able to:

- present or process a set of data in such a manner as to bring out any 'patterns'[1] that are present (IaS1.4, 2.1, 2.3-4);
- state conclusions based on these patterns (IaS 2.4);
- relate their conclusions to scientific theories or understanding (IaS 3.1, 3.3, 3.4).

In the following table, each row represents increasing achievement in a different aspect of performance.

Aspect of Performance	Strand I Mark			
	2	4	6	8
a graphical or numerical processing of data	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 (normally a line of best fit) or construct complex charts or diagrams (e.g. stacked histograms, species distribution maps).	Additionally, indicate the spread of data (e.g. through scatter-graphs or range bars) and give clear keys for displays involving multiple data sets.
	Select individual results as a basis for conclusions.	Carry out simple calculations (e.g. 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 (e.g. statistical methods, use of inverse relationships or calculation of gradient of graphs).
b summary of evidence	Note differences between situations/ cases, or compare individual results.	Identify trends or general correlations in the data.	Describe formal or statistical relationships within the cases/situations studied.	Review the extent of, or limitations to, formal conclusions in relation to the scatter evident in the data.
c explanations suggested	Link the outcomes to previous experience or 'common sense'.	Relate the conclusion to scientific ideas/ explanations.	Justify the conclusion by reference to relevant scientific knowledge and understanding.	Use detailed scientific knowledge to explain all aspects of the given conclusion.

[1] 'Patterns' here means similarities, or differences, or the presence or absence of a relationship (e.g. a correlation between a factor and an outcome, or a trend linking two variables)

Strand E: Evaluation

Candidates are expected to be able to look back at the experiment they have carried out, showing what they have learned from doing it and explaining how they would modify it in the light of this, were they to carry it out again. These suggestions may demonstrate understanding of:

- difficulties in collecting valid and reliable data (IaS 1.1-3);
- weaknesses in the design of the data set collected, such as imperfect control of independent variables, inadequate sample sizes and poor matching of the samples compared (IaS 2.3, 2.6-7);
- assessing the level of confidence that can be placed in these conclusions (IaS 2.2-3, 2.6-7).

In the following table, each row represents increasing achievement in a different aspect of performance.

Aspect of Performance	Strand E Mark			
	2	4	6	8
a evaluation of procedures	Make a relevant comment about how the data was collected and safety procedures.	Comment on the limitations to accuracy or range of data imposed by the techniques and equipment used.	Suggest improvements to apparatus or techniques, or alternative ways to collect the data, but without sufficient practical detail.	Describe in detail improvements to the apparatus or techniques, or alternative ways to collect the data, and explain why they would be an improvement.
b reliability of evidence	Make a claim for accuracy or reliability, but without appropriate reference to the data.	Note the presence or absence of results that are beyond the range of experimental error.	Use the general pattern of results or degree or scatter between repeats as a basis for assessing accuracy and reliability.	Consider critically the reliability of the evidence, accounting for any outliers.
c reliability of conclusion	Relate judgement of the reliability (or otherwise) of the conclusions only to techniques used, not to data collected.	Link confidence in the conclusion to the apparent reliability of the data collected.	Discuss the precision of apparatus and techniques, the range covered and reliability of data to establish a level of confidence in the conclusions.	Identify weaknesses in the data and give a detailed explanation of what further data would help to make the conclusion more secure.

Unit 4 (A229), Element 2: Case Study

The candidate presents one Case Study, a report based on detailed study of a chosen topic.

Choosing a topic

In everyday life, citizens most often become aware of science-related issues through reports in the media: newspapers, teenage magazines, television, etc. This element of the assessment is designed to help candidates develop strategies for evaluating such information, and to increase awareness of appropriate ways of making decisions about such issues.

Ideally, the study should arise from such a media source. Suitable topics involve some degree of controversy, or disagreement, either about the interpretation of the scientific evidence, or about how individuals or society should respond. The title for a Case Study is best phrased as a question to be answered by careful balancing of evidence and opinions from a variety of sources.

Suitable topics often fall into one of three main types:

- Evaluating claims where there is uncertainty in scientific knowledge (e.g. "Is there life elsewhere in the Solar System?" or "Does using mobile phones cause risk of brain damage?") Controversies of this type focus attention on the relationship between data and explanations in science, and on the quality of research which underlies competing claims.
- Contributing to decision making on a science-related issue (e.g. "Should the government restrict research into human cloning?") Studies in this category are more likely to involve elements of personal choice, values and beliefs, and may involve balancing of risks and benefits of any proposed action.
- Personal or social choices (e.g. "Should my child receive the triple MMR vaccine?"). Ethical and personal issues are likely to figure in such studies, but it is important to evaluate these in relation to what is known about the science which underlies the issue.

In all cases, an important factor in choice of subject should be the availability of information giving a variety of views in forms that can be accessed by the candidate. Candidates may be provided with the initial stimulus for the study, but should be encouraged to search for a range of opinions in order to reach a balanced conclusion.

The subject need not be restricted to topics studied in the course. However, it is necessary for the candidate to apply some relevant scientific knowledge and understanding to discussion of the issues raised. This is most likely to be the case if the study arises naturally during normal work on the course.

Candidates need not all study the same, or related, topics. Motivation is greatest if they are given some degree of autonomy in the choice of topic. This may be achieved by allowing choice of different issues related to a general topic (e.g. different aspects of cloning when studying You and Your Genes) or by encouraging candidates to identify topics of interest and begin collecting resource materials over an extended period. At a time chosen by the centre, candidates then complete their Case Study, and may each be working on different topics.

Presentation of the Case Study

Candidates will find it helpful to have a clear sense of audience in their writing – perhaps candidates in year 9, to encourage them to explain the basic science behind the topic.

The Case Study will often take the form of a 'formal' written report. However, candidates should not be discouraged from other styles of presentation, for example:

- a newspaper or magazine article;
- a PowerPoint presentation;
- a poster or booklet;
- a teaching/learning activity such as a game;
- a script for a radio programme or play.

In all cases, sufficient detail must be included to allow evaluation in all of the performance areas. Some types of presentation would require supporting notes.

A Case Study represents a major piece of work and it is not expected that candidates will attempt more than one during the two years of the course. If a candidate has attempted more than one case study, then the total for the assessment should be the highest total for any **one** case study.

It is **not** permitted to aggregate marks from two or more different pieces of work, nor to add marks obtained from separate, limited range tasks, exercises or part-studies.

Marking Criteria – Case Study

Marks are awarded under four headings, A, B, C and D.

Because of the risk of some studies becoming excessively long, it is important to link marks to the quality of the work done, rather than the quantity.

The four strands to be awarded credit are:

A: Quality of selection and use of information, on a scale of 0-4marks;

Here candidates should show an awareness of sources of information such as their own notes, text books or encyclopedias, or the internet. They should consider the reliability of any sources used. All sources should be credited, and it should be clear where each piece of information has come from. Credit is given for being selective in choosing only relevant material. Direct quotations should be acknowledged.

B: Quality of understanding of the case, on a scale of 0-8 marks;

Candidates should describe the basic science which helps understanding of the topic, and apply it to evaluate the reliability of claims made. In many cases, they may follow a topic beyond the normal limits of the specification, and credit should be awarded for understanding whether within or beyond the specification.

C: Quality of conclusions, on a scale of 0-8 marks;

Different evidence, arguments or views should be compared and evaluated and used as a basis for a balanced conclusion or proposal for action.

D: Quality of presentation, on a scale of 0-4 marks.

Communication skills should be rewarded for effective presentation including use of different forms for presenting different types of information (e.g. pictures, tables, charts, graphs, etc).

Strand A: Quality of Selection and Use of Information

Candidates will select and organise information from a variety of sources, bearing in mind both relevance to the study and the apparent reliability of the sources. It is expected that centres will make at least a basic selection of resources available for candidates to work from. A survey of the units included in the course will identify topics which are likely to be relevant, topical and of interest to candidates. In addition to standard textbooks and library books, resources are available from industry, from environmental groups and in popular science magazines, as well as through the internet.

Candidates should be encouraged to seek out their own additional resources, but should not be completely dependent on this, and in particular, should not be dependent on home or out of school support.

Credit will be given for selection of appropriate material from the available resources, rather than indiscriminate copying. It will also be given for judgement shown in selecting from a variety of sources to give a balanced view of the topic. Good work is characterised by the ability of the candidate to adapt and re-structure information to suit the purpose of the study.

In some cases, candidates may wish to collect information about the public acceptability of an idea or perception of risk through questionnaires (administered to classmates or other groups) or to test media claims through experimental work. Whilst relevant work of these types may be credited, it should not dominate the study.

In all cases, candidates should record the sources of information they have used. The assignment can be used as an introduction to the value of crediting sources in scientific communication.

Candidates should show awareness of the variety of sources of information relevant to science-based issues, and some understanding that the reliability of sources may vary.

This aspect of the work is linked to understanding of Ideas-about-Science 4: The Scientific Community (mainly IaS 4.1, 4.2, 4.3 and 4.4).

Aspect of Performance	Strand A Mark			
	1	2	3	4
a planning the use of sources of information	Very little information is given beyond that provided by the original stimulus material.	Information from a limited range of additional sources is included, although some may be irrelevant or inappropriate to the study.	Relevant information is selected from a variety of sources.	Sources of information are assessed for reliability as a basis for selection of relevant information from a wide variety of sources.
b Acknowledgement of sources used		Sources are identified by incomplete or inadequate references.	References to sources are clear, but limited in detail.	References to these sources are clear and fully detailed.
c Linking information to specific sources		Direct quotations are rarely indicated as such.	Direct quotations are generally acknowledged.	The sources of particular opinions are indicated at appropriate points in the text of the report.

Strand B: Quality of Understanding of the Case

Where possible, candidates should make reference to explanatory scientific theory to help them understand the significance of the information they are dealing with. However, controversies in science often arise in areas where there is no (GCSE level) descriptive theory to provide a basis for understanding and evaluating the issues involved. In such cases, candidates should draw on Ideas about Science, especially IaS 2 (Correlation and cause) to justify the conclusions they reach about the information they have collected.

Note that these studies should not be used to extend or assess the candidate's knowledge of basic academic theory related to the topic, but rather to encourage them to see how the science knowledge they have can be related to topical issues to help them reach valid judgements. Some candidates may wish to go beyond what they have been taught in class and, if they find and correctly apply theory which is directly relevant to the Case Study, this can help to raise their mark. However, credit should not be given to uncritical copying of large amounts of theory from texts.

Candidates should provide some background to the case study in relation to relevant scientific theory. They should also evaluate how well-founded are links between the available evidence and claims or views made on the basis of the evidence. Where little explanatory theory is available at this level, candidates should draw on Ideas about Science 2, 3 and 4 to help them evaluate the evidence they find.

This aspect of the work depends on understanding of:

Ideas about Science 1: Data and their limitations (mainly 1.2, 1.3 and 1.4);

Ideas about Science 2: Correlation and cause (mainly 2.1, 2.2, 2.4 - 2.7).

Aspect of Performance	Strand B Mark			
	2	4	6	8
a making use of science explanations	Only superficial mentions of science explanations, often not correctly applied to the case.	Provides a basic outline of the main scientific ideas which are relevant to the case.	Provides a detailed review of the scientific knowledge needed to understand the issues studied.	Considers how different views described in the study can be supported by detailed scientific explanations.
b recognition and evaluation of scientific evidence	Sources are uncritically quoted without distinguishing between scientific evidence and unsupported claims.	Science content and data in sources is recognised.	Claims and opinions are linked to the scientific evidence they are based on.	The quality of scientific evidence in sources is evaluated in relation to the reliability of any claims made.

Strand C: Quality of Conclusions

The work should take account of different views or opinions which are represented in the information collected. Credit will be given for discussion of the perceived benefits and associated risks of any proposed actions, and for judgements of the acceptability of any conclusions reached.

The case studied should be such that there is scope for taking views about the acceptability of some view or course of action.

Work on this aspect of the Case Study will be linked to understanding of:

Ideas about Science 1: Data and their limitations (mainly parts 1.2 and 1.4);

Ideas about Science 5: Risk (mainly parts 5.1, 5.2, 5.4, 5.6 and 5.7);

Ideas about Science 6: Making decisions about science and technology (mainly parts 6.3, 6.4, 6.5 and 6.6).

Aspect of Performance	Strand C Mark			
	2	4	6	8
a comparing opposing evidence and views	Information is unselectively reported without taking any clear view about any course of action.	Claims for a particular idea, development or course of action are reported without critical comment.	Claims and arguments for and against are reported, but with little attempt to compare or evaluate them.	Details of opposing views are evaluated and critically compared.
b conclusions and recommendations	A conclusion is stated without reference to supporting evidence.	A conclusion is based on evidence for one view only.	Some limits or objections to the conclusion are acknowledged.	Alternative conclusions are considered, showing awareness that different interpretations of evidence may be possible.

Strand D: Quality of Presentation

Candidates should be encouraged to be creative and imaginative in their choice of method and media for communicating their findings. Whatever form of presentation is chosen, it should be supported by sufficient documentation to allow assessment of all four qualities. It should also be remembered that the work may need to be posted to a moderator towards the end of the course. Where electronic media are included, a paper print-out must be provided for moderation purposes.

Note that quality and fitness for purpose should be rewarded in the assessment, rather than the sheer quantity of the work.

Where written reports are given, candidates should be encouraged to structure the report clearly. An attractive cover helps to improve motivation and make the work "special", thinking about a good structure for the contents can help candidates to organise their ideas. Use of tables of contents, and sub-headings between sections of text are valuable in this context.

Illustrations should be used where they lead to clearer communication of ideas. These may be taken from resource leaflets or 'clip-art' sources, or drawn by candidates: they may be pictorial or graphical. Tables, charts and graphs should be used to present and summarise data. Reports may be hand-written or word-processed.

Candidates should be encouraged to think carefully of their target audience and how to communicate their ideas clearly.

Aspect of Performance	Strand D Mark			
	1	2	3	4
a structure and organisation of the report	The report has little or no structure or coherence, or follows a pattern provided by worksheets.	The report has an appropriate sequence or structure.	Information is organised for effective communication of ideas, with contents listing, page numbering etc. as appropriate to aid location of key elements.	Considerable care has been taken to match presentation and format to present issues and conclusions clearly and effectively to a chosen audience.
b use of visual means of communication	There is little or no visual material (charts, graphs, pictures etc.) to support the text.	Visual material is merely decorative, rather than informative.	Visual material is used to convey information or illustrate concepts.	Pictures, diagrams, charts and or tables are used appropriately and effectively to convey information or illustrate concepts.
c spelling, punctuation and grammar	Spelling, punctuation and grammar are of generally poor quality, with little or no use of appropriate technical or scientific vocabulary.	Spelling, punctuation and grammar are of variable quality, with limited use of appropriate technical or scientific vocabulary.	Spelling, punctuation and grammar are generally sound, with adequate use of appropriate technical or scientific vocabulary.	The report is concise, with full and effective use of relevant scientific terminology. Spelling, punctuation and grammar are almost faultless.

Unit 5 (A230), Practical Investigation

This unit is designed to test the ability of the candidate to plan and undertake a whole investigation or problem-solving task. Scoring individual marks in different tasks, or parts of tasks, removes this holistic element, and can result in performances of very different quality leading to the same final assessment total. For this reason, the final unit mark for each candidate will be the highest total mark achieved on any one task. This total mark is obtained by adding together the marks achieved on each strand of the work on that task.

The requirement is for the highest mark from a single piece of work. It is not essential for this to be complete, in the sense of providing evidence across all strands. It may happen that some candidates achieve their highest total for a piece of work in which evidence for one or more strands is missing; in such cases this total should be chosen as the final assessment total.

Centres may assess the performance of candidates on any occasion when investigative work is taking place throughout the course.

Marking Criteria – Practical Investigation

Strand S: Strategy

Practical investigations are likely to arise out of work on most or all of the course modules. Suitable tasks might be suggested to candidates, but they should also have opportunities to modify or extend these, or to suggest questions or tasks to investigate in topic areas they are studying. Candidates can (and should) obtain more credit for tackling somewhat more demanding tasks, and for being involved in devising the question/task, rather than 'playing safe' with a given, or routine task, or one involving little skill in the use of equipment.

Whilst candidates should be encouraged to plan an investigation before starting, there is limited value in requiring them to produce a detailed written plan – as their actions should be open to modification as they proceed. Indeed, it is good practice to try taking a few measurements or making a few observations to get a 'feel' for the equipment and the system being investigated, before planning a detailed data collection strategy. For that reason, the candidate's understanding of issues concerning data is better assessed from the final data set they present (see strand C below), rather than from an initial plan.

Assessment of the quality of strand S focuses on –

- the complexity and demand of the task and approach chosen;
- the choice of equipment, materials and techniques;
- the degree of independence shown in formulating the task and the approach to it.

Aspect of Performance	Strand S Mark 2	4	6	8
a evaluation of procedures	Simple measurement or comparison task, based on straight-forward use of simple equipment	Routine task requiring only limited precision or range of data to be collected.	Straightforward task of limited complexity, but requiring good precision or a wide range of data.	Complex task requiring high levels of precision/reliability in the data collected.
b reliability of evidence	Follow a given technique, but with very limited precision or reliability.	Select and use basic equipment to collect a limited amount of data.	Select and use techniques and equipment which are appropriate for the range of data required.	Justify the choice of equipment and technique to achieve data which is precise and reliable.
c reliability of conclusion	The task has been set by the teacher and/or is based on specific, task-related structured worksheets.	The task is closely defined by the teacher, but is carried out with little further guidance.	The task is defined by the candidate from a more general brief, then carried out independently.	The topic is reviewed by the candidate to justify a choice of task. The work is completed independently.

Strand C: Collecting Data

Candidates are expected to be able to collect a set of data in a manner which shows understanding of how to ensure (and assess) quality.

The quality of a data set depends on:

- the quality of individual data points, which in turn depends on:
    - o how carefully the measurements have been taken, and how accurate the available instruments are (IaS 1.1-2);
    - o how much variation or scatter there is in repeated measurements and the steps that have been taken to assess and deal with this (IaS 1.1-4);
    - o whether the instruments used, or the way they are used, results in measurements that differ from the 'true' value of the quantity (IaS 1.1-2).
- the extent and design of the set of data points collected, that is:
    - o whether enough data points have been collected (IaS 2.1, 2.3, 2.7);
    - o whether these cover an adequate range (of cases, or situations, or values of an independent variable) (IaS 2.3);
    - o (if a relationship is being explored) whether the design of the data set enables the effect of other variables to be excluded. (IaS 2.2-3, 2.6-7).

Candidates should use preliminary experiments or other information to confirm that their choices of techniques and range of values to be tested will lead to results of good quality.

The statements are written to refer to primary data that the candidate has collected. Where this is supported by data from secondary sources, the statements should be read as referring to the data 'selected' (as opposed to 'collected'). The mark awarded should be based on all of the data considered as a whole.

	Aspect of Performance	Strand C Mark			
		2	4	6	8
a	identification and control of interfering factors	Little or no care has been taken to identify or control outside influences.	Identifies some factors which may affect the outcomes and need to be controlled or accounted for.	Identifies the majority of factors which may affect the outcomes and need to be controlled or accounted for.	Reviews factors which might affect the outcomes and describes how they have been controlled or account for.
b	extent and design of data set	The data is very limited in amount (e.g. isolated individual data points, with no clear pattern), covering only part of the range of relevant cases/ situations, with no checking for reliability.	An adequate amount or range of data is collected, but with little or no checking for reliability.	Data is collected to cover the range of relevant cases/ situations, with regular repeats or checks for reliability.	Values tested are well-chosen across the range, with regular repeats and appropriate handling of any outliers. Preliminary tests are used to establish the range.
c	quality/ precision of manipulation	Little care evident in use of apparatus. Data generally of low quality.	Use of techniques and apparatus generally satisfactory. Data of variable quality, with some operator error apparent.	Sound techniques in use of apparatus/ equipment. Data of generally good quality.	Consistent precision and skill shown in use of apparatus/ equipment. Where appropriate, checks or preliminary work are included to confirm or adapt the apparatus or techniques to ensure data of high quality.

Strand I: Interpreting Data

Candidates are expected to be able to:

- present or process a set of data in such a manner as to bring out any ‘patterns’[2] that are present (IaS1.4, 2.1, 2.3-4);
- state conclusions based on these patterns (IaS 2.4);
- relate their conclusions to scientific theories or understanding (IaS 3.1, 3.4, 3.5).

Aspect of Performance	Strand I Mark			
	2	4	6	8
a graphical or numerical processing of data	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 (normally a line of best fit) or construct complex charts or diagrams (e.g. stacked histograms, species distribution maps).	Additionally, indicate the spread of data (e.g. through scatter-graphs or range bars) and give clear keys for displays involving multiple data sets.
	Select individual results as a basis for conclusions.	Carry out simple calculations (e.g. 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 (e.g. statistical methods, use of inverse relationships or calculation of gradient of graphs).
b summary of evidence	Note differences between situations/ cases, or compare individual results.	Identify trends or general correlations in the data.	Describe formal or statistical relationships within the cases/situations studied.	Review the extent of, or limitations to, formal conclusions in relation to the scatter evident in the data.
c explanations suggested	Link the outcomes to previous experience or ‘common sense’.	Relate the conclusion to scientific ideas/ explanations.	Justify the conclusion by reference to relevant scientific knowledge and understanding.	Use detailed scientific knowledge to explain all aspects of the given conclusion.

[2] ‘Patterns’ here means similarities, or differences, or the presence or absence of a relationship (e.g. a correlation between a factor and an outcome, or a trend linking two variables)

Strand E: Evaluation

Candidates are expected to be able to look back at the investigation they have carried out, showing what they have learned from doing it and explaining how they would modify it in the light of this, were they to carry it out again. These suggestions may demonstrate understanding of:

- difficulties in collecting valid and reliable data (IaS 1.1-2);
- weaknesses in the design of the data set collected, such as imperfect control of independent variables, inadequate sample sizes and poorly matching of the samples compared (IaS 2.3, 2.6-7);
- assessing the level of confidence that can be placed in these conclusions (IaS 2.2-3, 2.7-8).

Aspect of Performance	Strand E Mark			
	2	4	6	8
a evaluation of procedures	Make a relevant comment about how the data was collected and safety procedures.	Comment on the limitations to accuracy or range of data imposed by the techniques and equipment used.	Suggest improvements to apparatus or techniques, or alternative ways to collect the data, but without sufficient practical detail.	Describe in detail improvements to the apparatus or techniques, or alternative ways to collect the data, and explain why they would be an improvement.
b reliability of evidence	Make a claim for accuracy or reliability, but without appropriate reference to the data.	Note the presence or absence of results that are beyond the range of experimental error.	Use the general pattern of results or degree or scatter between repeats as a basis for assessing accuracy and reliability.	Consider critically the reliability of the evidence, accounting for any outliers.
c reliability of conclusion	Relate judgement of the reliability (or otherwise) of the conclusions only to techniques used, not to data collected.	Link confidence in the conclusion to the apparent reliability of the data collected.	Discuss the precision of apparatus and techniques, the range covered and reliability of data to establish a level of confidence in the conclusions.	Identify weaknesses in the data and give a detailed explanation of what further data would help to make the conclusion more secure.

Strand P: Presentation

The ability to report clearly and effectively on one's work is essential in order to demonstrate understanding of the Ideas about Science that relate to practical investigations.

Credit is awarded for three aspects of reporting and communicating a practical investigation:

- completeness of the report, with all practical procedures clearly described, all parameters and evidence reported, a full analysis of the evidence, and an evaluation of both procedures and evidence;
- presentation of the report, including layout and effective sequencing, use of illustrations as appropriate and use of graphs and charts to present information;
- correct use of English, including accurate grammar, punctuation and appropriate use of scientific terms.

In the following table each row represents increasing achievement in a different aspect of performance.

Aspect of Performance	Strand P Mark			
	2	4	6	8
a Description of work planned and carried out	The purpose/ context of the investigation is not made clear. Key features of experi-mental procedures are omitted or unclear.	The purpose of the work is stated. Main features of the work are described, but there is a lack of detail.	There is a clear statement of the question/task and its scope. Practical procedures are clearly described.	All aspects of the task are reviewed. Practical procedures are discussed critically and in detail.
b Recording of data	Major experimental parameters are not recorded. Some data may be missing.	Most relevant data is recorded, but where repeats have been used, average values rather than raw data may be recorded.	All raw data, including repeat values, are recorded.	All relevant parameters and raw data including repeat values are recorded to an appropriate degree of accuracy.
	Labelling of tables is inadequate. Most units are absent or incorrect.	Labelling is unclear or incomplete. Some units may be absent or incorrect.	All quantities are identified, but some units may be omitted.	A substantial body of information is correctly recorded to an appropriate level of accuracy in well-organised ways.
	Observations are incomplete or sketchily recorded.	Recording of observations is adequate but lacks detail.	Observations are adequate and clearly recorded.	Observations are thorough and recorded in full detail.
c General quality of communication	Spelling, punctuation and grammar are of generally poor quality. Little or no relevant technical or scientific vocabulary is used.	Use of appropriate vocabulary is limited. Spelling, punctuation and grammar are of very variable quality.	Appropriate scientific vocabulary is used. Spelling, punctuation and grammar are generally sound.	There is full and effective use of relevant scientific terminology. Spelling, punctuation and grammar are almost faultless.

5.3 Regulations for Internally Assessed Work

Supervision and Authentication of work

OCR expects teachers to supervise and guide candidates who are undertaking work that is internally assessed. The degree of teacher guidance will vary according to the kind of work being undertaken. It should be remembered, however, that candidates are required to reach their own judgements and conclusions.

When supervising internally assessed tasks, teachers are expected to:

- offer candidates advice about how best to approach such tasks;
- exercise supervision of work in order to monitor progress and to prevent plagiarism;
- ensure that the work is completed in accordance with the specification requirements and can be assessed in accordance with the specified mark descriptions and procedures.

Coursework should, wherever possible, be carried out under supervision. However, it is accepted that some tasks may require candidates to undertake work outside the Centre. Where this is the case, the Centre must ensure that sufficient supervised work takes place to allow the teachers concerned to authenticate each candidate's work with confidence.

Production and Presentation of internally assessed work

Candidates must observe certain procedures in the production of internally assessed work.

- Any copied material must be suitably acknowledged.
- Where work is includes secondary data, the original sources must be clearly identified.
- Each candidate's assessed work submitted for moderation should be stapled together at the top left hand corner and have a completed cover sheet as the first page.

Annotation of Candidates' Work

Each piece of assessed work should be annotated to show how the marks have been awarded in relation to the mark descriptions.

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 of coursework.

However, the main purpose of annotating candidates' coursework is to provide a means of communication between teacher and moderator, showing where marks have been awarded and why they have been awarded.

Annotations should be made at appropriate points in the margins of the script of all work submitted for moderation. The annotations should indicate where achievement for a particular skill has been recognised.

It is suggested that the minimum which is necessary is that the 'shorthand' mark descriptions (for example, Ea8) should be written at the point on the script where it is judged that the work has met the mark description.

Moderation

All internally assessed work is marked by the teacher and internally standardised by the Centre. Marks are then submitted to OCR by a specified date, after which moderation takes place in accordance with OCR procedures. The purpose of moderation is to ensure that the standard of the award of marks is the same for each Centre and that each teacher has applied the standards appropriately across the range of candidates within the Centre.

It is the responsibility of the Centre to carry out effective internal standardisation to ensure that similar standards are applied by each teacher involved in the assessment. The Moderator will require a written statement describing how internal standardisation has been carried out within the Centre.

External moderation will be by postal sample selected by the Moderator.

The sample will represent performance across the whole ability range from the Centre. The sample of work which is presented to the Moderator for moderation must show how the marks have been awarded in relation to the mark descriptions.

Separate cover sheets are required for each candidate's work in the sample submitted for moderation.

Minimum Requirements for internally assessed work

If a candidate submits no work for this internally assessed unit, then the candidate should be indicated as being absent from that unit on the mark sheets submitted to OCR. If a candidate completes any work at all for an internally assessed unit, then the work should be assessed according to the criteria and mark descriptions and the appropriate mark awarded, which may be zero.

6 Technical Information

6.1 Making Unit Entries

Please note that centres must be registered with OCR in order to make any entries, including estimated entries. It is recommended that centres apply to OCR to become a registered centre well in advance of making their first entries. Centres should be aware that a minimum of ten candidates for summer examinations is normally required.

Unit Entry Options

Within Units A221, A222 and A223 candidates must be entered for either the Foundation Tier or the Higher Tier option. It is not necessary for candidates to enter at the same tier in every unit. Candidates may, if they wish, attempt papers at both tiers, **but not in the same examination series**, since the papers will be timetabled simultaneously.

Entry Code	Option Code	Component to be taken	
A221	F	01	Biology A Unit 1 – modules B1, B2, B3 Foundation
	H	02	Biology A Unit 1 – modules B1, B2, B3 Higher
A222	F	01	Biology A Unit 2 – modules B4, B5, B6 Foundation
	H	02	Biology A Unit 2 – modules B4, B5, B6 Higher
A223	F	01	Biology A Unit 3 – Ideas in Context plus B7 Foundation
	H	02	Biology A Unit 3 – Ideas in Context plus B7 Higher
A229	-	01	Biology A Unit 4 – Practical Data Analysis and Case Study
A230	-	01	Biology A Unit 5 – Practical Investigation

Candidate entries must be made by 21 October for the January series and by 21 February for the June series.

6.2 Making Qualification Entries

Candidates **must** be entered for certification code **J633** to claim their overall GCSE grade.

If a certification entry is not made, no overall grade can be awarded.

A candidate who has completed all the units required for the qualification may enter for certification either in the same examination series (within a specified period after publication of results) or at a later series.

First certification will be available in June 2008 and every January and June thereafter.

Certification cannot be declined.

6.3 Grading

GCSE results are awarded on the scale A*-G. Units are awarded a* to g. Grades are awarded on certificates. Results for candidates who fail to achieve the minimum grade (G or g) will be recorded as unclassified (U or u).

In modular schemes candidates can take units across several different sessions. They can also re-sit units or choose from optional units available. When working out candidates' overall grades OCR needs to be able to compare performance on the same unit in different sessions when different grade boundaries have been set, and between different units. OCR uses uniform marks to enable this to be done.

A candidate's uniform mark is calculated from the candidate's raw mark. The raw grade 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 e.g. 41/50.

Results for each unit will be published in the form of uniform marks according to the following scales.

	Unit Grade								
	a*	a	b	c	d	e	f	g	u
Units 1 and 2	50-45	44-40	39-35	34-30	29-25	24-20	19-15	14-10	10-0
Units 3, 4 and 5	100-90	89-80	79-70	69-60	59-50	49-40	39-30	29-20	19-0

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

Candidates' uniform marks for each module are aggregated and grades for the specification are generated on the following scale.

Qualification Grade								
A*	A	B	C	D	E	F	G	U
300-270	269-240	239-210	209-180	179-150	149-120	119-90	89-60	59-0

The candidate's grade will be determined by this total mark. Thus, 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. Candidates achieving less than the minimum mark for grade G will be unclassified.

6.4 Result Enquiries and Appeals

Under certain circumstances, a centre may wish to query the grade available to one or more candidates or to submit an appeal against an outcome of such an enquiry. Enquiries about unit results must be made immediately following the series in which the relevant unit was taken.

For procedures relating to enquires on results and appeals, centres should consult the OCR *Handbook for Centres* and the document *Enquiries about Results and Appeals – Information and Guidance for Centres* produced by the Joint Council. Copies of the most recent editions of these papers can be obtained from OCR.

6.5 Shelf-Life of Units

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

6.6 Unit and Qualification Re-sits

Candidates may re-sit any unit an **unlimited** number of times.

For each unit the best score will be used towards the final overall grade.

Candidates may enter for the full qualification an unlimited number of times.

6.7 Guided Learning Hours

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

6.8 Code of Practice/Subject Criteria/Common Criteria Requirements

These specifications comply in all respects with the revised *GCSE, GCE, VCE, GNVQ and AEA Code of Practice 2005/6*, the subject criteria for GCSE Biology A and *The Statutory Regulation of External Qualifications 2004*.

6.9 Arrangements for Candidates with Particular Requirements

For candidates who are unable to complete the full assessment or whose performance may be adversely affected through no fault of their own, teachers should consult the Access Arrangements and Special Consideration Regulations and Guidance Relating to Candidates who are Eligible for

Adjustments in Examinations. In such cases advice should be sought from OCR as early as possible during the course.

6.10 Prohibited Qualifications and Classification Code

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

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.

The classification code for this specification is 1010.

7 Other Specification Issues

7.1 Overlap with other Qualifications

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

7.2 Progression from these Qualifications

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

Many candidates who enter employment with one or more GCSEs would undertake training or further part-time study with the support of their employers.

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

Candidates intending to proceed to qualifications in biology at Advanced Level (Level 3 in the National Qualifications Framework) should have completed either a course in GCSE Biology A or both GCSE Science and GCSE Additional Science A.

7.3 ICT

In order to move on to more advanced study of science, 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 science.

Opportunities for ICT include:

- using of videos clips to show 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.

7.4 Citizenship

Since September 2002, the National Curriculum for England at Key Stage 4 has included a mandatory programme of study for Citizenship.

Core science 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.

Citizenship Programme of Study	Opportunities for Teaching the Issues during the Course
Section 1: Knowledge and understanding about becoming informed citizens	
The work of parliament, the government and the courts in making and shaping the law	B2: The role of government in determining vaccination policy and making decisions about public safety. The legal aspects of controlling animal experimentation.
The media's role in society, including the internet, in providing information and affecting opinion	B2: The media's role in reporting health issues such as vaccination and heart disease. B6: Media reporting of the effects of Ecstasy contrasted with the scientific evidence.
The rights and responsibilities of consumers, employers and employees	B1: The responsibility of the biotechnology industry to minimise damage to people and the environment while producing products that are effective and safe.
The issues and challenges of global interdependence and responsibility, including sustainable development and Local Agenda 21	B3: Maintaining biodiversity as an important part of sustainable development.
Section 2: Enquiry and communication	
Contributing to group and class discussions	There will be opportunities for discussion in every module e.g.: B1: Discussion of ethical issues arising from genetic testing, or the potential applications of stem cell technology.
Section 3: Developing skills of participation and responsible action	
Consider and evaluate views that are not their own	Case Study of a topical science-related issue. B2: Reflecting on different points of view with regard to MMR vaccination.

7.5 Key Skills

These specifications provide opportunities for the development of the Key Skills of *Communication*, *Application of Number*, *Information Technology*, *Working with Others*, I*mproving 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.

Level	Communication	Application of Number	IT	Working with Others	Improving Own Learning and Performance	Problem Solving
1	✓	✓	✓	✓	✓	✓
2	✓	✓	✓	✓	✓	✓

7.6 Spiritual, Moral, Ethical, Social, Legislative, Economic and Cultural Issues

A number of the scientific ideas which feature in this specification have a significant cultural influence on how people think about themselves and their environment. Also in this specification, candidates gain more insight into the reliability and significance of scientific data.

Issue	Opportunities for Teaching the Issues during the Course
The commitment of scientists to publish their findings and subject their ideas to testing by others.	B2: 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.
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.
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.
Scientific explanations which give insight into human nature.	B4: Insight into the ability of human beings to survive under extreme conditions. B6: The study of higher functions of the human brain – intelligence, memory, language and consciousness.
The ethical implications of selected scientific issues.	B1: Ethical issues arising from implications of modern genetic technologies.

Issue	Opportunities for Teaching the Issues during the Course
	B2: Ethical issues arising from vaccination policy.
Scientific explanations which give insight into the local and global environment.	B2: Vaccination policy, for different diseases, and in different countries.

7.7 Sustainable Development, Health and Safety Considerations and European Developments

OCR has taken account of the 1988 Resolution of the Council of the European Community and the Report Environmental Responsibility: An Agenda for Further and Higher Education, 1993 in preparing this specification and associated specimen assessments.

Issue	Opportunities for Teaching the Issues during the Course
Health and Safety issues	
Safe practice in the laboratory	Practical investigation: designing a strategy
Health and disease	B4: Scientific basis for heat stroke, hypothermia, dehydration and the effect of drugs on the body. B6: The beneficial and harmful effects of drugs which affect the nervous system.
Health and disease	B1: The study of inherited diseases. B2: A range of issues related to keeping healthy in a complex world including epidemiological studies for investigating the causes of disease.

OCR has taken account of the 1988 Resolution of the Council of the European Community in preparing this specification and associated specimen assessments. European examples should be used where appropriate in the delivery of the subject content.

Although this specification does not make specific reference to the European Dimension it may be drawn into the course of study in a number of ways. The table below provides some appropriate opportunities.

Issue	Opportunities for Teaching the Issues during the Course
The importance of the science-based industry to European economies	B7: Role of genetic technologies.
Differences in attitudes to key issues in different parts of Europe	B2: Contrasting attitudes across Europe to health issues.

7.8 Avoidance of Bias

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

7.9 Language

These specifications and associated assessment materials are in English only.

7.10 Support and Resources

The University of York Science Education Group (UYSEG) and the Nuffield Curriculum Centre have produced resources specifically to support this specification. The resources will comprise:

- candidates' texts;
- candidates' work books;
- teacher guide with suggested schemes of work and candidate activity sheets (in customizable format);
- technician guide;
- ICT resources (for example, animations, video clips, models and simulations);
- assessment materials;
- a website for teachers and candidates.

The resources are published by Oxford University Press. Further information is available from:

Customer Services: Telephone: 01536 741068
Fax: 01536 454579
email: schools.orders@oup.com

Appendix A: Grade Descriptions

Grade F

Candidates demonstrate a limited knowledge and understanding of science content and how science works. They use a limited range of the concepts, techniques and facts from the specification, and demonstrate basic communication and numerical skills, with some limited use of technical terms and techniques.

They show some awareness of how scientific information is collected and that science can explain many phenomena.

They use and apply their knowledge and understanding of simple principles and concepts in some specific contexts. With help they plan a scientific task, such as a practical procedure, testing an idea, answering a question, or solving a problem, using a limited range of information in an uncritical manner. They are aware that decisions have to be made about uses of science and technology and, in simple situations familiar to them, identify some of those responsible for the decisions. They describe some benefits and drawbacks of scientific developments with which they are familiar and issues related to these.

They follow simple instructions for carrying out a practical task and work safely as they do so.

Candidates identify simple patterns in data they gather from first-hand and secondary sources. They present evidence as simple tables, charts and graphs, and draw simple conclusions consistent with the evidence they have collected.

Grade C

Candidates demonstrate a good overall knowledge and understanding of science content and how science works, and of the concepts, techniques, and facts across most of the specification. They demonstrate knowledge of technical vocabulary and techniques, and use these appropriately. They demonstrate communication and numerical skills appropriate to most situations.

They demonstrate an awareness of how scientific evidence is collected and are aware that scientific knowledge and theories can be changed by new evidence.

Candidates use and apply scientific knowledge and understanding in some general situations. They use this knowledge, together with information from other sources, to help plan a scientific task, such as a practical procedure, testing an idea, answering a question, or solving a problem.

They describe how, and why, decisions about uses of science are made in some familiar contexts. They demonstrate good understanding of the benefits and risks of scientific advances, and identify ethical issues related to these.

They carry out practical tasks safely and competently, using equipment appropriately and making relevant observations, appropriate to the task. They use appropriate methods for collecting first-hand and secondary data, interpret the data appropriately, and undertake some evaluation of their methods.

Candidates present data in ways appropriate to the context. They draw conclusions consistent with the evidence they have collected and evaluate how strongly their evidence supports these conclusions.

Grade A

Candidates demonstrate a detailed knowledge and understanding of science content and how science works, encompassing the principal concepts, techniques, and facts across all areas of the specification. They use technical vocabulary and techniques with fluency, clearly demonstrating communication and numerical skills appropriate to a range of situations.

They demonstrate a good understanding of the relationships between data, evidence and scientific explanations and theories. They are aware of areas of uncertainty in scientific knowledge and explain how scientific theories can be changed by new evidence.

Candidates use and apply their knowledge and understanding in a range of tasks and situations. They use this knowledge, together with information from other sources, effectively in planning a scientific task, such as a practical procedure, testing an idea, answering a question, or solving a problem.

Candidates describe how, and why, decisions about uses of science are made in contexts familiar to them, and apply this knowledge to unfamiliar situations. They demonstrate good understanding of the benefits and risks of scientific advances, and identify ethical issues related to these.

They choose appropriate methods for collecting first-hand and secondary data, interpret and question data skilfully, and evaluate the methods they use. They carry out a range of practical tasks safely and skilfully, selecting and using equipment appropriately to make relevant and precise observations.

Candidates select a method of presenting data appropriate to the task. They draw and justify conclusions consistent with the evidence they have collected and suggest improvements to the methods used that would enable them to collect more valid and reliable evidence.

Appendix B: Requirements Relating to Mathematics

During the course of study for this specification, many opportunities will arise for quantitative work, including appropriate calculations. The mathematical requirements which form part of the specification are listed below. Items in the first table may be examined in written papers covering both Tiers. Items in the second table may be examined only in written papers covering the Higher Tier.

Both Tiers
add, subtract and divide whole numbers
recognise and use expressions in decimal form
make approximations and estimates to obtain reasonable answers
use simple formulae expressed in words
understand and use averages
read, interpret, and draw simple inferences from tables and statistical diagrams
find fractions or percentages of quantities
construct and interpret pie-charts
calculate with fractions, decimals, percentage or ratio
solve simple equations
substitute numbers in simple equations
interpret and use graphs
plot graphs from data provided, given the axes and scales
choose by simple inspection and then draw the best smooth curve through a set of points on a graph

Higher Tier only
recognise and use expressions in standard form
manipulate equations
select appropriate axes and scales for graph plotting
determine the intercept of a linear graph
understand and use inverse proportion
calculate the gradient of a graph

Appendix C: 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)
mass	kilogram (kg); gram (g); milligram (mg)
time	seconds (s); millisecond (ms) year (a); million years (Ma); billion years (Ga)
temperature	degree Celsius (°C); kelvin (K)
current	ampere (A); milliampere (mA)

Derived Quantities and Units	
Physical quantity	Unit(s)
area	cm^2; m^2
volume	cm^3; dm3; m^3; litre (l); millilitre (ml)
density	kg/m^3; g/cm^3
force	newton (N)
speed, velocity	m/s; km/h
energy	joule (J) ; kilojoule (kJ); megajoule (MJ)
momentum	Kg, m/s
power	watt (W); kilowatt (kW); megawatt (MW)
frequency	hertz (Hz); kilohertz (kHz)
gravitational field strength	N/kg
potential difference	volt (V)
resistance	ohm (Ω)

Appendix D: Health and Safety

In UK law, health and safety is the responsibility of the employer. For most centres entering candidates for GCSE examinations this is likely to be the Local Education Authority or the Governing Body. Teachers have a duty to co-operate with their employer on health and safety matters. Various regulations, but especially the COSHH Regulations 1996 and the Management of Health and Safety at Work Regulations 1992, require that before any activity involving a hazardous procedure or harmful microorganisms is carried out, or hazardous chemicals are used or made, the employer must provide a risk assessment.

A useful summary of the requirements for risk assessment in school or college science can be found in Chapter 4 of Safety in Science Education. 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, 10th edition, 1996, ASE ISBN 0 86357 250 2;

Hazcards, 1995 with 2004 updates, CLEAPSS School Science Service*;

CLEAPSS Laboratory Handbook, 1997 with 2004 update, CLEAPSS School Science Service*;

CLEAPSS Shorter Handbook (CLEAPSS 2000) CLEAPSS School Science Service*;

Hazardous Chemicals, A manual for Science Education, (SSERC, 1997) ISBN 0 9531776 0 2.

*Note that CLEAPSS publications are only available to members or associates.

Where an employer has adopted these or other publications as the basis of their model risk assessments, an individual Centre 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.

When candidates are planning their own investigative work the teacher has a duty to check the plans before the practical work starts and to monitor the activity as it proceeds.

Appendix E: Explanation of Terms Used in Module Content

All the module content statements are expressed in terms of what the candidates know, understand or can do, and are prefixed by 'Candidates should …..' which is followed by statement containing one or more 'command' words.

This appendix, which is not intended to be exhaustive or prescriptive, provides some guidance about the meanings of these command words.

It must be stressed that the meaning of a term depends on the context in which it is set, and consequently it is not possible to provide precise definitions of these words which can be rigidly applied in all circumstances. Nevertheless, it is hoped that this general guidance will be of use in helping to interpret both the specification content and the assessment of this content in written papers.

Command words associated with scientific knowledge and understanding (AO1)

Candidates are expected to remember the facts, concepts, laws and principles which they have been taught. Command words in this category include Learning Outcomes beginning:

recall…., state…; recognise…; name...; draw...; test for…; appreciate… ; describe…;

The words used on examination papers in connection with the assessment of these Learning Outcomes may include:

Describe...; List...; Give...; Name...; Draw...; Write...; What?...; How?...; What is meant by..?

e.g. `What is meant by the term `catalyst' ?'

`Name parts A, B and C on the diagram.'

Command words associated with interpretation, evaluation, calculation and communication (AO2)

The command words include:

...relate...; ...interpret…; ...carry out ...; …deduce...; ..explain...; ...evaluate...;

...predict..;. ...use…; ...discuss..; ...construct...; ...suggest...; ...calculate.;

...demonstrate..;.

The use of these words involves the ability to recall the appropriate material from the specification content and to apply this knowledge and understanding.

Questions in this category may include the command words listed above together with

Why…? Complete... Work out... How would you know that...? Suggest...

e.g. `Use the graph to calculate the concentration of the acid.'

`Explain why it is important for these materials to be recycled.'

`Suggest two reasons why some people are concerned about the use of these artificial flavours in foods.

Appendix F: Ideas About Science

In order to deal sensibly with science as we encounter it in everyday life, it is important not only to understand some of the fundamental scientific explanations of the behaviour of the natural world, but also to know something about science itself, how scientific knowledge has been obtained, how reliable it therefore is, what its limitations are, and how far we can therefore rely on it – and also about the interface between scientific knowledge and the wider society.

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

The aim of science is to find explanations for the behaviour of the natural world. A good explanation may allow us to predict what will happen in other situations, and perhaps to control and influence events.

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.

One kind of explanation is to identify a correlation between a factor and an outcome. This factor may then be the cause, or one of the causes, of the outcome. In complex situations, a factor may not always lead to the outcome, but increases the chance (or the risk) of it happening. Other explanations involve putting forward a theory to account for the data. Scientific theories often propose an underlying model, which may involve objects (and their behaviour) that cannot be observed directly.

Devising and testing a scientific explanation is not a simple or straightforward process. First, we can never be completely sure of the data. An observation may be incorrect. A measurement can never be completely relied upon, because of the limitations of the measuring equipment or the person using it.

Second, explanations do not automatically ‘emerge’ from the data. Thinking up an explanation is a creative step. So, it is quite possible for different people to arrive at different explanations for the same data. And personal characteristics, preferences and loyalties can influence the decisions involved.

The scientific community has established procedures for testing and checking the findings and conclusions of individual scientists, and arriving at an agreed view. Scientists report their findings to other scientists at conferences and in special 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 (for the time being).

Where possible scientists choose to study simple situations in order to gain understanding. But it can then be difficult to apply this understanding to complex, real-world situations. So there can be legitimate disagreements about how to explain such situations, even where there is no dispute about the basic science involved.

The application of scientific knowledge, in new technologies, materials and devices, greatly enhances our lives, but can also have unintended and undesirable side effects. An application of science may have social, economic and political implications, and perhaps also ethical ones. Personal and social decisions require an understanding of the science involved, but also involve knowledge and values beyond science.

This is, of course, a simplified account of the nature of science, which omits many of the ideas and subtleties that a contemporary philosopher or sociologist of science might think important. It is intended as an overview of science in terms which might be accessible to 14-16 year old candidates, to provide a basic understanding upon which those who wish may later build more sophisticated understandings. It is important to note that the language in which it is expressed may well not be that which one would use in talking to candidates of this age.

The following pages set out in more detail the key ideas that such an understanding of science might involve, and what candidates should be able to do to demonstrate their understanding.

1 Data and their 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.

	Ideas about science	A candidate who understands this…
1.1	Data are crucial to science. Explanations are sought to account for known data, and data are collected to test proposed explanations.	uses data rather than opinion in justifying an explanation
1.2	We can never be sure that a measurement tells us the true value of the quantity being measured.	can suggest reasons why a measurement may be inaccurate
1.3	If we make several measurements of the same quantity, the results are likely to vary. This may be because we have to measure several individual examples (e.g. the height of cress seedlings after 1 week), or because the quantity we are measuring is varying (e.g. amount of ozone in city air, time for a vehicle to roll down a ramp), and/or because of the limitations of the measuring equipment or of our skill in using it (e.g. repeat measurements when timing an event).	can suggest reasons why several measurements of the same quantity may give different results when asked to evaluate data, makes reference to its reliability (i.e. is it repeatable?)
1.4	Usually the best estimate of the value of a quantity is the average (or mean) of several repeat measurements.	can calculate the mean of a set of repeated measurements from a set of repeated measurements of a quantity, uses the mean as the best estimate of the true value can explain why repeating measurements leads to a better estimate of the quality
1.5	The spread of values in a set of repeated measurements give a rough estimate of the range within which the true value probably lies.	can make a sensible suggestion about the range within which the true value of a measured quantity probably lies **can justify the claim that there is/is not a 'real difference' between two measurements of the same quantity**
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.	can identify any outliers in a set of data, and give reasons for including or discarding them.

2 Correlation and cause

Scientists look for patterns in data, as a means of identifying possible cause-effect links, and working towards explanations.

	Ideas about science	A candidate who understands this…
2.1	It is often useful to think about processes in terms of factors which may affect an outcome (or input variable(s) which may affect an outcome variable).	in a given context, can identify the outcome and the factors that may affect it in a given context, can suggest how an outcome might be affected 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').	can 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 feature, or the fact that they are not as a design flaw **can explain why it is necessary to control all factors thought likely to 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.	can give an example from everyday life of a correlation between a factor and an outcome
2.4	A correlation between a factor and an outcome does not necessarily mean that one causes the other; both might, for example, be caused by some other factor.	uses the ideas of correlation and cause appropriately when discussing historical events or topical issues in science **can explain why a correlation between a factor and an outcome does not necessarily mean that one causes the other, and give an example to illustrate this**
2.5	In some situations, a factor increases the chance (or probability) of an outcome, but does not invariably lead to it, e.g. a diet containing high levels of saturated fat increases an individual's risk of heart disease, but may not lead to it. We also call this a correlation.	can suggest factors that might increase the chance of an outcome, but not invariably lead to it can explain that 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, we compare samples (e.g. 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.	can evaluate the design for a study to test whether or not a factor increases the chance of an outcome, by commenting on sample size and how well the samples are matched **can use data to develop an argument that a factor does/does not increase the chance of an outcome**
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.	**can identify the presence (or absence) of a plausible mechanism as significant for the acceptance (or rejection) of a claimed causal link.**

3 Developing explanations

Scientific explanations are of different types. Some are based on a proposed cause-effect link. Others show how a given event is in line with a general law, or with a general theory. Some theories involve a model, which may include objects or quantities that cannot be directly observed, which accounts for the things we can observe.

	Ideas about science	A candidate who understands this…
3.1	A scientific explanation is a conjecture (a hypothesis) about how data might be accounted for. It is not simply a summary of the data, but is distinct from it.	can identify statements which are data and statements which are (all or part of) an explanation can recognise data or observations that are accounted for by, or conflict with, an explanation
3.2	An explanation cannot simply be deduced from data, but has to be thought up imaginatively to account for the data.	can identify imagination and creativity 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 wide range of observations. It should also enable predictions to be made about new situations or examples.	can justify accepting or rejecting a proposed explanation on the grounds that it: • accounts for observations • **and/or provides an explanation that links things previously thought to be unrelated** • **and/or leads to predictions that are subsequently confirmed**
3.4	Scientific explanations are tested by comparing predictions made from them with data from observations or experiments.	can draw valid conclusions about the implications of given data for a given explanation, in particular: • recognises that an observation that agrees with a prediction (derived from an explanation) increases confidence in the explanation **but does not prove it is correct** • recognises that an observation that disagrees with a prediction (derived from an explanation) indicates that either the observation or the prediction is wrong, **and that this may decrease our confidence in the explanation**
3.5	For some questions that scientists are interested in, there is not yet an answer.	can identify a scientific question for which there is not yet an answer, **and suggest a reason why**

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.

	Ideas about science	A candidate who understands this…
4.1	Scientists report their findings to other scientists through conferences and journals. Scientific findings are only accepted once they have been evaluated critically by other scientists.	can describe in broad outline the 'peer review' process, in which new scientific claims are evaluated by other scientists can recognise that new scientific claims which have not yet been evaluated by the scientific community are less reliable than well-established ones
4.2	Scientists are usually sceptical about findings that cannot be repeated by anyone else, and about unexpected findings until they have been replicated.	can identify absence of replication as a reason for questioning a scientific claim **can explain why scientists regard it as important that a scientific claim can be replicated by other scientists**
4.3	Explanations cannot simply be deduced from the available data, so 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. (e.g. data open to several interpretations; influence of personal background and experience; interests of employers or sponsors).	can suggest plausible reasons why scientists involved in a scientific event or issue disagree(d)
4.4	A scientific explanation is rarely abandoned just because some data are not in line with it. An explanation usually survives until a better one is proposed. (e.g. anomalous data may be incorrect; new explanation may soon run into problems; safer to stick with ideas that have served well in the past).	**can suggest reasons for scientists' reluctance to give up an accepted explanation when 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.

	Ideas about science	A candidate who understands this…
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.	can explain why it is impossible for anything to be completely safe can identify examples of risks which arise from a new scientific or technological advances can suggest ways of reducing specific risks
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.	can 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.	**can discuss a given risk, taking account of both the chance of it occurring and the consequences if it did**
5.4	People are often willing to accept the risk associated with an activity if they enjoy or benefit from it. We are also more willing to accept the risk associated with things we choose to do than things that are imposed, or that have short-lived effects rather than a long-lasting ones.	can suggest benefits of activities that have a known risk can offer reasons for people's willingness (or reluctance) to accept the risk of a given activity can discuss personal and social choices in terms of a balance of risk and benefit
5.5	If you are not sure about the possible results of doing something, and if serious and irreversible harm could result from it, then it makes sense to avoid it (the 'precautionary principle').	**can identify, or propose, an argument based on the 'precautionary principle'**
5.6	Our perception of the size of a risk is often very different from the actual measured risk. We tend to over-estimate the risk of unfamiliar things (like flying as compared with cycling), and things whose effect is invisible (like ionizing radiation).	**can distinguish between actual and perceived risk, when discussing personal and social choices** **can suggest reasons for given examples of differences between actual and perceived risk**
5.7	Reducing the risk of a given hazard costs more and more, the lower we want to make the risk. As risk cannot be reduced to zero, individuals and/or governments have to decide what level of risk is acceptable.	**can explain what the ALARA (as low as reasonably achievable) principle means and how it applies in a given context.**

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.

	Ideas about science	A candidate who understands this…
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, can identify the groups affected and the main benefits and costs of a course of action for each group
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.	can explain the idea of sustainable development, and apply it to specific situations
6.3	In many areas of scientific work, the development and application of scientific knowledge are subject to official regulations and laws (e.g. on the use of animals in research, levels of emissions into the environment, research on human fertility and embryology).	shows awareness that scientific research and applications are subject to official regulations and laws.
6.4	Some questions, such as those involving values, cannot be addressed by scientists.	can distinguish questions which could be addressed using a scientific approach, from questions which could not.
6.5	Some applications of science have ethical implications. As a result, people may disagree about what should be done (or permitted).	where an ethical issue is involved, can: • 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 majority of people involved. Another is that certain actions are unnatural or wrong, and should not be done in any circumstances. A third is that is that it is unfair for a person to choose to benefit from something made possible only because others take a risk, whilst avoiding that risk themselves.	in a particular context, can identify, and develop, arguments based on the ideas that: • the right decision is the one which leads to the best outcome for the majority of people involved • certain actions are never justified because they are unnatural or wrong
6.7	In assessing any proposed application of science, we must first decide if it is technically feasible. Different decisions on the same issue may be made in different social and economic contexts.	**in a particular context, can distinguish what can be done (technical feasibility), from what should be done (values)** **can explain why different courses of action may be taken in different social and economic contexts**

Appendix G: Science Explanations

Material in *italics* is from earlier Key Stages. This material will not be the focus of assessment items but clearly there will be instances where an understanding of material from earlier stages will underpin an understanding of Key Stage 4 material. Material in **bold** is only intended for Higher Tier candidates.

This section lists the Science Explanation relevant to this specification. Other Science Explanations are listed in the GCSE Chemistry A and GCSE Physics A specifications. The full set of Science Explanations are included in the GCSE Science A specification.

SE 4	The interdependence of living things
a	*All living things need materials and energy from their surroundings to stay alive. They also produce waste materials that they must get rid of into their surroundings. The Sun provides the energy that all living things need. The leaves of green plants use the energy in sunlight to make a sugar called glucose from carbon dioxide (taken from air) and water (taken by roots from the ground). This process is called photosynthesis; oxygen is the waste product. Plants use glucose and chemicals (minerals) from the soil to make all the other chemicals that they need to live and grow. Animals obtain the materials they need to live and grow by eating plants (or by eating other animals that have eaten plants). They obtain the energy they need by reacting glucose (from their food) with oxygen (from the air). This process happens in their cells and is called respiration; carbon dioxide and water are the waste products.*
b	*We can show what eats what else in a particular habitat (or ecosystem) by using a food web.*
c	There is often competition between different species of animals or plants in a particular habitat for the same space or the same food source. A change which affects one species in a food web also affects other species that are part of the same food web. Ecosystems can often adjust to changes but large disruptions may change an ecosystem permanently.
SE 6	**Cells as the basic units of living things**
a	*All living things (organisms) are made from small units called cells.* Cells are 'chemical factories': the chemical reactions that must happen for living things to stay alive take place inside cells. For example cells make protein molecules and obtain the energy needed to do this by reacting glucose with oxygen (respiration).
b	*Most organisms are made up of many different types of cell. Different types of cell are built in different ways* (they have a different structure) so that they can do their particular job (function). *We say that the cells are specialised.*
SE 7	**Maintenance of life**
a	*All living things need to maintain themselves if they are to survive. Animals, including humans, need to take in a balanced mix of proteins, carbohydrates, fats, minerals, vitamins and water in their diet.* Larger molecules are broken down in the human gut by chemicals called enzymes to form smaller molecules. Starch is digested into glucose, and proteins are digested into amino acids. These smaller molecules pass through the wall of the small intestine into the blood which transports them to all the cells of the body.
b	In cells glucose reacts with oxygen to provide energy; this process is called respiration. Cells use some of this energy to build up amino acids into the much larger molecules of many different proteins.
c	*In humans and in many other animals, the heart pumps blood around the body. The lungs provide the blood with oxygen which is transported from the lungs, via the heart, to*

all the cells of the body (including the cells of the heart itself). Regular, but not excessive, exercise reduces the risk of developing heart disease. The risk of heart disease is increased by poor diet, stress, and such activities as cigarette smoking and high levels of alcohol consumption.

d *The cells in the body produce waste materials which are toxic and so must be got rid of. The carbon dioxide that is produced from glucose and oxygen by cells when they respire is transported to the lungs where it is breathed out*. Urea, produced by the breakdown of protein, is excreted from the body by the kidneys in urine. *Undigested food never actually enters our bloodstream but passes through our gut and leaves as faeces.*

e *Organisms are more likely to survive if they can sense, in their surroundings, the things that they need (e.g. water, food or light) and what they need to avoid (e.g. harmful chemicals, extreme temperatures or predators).* Multicellular organisms have sensor cells that are specialised to detect things in their surroundings and effector cells that are specialised to respond to what is detected. Multicellular animals have nervous systems, comprising nerve cells (neurons) which link sensor cells (in e.g. eyes, ears and skin) to effector cells (e.g. muscles). In humans, and other vertebrates, this linking is coordinated via a central nervous system (spinal cord and brain). Hormones are chemicals which travel in the blood and bring about slower, longer-lasting responses. **Nervous and hormonal communication systems are involved in maintaining a constant internal environment (homeostasis).**

SE 8 The gene theory of inheritance

a *Most animals and plants reproduce by sexual reproduction. In this process a male sex cell joins with a female sex cell to form a fertilised egg. This single cell then grows by cell division and differentiation to form a new individual. Differences between individuals are caused by both genes and environment.*

b Instructions for how an organism develops are found in the nucleus of its cells. The information consists of many pairs of genes which control what the organism is like, for example its shape, its size, its colour and many other characteristics. Each gene affects a specific characteristic. Genes are sections of very long DNA molecules that make up the chromosomes in the nuclei of cells, so each chromosome contains a large number of genes. Chromosomes occur in pairs. One chromosome from each pair came originally from each parents' sex cell. Both chromosomes in a pair carry the same genes in the same place, but genes in a pair are often slightly different versions (called alleles).

c Offspring may be similar to their parents because of this combination of maternal and paternal alleles. Different offspring from the same parents receive different combinations of the alleles of all the genes, so they can differ from each other in many ways.

d Genes are instructions for a cell that describe how to make proteins.

e Because all organisms use the same genetic code to carry units of information, a gene can be taken from the nucleus of one cell and placed into a different cell. This is called genetic modification. The gene may be from a different organism. This process produces cells with a new combination of genes, and the resulting organism will display new characteristics which may be useful to humans.

f Bacteria, simple animals and most plants can reproduce without sex (asexually). A new organism just starts to grow from a small part of the older one. Each time a body cell divides, the chromosomes (and hence the genes) are copied so that each body cell contains an identical set of genes. So new individuals produced asexually have exactly the same genes in their cells as the parent (they are called clones). This means that they also have very similar characteristics. Any differences are due only to environment.

g The cells of multicellular organisms become specialised during the early development of the organism. However, some remain unspecialised and can develop into any type of plant cell. This is why clones of plants can often be grown from small parts (cuttings) of their roots, stems or leaves.

SE 9 The theory of evolution by natural selection

a The first living things developed from molecules that could copy themselves. These molecules were produced in the conditions on Earth at that time. Most biologists believe that the many different species of living things that now exist, and the many more species which once existed but have died out (become extinct) all evolved from the same, very simple living things that first appeared on Earth about 3 500 million years ago.

b Evolution happened, and continues to happen, mainly because of a process called natural selection. Individuals of the same species are not identical; their characteristics vary. If the environment changes, or if vital resources become scare, individuals with certain characteristics may have a better chance of surviving long enough to reproduce. This means that there will be more individuals with these characteristics in the next generation and, if the environment stays the same, even more in the generation after that. This process is called natural selection because it produces changes like the ones deliberately produced by farmers or pet-owners when they select the animals or plants with the characteristics that they prefer for breeding the next generation. Natural selection, however, does not involve people making deliberate selections.

c **The genes that control the way an organism develops can be changed by certain chemicals, by ionising radiation and by copying errors when chromosomes are copied. This is called mutation. Mutations can cause body cells to reproduce in an uncontrolled way (cancer). Mutated genes in sex cells may be passed on to offspring and produce new characteristics. Mutations usually have such a harmful effect that the fertilised eggs do not develop. Some mutations, though, have no effect on an individual or may even improve the chance of surviving and reproducing. When this happens, the mutated gene is passed on and becomes more common.**

d Over a very long period of time (and many generations) new species have evolved. **The combined effects of mutations, environmental changes and natural selection can produce new species. The 3 500 million years since life on Earth first evolved are believed by most biologists to have been long enough for all the living things that exist (or that have existed) to have evolved in this way.** A large change in the environment may cause a whole species to become extinct.

e **Evolution has happened in the way that it has because of random mutation, random breeding and natural selection. If the conditions on Earth had, at any stage, been different from what they actually were, evolution by natural selection would have produced different results.**

SE 10 The germ theory of disease

a *Many diseases are caused by small organisms (microbes) such as bacteria, fungi and viruses. These are present in the environment and can get inside the bodies of humans or other organisms*. The body has natural barriers to reduce the likelihood of harmful microorganisms entering the body from outside. Our skin acts as a barrier and chemicals in tears and sweat and acid in the stomach kill microorganisms.

b If they get inside a body, the microorganisms can reproduce rapidly. The reproducing microorganisms may cause damage to cells or produce poisons (toxins) they produce to cause the symptoms of the disease. Our bodies have an immune system to defend themselves against the microorganisms that cause infections. Some of our white blood cells can surround microorganisms and destroy them by digesting them. Other white blood cells produce chemicals called antibodies that help destroy microorganisms. A different antibody is needed to recognise each different type of microorganism. Once your body has made the antibody to kill a particular microorganism it can make that antibody again very quickly. This means that your body is then protected against that particular microorganism. We can use this idea to immunise people against diseases: we deliberately infect (vaccinate) them with a form of the microorganism that has been altered so that it is unable to cause disease. The body produces antibodies and, on future exposure to the natural form of the microorganism, protective antibodies will be produced quickly. **Vaccines are not so effective against influenza because there are so many different strains of the virus that causes the disease. As yet, there is no effective vaccination against AIDS, a disease caused by the virus called HIV, because the virus has a high mutation rate within the body.**

c Sometimes microorganisms against which we have not been immunised get into our bodies. These can cause illness, or even death, before our immune systems can destroy them. In such cases, we can kill bacteria and fungi, but not viruses, using chemicals called antibiotics. Over a period of time, however, bacteria and fungi may become resistant to antibiotics. **Random mutations in the genes of these microorganisms sometimes lead to varieties which are less affected by the antibiotic. These have a better chance of surviving a course of antibiotic treatment, especially if the patient does not complete the course when they feel better.** To prevent this happening we should only use antibiotics when really necessary and always complete the prescribed course.