Syllabus

Cambridge International A & AS Level Marine Science
Syllabus code 9693
For examination in June 2011

UNIVERSITY *of* CAMBRIDGE
International Examinations

Note for Exams Officers: Before making Final Entries, please check availability of the codes for the components and options in the E3 booklet (titled "Procedures for the Submission of Entries") relevant to the exam session. Please note that component and option codes are subject to change.

Contents

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1. Introduction

1.1 Why choose Cambridge?

University of Cambridge International Examinations (CIE) is the world's largest provider of international qualifications. Around 1.5 million students from 150 countries enter Cambridge examinations every year. What makes educators around the world choose Cambridge?

Recognition

A Cambridge International A or AS Level is recognised around the world by schools, universities and employers. The qualifications are accepted as proof of academic ability for entry to universities worldwide. Cambridge International A Levels typically take two years to complete and offer a flexible course of study that gives students the freedom to select subjects that are right for them. Cambridge International AS Levels often represent the first half of an A Level course but may also be taken as a freestanding qualification. They are accepted in all UK universities and carry half the weighting of an A Level. University course credit and advanced standing is often available for Cambridge International A/AS Levels in countries such as the USA and Canada. Learn more at **www.cie.org.uk/recognition**.

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CIE provides a world-class support service for teachers and exams officers. We offer a wide range of teacher materials to Centres, plus teacher training (online and face-to-face) and student support materials. Exams officers can trust in reliable, efficient administration of exams entry and excellent, personal support from CIE Customer Services. Learn more at **www.cie.org.uk/teachers**.

Excellence in education

Cambridge qualifications develop successful students. They not only build understanding and knowledge required for progression, but also learning and thinking skills that help students become independent learners and equip them for life.

Not-for-profit, part of the University of Cambridge

CIE is part of Cambridge Assessment, a not-for-profit organisation and part of the University of Cambridge. The needs of teachers and learners are at the core of what we do. CIE invests constantly in improving its qualifications and services. We draw upon education research in developing our qualifications.

1.2 Why choose Cambridge International A & AS Level Marine Science?

Cambridge International A & AS Level Marine Science are accepted by universities and employers as proof of essential knowledge and ability.

A & AS Level Marine Science provides a coherent and stimulating introduction to the science of the marine environment. The content of the AS part of the course concentrates on the scientific study of the sea and its ecosystems, while the A Level part of the course concentrates on human activities that depend on the sea and have an impact on it.

The emphasis throughout is on the understanding of concepts and the application of ideas to new contexts, as well as on the acquisition of knowledge. The course will foster creative thinking and problem-solving skills, which are transferable to any future career path.

Practical activities should underpin the teaching of the whole course and candidates may be asked about practical activities in examination questions, but there is no practical paper and no coursework.

A & AS Level Marine Science can form part of an ideal subject combination for students who want to study Marine Biology or Environmental Science at university, or to follow a career in shipping, fisheries, tourism or aquaculture.

1.3 How can I find out more?

If you are already a Cambridge Centre

You can make entries for this qualification through your usual channels, e.g. CIE Direct. If you have any queries, please contact us at **international@cie.org.uk**.

If you are not a Cambridge Centre

You can find out how your organisation can become a Cambridge Centre. Email us at **international@cie.org.uk**. Learn more about the benefits of becoming a Cambridge Centre at **www.cie.org.uk**.

2. Assessment at a glance

Cambridge International A & AS Level Marine Science Syllabus code 9693

Centres and candidates may choose to:

- take all A & AS components at one exam session (Papers 1, 2, 3 & 4), leading to the full A Level qualification
- take the AS components (Papers 1 & 2) at one exam session and, having received the AS qualification, take the A2 components (Papers 3 & 4) at a later session, leading to the full A Level qualification
- take the AS components (Papers 1 & 2) only, leading to the Advanced Subsidiary qualification.

In each of the four papers, every question is compulsory.

Paper	Type of Paper	Duration	Marks	Weighting %	
				AS	A
1	Structured questions on AS topics	1 h 30 min	75	60	30
2	Data-handling questions (20 marks). Data may be provided in written, numerical, diagrammatic or graphical forms, or a mixture of these. Two free-response questions (15 marks each) in which candidates will be required to demonstrate aspects of Assessment Objectives A and B.	1 h 15 min	50	40	20
3	Structured questions on A2 topics making links to AS topics where appropriate.	1 h 30 min	75	–	30
4	Data-handling questions (20 marks), and longer written questions on A2 topics Data may be provided in written, numerical, diagrammatic or graphical forms, or a mixture of these. Two free-response questions (15 marks each) on the A2 topics, making links where appropriate to AS topics in which candidates will be required to demonstrate aspects of Assessment Objectives A and B.	1 h 15 min	50	–	20

3. Syllabus aims and assessment

3.1 Aims

1. To provide a worthwhile educational experience for all candidates, through well designed studies of Marine Science, whether or not they go on to study a related subject beyond this level.
2. To enable candidates to acquire sufficient understanding and knowledge to:
   - become confident citizens in a technological world, able to take or develop an informed interest in matters of scientific importance,
   - recognise the usefulness, and limitations, of scientific method and to appreciate its applicability in other disciplines and in everyday life,
   - be suitably prepared for studies beyond A Level in subjects relating to the marine environment, in further or higher education, and for professional courses.
3. To stimulate candidates, to create and sustain their interest in Marine Science, and to enhance their understanding of its relevance to society.
4. To develop abilities and skills that:
   - are relevant to the study and practice of Marine Science,
   - are useful in everyday life,
   - encourage effective communication.
5. To assist the development of:
   - objectivity,
   - integrity,
   - initiative,
   - the skills of scientific inquiry.
6. To stimulate interest in, and care for, the local and global environment, and to understand the need for conservation.
7. To promote an awareness:
   - that scientific theories and methods have developed, and continue to do so, as a result of co-operative activities of groups and individuals,
   - that the study and practice of science is subject to social, economic, technological, ethical and cultural influences and limitations,
   - that science transcends national boundaries and that the language of science, correctly and rigorously applied, is universal,
   - of the importance of the use of IT for communication, as an aid to experiments and as a tool for the interpretation of experimental and theoretical results.

3.2 Assessment objectives

These assessment objectives describe the knowledge, skills and abilities that candidates are expected to demonstrate at the end of the course. They reflect those aspects of the aims that will be assessed.

A Knowledge with understanding

Candidates should be able to demonstrate knowledge and understanding in relation to:

1. scientific phenomena, facts, laws, definitions, concepts, theories
2. scientific vocabulary, terminology, conventions (including symbols, quantities and units)
3. scientific quantities and their determination
4. human activities that impact on the marine environment, including the needs and interests of those involved.

The syllabus content defines the factual material that candidates need to recall and explain. Questions testing the objectives above will often begin with one of the following words: *define, name, describe, explain* or *outline.*

B Handling information and solving problems

Candidates should be able to use oral, written, symbolic, graphical and numerical forms of presentation to:

1. locate, select, organise and present information from a variety of sources
2. translate information from one form to another
3. manipulate numerical and other data
4. use information to identify patterns, report trends and draw inferences
5. interpret and evaluate observations and experimental data
6. present reasoned explanation for phenomena, patterns and relationships
7. make predictions and propose hypotheses
8. devise and plan investigations
9. evaluate investigative methods and techniques, and suggest possible improvements
10. apply knowledge, including principles, to novel situations
11. solve problems.

Questions testing these skills may be based on information that is unfamiliar to candidate, requiring them to apply the principles and concepts from the syllabus to new situations, in a logical, reasoned or deductive way. In answering such questions, candidates are required to use principles and concepts that are within the syllabus and apply them in a logical, deductive manner. Questions testing these objectives may begin with one of the following words: *discuss, predict, suggest, explain, calculate* or *determine.*

3.3 Weighting of assessment objectives

Assessment objective	AS Level	A Level
A	50%	45%
B	50%	55%

The table above gives the overall allocation of marks to assessment objectives A and B in the whole examination. The balance on individual papers may vary slightly.

3.4 Mark allocations as a guide

In all questions, the number of marks allocated is shown on the examination paper. This number should be used by candidates as a guide to how much detail they should give in their answers.

In describing a process, the mark allocation should guide the candidate about how many steps to include. In explaining why something happens, the mark allocation indicates how many reasons to give, or how much detail to give for each reason.

4. Curriculum content

4.1 Structure of the syllabus

This syllabus is designed:

- to give a thorough introduction to the study of Marine Science
- to give flexibility to both teachers and candidates
- to place greater emphasis on the understanding and application of concepts and principles than on the recall of factual material.

The subject content of the syllabus is divided into 15 sections:

- sections 1–7 are to be studied by AS candidates
- sections 8–15 contain additional material to be studied by A Level candidates.

The content of the AS level course concentrates on the scientific study of the sea and its ecosystems. The A2 part of the course concentrates on human activities that depend on the sea and have an impact on it.

Section		AS	A2
1	Scientific method	✓	
2	Marine ecosystems and biodiversity	✓	
3	Energetics of marine ecosystems	✓	
4	Nutrient cycles in marine ecosystems	✓	
5	Coral reefs and lagoons	✓	
6	The ocean floor and the coast	✓	
7	Physical and chemical oceanography	✓	
8	Physiology of marine primary producers		✓
9	Aspects of marine animal physiology		✓
10	Marine animal reproductive behaviour		✓
11	Fisheries management		✓
12	Aquaculture		✓
13	Human impact on marine ecosystems		✓
14	Marine conservation and ecotourism		✓
15	Marine biotechnology		✓

4. Curriculum content

To specify the syllabus as precisely as possible, and also to emphasise the importance of skills other than recall, learning outcomes are listed for each section.
The syllabus is not intended to be a teaching syllabus, nor is it intended to represent a teaching order.

Examples to illustrate concepts and content should be drawn from a wide range of marine organisms and environments.

Practical activities should underpin the teaching of the whole syllabus. In some topics, these practical activities will be primarily laboratory-based; in other topics the practical activities are more likely to involve field trips. Candidates may be asked about practical activities in examination questions.

4.2 AS Topics (sections 1–7)

1. Scientific method
Content The relationship *between* hypothesis, experiment and theory in science. Uncertainty in experimental results.
Learning outcomes Candidates should be able to: (a) describe how scientific method involves interplay between observations and the formation, testing and evaluation of hypotheses (b) design experiments to test a given hypothesis, in which variables are controlled and quantitative results are collected (c) interpret experimental data to determine whether they support or refute the hypothesis being tested (d) formulate a hypothesis on the basis of experimental data (e) explain how inherent variations and limitations in the measurement of experimental data lead to uncertainty in the results (f) demonstrate an understanding that a hypothesis that is consistently supported by experimental testing and observation can become a theory (g) explain the meaning of the term *theory* with reference to examples from the Subject Content (h) use the knowledge and understanding gained in this section in new situations, or to solve related problems.

4. Curriculum content

2. Marine ecosystems and biodiversity

Content

The relationships between organisms within ecosystems.
Predator-prey relationships.
The connection between environment, biodiversity and ecological niches.

Learning outcomes

Candidates should be able to:

(a) explain the meaning of the terms *ecosystem, habitat, population, community, species, biodiversity, ecological niche*

(b) describe each of the following types of interrelationship within a marine ecosystem:
- symbiosis, with examples including coral and zooxanthellae, cleaner fish and grouper, chemosynthetic bacteria and tube worms
- parasitism, with examples including tuna and nematodes

(c) explain the meanings of the terms *producer, consumer, predator, prey* and *trophic level* in the context of food chains and food webs

(d) explain how populations of predator and prey may be interrelated

(e) describe shoaling and explain why shoaling may be a successful strategy for feeding, reproduction and predator avoidance, with reference to tuna and sardines

(f) explain the meaning of the term *succession* and describe examples, including the tube worms *Tevnia* and *Riftia*

(g) understand why extreme and unstable environments tend to have relatively low biodiversity, giving examples including coral reefs (stable and not extreme), sand on a reef slope (unstable) and hydrothermal vents (extreme)

(h) give examples of organisms that occupy specialised and general ecological niches, including coral-eating butterfly fish and tuna

(i) explain why habitats with high biodiversity tend to contain narrow ecological niches

(j) use the knowledge and understanding gained in this section in new situations, or to solve related problems.

4. Curriculum content

3. Energetics of marine ecosystems

Content

Photosynthesis and chemosynthesis as means of energy capture.
Productivity and energy flow along food chains.

Learning outcomes

Candidates should be able to:

(a) explain that photosynthesis captures the energy of sunlight and makes the energy available to the food chain

(b) explain that chemosynthesis captures the chemical energy of dissolved minerals, and that chemosynthetic bacteria at hydrothermal vents make energy available to the food chain

(c) explain the meaning of the term *productivity*, and how high productivity may influence the food chain

(d) calculate and explain the energy losses along food chains due to respiration and wastage

(e) calculate and account for the efficiency of energy transfer between trophic levels

(f) represent food chains as pyramids of energy, numbers and biomass

(g) use the knowledge and understanding gained in this section in new situations, or to solve related problems.

4. Nutrient cycles in marine ecosystems

Content

Inputs and outputs to the reservoir of dissolved nutrients.
The biological uses of nutrients.
Nutrient availability and productivity.

Learning outcomes

Candidates should be able to:

(a) demonstrate an understanding that there is a reservoir of nutrients dissolved in the surface layer of the ocean

(b) explain the processes by which the reservoir of dissolved nutrients is replenished, including upwelling, runoff from the land and dissolving of atmospheric gases

(c) demonstrate an understanding that the reservoir of dissolved nutrients is depleted by uptake into organisms in food chains

(d) explain how productivity may be limited by the availability of dissolved nutrients

(e) demonstrate an understanding that the nutrients taken up by organisms in food chains may sink to the sea floor in faeces or after death, may be incorporated into coral reefs, or may be removed by harvesting

(f) show that each of the nutrient cycles listed below can be summarised as shown in Figure 1, and state the biological use of each nutrient:

- nitrogen, which is used to make proteins
- carbon, which is used to make all organic materials
- magnesium, which is used to make chlorophyll
- calcium, which is used to make bones, corals and shells
- phosphorus, which is used to make DNA and bone

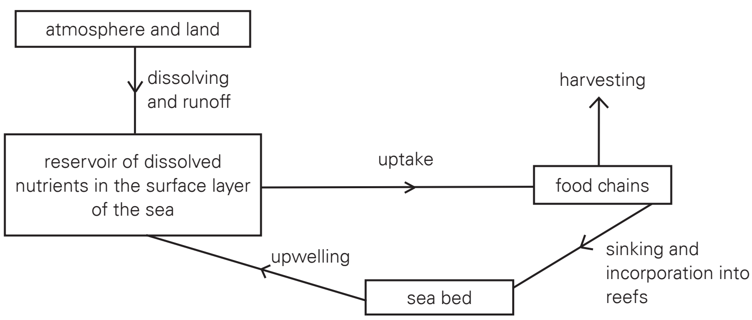

Figure 1

(g) use the knowledge and understanding gained in this section in new situations, or to solve related problems.

5. Coral reefs and lagoons

Content

The Darwin-Dana-Daly theory of atoll formation.
The protective role of reefs, and the causes and effects of reef erosion.
Reconstructing the history of reefs.

Learning outcomes

Candidates should be able to:

(a) demonstrate an understanding of the Darwin-Dana-Daly theory of atoll formation, and the evidence supporting the theory

(b) relate the Darwin-Dana-Daly theory to the physiology of coral

(c) discuss the role of reefs in dissipating the energy of waves, and in providing protection for shores and anchorages

(d) discuss the factors that can lead to a transition from reef growth to reef erosion

(e) discuss the impact of reef erosion, and the use of artificial reefs, on the protection of shores and anchorages

(f) describe the methods used for reconstructing the history of reefs, including drilling, geomorphologic analysis and carbon dating

(g) explain how these methods may be used to investigate the effect of sea level changes on coral reefs

(h) use the knowledge and understanding gained in this section in new situations, or to solve related problems.

6. The ocean floor and the coast

Content
Tectonic processes and the ocean basin.
The littoral zone.

Learning outcomes
Candidates should be able to:

(a) describe the theory of plate tectonics, and the evidence supporting the theory
(b) relate tectonic processes to the production of ocean trenches, mid-ocean ridges, hydrothermal vents, abyssal plains, volcanoes, earthquakes and tsunamis
(c) explain why the water coming from hydrothermal vents is under pressure, hot and rich in minerals
(d) explain how isostasy may produce shallow seas within or at the edge of continents
(e) demonstrate an understanding of the processes of erosion and sedimentation that give rise to the morphology of the littoral zone, including rocky shores, sandy shores, muddy shores, estuaries and deltas
(f) demonstrate an understanding of how environmental factors influence the formation of ecological communities in the littoral zone, including mangrove, sandy shore and rocky shore
(g) use the knowledge and understanding gained in this section in new situations, or to solve related problems.

4. Curriculum content

7. Physical and chemical oceanography

Content

Factors affecting the chemical composition of seawater.
Layering and mixing in the oceans.
The tides.
Ocean currents.
El Niño, monsoon winds and tropical cyclones.

Learning outcomes

Candidates should be able to:

(a) demonstrate an understanding of the effects of volcanic activity, runoff and atmospheric dissolution on the chemical composition of sea water

(b) outline the effects of evaporation and precipitation on salinity

(c) describe how temperature and salinity gradients form in water columns to produce ocean layers (including the surface layer, thermocline and deep ocean), and how subsequent mixing of these layers may occur

(d) demonstrate an understanding of the physical and biological reasons for the variability of the concentration of dissolved oxygen

(e) describe how tides are produced, and how the alignment of Moon and Sun, coastal geomorphology, wind, air pressure and size of water body affect the tidal range

(f) explain how wind, temperature, density, the Coriolis effect and the shape of the sea bed produce ocean currents and upwelling

(g) discuss the causes and effects of El Niño events in the Pacific Ocean

(h) explain the seasonal differences in temperature between the Asian continent and the Indian Ocean, and explain how these differences give rise to the patterns of monsoon winds

(i) discuss the factors required for a region of low pressure to develop into a tropical cyclone, and explain the role of evaporation, condensation and latent heat in tropical cyclones

(j) recall that tropical cyclones are also known as hurricanes and typhoons, and discuss their impact on coastal communities

(k) use the knowledge and understanding gained in this section in new situations, or to solve related problems

4. Curriculum content

4.3 A2 Topics (sections 8–15)

Sections 8–15 contain additional material to be studied by A Level candidates.

8. Physiology of marine primary producers
Content The relationship between habitat and the distribution of primary producers. Factors affecting the rate of photosynthesis.
Learning outcomes Candidates should be able to: (a) demonstrate an understanding of the ecological importance of primary producers for carbon fixation and shelter (b) explain why different types of primary producer are found in different habitats, including • the open ocean (containing phytoplankton [confined to diatoms, dinoflagellates and cyanobacteria] and floating macroscopic algae [confined to sargassum]) • shallow waters (containing zoonxanthellae in corals, sea grass such as *Thalassea* and kelp forests) • intertidal regions (containing green, red and brown algae) (c) demonstrate an understanding that photosynthesis (carbon dioxide + water → glucose + oxygen) is the process that nearly all primary producers use to fix carbon (d) demonstrate an understanding that photosynthesis involves the use of light energy from the Sun, pigments including chlorophyll, and a number of enzymes (e) explain how and why light intensity, light wavelength and temperature affect the rate of photosynthesis, and can act as limiting factors (f) describe how light of different wavelengths penetrates to different depths in water, and relate this to the presence of accessory pigments, including xanthophylls and phycobilins, in marine primary producers (g) use the knowledge and understanding gained in this section in new situations, or to solve related problems.

9. Aspects of marine animal physiology

Content

Respiration.

Gaseous exchange and transport systems.

Osmoregulation.

Learning outcomes

Candidates should be able to:

(a) demonstrate an understanding that respiration (glucose + oxygen → carbon dioxide + water) is the process that organisms use to release the energy they require

(b) demonstrate an understanding that the raw materials and waste products of respiration must be moved to and from the surface of organisms

(c) discuss how surface area to volume ratio is dependent on the size and shape of an organism, and relate this to the need for specialised gaseous exchange surfaces in larger animals

(d) explain the need for transport systems in large, active animals

(e) demonstrate an understanding that marine animals are adapted to live in water which, in comparison with air, contains low and variable concentrations of oxygen

(f) describe gaseous exchange by simple diffusion, pumped ventilation and ram ventilation, in examples including coral polyps, grouper and tuna

(g) explain why marine organisms may need to regulate their water content and ion content, with reference to the composition of sea water and of body fluids

(h) outline the process of osmoregulation in a marine bony fish (limited to drinking and absorbing salty water, and then actively excreting salt, using energy from respiration)

(i) explain the meaning of the term *osmoconformer*, with reference to mussels

(j) explain the meaning of the term *euryhaline*, with reference to salmon

(k) use the knowledge and understanding gained in this section in new situations, or to solve related problems.

10. Marine animal reproductive behaviour
Content Life cycles of marine animals.
Learning outcomes Candidates should be able to: (a) compare and contrast the stages in the life cycle of salmon, tuna, oyster, shrimp, giant clam and grouper (b) state the principal habitats for each stage in these life cycles, and discuss why these habitats are advantageous (c) compare the advantages and disadvantages of internal and external fertilisation, and subsequent investment in the care of offspring, with reference to tuna, shark and whale (d) use the knowledge and understanding gained in this section in new situations, or to solve related problems.

11. Fisheries management

Content

The need for sustainable fisheries.
Monitoring of fish stocks.
Methods of stock management and the enforcement of restrictions.
Methods of rehabilitating depleted stocks.

Learning outcomes

Candidates should be able to:

(a) explain the need for sustainable exploitation of fish stocks, with reference to North Sea fisheries

(b) discuss the impact of modern fishing technology, including sonar, purse seine fishing, benthic trawling and factory ships, on fish stocks and habitats

(c) compare and contrast the long-term and short-term sociological impacts of restrictions on fishing, and of unrestricted fishing

(d) describe the principal information needed to decide how best to exploit fish stocks on a sustainable basis, including recruitment, growth, natural mortality, fishing mortality, age of reproductive maturity, fecundity and dependency on particular habitats

(e) outline the principal tools used to ensure that fish stocks are exploited on a sustainable basis, including:

- restriction by season
- restriction of location, including refuge zones
- restriction of method, including minimum mesh sizes and the compulsory use of rod-and-line
- restrictions on the size of fish that can be retained
- restriction of fishing intensity, including restrictions on the number of boats, boat and engine size, and the amount of fishing gear
- market-oriented tools, including the labelling of tuna as dolphin-friendly

(f) discuss the principal methods of monitoring (including air and sea patrolling, inspection of catch, catch per unit effort, satellite monitoring) and enforcement (including imposition of fines, confiscation of boats and gear, imprisonment)

(g) discuss the advantages and disadvantages of the tools and methods in (e) and (f), including their effectiveness and their impact on non-target species

(h) discuss the opportunities for, and advantages and disadvantages of, the rehabilitation of depleted stocks, including replanting mangroves, building artificial reefs and introducing cultivated stock to the wild

(i) use the knowledge and understanding gained in this section in new situations, or to solve related problems.

12. Aquaculture

Content

Processes for intensive and extensive aquaculture.
The requirements and impacts of aquaculture.

Learning outcomes

Candidates should be able to:

(a) explain the meaning of the terms *intensive* and *extensive* aquaculture techniques

(b) outline the process for the aquaculture of grouper, tuna, shrimp and giant clam

(c) explain the requirements for sustainable aquaculture (availability of stock, availability of clean water, availability of feed, efficiency of use of feed, availability of labour, disease management, availability of location, market demand, access to market, return on investment)

(d) identify the principal impacts of aquaculture (habitat destruction, overexploitation of feedstocks, pollution, introduction of exotics, spread of disease, competition for resources, social impacts, economic impacts)

(e) use this knowledge and understanding to assess the suitability of proposed aquaculture projects, in terms of requirements and impacts

(f) suggest how the negative impacts of aquaculture might be minimised

(g) use the knowledge and understanding gained in this section in new situations, or to solve related problems.

13. Human impact on marine ecosystems

Content
Ecological impacts of industrial activities.
The accumulation of toxins in food chains.
Global warming and its impact.
The ecological effects of shipwrecks.

Learning outcomes
Candidates should be able to:

(a) explore the ecological impacts of
- the oil industry
- desalination plants
- agriculture
- sewage and refuse disposal
- dredging

on marine water quality, habitats, biodiversity and food webs

(b) explain the reasons for the links between the human activities in (a) and their ecological impacts, making reference to the physical properties and chemical composition of the sea where necessary

(c) explain the accumulation of toxins in food chains, making reference to antifouling paint and mercury pollution, and explore its impact on human food sources

(d) demonstrate an understanding of the evidence for global warming

(e) discuss and evaluate the evidence for and against the hypothesis that global warming is caused by human activity

(f) describe the possible impact of global warming, including sea level rise and coral bleaching

(g) compare and contrast the ecological impacts of the wreck of an oil-filled tanker and a vessel deliberately sunk as a wreck dive

(h) use the knowledge and understanding gained in this section in new situations, or to solve related problems.

14. Marine conservation and ecotourism

Content

Conservation.

Ecotourism.

Learning outcomes

Candidates should be able to:

(a) explain the meaning of the term *conservation*

(b) explain the arguments for and against the desirability of conserving marine species and ecosystems

(c) discuss, in the context of human activity on marine species and ecosystems, the need for conservation

(d) demonstrate an understanding of why, to be successful, conservation must sustain ecological linkages and processes

(e) demonstrate an understanding that there are competing requirements between the activities of coastal communities, including agriculture, industry, shipping, sewage and refuse disposal, aquaculture, fisheries, tourism and conservation

(f) in given examples of conservation issues, identify stakeholders, conflicts of interest, causes and possible solutions

(g) define *ecotourism* as tourism based on the appreciation of the natural environment, and identify and assess types of ecotourism that support or undermine conservation

(h) argue the benefits to conservation of responsible practice in tourism, including energy conservation, recycling, use of sustainable sources of building materials and sponsorship of conservation

(i) use the knowledge and understanding gained in this section in new situations, or to solve related problems.

4. Curriculum content

15. Marine biotechnology

Content

Biotechnology.
Genes, promoters and phenotypes.
Advantages and dangers of genetic engineering.

Learning outcomes:

Candidates should be able to:

(a) define *biotechnology* as the industrial application of biological processes

(b) state that some microorganisms digest oil, and that these microorganisms are used to digest oil pollution

(c) define the term *gene* and outline the effect of genotype on phenotype

(d) outline the role of promoters in the control of genes

(e) define *genetic engineering* as the transfer of a gene or genes from one species to another

(f) distinguish genetic engineering from other types of biotechnology, and from selective breeding

(g) show an understanding that genes cannot be accurately placed in the genome when transferred, and that a promoter may need to be attached to a gene before transfer

(h) state that salmon has been genetically engineered with a growth-promoting gene from another fish, and a promoter to turn this gene on all year round

(i) discuss the advantages of genetic engineering for aquaculture, and the possible impact of the escape of genetically engineered species into the wild

(j) demonstrate an understanding of the term *precautionary principle*

(k) use the knowledge and understanding gained in this section in new situations, or to solve related problems.

5. Appendix

5.1 Mathematical requirements

Candidates should be able to:

- recognise and use expressions in decimal and standard form (scientific) notation
- recognise and use percentages and ratios
- use appropriate calculating aids (electronic calculator or tables) for addition, subtraction, multiplication and division
- find arithmetic means, standard deviations and powers (including reciprocals and square roots)
- take account of accuracy in numerical work and handle calculations so that significant figures are neither lost unnecessarily nor carried beyond what is justified
- change the subject of an equation
- substitute values into and solve linear equations
- comprehend and use the symbols <, >, ≈, /, <x>, Σ, √, Δ, ∝
- calculate the perimeters and areas of circles, squares and rectangles
- calculate the surface areas and volumes of spheres, cylinders, cubes and rectangular blocks
- translate information between graphical, numerical, algebraic and verbal forms
- construct and interpret frequency tables and diagrams, pie charts and histograms
- select appropriate variables and scales for graph plotting
- choose, by inspection, a straight line or curve which will serve as the best line through a set of data points presented graphically
- draw the tangent to a curved graph
- for linear graphs, determine the slope and intercept
- use the concept of rate of change, and determine the rate of change from a linear or curved graph
- recognise and correctly use SI units
- recognise and use the prefixes tera (T), giga (G), mega (M), kilo (k), milli (m), micro (*μ*) and nano (n)

5. Appendix

5.2 Glossary of terms used in science papers

It is hoped that the glossary (which is relevant only to science subjects) will prove helpful to candidates as a guide, i.e. it is neither exhaustive nor definitive. The glossary has been deliberately kept brief, not only with respect to the number of terms included, but also to the descriptions of their meanings. Candidates should appreciate that the meaning of a term must depend in part on its context.

1. *Define* (the term(s)…) is intended literally, only a formal statement or equivalent paraphrase being required.
2. *What do you understand by/What is meant by* (the term(s)…) normally implies that a definition should be given, together with some relevant comment on the significance or context of the term(s) concerned, especially where two or more terms are included in the question. The amount of supplementary comment intended should be interpreted in the light of the indicated mark value.
3. *State* implies a concise answer with little or no supporting argument, e.g. a numerical answer that can readily be obtained 'by inspection'.
4. *List* requires a number of points, generally each of one word, with no elaboration. Where a given number of points is specified, this should **not** be exceeded.

5 (a) *Describe*, the data or information given in a graph, table or diagram, requires the candidate to state the key points that can be seen in the stimulus material. Where possible, reference should be made to numbers drawn from the stimulus material.

(b) *Describe*, a process, requires the candidate to give a step by step written statement of what happens during the process.

6 (a) *Explain* may imply reasoning or some reference to theory, depending on the context. It is another way of asking candidates to give reasons for. The candidate needs to leave the examiner in no doubt **why** something happens.

(b) *Give a reason/Give reasons* is another way of asking candidates to explain **why** something happens.

Describe and *explain* may be coupled, as may *state* and *explain*.

7. *Discuss* requires the candidate to give a critical account of the points involved in the topic.
8. *Outline* implies brevity, i.e. restricting the answer to giving essentials.
9. *Predict* implies that the candidate is **not** expected to produce the required answer by recall but by making a logical connection between other pieces of information. Such information may be wholly given in the question or may depend on answers extracted in an earlier part of the question.

   Predict also implies a concise answer, with no supporting statement required.
10. *Deduce* is used in a similar way to *predict* except that some supporting statement is required, e.g. reference to a law or principle, or the necessary reasoning is to be included in the answer.

11. *Suggest* is used in two main contexts, i.e. either to imply that there is no unique answer (e.g. in Chemistry, two or more substances may satisfy the given conditions describing an 'unknown'), or to imply that candidates are expected to apply their knowledge to a 'novel' situation, one that may not be formally 'in the syllabus'.
12. *Find* is a general term that may variously be interpreted as *calculate, measure, determine*, etc.
13. *Calculate* is used when a numerical answer is required. In general, working should be shown, especially where two or more steps are involved. Suitable units should be given where possible.
14. *Measure* implies that the quantity concerned can be directly obtained from a suitable measuring instrument, e.g. length, using a rule. Suitable units should be given where possible.
15. *Determine* often implies that the quantity concerned cannot be measured directly but is obtained by calculation, substituting measured or known values of other quantities into a standard formula.
16. *Estimate* implies a reasoned order of magnitude statement or calculation of the quantity concerned, making such simplifying assumptions as may be necessary about points of principle and about the values of quantities not otherwise included in the question.
17. *Sketch*, when applied to graph work, implies that the shape and/or position of the curve need only be qualitatively correct, *but* candidates should be aware that, depending on the context, some quantitative aspects may be looked for, e.g. passing through the origin, having an intercept, asymptote or discontinuity at a particular value.

    In diagrams, *sketch* implies that a simple, freehand drawing is acceptable; nevertheless, care should be taken over proportions and the clear exposition of important details.
18. *Compare* requires candidates to provide both the similarities and differences between things or concepts.
19. *Recognise* is often used to identify facts, characteristics or concepts that are critical (relevant/appropriate) to the understanding of a situation, event, process or phenomenon.
20. *Classify* requires candidates to group things based on common characteristics.

University of Cambridge International Examinations
1 Hills Road, Cambridge, CB1 2EU, United Kingdom
Tel: +44 (0)1223 553554 Fax: +44 (0)1223 553558
Email: international@cie.org.uk Website: www.cie.org.uk