# IGCSE

London Examinations IGCSE

Biology (4325)

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Teacher's Guide

London Examinations IGCSE

Biology (4325)

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# Contents

# Introduction

This guide provides support and guidance for teachers and lecturers preparing students for IGCSE Biology. It provides helpful information about the course content, including practical work, the assessment model and course planning.

The purpose of the guide is

- to advise about the different patterns of entry that are possible in this flexible specification both in terms of tier of entry and the assessment of experimental work
- to describe the assessment objectives and weightings given to them in each component of the assessment
- to assist the teacher in planning the delivery of the specification by discussing some of the parameters which need careful consideration, and suggesting a possible timetable for teaching
- to advise the teacher on the procedures relating to coursework for those who wish to pursue this option. Important features like task setting, assessment, recording marks and standardisation are all described in detail.

This guide will help the teacher to translate the specification content into a course that suits the conditions within each individual centre and reflects their preferred order of teaching.

The Specification, Specimen Papers and Mark Schemes and Teacher's Guide provide teachers with all the support they need to deliver this course successfully.

**In addition, from early 2004, a detailed Coursework Guide for all IGCSE Science subjects (Biology 4325, Chemistry 4335, Physics 4420 and Dual Award Science 4437, first examination May 2006), which will include exemplar work, will be available on the Edexcel International website. The publication code will be UG014326. The information will also be helpful to teachers preparing students for paper 03.**

# Tiers of entry

Students are entered for either Foundation Tier or Higher Tier.

The **Foundation Tier** written paper (1F) is designed for students who are unlikely to achieve a high grade, but whose achievement can still be recognised with a grade at the appropriate level. No matter how well students may do on the Foundation Tier paper, the highest grade they can be awarded is grade C. Students who fail to achieve grade G will be awarded ‘Ungraded’.

The **Higher Tier** written paper (2H) contains questions that are more demanding, and which cover some topics that are for Higher Tier students only. These topics are printed in bold type in the specification. The highest grade which can be awarded on the Higher Tier is A*, a grade reserved for only the highest achievers at the top of grade A. Questions on the Higher Tier are targeted at grades A* to D, but there is a ‘safety net’ for those who narrowly fail to achieve grade D.  A grade E can be awarded to students who are within a few marks of grade D. Students who fail to achieve the safety net grade E will be awarded ‘Ungraded’.

The Foundation and Higher Tier papers take place at the same time, so students cannot be entered for both examinations. This puts a responsibility on the teacher to ensure that a student is entered for the appropriate tier.  Students who consistently achieve grade C standard work in practice tests would normally be entered for the Higher Tier, where they have the opportunity to achieve the higher grades.

Because of the overlap at grades C and D between the two tiers, there are some questions common to both tiers. In Biology, the overlap questions carry 50 marks. On the Foundation Tier paper this is 50 marks out of a total of 100 marks, and on the Higher Tier paper this is 50 marks out of a total of 120 marks.

**Investigative skills** are assessed either by the **written alternative to coursework** (paper 03) or by internally assessed **coursework** (component 4). Unlike papers 1F and 2H, paper 03 and the coursework are untiered and assess achievement in the whole range of grades from A* to G. They are taken by both Foundation and Higher Tier candidates.

# Structure of specification

## Summary of the scheme of assessment

| Paper / Component | Mode of assessment | Weighting | Length |
|---|---|---|---|
| 1 | Examination Paper 1F, targeted at grades C – G (Foundation Tier) | 80% | 1½ hours |
| OR | | | |
| 2 | Examination Paper 2H, targeted at grades A* – D (Higher Tier) | 80% | 2 hours |
| 3 | Examination Paper 03, targeted at grades A* – G (common to both tiers) | 20% | 1¼ hours |
| OR | | | |
| 4 | Coursework, targeted at grades A* – G (common to both tiers) | 20% | – |

Candidates will be required to take **two** components.

- **Foundation Tier** candidates will take Paper 1F, and **either** Paper 03 **or** component 4 (coursework).
- **Higher Tier** candidates will take Paper 2H, and **either** Paper 03 **or** Component 4 (coursework).

Use of calculators is permitted in all written examinations.

# Assessment requirements

## Assessment objectives

This specification requires that all candidates demonstrate the following assessment objectives in the context of the content and skills prescribed.

### AO1 Knowledge and understanding

In the examination, students will be tested on their ability to

- recognise, recall and show understanding of specific biological facts, terminology, principles, concepts and practical techniques including aspects of safety
- draw on existing knowledge to show understanding of the ethical, social, environmental, economic and technological applications and implications of biology
- select, organise and present relevant information clearly and logically, using appropriate vocabulary.

### AO2 Application of knowledge and understanding, analysis and evaluation

In the examination, students will be tested on their ability to

- describe, explain and interpret phenomena, effects and ideas in terms of biological principles and concepts, presenting arguments and ideas clearly and logically
- interpret and translate data presented as continuous prose or in tables, diagrams drawings and graphs, from one form to another
- carry out relevant calculations
- apply biological principles and concepts in solving problems in unfamiliar situations, including those related to the ethical, social, economic and technological applications and implications of biology
- assess the validity of biological information, experiments, inferences and statements and make informed judgements from them.

### AO3 Experimental and investigative skills

In the assessment of these practical skills, students will be tested on their ability to

- devise and plan investigations, drawing on biological knowledge and understanding in selecting appropriate techniques
- demonstrate or describe appropriate experimental and investigative methods, including safe and skilful practical techniques
- make observations and measurements with appropriate precision, record these methodically, and present them in a suitable form
- analyse and interpret data to draw conclusions from experimental activities which are consistent with the evidence, using biological knowledge and understanding, and to communicate these findings using appropriate specialist vocabulary, relevant calculations and graphs
- evaluate data and methods.

## Weighting of assessment objectives

In the examination, the weighting given to each assessment objective will be as shown in the following table.

| Assessment objective | | Weighting |
|---|---|---|
| AO1 | Knowledge and understanding | 45 – 55%<br>(of which no more than half will be recall) |
| AO2 | Application of knowledge and understanding, analysis and evaluation | 25 – 35%<br>(evenly distributed across all aspects of the objective) |
| AO3 | Experimental and investigative skills | 20% |

The weightings given to each assessment objective in the examination papers will be

**Papers 1F and 2H**

AO1 45 - 55% AO2 25 - 35% AO3 0%

**Paper 03 and coursework**

AO1 0% AO2 0% AO3 20%

# Course content

This guide outlines one possible approach to planning the course over a period of five terms. It also includes suggestions for the practical work that forms an integral part of the specification together with brief supportive notes on carrying out investigations.

There are five areas of content.

### Section 1: Nature and variety of living organisms

a) Characteristics of living organisms

b) Variety of living organisms

### Section 2: Structures and functions in living organisms

a) Levels of organisation

b) Cell structure

c) Biological molecules

d) Movement of substances into and out of cells

e) Nutrition

f) Respiration

g) Gas exchange

h) Transport

i) Excretion

j) Co-ordination and response

### Section 3: Reproduction and inheritance

a) Reproduction

b) Inheritance

### Section 4: Ecology and the environment

a) The organism in the environment

b) Feeding relationships

c) Cycles within ecosystems

d) Human influences on the environment

### Section 5: Use of biological resources

a) Food production

b) Selective breeding

c) Genetic modification

d) Cloning

## Teaching time for each section of the specification

The questions on the examination papers will take into account the different amount of content within each of the sections. The table below gives a guide to the approximate number of marks allocated to each section and hence to the amount of teaching time recommended for each section.

## Section topics – teaching time and mark allocation

| Section topic | | Recommended time allocation for teaching | Paper 1F Approximate mark allocation (out of 100) | Paper 2H Approximate mark allocation (out of 120) |
|---|---|---|---|---|
| 1 | Nature and variety of living organisms | 4% | 5 | 6 |
| 2 | Structures and functions in living organisms | 40% | 50 | 60 |
| 3 | Reproduction and inheritance | 8% | 10 | 12 |
| 4 | Ecology and the environment | 12% | 15 | 18 |
| 5 | Use of biological resources | 16% | 20 | 24 |
| **Coursework** | | 20% | | |

## Command words

'Command words' used within the specification include **describe**, **evaluate**, **explain**, **recall**, **recognise**, and **understand**.

These indicate the depth of knowledge and understanding required for a particular topic, and are also likely to be used in questions set on the topic.

**Describe** - the student will be required to write prose answers to demonstrate the facts remembered about a topic.

**Evaluate** - the student will be asked to analyse information and explain the underlying biology.

**Explain** – the student will need to comment on the underlying biology.

**Recall** - the student will be expected to remember brief facts.

**Recognise** – the student will be expected to identify parts on a diagram.

**Understand** – the student will need to appreciate the importance and relevance of biological facts.

## Target mark allocation for each grade

The table below shows the approximate mark allocation for different grade ranges in papers 1F and 2H.

| | **Mark allocation** | |
|---|---|---|
| **Grade range** | **Paper 1F** | **Paper 2H** |
| Grades G – E | 50 | 0 |
| Grades C – D | 50 | 50 |
| Grades B – A* | 0 | 70 |

# Course planning

The scheme that follows shows a way to plan the teaching over five terms of ten weeks. The scheme is described for teachers preparing candidates for the Higher Tier examination; teachers preparing candidates for the Foundation Tier examination can easily adapt the scheme by ignoring the topics in bold type. Teachers may wish to plan their own scheme. This is perfectly acceptable and allows a degree of flexibility, but any approach must ensure full coverage of the specification content including the obligatory practical work and student investigations.

This course plan only includes practical work that is in the specification, but teachers are encouraged to include additional practical work as appropriate to their interest, and the time and facilities available.

## Section 1 – The variety of life

To help teachers judge the depth of coverage required, the knowledge expected of a student has been given in full under each bullet point. The knowledge and ideas included in section 1 are fundamental to the understanding of biology, hence it is recommended that these topics should not be taught as a separate section but covered at appropriate points throughout the course. They have therefore not been included in the course plan outlined below, to enable teachers to incorporate the topics according to their own teaching preferences. Teachers are reminded that only 4% of the final marks for the subject will be based on this section.

Candidates should be able to

- recall that living organisms share the following basic characteristics

  they require nutrition

  they respire

  they excrete their waste

  they respond to their surroundings

  they move

  they control their internal conditions

  they reproduce

  they grow and develop.

- understand that there is a wide variety of living organisms and that modern biology classifies organisms on the basis of their structure and how they function.

- describe the common features shared by organisms within the five main groups, plants, animals, fungi, bacteria and viruses, and for each group describe examples and their features as follows, (details of life cycle and economic importance are not required).

- Plants: These are multicellular organisms; they contain chloroplasts and are able to carry out photosynthesis; they have cellulose cell walls; they store carbohydrates as starch or sucrose. Examples include flowering plants, such as a cereal (e.g. maize) and a herbaceous legume (e.g. peas or beans).

- Animals: These are multicellular organisms; they do not contain chloroplasts and are not able to carry out photosynthesis; they have no cell walls; they usually have nervous co-ordination and are able to move from one place to another; they often store carbohydrate as glycogen. Examples include mammals (e.g. humans) and insects (e.g. housefly).

- Fungi: These are organisms that are not able to carry out photosynthesis; their body is usually organised into a mycelium made from thread-like structures called hyphae, which contain many nuclei; some examples are single-celled; they have cell walls made of chitin; they feed by extracellular secretion of digestive enzymes onto food material and absorption of the organic products; this is known as saprotrophic nutrition; they may store carbohydrate as glycogen. Examples include Mucor, which has the typical fungal hyphal structure, and yeast which is single-celled.

- Bacteria: These are microscopic single-celled organisms; they have a simple cell structure that lacks a nucleus but contains a circular chromosome of DNA; some bacteria can carry out photosynthesis but most feed off other living or dead organisms. Examples include Lactobacillus bulgaricus, a rod shaped bacterium used in the production of yoghurt from milk, and Pneumococcus, a spherical bacterium that acts as the pathogen causing pneumonia.

- Viruses: These are small particles, smaller than bacteria; they are parasitic and can only reproduce inside living cells; they infect every type of living organism. They have a wide variety of shapes and sizes; they have no cellular structure but have a protein coat and contain one type of nucleic acid, either DNA or RNA.  Examples include the tobacco mosaic virus that causes discolouring of the leaves of tobacco plants by preventing the formation of chloroplasts, and the influenza virus that causes 'flu' in humans.

## Term 1

| Week | Topic | Specification Detail | Practical Work |
|---|---|---|---|
| 1 – 4 | **Nutrition in humans and biological molecules** | • understand that a balanced diet should include carbohydrate, protein, lipid, vitamins, minerals, water and dietary fibre<br>• recall sources and describe functions of carbohydrate, protein, lipid (fats and oils), vitamins A, C and D, and the mineral ions calcium and iron<br>• understand that energy requirements vary with activity levels, age and pregnancy<br>• recognise the structures of the human alimentary canal and describe in outline the functions of the mouth, oesophagus, stomach, small intestine, large intestine, and pancreas<br>• understand the processes of ingestion, digestion, absorption, assimilation and egestion<br>• explain how and why food is moved through the gut by peristalsis<br>• understand the role of digestive enzymes to include the digestion of starch to glucose by amylase and maltase, the digestion of proteins to amino acids by proteases and the digestion of lipids to fatty acids and glycerol by lipases<br>• recall that bile is produced by the liver and stored in the gall bladder, and understand the role of bile in neutralising stomach acid and emulsifying lipids<br>• explain how the structure of a villus helps absorption of the products of digestion in the small intestine<br>• recall the chemical elements present in carbohydrates, proteins and lipids (fats and oils)<br>• describe the structure of carbohydrates, proteins and lipids as large molecules made up from smaller basic units: starch and glycogen from simple sugars; protein from amino acids; lipid from fatty acids and glycerol<br>• understand the role of enzymes as biological catalysts in metabolic reactions<br>• understand how the functioning of enzymes can be affected by changes in temperature and pH | • recall how to carry out a simple experiment to determine the energy content in a food sample<br>• describe the tests for glucose, starch, lipid and protein<br>• describe how to carry out simple controlled experiments to illustrate how enzyme activity can be affected by changes in temperature. |
| 5 | Respiration | • recall that the process of respiration releases energy in living organisms<br>• describe the differences between aerobic and anaerobic respiration<br>• recall the word equation **and the balanced chemical symbol equation** for aerobic respiration in living organisms<br>• recall the word equation for anaerobic respiration in plants and in animals | • describe simple controlled experiments to demonstrate the evolution of carbon dioxide and heat from respiring seeds or other suitable living organisms |

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|---|---|---|---|
| 6 – 7 | **Gas Exchange in humans** | • recall the structure of the thorax, including the ribs, intercostal muscles, diaphragm, trachea, bronchi, bronchioles, alveoli and pleural membranes<br>• understand the role of the intercostal muscles and the diaphragm, in ventilation<br>• explain how alveoli are adapted for gas exchange by diffusion between air in the lungs and blood in capillaries<br>• understand the role of diffusion in gas exchange<br>• understand the biological consequences of smoking in relation to the lungs and the circulatory system | • describe a simple experiment to investigate the effect of exercise on breathing in humans |
| 8 – 10 | **Transport in humans** | • recall the composition of the blood: red blood cells, white blood cells, platelets and plasma<br>• understand the role of plasma in the transport of carbon dioxide, digested food, urea, hormones and heat energy<br>• describe the adaptations of red blood cells for the transport of oxygen, including shape, structure and the presence of haemoglobin<br>• describe the role of white blood cells in preventing disease by ingestion of micro-organisms and the production of antibodies to destroy micro-organisms<br>• recall that platelets are involved in blood clotting, which prevents blood loss and the entry of micro-organisms<br>• describe the structure of the heart and how it functions<br>• understand that the heart rate changes during exercise and under the influence of adrenaline<br>• describe the structure of arteries, veins and capillaries and understand their roles<br>• recall the general plan of the circulation system to include the blood vessels to and from the heart, the lungs, the liver and the kidneys. | • describe a simple practical on the effects of exercise on heart rate in humans. |

## Term 2

| Week | Topic | Specification Detail | Practical Work |
|---|---|---|---|
| 1 – 2 | **Cell structure**<br><br>**Movement of substances into and out of cells** | • describe the levels of organisation within organisms: organelles, cells, tissues, organs and systems<br>• recognise cell structures, including the nucleus, cytoplasm, cell membrane, cell wall, chloroplast and vacuole<br>• describe the functions of the nucleus, cytoplasm, cell membrane, cell wall, chloroplast and vacuole<br>• describe the differences between plant and animal cells<br>• recall simple definitions of diffusion, osmosis and active transport<br>• understand that movement of substances into and out of cells can be by diffusion, osmosis and active transport<br>• understand the importance in plants of turgid cells as a means of support<br>• **understand the factors that affect the rate of movement of substances into and out of cells to include the effects of surface area to volume ratio, temperature and concentration gradient** | • describe simple experiments on diffusion and osmosis using living and non-living systems |
| 3 – 4 | **Human excretion** | • recall that the lungs, kidneys and skin are organs of excretion<br>• understand how the kidney carries out its roles of excretion and of osmoregulation<br>• describe the structure of the urinary system, including the kidneys, ureters, bladder and urethra<br>• describe the structure of a nephron, to include Bowman's capsule and glomerulus, convoluted tubules, loop of Henlé and collecting duct<br>• describe ultrafiltration in the Bowman's capsule and the composition of the glomerular filtrate<br>• understand that water is reabsorbed into the blood from the collecting duct<br>• **understand that selective reabsorption of glucose occurs at the proximal convoluted tubule**<br>• **describe the role of ADH in regulating the water content of the blood**<br>• recall that urine contains water, urea and salts | |
| 5 – 6 | **Human coordination and response**<br><br>**Homeostasis** | • understand that organisms are able to respond to changes in their environment<br>• understand that homeostasis is the maintenance of a constant internal environment and that body water content and body temperature are both examples of homeostasis<br>• understand that a co-ordinated response requires a stimulus, a receptor and an effector<br>• **describe the role of the skin in temperature regulation, with reference to sweating, vasoconstriction and vasodilation**<br>• understand the sources, roles and effects of the following hormones: ADH, adrenaline, insulin, testosterone, progesterone and oestrogen | |

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|---|---|---|---|
| 7 – 8 | **Nerves and eye** | • describe how responses can be controlled by nervous or by hormonal communication and understand the differences between the two systems<br>• recall that the central nervous system consists of the brain and spinal cord and is linked to sense organs by nerves<br>• understand that stimulation of receptors in the sense organs sends electrical impulses along nerves into and out of the central nervous system, resulting in rapid responses<br>• **describe the structure and functioning of a simple reflex arc illustrated by the withdrawal of a finger from a hot object**<br>• describe the structure and function of the eye as a receptor<br>• understand the function of the eye in focusing near and distant objects, and in responding to changes in light intensity | • describe a simple experiment to show how the sensitivity of skin differs on fingers, back of hand, wrist and forearm |
| 9 – 10 | **Plant coordination and response** | • understand that plants respond to stimuli<br>• describe the geotropic responses of roots and stems<br>• describe positive phototropism of stems<br>• **understand that phototropic responses in stems are the result of differential growth caused by auxin** | • recall controlled experiments to demonstrate phototropic and geotropic plant growth responses |

## Term 3

| Week | Topic | Specification Detail | Practical Work |
|---|---|---|---|
| 1 – 2 | **Plant nutrition** | • describe the process of photosynthesis and understand its importance in conversion of light energy to chemical energy<br>• recall the word equation **and the balanced chemical symbol equation** for photosynthesis<br>• understand how carbon dioxide concentration, light intensity and temperature affect the rate of photosynthesis<br>• explain how the structure of the leaf is adapted for photosynthesis<br>• recall that plants require mineral ions for growth and that magnesium ions are needed for chlorophyll and nitrate ions are needed for amino acids | • describe simple controlled experiments to investigate photosynthesis, showing the evolution of oxygen from a water plant, the production of starch and the requirements of light, carbon dioxide and chlorophyll |
| 3 – 4 | **Plant gas exchange** | • understand gas exchange (of carbon dioxide and oxygen) in relation to respiration and photosynthesis<br>• **understand that respiration continues during the day and night, but that the net exchange of carbon dioxide and oxygen depends on the intensity of light**<br>• explain how the structure of the leaf is adapted for gas exchange<br>• describe the role of stomata in gas exchange<br>• recall the origin of carbon dioxide and oxygen as waste products of metabolism and their loss from the stomata of a leaf | • describe simple controlled experiments to investigate the effect of light on net gas exchange from a leaf, using hydrogen-carbonate indicator |
| 5 | **Plant transport** | • describe the position of phloem and xylem in a stem<br>• describe the role of phloem in transporting sucrose and amino acids between the leaves and other parts of the plant<br>• describe the role of the xylem in transporting water and mineral salts from the roots to other parts of the plant<br>• explain how water is absorbed by root hair cells<br>• recall that transpiration is the evaporation of water from the surface of a plant<br>• **explain how the rate of transpiration is affected by changes in humidity, wind speed, temperature and light intensity** | • describe experiments that investigate the role of environmental factors in determining the rate of transpiration from a leafy shoot |

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|---|---|---|---|
| 6 – 8 | **The organism in the environment and feeding relationships** | • understand the terms population, community, habitat and ecosystem<br>• describe the use of quadrats as a technique for sampling the distribution of organisms in their habitats<br>• recall the names given to different trophic levels to include producers, primary, secondary and tertiary consumers and decomposers<br>• understand the concepts of food chains, food webs, pyramids of number, pyramids of biomass **and pyramids of energy transfer**<br>• understand the transfer of substances and of energy along a food chain<br>• **explain why only about 10% of energy is transferred from one trophic level to the next** | • recall the use of quadrats to estimate the population size of an organism in two different areas |
| 9 – 10 | **Carbon, nitrogen and water cycles** | • describe the stages in the water cycle, including evaporation, transpiration, condensation and precipitation<br>• describe the stages in the carbon cycle, including respiration, photosynthesis, decomposition and combustion<br>• **describe the stages in the nitrogen cycle, including the roles of nitrogen fixing bacteria, decomposers, nitrifying bacteria and denitrifying bacteria (specific names of bacteria are not required)** | |

## Term 4

| Week | Topic | Specification Detail | Practical Work |
|---|---|---|---|
| 1 – 3 | **Reproduction** | • describe the differences between sexual and asexual reproduction<br>• understand that fertilisation involves the fusion of a male and female gamete to produce a zygote<br>• describe the structures of an insect-pollinated and a wind-pollinated flower and explain how each is adapted for pollination<br>• describe pollination and the growth of the pollen tube<br>• understand that fertilisation leads to seed and fruit formation<br>• recall the conditions needed for seed germination<br>• understand how germinating seeds utilise food reserves until the seedling can carry out photosynthesis<br>• understand that plants can reproduce asexually by natural methods (illustrated by runners), and by artificial methods (illustrated by cuttings)<br>• recall the structure and function of the male and female reproductive systems<br>• understand the roles of oestrogen and progesterone in the menstrual cycle<br>• recall that fertilisation produces a zygote that undergoes cell division and develops into an embryo<br>• describe the role of the placenta in the nutrition of the developing embryo<br>• understand how the developing embryo is protected by amniotic fluid<br>• recall the roles of oestrogen and testosterone in the development of secondary sexual characteristics | • a practical exercise to compare structures in an insect-pollinated and a wind-pollinated flower using suitable local specimens |
| 4 – 6 | **Inheritance** | • recall that the nucleus of a cell contains chromosomes on which genes are located<br>• understand that a gene is a section of a molecule of DNA<br>• understand that genes exist in alternative forms called alleles which give rise to differences in inherited characteristics<br>• recall the meaning of the terms dominant, recessive, homozygous, heterozygous, phenotype, genotype **and co-dominance**<br>• describe patterns of monohybrid inheritance using a genetic diagram<br>• **understand how to interpret family pedigrees**<br>• **predict probabilities of outcomes from monohybrid crosses**<br>• recall that the sex of a person is controlled by one pair of chromosomes, XX in a female and XY in a male | |

| | | | |
|---|---|---|---|
| 4 – 6 Cont. | | • describe the determination of the sex of offspring at fertilisation, using a genetic diagram<br>• understand that random fertilisation produces genetic variation of offspring<br>• recall that in human cells the diploid number of chromosomes is 46 and the haploid number is 23<br>• understand that variation within a species can be genetic, environmental, or a combination of both<br>• recall that mutation is a rare, random change in genetic material that can be inherited<br>• understand that many mutations are harmful but some are neutral and a few are beneficial<br>• **understand that mutant organisms can increase in a population by natural selection**<br>• understand that the incidence of mutations can be increased by exposure to ionising radiation (e.g. gamma rays, X-rays and ultraviolet rays) and some chemical mutagens (e.g. chemicals in tobacco) | |
| 7 – 8 | **Cell division** | • understand that division of a diploid cell by mitosis produces two cells which contain identical sets of chromosomes<br>• understand that mitosis occurs during growth, repair, cloning and asexual reproduction<br>• understand that division of a cell by meiosis produces four cells, each with half the number of chromosomes, and that this results in the formation of genetically different haploid gametes | |
| 9 | **Cloning** | • describe the process of micropropagation (tissue culture) in which small pieces of plants (explants) are grown in vitro using nutrient media<br>• understand how micropropagation can be used to produce commercial quantities of identical plants (clones) with desirable characteristics<br>• **describe the stages in the production of cloned mammals involving the introduction of a diploid nucleus from a mature cell into an enucleated egg cell, illustrated by Dolly the sheep**<br>• **evaluate the potential for using cloned transgenic animals, for example, to produce commercial quantities of human antibodies or organs for transplantation** | |
| 10 | **Selective breeding** | • understand that plants with desired characteristics can be developed by selective breeding (illustrated by increased yield and reduction of stem length in wheat)<br>• understand that animals with desired characteristics can be developed by selective breeding (illustrated by increased yield of meat and milk in cattle) | |

## Term 5

| Week | Topic | Specification Detail | Practical Work |
|---|---|---|---|
| 1 – 2 | **Food production and fish farming** | • describe how glasshouses and polythene tunnels can be used to increase the yield of certain crops<br>• understand the effects on crop yield of increased carbon dioxide and increased temperature in glasshouses<br>• understand the use of fertiliser to increase crop yield<br>• understand the reasons for pest control and the advantages and disadvantages of using pesticides and biological control with crop plants<br>• **explain the methods which are used to farm large numbers of fish to provide a source of protein, including maintenance of water quality, control of intraspecific and interspecific predation, control of disease, removal of waste products, quality and frequency of feeding and the use of selective breeding** | |
| 3 – 4 | **Genetic modification** | • **describe a DNA molecule as two strands coiled to form a double helix, the strands being linked by a series of paired bases: adenine (A) with thymine (T), and cytosine (C) with guanine (G)**<br>• **describe the use of restriction enzymes to cut DNA at specific sites and ligase enzymes to join pieces of DNA together**<br>• **describe how plasmids and viruses can act as vectors, which take up pieces of DNA, then insert this recombinant DNA into other cells**<br>• understand that large amounts of human insulin can be manufactured from genetically modified bacteria that are grown in a fermenter<br>• evaluate the potential for using genetically modified plants to improve food production (illustrated by plants with improved resistance to disease)<br>• **recall that the term transgenic means the transfer of genetic material from one species to a different species** | |

| | | | |
|---|---|---|---|
| 5 – 6 | **Micro-organisms** | • understand the role of yeast in the production of beer<br>• understand the role of bacteria (Lactobacillus) in the production of yoghurt<br>• **interpret and label a diagram of an industrial fermenter and explain the need to provide suitable conditions in the fermenter, including aseptic precautions, nutrients, optimum temperature and pH, oxygenation and agitation, for the growth of micro-organisms** | • describe a simple experiment to investigate carbon dioxide production by yeast, in different conditions |
| 7 – 9 | **Human influences on the environment** | • understand the biological consequences of pollution of air by sulphur dioxide and by carbon monoxide<br>• recall that water vapour, carbon dioxide, nitrous oxide, methane and CFCs are greenhouse gases<br>• understand how human activities contribute to greenhouse gases<br>• understand how an increase in greenhouse gases results in an enhanced greenhouse effect and that this may lead to global warming and its consequences<br>• understand the biological consequences of pollution of water by sewage including increases in the number of micro-organisms causing depletion of oxygen<br>• **understand that eutrophication can result from leached minerals from fertiliser**<br>• understand the effects of deforestation, including leaching, soil erosion, disturbance of the water cycle and of the balance in atmospheric oxygen and carbon dioxide<br>• **explain the biological consequences of overfishing and overgrazing** | |
| 10 | **Revision** | | Use specimen papers as practice for examination. |

# Experimental and investigative work

Experimental work should be an integral part of the study of Biology and consequently it is appropriate that assessment of experimental and investigative skills should form 20% of the final assessment.

It is strongly recommended that 20% of the teaching time should be devoted to practical work carried out by the students themselves, whether they are being assessed via coursework or via Paper 03. It is envisaged that many of the topics in the specification will be taught in a way that allows the facts to arise from practical work rather than the practical work being used to demonstrate what the students have already been taught.

Practical work should be carried out by all students, whichever assessment route is followed. It should be marked using the criteria for assessing the four practical skill areas, P (Planning), O (Obtaining evidence), A (Analysing and considering evidence) and E (Evaluating). The mark descriptions for assessing practical skills are given in Appendix 1, and a 'student-speak' version for issue to students is provided as Appendix 2.

**From early 2004, a detailed Coursework Guide for all IGCSE Science subjects (Biology 4325, Chemistry 4335, Physics 4420 and Dual Award Science 4437, first examination May 2006), which will include exemplar work, will be available on the Edexcel International website. The publication code will be UG014326. The information will also be helpful to teachers preparing students for paper 03.**

The two alternative assessment routes are outlined on the next page, for reference.

## Paper 03 – written alternative to coursework

Candidates will be assessed on their ability to

- plan experimental procedures (P)
- describe practical techniques and take measurements (O)
- analyse evidence and draw conclusions, communicating findings using calculations, tables and graphs (A)
- evaluate evidence (E).

The paper carries a total of 50 marks that will be scaled to 20% of the assessment. A specimen paper and mark scheme have been produced to illustrate the types of questions that will be asked.

- **Coursework**

Candidates are required to submit coursework that will be assessed by the teacher and moderated by Edexcel International. Candidates will be required to show the ability to

- plan experimental procedures (P)
- obtain evidence(O)
- analyse this evidence and draw conclusions, communicating findings using calculations, tables and graphs (A)
- evaluate evidence (E).

The component carries a total of 30 marks that will be scaled to 20% of the assessment.

Guidance for teachers on how to select work for assessment and how to complete the final mark aggregation sheet will be found in Appendices 3 and 4. Instructions for submitting samples of coursework and the coursework marks to London Examinations will be sent to centres once London Examinations has received estimated entries from the centre.

## Paper 03 or coursework? Which is better?

There is no ‘best way’ to assess practical skills – both methods have their advantages and their drawbacks. Bearing in mind the limitations described below, it is for each centre to decide the most appropriate assessment method for their candidates.

Paper 03 is a written examination. The questions are designed to assess the same four skill areas as the coursework, to the same marking criteria, so the best way to prepare students for Paper 03 is to give them the same opportunities to carry out experimental and investigative tasks as those students following the coursework option.

The same advice for training and guiding students should be followed, including the use of ‘student-speak’ marking criteria (Appendix 2) and the gradual introduction to carrying out whole investigations (see below). Students should be offered several opportunities to plan and carry out experimental tasks and whole investigations themselves, and to practise the skills needed to achieve their highest potential in such work.

The specimen paper and mark scheme illustrate the range of question types that will be set on paper 03.

Teachers are asked to note that only centres which have been specifically approved by Edexcel International may offer the coursework option. Please refer to the section ‘Availability of coursework to international centres’ in the Specification for full details.

## Training students in practical skills

Many students will need considerable guidance in order to progress from simply carrying out a set of practical instructions provided by the teacher, to the point where they are able to plan and carry out a whole investigation themselves, and critically evaluate the outcome. However, the effort required will be well rewarded, as the student will then more fully understand the principles and parameters upon which scientific method is based.

Whether the student will ultimately be assessed via coursework or via Paper 03, the written alternative to coursework, the course plan should allow for the gradual development of experimental skills over the two years (advisory minimum time). As 20% of the final marks is derived from these skills, it would be advisable to devote this proportion of teaching time to them.

Please note that it is beneficial to students to be introduced to the concept of practical investigative work well before they begin the two-year examination course; research evidence has shown that students take a considerable time to gain the confidence needed for higher level investigative skills such as critical evaluation.

Students should be encouraged to participate in practical work wherever possible. The scheme is designed to encourage a wide variety of activities, including those based on the collection of first-hand evidence and those which depend on secondary evidence. (The term ‘evidence’ is used to mean observations, measurements or other data.)

Before attempting whole investigations, students should be given experimental tasks that test only one or two skill areas. For example, as an introduction to the concept of planning whole investigations, students could be asked to write a plan for an experiment that is subsequently carried out in class. Teacher feedback is essential during this early stage of learning.

Towards the second half of the course, students should be provided with several opportunities to develop their investigative skills to allow them to achieve their highest potential in such work.

A simpler, ‘student-speak’ version of the coursework criteria is given in Appendix 2 and it is recommended that this is given to all students at the start of the course, and thereafter referred to frequently.

**A checklist for teachers of required practical work and student investigations**

1. Tests for glucose, starch, lipid and protein
2. Controlled experiments to illustrate how enzyme activity can be affected by changes in temperature
3. Simple experiments on diffusion and osmosis using living and non-living systems
4. Controlled experiments to investigate photosynthesis showing the evolution of oxygen from a water plant, the production of starch and the requirements of light, carbon dioxide and chlorophyll
5. A simple experiment to determine the energy content of a food sample
6. Controlled experiments to demonstrate the evolution of carbon dioxide and heat from respiring seeds or other suitable living organisms
7. Simple controlled experiments to investigate the effect of light on net gas exchange from a leaf, using hydrogen-carbonate indicator
8. A simple experiment to investigate the effect of exercise on breathing in humans
9. Experiments to investigate the role of environmental factors in determining the rate of transpiration from a leafy shoot
10. Controlled experiments to demonstrate phototropic and geotropic plant growth responses
11. The use of quadrats to estimate the population size of an organism in two different areas
12. An experiment to investigate carbon dioxide production by yeast, in different conditions

## Practical work and student investigations

The list below gives all the practical work in the order in which it appears in the specification (not in the order in which it appears in the course plan in this guide). Advice on how to approach each of these experiments or investigations is given in each case. The advice is not obligatory; it is recognised that there are many ways in which the practical work could be carried out to fulfil the requirements.

### Tests for glucose, starch, lipid and protein

The tests that are expected

- Benedict's test for glucose
- iodine test for starch
- the emulsion test for lipid
- biuret reagent for protein.

These tests could be carried out

- on prepared samples of pure substances
- on foods that contain the substances
- in a context.

**Example**

To demonstrate health applications, a fake 'urine sample' can be made by colouring water with iodine solution. A similar solution, with glucose added, could mimic the urine of an untreated diabetic. Students can use Benedict's test to identify the diabetic.

The iodine test could be introduced when teaching that plants manufacture starch by photosynthesis, or when investigating the effect of amylase on starch digestion

**Controlled experiments to illustrate how enzyme activity can be affected by changes in temperature**

The effect of amylase on starch digestion is a particularly easy system to use. At each temperature selected, from 0°C to 100°C, samples of amylase solution and of starch solution are brought to temperature before being added together. The mixture is then kept at the same temperature. To measure the rate of reaction, drops of the mixture can be collected at intervals of one minute and added to individual iodine drops on a white tile. The time taken for the starch to disappear is recorded for each temperature.

Temperature-controlled water baths help the students, but stable temperatures can also be achieved by using beakers of water, thermometers, ice and Bunsen burners.

There is plenty of scope for students working individually to plan how to keep all variables except for temperature the same, to consider repetition, to display their results in tables and to plot them as graphs, and to evaluate their results.

Catalase is another enzyme that can be used. There are a number of sources, but potato or liver are most commonly used. Catalase converts hydrogen peroxide into water and oxygen. The rate of oxygen production can be measured as an indication of enzyme activity. An upturned burette previously filled with water can be used to collect and measure the volume of oxygen evolved. Hydrogen peroxide is toxic and so great care needs to be taken with its use.

**Simple experiments on diffusion and osmosis using living and non-living systems**

(a) Cubes of agar jelly placed into solutions of methylene blue or potassium permanganate will absorb the pigment by diffusion. The cubes are left in the pigmented solution for different measured periods of time and are then sliced open. The distance between the edge of each cube and the edge of the coloured agar may be used as a measure of the distance the pigment molecules have moved by diffusion.

(b) A crystal of potassium permanganate can be dropped into a beaker of water and the appearance of the water noted over time.

(c) To demonstrate osmosis, Visking tubing (dialysis tubing) can be tied at one end and filled with 20% sucrose solution. The other end is attached to a capillary tube. The level of the sucrose can be noted before and after the tubing has been placed in a beaker of water for about thirty minutes.

(d) Onion epidermis can be peeled away, cut into squares and mounted on slides in different concentrations of sucrose solution. Observation under a microscope will show the effects of osmosis.

(e) Red blood cells in blood obtained from a butcher may be mounted on slides in hypotonic, isotonic and hypertonic saline, and observed under a microscope to show the effects of osmosis.

(f) Osmosis can be demonstrated by using strips of potato, and this basic experimental method provides a good opportunity for students to carry out individual whole investigations. Because of the difficulty of the osmosis concept, it is better to keep this investigation until the latter part of the course so that students will have had previous experience of carrying out investigations on simpler topics. Students enjoy the reference to 'chips', but should quickly realise that it can be difficult to keep the size constant - to achieve consistency lengths of potato tissue can be drilled from a potato using a cork borer. The 'chips' are measured by mass or by length and are placed into sucrose solutions of different concentrations for at least one hour. The percentage change in mass or length is a measure of the degree of osmosis that has occurred.

(g) A variation on this theme is to cut potato cubes of different sizes, which have different surface area to volume ratios. After measuring and recording the masses of the cubes, they are immersed in water. After one hour, the cubes are blotted dry and their masses measured and recorded again. The percentage increase in mass for cubes of different surface area to mass ratio can be compared, to explore the concept of how surface area to volume ratio influences water uptake.

**Controlled experiments to investigate photosynthesis, showing the evolution of oxygen from a water plant, the production of starch by leaves and the requirements for light, carbon dioxide and chlorophyll**

(a) The evolution of oxygen from a water plant can be seen if a water plant (typically *Elodea* or similar species) is placed in a beaker of water and covered with a glass funnel which has a water-filled test tube placed over its opening. After 24 hours, a colourless gas will have displaced water from the test tube – a test for oxygen is then carried out.

(b) To measure the rate of oxygen production, the stem of a water plant is cut under water, and the plant kept immersed in water in a beaker or boiling tube. The number of bubbles of gas given off over a measured time period can be counted. This simple experimental set up can provide an opportunity for students to carry out individual investigations into the effect of different factors on the rate of bubble production. Suitable variables include: light intensity (the plant is exposed to a light source and the rate of bubble production measured at different light intensities by changing the distance between the light source and the water plant); colour/wavelength of light (coloured filters are placed between the plant and the light source); carbon dioxide availability (the plant is immersed in solutions of different concentration of sodium hydrogen carbonate).

(c) Starch production can be investigated by placing a plant in the dark for 24 hours to destarch the leaves. A starch test on a leaf will not give a blue-black colour, whereas a similar test on a control leaf from a plant kept in the light will give a blue-black colour.

(d) A starch test on a variegated leaf can be used to demonstrate that chlorophyll is needed for photosynthesis.

(e) To show that carbon dioxide is needed for photosynthesis a leaf on a plant may be surrounded by air with no carbon dioxide by inserting it into a conical flask containing a small amount of potassium or sodium hydroxide. The plant is left in good light for 24 hours. The test leaf and a control leaf from the plant are then tested for starch.

To test leaves for starch

- put into very hot/boiling water for one minute (to destroy the cell membranes so that chlorophyll molecules can pass through)
- put into hot ethanol (to remove/dissolve the green chlorophyll)
- put leaf into water (to rehydrate and soften the leaf so that it can be spread out)
- put iodine solution onto the leaf (test for starch) – blue-black colour will show the presence of starch.

**A simple experiment to determine the energy content of a food sample**

Fat-containing foods such as dried crisps work very well.

- A known mass of the food sample is weighed and the mass noted.
- A boiling tube is prepared, containing a known volume of water. The water temperature is recorded.
- The food sample is put in a crucible or burning spoon and ignited (eg in the flame of a Bunsen burner).
- The food sample is quickly placed under the boiling tube. As soon as the food sample has completely burnt the water temperature in the boiling tube is re-measured.
- The equation used to calculate the energy content of the food is:

Energy content of food sample (joules per gram) =

mass of water heated (g) x temperature rise ($^{o}$C) x 4.2 x 1/mass of food sample (g)

**Warning! Peanuts should not be used as the food sample because some people have a serious allergic reaction to them.**

To obtain an accurate result, all the energy in the food sample needs to be transferred to the water. Students could be asked to think of the reasons this method produces an inaccurate result and to suggest ways in which the apparatus could be modified to make the result they obtain more accurate.

**Controlled experiments to demonstrate the evolution of carbon dioxide and heat from respiring seeds or other suitable living organisms**

The use of thermos flasks is needed for this. Surface sterilised seeds are put into a flask which is sealed with a bung. A glass tube runs from inside the flask, through the bung and into an indicator solution of either limewater or hydrogen carbonate .The carbon dioxide produced changes the colour of the indicator solution. To show heat production the flask needs a cotton wool bung with a thermometer going through the bung into the flask.

Students could demonstrate that they produce carbon dioxide by breathing out through a tube into lime water or hydrogen carbonate indicator.

**Simple controlled experiments to investigate the effect of light on net gas exchange from a leaf, using hydrogen carbonate indicator**

A water plant can be placed in a sealed tube of air-equilibrated hydrogen carbonate solution (red in colour) and placed in the light or in the dark. The solution will turn purple if kept in the light and will turn yellow if kept in the dark.

A variation could involve the use of water snails or, if not available, small land insects placed on a gauze platform above the indicator, with and without the water plant. This variation allows students to think about the balance between carbon dioxide used by photosynthesis and carbon dioxide produced by respiration.

A useful demonstration uses four tubes containing hydrogen carbonate solution: one with water plant only, one with animals only, one with both water plant and animals and one with no living organisms. One set of the tubes is exposed to light and left for 12 to 24 hours and another set placed in the dark for the same length of time.

### A simple experiment to investigate the effect of exercise on breathing in humans

The breathing rate can be measured at rest and after a period of exercise by counting the number of inhalations per minute.

To help students appreciate that exercise also influences the rate of breathing by increasing the volume of each breath they can measure the volume of one exhalation before and after exercise. This can be done by breathing through a tube into a plastic container filled with water. The volume of displaced water can be measured. The breathing rate at rest and after exercise can be calculated as number of breaths per minute x volume of each breath.

### Experiments to investigate the role of environmental factors in determining the rate of transpiration from a leafy shoot

A bubble potometer can be used to illustrate the effects of light, wind, temperature and air humidity. Plants covered with dark polythene bags simulate darkness and can be compared with plants covered with transparent polythene bags. Hair dryers can simulate wind. The use of potted plants is also acceptable, where the pot and the soil is sealed with polythene and the mass of the potted plant is measured before and after a period of exposure to the environmental factor.

### A simple experiment to investigate the effect of exercise on heart rate in humans

Students should be shown how to measure and record their pulse. They can measure this at rest. A short period of exercise can follow, stepping on and off a low stool, or running up and down a flight of stairs for five minutes. (Safety note: careful supervision is required.)

The pulse rate should now be recorded for five minutes or until it returns to its rest level. This experiment can provide a great deal of interesting data on the variation in resting heart rate, the effects of exercise and how quickly the heart recovers. Discussion can include measures of fitness, heart disease, cardiac output and the effects of long-term exercise on stroke volume.

### A simple experiment to show how the sensitivity of the skin differs on finger tips, back of hand, wrist and forearm

The students work in pairs. A piece of hard cardboard or cork can be used to fix the two prongs of a hairpin or two pins 5mm apart. This is then used by one student to lightly touch the fingertips of another who is looking away. The first student can use both points or one point as a stimulus. The second student then has to judge whether one or two points were used and his/her response recorded as correct or incorrect. This can be repeated ten times for each area of the hand. It is then repeated using pins 1cm apart and 2cm apart. The students can then identify the most sensitive area as this should have the most correct responses with the smaller distance. Conclusions can be made about the number of sensory nerve endings, receptive field size and the thickness of skin. This practical also provides opportunities to discuss data analysis, experiment design and anomalous results, and the benefits of grouping class results.

### A practical exercise comparing floral structure in insect-pollinated and wind-pollinated flowers

Most areas should have access to suitable specimens. Insect-pollinated flowers can be examined and the various structures observed. Wind-pollinated grasses should be available but have fewer structures to see. Teachers should demonstrate the features.

### Controlled experiments to demonstrate phototropic and geotropic plant growth responses

Plant material such as wheat, maize, oat or cress seedlings can be used to demonstrate phototropism. Petri dishes containing moist cotton wool and the plant material can be put into light proof boxes such as shoe boxes. To create unilateral light a small slit can be cut in one side of the box and light can be shone into the box. Control seedlings can either have aluminium caps put on their tips or can be kept in a shoe box without a slit for light. A klinostat needs to be used to demonstrate geotropism.

### The use of quadrats to estimate the population size of an organism in two different areas

Quadrats can be used to sample part of each area. Calculation will be needed to work out the estimated population size. For example, if ten quadrats have been used and the total area amounts to 100 quadrats, the estimated population size will be the number of organisms counted in the ten sample quadrats x 10.

Students are expected to understand the importance of placing the sample quadrats randomly.

An interesting way to practice the technique is to throw plastic beads on the floor of the classroom and ask the students to guess how many beads there are. The quadrat sampling procedure can be used in front of the students to get an estimate. The beads can then be collected and counted. The actual number can be compared to the estimated number and used to see how accurate the estimation was.

### A simple experiment to investigate carbon dioxide production by yeast, in different conditions

Students add yeast to glucose solution in a side-arm test tube. Anaerobic conditions are achieved by putting a drop of oil (cooking oil will do) onto the yeast and glucose mixture. A rubber tube is attached to the side arm of the test tube and a glass pipette is inserted at the other end of the rubber tube. The pipette is placed under water to allow the bubbles of carbon dioxide gas to be counted. Temperature is the easiest condition to investigate. Glucose concentration and pH could also be investigated.

# Coursework

The coursework option is normally available only to candidates studying at centres that have been recognised by Edexcel International as International Teaching Institutions.

Candidates who submit coursework are required to produce evidence in the four skill areas P, O, A and E.  Candidates will be expected to

| | **Mark scale** |
|---|---|
| Plan experimental procedures (P) | 0 – 8 |
| Obtain evidence (O) | 0 – 8 |
| Analyse this evidence and draw conclusions (A) | 0 – 8 |
| Evaluate evidence (E) | 0 – 6 |

The coursework will be assessed by the school or college according to the principles described below and the mark descriptions in Appendix 1 and will be moderated by Edexcel International.

The evidence for assessment will be coursework carried out by the candidate, in the context of the specification content.

The coursework must be the candidate’s own unaided work, carried out under the supervision of the teacher.

Candidates should undertake experimental and investigative work during the course, as described earlier, and be assessed on several occasions in both types of activity. The aim is to allow them to achieve their highest potential in such work.

An activity can take the form of experimental work or an investigation. Experimental work may be used to assess one, two or three skill areas.

A whole investigation consists of work that covers each of the four skill areas, although not all of these need to be used for the final assessment.

## Applying the mark descriptions

The mark descriptions are given in Appendix 1.

Mark descriptions are provided for 2, 4, 6 and 8 marks in skill areas P (Planning), O (Obtaining evidence) and A (Analysing and considering evidence), and for 2, 4 and 6 marks in the skill area E (Evaluating).

Although the general mark descriptions give guidance for the level of performance to be expected at 2, 4, 6 and 8 teachers may give marks of 1, 3, 5 and 7 for intermediate performance.

Whenever assessments are made, the mark descriptions should be used to judge which mark best fits the candidate's performance. The statements should not be taken as hurdles, all of which must be fulfilled for a mark to be awarded. Adjacent descriptions should be considered when making judgements and use made of the intermediate marks (3, 5 and 7) where performance exceeds one description and only partially satisfies the next.

The mark descriptions within a skill area are designed to be hierarchical. This means that, in general, a description at a particular mark subsumes those at lower marks. It is assumed that activities that access higher marks will involve a more sophisticated approach and/or a more complex treatment.

A candidate who fails to meet the requirements for 2 marks but who has made a creditworthy attempt in a skill area should be given 1 mark for that skill. Zero marks should only be awarded for a skill area in the unlikely event of a candidate failing to demonstrate any achievement in that skill.

The professional judgement of the teacher in making these assessments is important.

### *Examples*

Part of the mark description for skill area O is shown below.

| | | |
|---|---|---|
| 6 marks | O.6a | collect sufficient systematic and accurate evidence and repeat or check where appropriate |
| | O.6b | record clearly and accurately the evidence collected |

Where a student fully satisfies the requirements of O.6a but fails to include units in the results table (thereby not meeting the requirements of O.6b) a mark of 5 should be given.

Intermediate marks may also be awarded to the student who partially satisfies both of the mark descriptions at a particular level.

Part of the mark description for skill area A is shown below.

| | | |
|---|---|---|
| 6 marks | A.6a | construct and use suitable diagrams, charts, graphs (with lines of best fit, where appropriate), or use numerical methods, to process evidence for a conclusion |
| | A.6b | draw a conclusion consistent with the evidence and explain it using scientific knowledge and understanding |

At A.6a, a student might meet the description except for mis-plotting a point, and at A.6b there might be an explanation containing an error in the scientific knowledge. In this case, 5 marks should be awarded.

Each of the tables of mark descriptions in Appendix 1 has a vertical arrow running down the page to signify that an important consideration in designing appropriate assessment tasks is the level of demand expected.

Differentiation by outcome using a common task is appropriate for a group of students with similar ability, but difficult where a class is of mixed ability. However, students do need to be given appropriate tasks to match their abilities, and which fully challenge them. A possible solution is to present two or three similar activities (targeted at different abilities) and to allow students to make a guided choice as to which activity to engage in.

## Keeping records

Whenever a student's work is assessed by the teacher, a form such as the *Provisional Assessment Record* (Appendix 5) should be attached to the work. As the teacher reads the work, a tick is all that is needed to show that the particular mark description is achieved. There is enough space to write a few words to explain why a particular mark description may not have been fully satisfied.

The work with its attached form may then be returned to the student so that they can have an opportunity to consider their work, and redraft if appropriate. This procedure is perfectly acceptable so long as 'material help' is not given. For example, a teacher assessing P.8a might write

'*not awarded – insufficient scientific knowledge provided'*

This is not 'material help', so a student could have the opportunity to revise the work. However, a comment such as

'*no reference to the distance of the plant from the light source'*

would be considered 'material help' by the centre's moderator.

The teacher should also indicate in the margin alongside the appropriate part of the script, P.4a✓, etc.

Where there is any doubt about whether a particular mark should be awarded, external moderators appreciate a written comment to help to understand the rationale behind the teacher's decision.

Each time coursework is assessed by the teacher, the provisional marks awarded should be recorded.

## Standardising teachers and submitting the coursework marks

It is in the centre's own interest to devise an efficient method of internal standardisation, so that all teachers apply the criteria in the same way. This is particularly important where work from several teaching groups and several teachers is being presented for moderation.

Once coursework marks have been internally standardised and agreed, the Final mark aggregation sheet (Appendices 3 and 4) may be completed for each student.

Instructions for submitting samples of coursework and the coursework marks to London Examinations - *Instructions for moderation of internal assessment* - will be found in later editions of the specification, and on the Edexcel International website.

## A teacher's checklist for final assessment of coursework

- One mark from each skill area P, O, A and E should be identified.
- These marks are added together to form the final mark.
- The marks should be drawn from one or two pieces of work only.
- The work must be derived from the content of the specification.
- At least one mark must be from a practically based, whole investigation.

  A *whole investigation* is defined as a piece of work, carried out by the student, in which all four skill areas are attempted. A *practically based investigation* is one in which first-hand evidence is gathered by the student through observation or measurement.
- The *Final mark aggregation sheet* (see Appendices 1 and 2) is completed for the candidate and attached to the corresponding practical work.
- The work must be the candidate's own unaided work, carried out under the supervision of the teacher. The declaration of authentication on the bottom of the Final mark aggregation sheet (Appendix 2) must be signed by the candidate and the teacher.

## Use of ICT

The use of ICT, where available, e.g. for word-processing, data-logging and graphical display (including lines of best fit) is to be encouraged. However, teachers are advised that some spreadsheet software does not properly produce a line of best fit on graphs.

Data loggers might be used to carry out investigations. A comparison could be made using data-logging with more traditional techniques. The rate of a chemical reaction might be monitored by recording changes in pH, for example.

Formulae functions in a spreadsheet can be used to analyse data. Students could compare this with using a calculator or manual calculations.

Data-handling software could be used to create, analyse and evaluate charts or graphs.

The Internet or CD-ROM software could be used as a source of secondary evidence.

Students should develop the ability to judge when it is appropriate to use ICT in their work. All sources and references used must be clearly identified by the student.

## Safe practice

Attention is drawn to the need for safe practice when candidates carry out laboratory investigations or observe demonstrations. Particular attention is drawn to the possible hazards associated with electrical equipment, the handling of microorganisms, and ionising radiations. Strict aseptic conditions should be used when undertaking practical work with microorganisms. Reference should be made to local health and safety regulations, and widely accepted publications such as

- *COSHH* ; *Guidance for Schools* (HSC, 1989) (HMSO) ISBN 011 885 5115
- *Topics in Safety* – 3rd Edition, Association for Science Education (ASE , 2001) ISBN 086 357 3169
- *CLEAPSS Laboratory Handbook and Hazards*, available from Consortium, of Local Education Authorities for the Provision of Service Sciences (CLEAPSS).

# Resources

The following textbook is particularly recommended for studying this specification:

*Longman Biology for IGCSE* – S Potter and P Bradfield (Longman, 2004)
ISBN: 1405 80206 5

Teachers will find a good deal of useful information on the following websites.

**BBC Education (Revision guides)**
www.bbc.co.uk/education/gcsebitesize

**Association for Science Education**
http://www.ase.org.uk

**BBC Science**
http://www.bbc.co.uk/science

**Biochemistry Society**
http://www.biochemistry.org

**Biotechnology and Biological Research Council**
http://www.bbsrc.ac.uk

**BP Amoco Educational Service**
http://www.bpes.com

**British Association for the Advancement of Science**
http://www.britassoc.org.uk

**British Library**
http://www.bl.uk

**Esso**
http://www.esso.co.uk

**Friends of the Earth**
http://www.foe.co.uk

**Institute of Education (London)**
http://www.ioe.ac.uk

**Multimedia – Key Concepts in Science**
http://www.new-media.co.uk

**New Scientist**
http://www.newscientist.com

**Schoolscience**
http://www.schoolscience.org.uk

**School Science Service**
http://www.cleapss.org.uk

**Science Consortium**
http://www.scienceconsortium.co.uk

**Science Enhancement Programme**
http://www.sep.org.uk

**Science Museum**
http://www.sciencemuseum.org.uk

**Shell**
http://www.shell.co.uk

# Subject-specific information

In the IGCSE course, 20% of class time should be devoted to practical investigative work whether opting for the coursework or for Paper 03. Practicals that the students should be familiar with are given in the specification. However, centres are encouraged to carry out other investigations or practicals that help students to understand and practise the skills needed to help them complete their coursework or Paper 03.

Inevitably centres will require the apparatus needed to fulfil the practical work, particularly apparatus needed for the coursework chosen. It is envisaged that many of the topics in the specification will be taught in a way that allows the biological facts to arise from practical work rather than the practical work being used to demonstrate what the students have been already been taught. The emphasis is to encourage students to think for themselves.

During practical investigations students can work in groups or in pairs, but it is important that students work **individually** when doing any practical that may be included in their coursework submission.

# Support and training

## Training

A programme of INSET courses covering various aspects of the specifications and assessment will be arranged by London Examinations on a regular basis. Full details may be obtained from

International Customer Relations Unit
Edexcel International
190 High Holborn
London
WC1V 7BE
United Kingdom

Tel: +44 (0) 190 884 7750

E-mail: international@edexcel.org.uk

## Edexcel publications

Support materials and further copies of this specification can be obtained from

Edexcel International Publications
Adamsway
Mansfield
Notts NG18 4LN
UK

Tel: +44 (0) 1623 450 781
Fax: +44 (0) 1623 450 481
E-mail: intpublications@linneydirect.com

Other materials available in 2003 include

- Specimen papers and mark schemes (Publication code: UG013059)
- Specification (Publication code: UG013282)
- Coursework Guide for all IGCSE Science subjects (Publication code: UG014326) *Available 2004.*

# Appendices

## Appendix 1 – Mark descriptions for the four skill areas

### Skill Area P: Planning

| **Skill Area P** |
|---|
| Candidates should be encouraged to<br>**a** use scientific knowledge and understanding to turn ideas into a form that can be investigated, and to plan an appropriate strategy<br>**b** decide whether to use evidence from first-hand experience or secondary sources<br>**c** carry out preliminary work and make predictions, where appropriate<br>**d** consider key factors that need to be taken into account when collecting evidence, and how evidence can be collected in contexts in which the variables cannot readily be controlled<br>**e** decide the extent and range of data to be collected, and the techniques, equipment and materials to use. |

| **Mark descriptions for internal assessment** | | | |
|---|---|---|---|
| The mark descriptions are designed to be hierarchical.<br>All work should be assessed in the context of the specification content. | | | |
| Candidates | | | Increasing demand of activity |
| 2 marks | P.2a | outline a simple procedure | ↓ |
| 4 marks | P.4a | plan to collect evidence which will be valid | |
| | P.4b | plan the use of suitable equipment or sources of evidence | |
| 6 marks | P.6a | use scientific knowledge and understanding to plan and communicate a procedure, to identify key factors to vary, control or take into account, and to make a prediction where appropriate | |
| | P.6b | decide a suitable extent and range of evidence to be collected | |
| 8 marks | P.8a | use detailed scientific knowledge and understanding to plan and communicate an appropriate strategy, taking into account the need to produce precise and reliable evidence, and to justify a prediction, when one has been made | |
| | P.8b | use relevant information from preliminary work, where appropriate, to inform the plan | |

## Skill Area O: Obtaining evidence

| **Skill Area O** |
|---|
| Candidates should be encouraged to |
| **f** use a wide range of equipment and materials appropriately, and manage their working environment to ensure the safety of themselves and others |
| **g** make observations and measurements, to a degree of precision appropriate to the context |
| **h** make sufficient observations and measurements to reduce error and obtain reliable evidence |
| **i** judge the level of uncertainty in observations and measurements |
| **j** represent and communicate qualitative and quantitative data using diagrams, tables, charts and graphs. |

| **Mark descriptions for internal assessment** | | | |
|---|---|---|---|
| The mark descriptions are designed to be hierarchical.<br>All work should be assessed in the context of the specification content. | | | |
| | | Candidates | Increasing demand of activity |
| 2 marks | O.2a | collect some evidence using a simple and safe procedure | ↓ |
| 4 marks | O.4a<br>O.4b | collect appropriate evidence which is adequate for the activity<br>record the evidence | |
| 6 marks | O.6a<br>O.6b | collect sufficient systematic and accurate evidence and repeat or check where appropriate<br>record clearly and accurately the evidence collected | |
| 8 marks | O.8a | use a procedure with precision and skill to obtain and record an appropriate range of reliable evidence | |

## Skill Area A: Analysing and considering evidence

| Skill Area A |
|---|
| Candidates should be encouraged to<br>**k** use diagrams, tables, charts and graphs, and identify and explain patterns or relationships in data<br>**l** present the results of calculations to an appropriate degree of accuracy<br>**m** use observations, measurements or other data to draw conclusions<br>**n** explain to what extent these conclusions support any predictions made, and enable further predictions to be made<br>**o** use scientific knowledge and understanding to explain and interpret observations, measurements or other data, and conclusions. |

| Mark descriptions for internal assessment | | | |
|---|---|---|---|
| The mark descriptions are designed to be hierarchical.<br>All work should be assessed in the context of the specification content. | | | |
| Candidates | | | Increasing demand of activity |
| 2 marks | A.2a | state simply what is shown by the evidence | ↓ |
| 4 marks | A.4a<br>A.4b | use simple diagrams, charts or graphs as a basis for explaining the evidence<br>identify trends and patterns in the evidence | |
| 6 marks | A.6a<br>A.6b | construct and use suitable diagrams, charts, graphs (with lines of best fit, where appropriate), or use numerical methods, to process evidence for a conclusion<br>draw a conclusion consistent with the evidence and explain it using scientific knowledge and understanding | |
| 8 marks | A.8a<br>A.8b | use detailed scientific knowledge and understanding to explain a valid conclusion drawn from processed evidence<br>explain the extent to which the conclusion supports the prediction, if one has been made | |

## Skill Area E: Evaluating

| **Skill Area E** | |
|---|---|
| Candidates should be encouraged to | |
| **p** | consider anomalous data, giving reasons for rejecting or accepting them, and consider the reliability of data in terms of uncertainty of measurements and observations |
| **q** | consider whether the evidence collected is sufficient to support any conclusions or interpretations made |
| **r** | suggest improvements to the methods used |
| **s** | suggest further investigations. |

| **Mark descriptions for internal assessment** | | | |
|---|---|---|---|
| The mark descriptions are designed to be hierarchical.<br>All work should be assessed in the context of the specification content. | | | |
| | | Candidates | Increasing demand of activity |
| 2 marks | E.2a | make a relevant comment about the procedure used or the evidence obtained | ↓ |
| 4 marks | E.4a | comment on the quality of the evidence, identifying any anomalies | ↓ |
| | E.4b | comment on the suitability of the procedure and, where appropriate, suggest changes to improve it | ↓ |
| 6 marks | E.6a | consider critically the reliability of the evidence and whether it is sufficient to support the conclusion, accounting for any anomalies | ↓ |
| | E.6b | describe, in detail, further work to provide additional relevant evidence | ↓ |

# Appendix 2 – A student guide to science coursework criteria

| Skill Area P **Planning** | Skill Area O **Obtaining Evidence** |
|---|---|
| ❑ 2 marks<br>♦ Plan a simple procedure<br><br>❑ 4 marks<br>♦ Plan to collect valid evidence<br>♦ Make a list of the equipment or other sources of evidence<br><br>❑ 6 marks<br>♦ Produce a plan for your task using scientific knowledge and understanding<br>♦ Say what things will affect how well the investigation will work and say how you plan to change or control these<br>♦ Give scientific reasons for why you think these things are important<br>♦ Say what you think will happen and give scientific reasons<br>♦ Say what evidence you are planning to obtain and how much evidence you think will be needed<br><br>❑ 8 marks<br>♦ Give a detailed description of what you are planning to do<br>♦ Use detailed scientific reasons to explain why you think your plan is a good way of carrying out the task<br>♦ Explain how you will use the equipment to make sure the results you obtain will be correct and as precise as possible<br>♦ Say what you think will happen and give detailed scientific reasons to explain this<br>♦ Describe any earlier work that helped your planning<br>♦ Give any information that you have obtained from books CD ROMs, the Internet, or other sources to help your planning | ❑ 2 marks<br>♦ Collect some evidence in a safe way<br><br>❑ 4 marks<br>♦ When you carry out the task, make sure you have enough evidence so that you will be able to say what you have found out<br>♦ Keep a record of your results<br><br>❑ 6 marks<br>♦ Use the equipment to obtain the evidence as accurately as possible<br>♦ Make sure your evidence covers a good range<br>♦ Make sure you have enough evidence to allow you to draw a conclusion<br>♦ If you think your evidence varies a lot, then take some repeat readings if you can<br>♦ Use a clear way of accurately recording your evidence<br>♦ Consider using a table of results with clear headings and correct units<br><br>❑ 8 marks<br>♦ Use equipment that will help you obtain precise evidence<br>♦ Repeat results in order to obtain averages readings. Check that your evidence is reliable<br>♦ Record the evidence in a clear and accurate way |

| Skill Area A **Analysing and considering evidence** | Skill Area E **Evaluating** |
|---|---|
| ❑ 2 marks<br>♦ Say what you have found out from your evidence<br><br>❑ 4 marks<br>♦ Choose a way of showing any pattern in your evidence more clearly<br>♦ Use a pie chart, bar chart, graph or a clearer way of showing your evidence<br>♦ Say what pattern or trend you can see in your evidence<br><br>❑ 6 marks<br>♦ Use the best way of displaying your evidence clearly e.g. by using a chart, diagram, line graph or by doing calculations that help you to make good use of your data<br>♦ Is a line of best fit appropriate?<br>♦ Make use of your evidence and any processing that you have done to write a sensible conclusion that explains what has been found out<br>♦ Using your evidence, include in your conclusion a scientific explanation<br><br>❑ 8 marks<br>♦ Use the best way of processing your evidence e.g. diagrams, graphs, calculations<br>♦ Use this work to draw a meaningful conclusion for the investigation<br>♦ Use scientific knowledge in a detailed way to explain the conclusion you have written<br>♦ If you have made a prediction of what you thought would happen, say if your results turned out the way you expected<br>♦ If the evidence did turn out as expected, explain how well the evidence matched your prediction<br>♦ If the evidence did not turn out as expected, explain why you think the evidence did not support your prediction | ❑ 2 marks<br>♦ Say if you think the task worked out well or not, (give a reason for what you have said) based on what you did, or what evidence you got<br><br>❑ 4 marks<br>♦ Say if you think the evidence was accurate enough for the task–refer to your graph<br>♦ Were there any anomalous results? If so show where they are on the graph. If not, say something about the shape of your graph<br>♦ Suggest at least one improvement that you would like to make to the method to try to get more accurate evidence<br><br>❑ 6 marks<br>♦ Say whether your method gave evidence that is reliable and so could always be counted on to be correct – give detailed reasons for what you have said<br>♦ Point out any results that did not seem to fit in with the main pattern and explain why you think these differences happened<br>♦ Say if you think you have enough evidence to draw a conclusion – give detailed reasons for what you have said<br>♦ Think about your method and your evidence. How might you improve your method to obtain more evidence to support your conclusion? |

# Appendix 3 – Assessment of practical skills – an example of a completed final mark aggregation sheet

| | |
|---|---|
| Month and year of examination: *May 2005* | Specification title: *IGCSE Biology* |
| Specification code: *4325* | |
| Centre: *xyz International School* | Candidate name: *Fatima Khan* |
| | Teaching group: *5H* |
| Centre number: *9xxxx* | Candidate number: *xxxx* |

Marks should be reported for each of the skill areas P, O, A and E.

**One** mark is required for **each** skill area. Thus a total of four marks must be added together to give a mark not exceeding a maximum of 30. These marks should be drawn from **not more than two** pieces of work. At least **one** mark must be from a practically-based whole investigation. For the single award, all marks may be drawn from one attainment target.

**The reported marks from each activity should be ringed.**

| Activity title(s) | P | O | A | E |
|---|---|---|---|---|
| *The effect of exercise on breathing rate* | (5) | 5 | (6) | |
| *The effect of pH on pepsin activity* | 4 | (*6) | 5 | (*5) |

Please indicate whether the reported mark(s) are taken from an investigation by putting an asterisk next to the appropriate mark(s).

The skill area marks are reported in the appropriate Centre Mark boxes in the table below and then aggregated to give a total reported mark.

| | Skill area P | Skill area O | Skill area A | Skill area E | Total mark | Max mark |
|---|---|---|---|---|---|---|
| Centre mark | *5* | *6* | *6* | *5* | *22* | 30 |
| Moderator mark | | | | | | |
| Team leader mark | | | | | | |

**Declaration of Authentication**

I declare that the work submitted for assessment has been carried out without assistance other than that which is acceptable under the scheme of assessment.

Candidate's signature ……*F. Khan*………… Date …*12..01.05*…

Teacher's signature ……*A. N. Other* …… Date …*9 / 02 / 05*..

# Appendix 4 – Assessment of practical skills – final mark aggregation sheet

| | |
|---|---|
| Month and year of examination: | Specification title: |
| Specification number: | |
| Centre: | Candidate name: |
| | Teaching group: |
| Centre number: | Candidate number: |

Marks should be reported for each of the skill areas P, O, A and E.

**One** mark is required for **each** skill area. Thus four marks are required in total to give a maximum mark of 30. These marks should be drawn from **not more than two** pieces of work. At least **one** mark must be from a practically based whole investigation.

**The reported marks from each activity should be ringed.**

| Activity title(s) | P | O | A | E |
|---|---|---|---|---|
| | | | | |
| | | | | |

Please indicate whether the reported mark(s) are taken from an investigation by putting an asterisk next to the appropriate mark(s).

The skill area marks are reported in the appropriate Centre Mark boxes in the table below and then aggregated to give a total reported mark.

| | Skill area P | | Skill area O | | Skill area A | | Skill area E | | Total mark | Max mark |
|---|---|---|---|---|---|---|---|---|---|---|
| Centre mark | | | | | | | | | | 30 |
| Moderator Mark | | | | | | | | | | |
| Team leader Mark | | | | | | | | | | |

**Declaration of Authentication**

I declare that the work submitted for assessment has been carried out without assistance other than that which is acceptable under the scheme of assessment.

Candidate's signature …………………………………………… Date …………………

Teacher's signature ……………………………………………… Date …………………

# Appendix 5 – Provisional assessment record

Student Name……………………… Group/Set ……………………..………..

Task ……………………………………………………………………………………

P.2a ……………………………………………………………………………………

P.4a ……………………………………………………………………………………

P.4b ……………………………………………………………………………………

P.6a ……………………………………………………………………………………

P.6b ……………………………………………………………………………………

P.8a ……………………………………………………………………………………

P.8b ……………………………………………………………………………………

O.2a ……………………………………………………………………………………

O.4a ……………………………………………………………………………………

O.4b ……………………………………………………………………………………

O.6a ……………………………………………………………………………………

O.6b ……………………………………………………………………………………

O.8a ……………………………………………………………………………………

A.2a ……………………………………………………………………………………

A.4a ……………………………………………………………………………………

A.4b ……………………………………………………………………………………

A.6a ……………………………………………………………………………………

A.6b ……………………………………………………………………………………

A.8a ……………………………………………………………………………………

A.8b ……………………………………………………………………………………

E.2a ……………………………………………………………………………………

E.4a ……………………………………………………………………………………

E.4b ……………………………………………………………………………………

E.6a ……………………………………………………………………………………

E.6b ……………………………………………………………………………………

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