

Getting Started

GCE Biology

Edexcel Advanced Subsidiary GCE in Biology (8BI01)

First examination 2009

Edexcel Advanced GCE in Biology (9BI01)

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Getting started for teachers

Introduction	1
Course overviews	3
Course overviews	3
Unit overviews	5
What's new?	10
FAQs	10
Information for current SNAB centres	12
Information for current GCE Biology Edexcel centres	14
Course planner	15
Internal assessment guide	16

Getting started for students

Student guide	54
Individual investigation: Student checklist	57

Introduction

This Getting Started book will give you an overview of the new Edexcel GCE in Biology and what it means for you and your students. The guidance in this book is intended to help you plan the course in outline and to give you further insight into the principles behind the content to help you and your students succeed in the course.

Key principles

The specification has been developed with the following key principles:

Inspiring content

The specification has been designed after extensive consultation with practising teachers and professional bodies. It provides an innovative and contemporary GCE Biology course with inspiring topics that include current scientific developments, and motivating practical work.

A focus on choice

You can choose whether to teach the course using a context-led approach or a concept-led approach, or even a mixture of the two, whichever is the most appropriate style for you and your students. The context-led approach is based on the Salters-Nuffield Advanced Biology Project. Throughout this material the acronym SNAB is used to denote Salters-Nuffield Advanced Biology.

Manageable and well supported

The specification has a realistic and manageable level of content and assessment. Extensive support is available from Edexcel — Ask the Expert team plus the Project Director based at the University of York Science Curriculum Centre.

Assessment overview

AS units

Unit 1: Lifestyle, Transport, Genes and Health	Unit 2: Development, Plants and the Environment	Unit 3: Practical Biology and Research Skills
One exam: 1 hour 15 minutes 40% of AS January or June entry	One exam: 1 hour 15 minutes 40% of AS January or June entry	Internally assessed: One visit or one issue 20% of AS

A2 units

Unit 4: The Natural Environment and Species Survival	Unit 5: Energy, Exercise and Coordination	Unit 6: Practical Biology and Experimental Investigation
One exam: 1 hour 15 minutes 40% of A2 January or June entry	One exam: 1 hour 30 minutes 40% of A2 January or June entry	Internally assessed: One practical 20% of A2

International centres

International centres have a 100% examination option available. Coursework units 3 and 6 are available as externally assessed units ONLY to International Teaching Centres.

Overviews

This section provides at a glance overviews of the course to help you see what you will need to teach.

- The Course overviews are a diagrammatic representation of the course in outline, whether you want to teach a concept-led or context-led curriculum.
- The Unit overviews give a summary of the content of each unit so that you can organise your teaching effectively.

Course overviews

Concept-led approach



Context-led approach



Unit overviews

There are three possible approaches to each unit so that you can choose the approach that most suits your students. Whichever approach you take, the assessment will be exactly the same.

Concept approach

This approach begins with a study of the laws, theories and models of biology, and finishes with an exploration of their practical applications.

Context approach – based on SNAB

This approach begins with an application that draws on many different areas of biology, and then moves on to the biological concepts underlying this application.

Integrated approach

In this approach, concept and context approaches are mixed according to the needs of the students. All approaches include understanding *How Science Works*, looking at the way scientific knowledge develops.

The following tables summarise the content of each unit, which is the same whichever approach you take.

AS units

UNIT 1: Lifestyle, Transport, Genes and Health

Topic 1: Lifestyle, health and risk

- Circulatory system
- Lifestyle factors (role of diet, exercise, smoking) in relation to cardiovascular disease
- Correlation, causation and concept of risks to health
- Structure and function of molecules, eg carbohydrates

Core practicals

- Effect of caffeine on Daphnia heart rate
- Vitamin C content of food and drink

Topic 2: Genes and health

- Properties and transport of materials across cell membranes; osmosis, passive and active transport
- Structure and function of carbohydrates, lipids and proteins; enzyme action
- Structure and role of DNA and RNA
- DNA replication; protein synthesis
- Meselson and Stahl's classic experiment
- Monohybrid inheritance
- Cystic fibrosis
- Gene mutations
- Principles of gene therapy; social and ethical issues

Core practicals

- Alcohol concentration or temperature on membrane permeability
- How enzyme concentration affects the rate of reactions

UNIT 2: Development, Plants and the Environment

Topic 3: The voice of the genome

- Development of multicellular organisms from single cells
- Cell structure and ultrastructure of eukaryote and prokaryote cells
- Cell differentiation
- Cell division
- Fertilisation
- Tissue organisation
- Genotype and environmental influence on phenotype
- Stem cell research and its implications

Core practicals

- Staining root tip to observe mitosis
- Plant tissue culture to demonstrate totipotency

Topic 4: Biodiversity and natural resources

- Biodiversity, endemism, adaptations and natural selection
- Principles of taxonomy
- Plant cell structure and relationship to function
- Structure and role of cellulose, starch, inorganic ions
- Transport of water
- Traditional and novel uses of plant products, natural resources
- Role of zoos and seed banks in conservation of endangered species

Core practicals

- Determining tensile strength of plant fibres
- Investigating plant mineral deficiencies
- Investigating antimicrobial properties of plants

UNIT 3: Practical Biology and Research Skills

Part 1: Practical biology skills

Students will carry out practical work during the GCE Biology AS course, which will be verified by the teacher using the criteria below and submitted to Edexcel using a verification of practical skills record.

- Use apparatus skilfully and safely.
- Produce and record reliable and valid results.
- Present and analyse data.

Part 2: Visit or issue report (40 marks)

Students present a written (word-processed) report of 1500–2000 words on a visit to a site of biological interest or on non-practical research into a biological topic. This is intended to bring students into contact with real-life uses of biology.

Students are assessed on their ability to:

- describe methods and processes
- identify questions/problems
- identify applications and implications
- use appropriate information sources to back up arguments
- clearly communicate and use visuals appropriately.

A2 Units

UNIT 4: The Natural Environment and Species Survival

Topic 5: On the wild side

- Photosynthesis
- How ecosystems work, energy transfer within ecosystems
- Habitats, abiotic, biotic factors
- Evidence for global warming; effects on plants and animals
- Reproductive isolation leading to speciation
- Will climate change lead to extinction of species or evolution by natural selection?
- Light-dependent and independent reactions
- Nutrient recycling

Core practicals

- Study on the ecology of a habitat
- Effects of temperature on the development of organisms

Topic 6: Infection, immunity and forensics

- Analytical techniques in forensics — DNA profiling and polymerase chain reaction (PCR)
- Determining time of death of an animal
- Structure of bacteria and viruses
- Infectious diseases (eg HIV and TB) and immunology
- Combating infection, developing immunity, host immunity, antigens, antibodies, antibiotics, the immune response
- Evolutionary battles between invading pathogens and hosts
- Hospital practice relating to infection prevention and control

Core practicals

- DNA amplification using PCR
- Gel electrophoresis
- Effect of different antibiotics on bacteria

UNIT 5: Energy, Exercise and Coordination

Topic 7: Run for your life

- Physiological adaptations of animals to undertake strenuous exercise
- Biochemical requirements — ATP, glycolysis, anaerobic/aerobic respiration
- Homeostasis (gene regulation, temperature regulation)
- Muscle physiology
- Performance-enhancing substances

Core practicals

- Investigating respiration
- Effects of exercise on tidal volume and breathing rate

Topic 8: Grey matter

- The nervous system
- Development of vision and learning, response to stimuli, Hubel and Wiesel's experiments
- Brain structure and function
- Brain imaging
- Imbalances in brain chemicals, eg Parkinson's disease
- Ethical issues raised by the Human Genome Project and genetically modified organisms

Core practicals

- Investigating habituation to a stimulus

UNIT 6: Practical Biology and Investigative Skills

Students will further develop their practical skills, whichever approach (context or concept) has been taken. Students will carry out the recommended core practicals in Units 4 and 5 and their individual investigations.

Students present a written (word-processed) report of 2700–3300 words on an experimental investigation that they have devised and carried out.

Students are assessed on the following skills:

- explaining choice of investigation
- using apparatus safely and skilfully
- observing and recording
- interpreting and evaluating
- presentation of report

What's new?

All biology specifications have changed due to revised QCA Science criteria published in 2007. The new criteria are designed to ensure:

- integration of *How Science Works*
- reduced assessment burden
- increased participation in post-16 study

This section outlines the key features of the new specification.

FAQs

What is new about the specification compared with the existing GCES in Biology?

The new specification allows a context-based approach (considering an application that draws on biology first, followed by the theories that explain this application) as well as a concept-based approach (laws, theories and models, followed by examples of a practical application) — or a mix-and-match option depending on the needs of the students. This allows you to use the appropriate teaching and learning style to meet your students' needs, but leading to one common assessment structure. Assessments can take place following distinct modules during the course, or at the end of a linear course of teaching and learning.

How can I take a contemporary route through the specification?

The specification is designed to enable students to engage with modern and up-to-date issues in biology, irrespective of the approach taken.

How do I attempt practicals and how much do students need to do in order to succeed in the examination?

Recommended core practicals are provided for each unit. Extensive support is offered for students, teachers and technicians relating to the core practicals. Practical-related questions will be asked in the written exams as well as contributing to internal assessment.

What is 'How Science Works' and how does it affect the new specification?

How Science Works is a newly-introduced section of the GCE Science criteria, building on the Key Stage 4 Programme of Study for science, so that students continue to develop an understanding of the scientific process, the development of models and theories to explain scientific phenomena, and all the factors surrounding the advance of scientific knowledge. This allows students to understand the wider applications and implications of biology.

How do I teach Human Biology using this specification?

The specification allows you to focus on human biology topics throughout as you can exemplify the content by reference to the human body. For example, in Topic 3: The voice of the genome explores the impact of understanding of genetics and the related social and ethical issues facing us.

This means that you can effectively teach a human biology course, and all the content you would have covered in the previous Edexcel GCE in Human Biology course is contained in the new Edexcel GCE in Biology specification.

Any plant biology included in the specification is set in a 'human' context, such as our use of plant materials in terms of medicines and packaging materials and the impact on society of climate change.

Information for current SNAB centres

Current SNAB centres will recognise the topics and the content of the new specification. Only minor changes have been required by the change in the QCA Science criteria with some parts of some topics moving from AS to A2 or vice versa. The table shows the main changes.

Unit	Topic	Content from the existing SNAB specification	New content includes:	Content from existing SNAB not included
1 Lifestyle, Transport, Genes and Health	1 Lifestyle, transport, genes and health	Biological molecules; heart and circulation; risk factors in CHD; atherosclerosis; blood clotting; analysis of health risk data; risk perception	Importance of water; practical work on vitamin C content; evaluate design of health risk studies	Electrical activity of the heart and ECGs
	2 Genes and health	Cystic fibrosis; gas exchange surface properties; membrane structure and function; proteins, enzymes; DNA, protein synthesis, genetics and genetic screening	Development of theories for replication	Protein synthesis detail
2 Development, Plants and the Environment	3 The voice of the genome	Cell structure; mitosis; meiosis, gametes and fertilisation; independent assortment; stem cells, cell differentiation and gene expression; environment and phenotype interactions	Fertilisation in flowering plants; crossing over; the way society uses scientific knowledge to make decisions about the use of stem cells in medical therapies; tissue formation; polygenic inheritance	Details of transcription factors; outcomes of the Human Genome Project; climate change; carbon cycle
	4 Biodiversity and natural resources	Plant cell structure, plant fibre structure and function; polysaccharides; importance of water; plant mineral nutrition; importance of plant products to humans	Biodiversity; endemism; adaptation; the concept of niche; natural selection and evolution; taxonomic groupings; zoos, seedbanks and conservation of endangered species	Transpiration; genetically engineered plants
3 Practical Biology and Research Skills	Assessment of practical skills developed in Units 1 and 2, and a report of either a visit to a site of biological interest, or an issue relating to biology in a contemporary setting.			

Unit	Topic	Content from the existing SNAB specification	New content includes:	Content from existing SNAB not included
4 The Natural Environment and Species Survival	5 On the wild side	Ecology; photosynthesis and productivity; energy transfer; human influences on the environment; evolution; speciation	Evidence for global warming; the role of the scientific community in validating new evidence; the carbon cycle; enzymes	Zoos; conflicts between wildlife and humans; conservation legislation; taxonomy; genetic diversity
	6 Infection, immunity and forensics	Forensics; succession; DNA profiling, bacteria, viruses; antibiotics; PCR; infection and the body's responses to infection; infection control	Microorganisms and carbon cycle; genetic code and protein synthesis	Negative feedback and thermoregulation
5 Energy, Exercise and Coordination	7 Run for your life	Muscle structure and function; aerobic and anaerobic respiration; control of cardiac output and ventilation; homeostasis; medical technology; ethics of the use of performance-enhancing substances		
	8 Grey matter	Nervous system and nerve impulse; nervous and hormonal coordination; detection of light; the brain; critical window for visual development; medical imaging; learning (only habituation); use of animals in medical research; drugs and synaptic transmission	Production of drugs by GMOs, Human Genome Project and drug development	Visual perception; classical conditioning, operant conditioning and insightful learning; polygenic inheritance
6 Practical Biology and Investigative Skills	A written report on an individual experimental investigation, including presentation and analysis of numerical data.			

Information for current GCE Biology Edexcel centres

Most of the content of the current Edexcel specification remains unchanged. Some topics have been removed to allow a few more contemporary topics to be introduced to reflect the huge changes in biology in recent years. The table below summarises the changes and shows you where you'll find the content you are familiar with.

Unit	Topic	Content from the existing Edexcel specification	New content
1 Lifestyle, Transport, Genes and Health	1 Lifestyle, transport, genes and health	Biological molecules; heart and circulation; risk factors in CHD	Blood clotting; analysis of health risk data; risk perception
	2 Genes and health	Membrane structure and function; proteins, enzymes; DNA, protein synthesis and genetics	Practical investigation of membrane structure; cystic fibrosis
2 Development, Plants and the Environment	3 The voice of the genome	Cell structure; mitosis; meiosis, gametes and fertilisation	Stem cells, cell differentiation and gene expression
	4 Biodiversity and natural resources	Plant cell structure, polysaccharides; plant mineral nutrition; biodiversity; natural selection	Importance of plant products to humans; zoos, seed banks and conservation of endangered species
3 Practical Biology and Research Skills	Assessment of practical skills developed in Units 1 and 2, and a report on either a visit to a site of biological interest, or an issue relating to biology in a contemporary setting.		
4 The Natural Environment and Species Survival	5 On the wild side	Ecology; photosynthesis, the carbon cycle and productivity; human influences on the environment	Evidence for global warming; the role of the scientific community in validating new evidence
	6 Infection, immunity and forensics	Protein synthesis; bacteria, viruses; antibiotics; PCR	Infection and the body's responses to infection; infection control; forensics
5 Energy, Exercise and Coordination	7 Run for your life	Muscle structure and function; aerobic and anaerobic respiration; the heart; ventilation; homeostasis	Muscles, movement and medical technology; ethics of the use of performance-enhancing substances
	8 Grey matter	Detection of light; the brain, nervous system and nerve impulse; nervous and hormonal coordination	Brain development; medical imaging; learning; drugs and synaptic transmission; production of drugs by GMOs
6 Practical Biology and Investigative Skills	A written report on an individual experimental investigation, including presentation and analysis of numerical data.		

Course planner

This course planner has been developed to help you plan the organisation and delivery of the course. You can use the course planner to plan your course delivery in outline. The timings are based on a two-year course but they can easily be adapted for one-year courses.

Week number	Examined content
Year 1	
1–7	Unit 1, Topic 1: Lifestyle, health and risk
8–14	Unit 1, Topic 2: Genes and health
15	Revision and Exams
16–22	Unit 2, Topic 3: The voice of the genome
23–29	Unit 2, Topic 4: Biodiversity and natural resources
30–31	Revision and AS exams
32–34	Unit 4, Topic 5: On the wild side (start)
Year 2	
1–4	Unit 4, Topic 5: On the wild side (continued)
5–12	Unit 4, Topic 6: Infection, immunity and forensics
13–14	Revision and AS exams
15–21	Unit 5, Topic 7: Run for your life
22–28	Unit 5, Topic 8: Grey matter
31–35	Revision and A2 exams

Internal assessment guide

Introduction

This section provides guidance on internal assessment for Unit 3 (AS) and Unit 6 (A2).

AS internal assessment: Unit 3

The internal assessment for Unit 3 is in 2 parts.

Part 1: Practical biology skills

In this assessment, students will further develop their practical skills, whichever approach (context or concept) has been taken. Students will carry out the recommended core practicals and other practical investigations which will require them to work safely, produce valid results and present data in the most appropriate format.

Students will carry out practical work which will be verified by the teacher.

The teacher will verify students' ability to:

- a) use apparatus skilfully and safely to carry out manipulative techniques in an appropriate manner
- b) produce and record valid and reliable measurements and observations with precision
- c) present and analyse data using appropriate methods, identify trends, patterns and/or observations.

Other practical-related skills, including analysis and evaluation of data, may be assessed in the externally assessed components.

Part 2: The report of the visit or issue

Students produce **either**:

- a record of a visit to a site of biological interest; **or**
- a record of non-practical research into a biological topic.

Exemplars of student work are provided so you can see how the mark scheme will be applied.



A2 internal assessment: Unit 6

Students will further develop their practical skills, whichever approach (context or concept) has been taken. Students will carry out the recommended core practicals in Units 4 and 5 and their individual investigations.

At A2, students will complete an individual investigation. They are required to produce a written report of an experimental investigation that they have devised and carried out.

There is a short guidance section for this aspect of the course to help you manage the work effectively.

The application of the mark scheme is illustrated with exemplars of student work.

Student exemplars

Please note

- Whilst the mark schemes have been applied to the student exemplars, they have not been through the moderation procedure and so we can only give an indication of the likely grade rather than the actual grade awarded.
- Centres are reminded that they are responsible for conducting risk assessments for all practical work undertaken by students.

Unit 3 Part 2 student exemplars

Three exemplars are included:

- Exemplar A: A report following a brewery visit
- Exemplar B: A report following a visit to the Millennium Seed Bank Project
- Exemplar C: A record of research into a biological topic

Each exemplar is followed by examiner's comments.

Please note that the students used photographs from the internet to illustrate their work and that every effort has been made to contact copyright holders to obtain their permission for use of copyright material. Edexcel will, if notified, be happy to rectify any errors or omissions and include any such rectifications in future editions.

Exemplar A: A Brewery visit report

The aims of my visit to the brewery are:

- To investigate the biological interactions of the raw materials.
- To find out how beer is conditioned and pasteurised.
- To find out how beers become different from each other.
- To find out how flavours are produced.
- To consider the social and environmental implications of the brewing industry.

When I went round my local brewery, I saw all the processes taking place and made some notes as the guide explained each stage.

The brewing processes

- mashing
- lautering
- boiling
- fermenting
- conditioning
- filtering
- secondary fermentation

Raw materials

The raw materials for brewing beer are barley, hops, yeast and water.

Barley seeds are soaked with water so they germinate. This changes the starch into a disaccharide sugar called maltose. This process takes several days. First the grain is taken out of cold storage (-20 degrees C) and soaked in water for 48 hours. This is called steeping. During this time water enters the cells by osmosis and the increase in turgor pressure (1) ruptures the seed coat.

Biological activity

Enzymes are activated, especially amylase, so that the food store of starch can be mobilised to the growing tip of the radicle. This happens over the next 3-4 days in a special room kept at 16 degrees C. Plant hormones, gibberellins, are released inside the seed to stimulate the breakdown of starch by hydrolysis. This involves the breakdown of 1-4 glycosidic bonds by adding a water molecule. (2) A molecule of maltose is made of two glucose molecules bonded together. These molecules are released after β amylase specifically acts on every other 1-4 glycosidic bond. This enzyme cannot break down 1-6 bonds. (3)

The malting process is halted before all the starch has been broken down by the enzymes. Kilning is the next stage, the malt is dried by increasing temperature slowly to 55 degrees for 5 hours to make sure the enzymes do not get denatured by rapid temperature rises. After this, the time and temperature are altered to give different grades of malt. A maximum temperature of 60 degrees for 12 hours gives a light colour suitable for lager, 33 hours at 90 degrees gives a very dark colour for chocolate malts/stouts.

Preparing the substrate

To start the beer-making process the dried malt is ground up and added to water. This is known as mashing and takes place in a 'mash tun' and lasts for one to two hours. This allows further hydrolysis of starch by enzymes, and lipases and proteases also digest lipid and protein respectively, these products of digestion add to the final flavour of the beer and prevent the beer becoming hazy. Also if too much undigested protein remains, the beer cannot hold its 'head' (the froth on top). When the mash reaches 60 degrees C beta-glucanase enzyme breaks down beta-glucans and so allow sugars to be more available for fermentation later in the brewing process. At the end of mashing the temperature is raised to about 75 degrees C to denature the enzymes from the barley seeds.

After mashing, the liquid is strained from the spent grains in a process called 'lautering'. The liquid is moved into a vessel called a 'copper' and boiled to completely terminate any enzyme activity. Hops are added to give the characteristic bitter flavour as the resins in the hops dissolve in the wort. The wort now has to be cooled to 20-10 degrees C by means of heat exchange plates that transfer the heat to warm up water that can be used to help bring more wort to the boil. Another filtration takes place before fermentation, followed by oxygen being dissolved into the wort to help yeast reproduce rapidly using energy from its aerobic respiration when yeast is first added.(2)

Fermentation

In the past a strain of the yeast *Saccharomyces cerevisiae*, known as a beer yeast, taken from an earlier fermentation was added to the mixture. Fermentation takes between five and ten days at low temperatures. The exact conditions are varied depending on the type of beer being produced. Modern brewing uses pure yeast strains that have been specially grown under aseptic conditions.(5)

This used to be done in large wooden vats but to prevent infection stainless steel containers are now used so that, apart from the yeasts, the mixtures remain sterile.

Fermentation is the anaerobic respiration of yeast. The process of glycolysis takes place and the pyruvate is then converted to ethanol and carbon dioxide. The yeast cells continue to gain some supplies of ATP from this process and continue to divide by budding. However the ethanol is ultimately toxic to yeast cells. During fermentation large quantities of carbon dioxide are released and this is often used to hold the beer under pressure and dissolve carbon dioxide in the beer so it becomes carbonated.

Conditioning

When the fermentation is nearly complete the yeast sinks to the bottom of the tank and the beer is cooled to nearly freezing. This helps to remove proteins by coagulation so the beer will look clear and some unpleasant flavours become insoluble at low temperatures.

Filtering

This makes the beer 'shine'. Diatomaceous earth can be used to remove any haze (it is also used for swimming pools) and finally the beer goes through a sterile filtration so hardly any micro•organisms are in the beer.

Ales and lagers

Ale is made by what are called top-fermenting yeasts – they work best at warmer temperatures usually 15-20 degrees C. Lager is made using bottom-fermenting yeasts and they prefer lower fermentation temperatures around 10 degrees C. In the past, wild yeasts were used to produce beers of spontaneous fermentation.

The diseases of beer

The diseases of beers were first studied by Pasteur and they often occur during maturation or after bottling. A wild yeast, *Saccharomyces pasteurianus*, makes the beer very bitter. There are also lactic acid bacteria that can make the beer acid and cloudy. To avoid these problems the process of pasteurisation of the final product is necessary.

Pasteurisation takes place as follows:

- beer is heated up
- then cooled – this destroys bacteria and kills yeast.

An alternative is to flash pasteurise by heating the beer to 70 degrees for a few seconds and immediately chilling it. Some brewers will not use flash pasteurisation as they consider it ruins the flavour of the beer.

Traditional beers are often not pasteurised, this is usually called ‘real ale’. Some live yeast remains to continue a little further fermentation to give the best flavour and a little more alcohol content. This is called secondary fermentation.(4)

Environmental issues

The brewing industry uses large quantities of energy to heat up the substrates and has a significant spent biomass disposal problem. Research is expanding as to how spent grains from brewing could be used to produce bioethanol fuel as a renewable energy source. Green Spirit Fuels aims to have their first factory operational in 2008. This means that some of the energy used to create the spent grains can be offset against the energy gained from the creation of a fuel from previously wasted biomass.(6) The brewing companies might then claim that they are brewing in a more sustainable way and that they are committed to sustainable development projects.

Do breweries contribute to global warming? They must do as carbon dioxide is a waste gas. To become a green industry, more gas will have to be captured and used for other industrial processes.

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Biological Science 1&2 Green, Stout and Taylor

www.beer-naturally.co.uk

<http://breweryhistory.com>

www.beveragedaily.com/news/printNewsBis.asp?id=69170

Exemplar A: Examiner's comments

A Brewery visit report

1. Biological methods and processes used

It is not at all obvious what problems with brewing are being solved here (0). There is a good deal of information about the methods used but no data or any hint of how a problem is being solved (2). There is some data on various aspects of fermentation but very little in the way of a solution being illustrated with charts diagrams etc. This is too descriptive and it's impossible to work out what is 'appropriate'. (1)

(3 marks)

2. Applications and implications of the biology encountered

Notice that this part is to with applied biology and in this case, economic and environmental implications are identified and described although perhaps somewhat briefly (3). The benefits of 'Biofuels' are described reasonably well but there is not much more on risks (3). There is not much at all on alternatives and no detail at all on precisely how carbon dioxide is 'captured'. (0)

(7 marks)

3. Evaluation of source material

There are sufficient sources both web based and non web based (4). They are identified clearly and quotes are acknowledged throughout the report (4). However, there was no attempt to investigate the validity of these sources. (0)

(8 marks)

4. Communicate clearly, concisely and logically

The report is quite well set out and presented; spelling, punctuation and grammar are fine (2). The technical language is good but there are no visuals to enhance the report. (1)

(3 marks)

Overall mark – 20 marks out of 40 (possibly a grade 'D')

Improvements: This report needs a clear problem to be stated. Then, all methodology would be discussed in the light of attempting to solve the 'problem' identified. Also, there must be some data or examples as a means of explaining how the problem is being solved together with any alternative solutions. At least two sources must be investigated for their validity.

Exemplar B: The role of seed banks in the 21st Century



Combretum fragrans collected in Burkina Faso and now in the seed bank
Copyright Board of Trustees, Royal Botanical Gardens, Kew

I visited the Millennium Seed Bank Project (MSPB) at Wakehurst Place to see how scientists from Kew are storing seeds from around the world and to try and find out the methods they use and how their research is likely to benefit mankind. The Head of the Millennium Seed Bank said ‘the need for the kind of insurance policy the MSB provides has never been greater’.(1)

The billionth seed has recently been stored at Wakehurst Place. The aim is to have stored 25% of the world’s species of plant by 2020. Our tour visited all the sections and each process, except we were not allowed to go into the cold room due to the risk of carrying organisms that might infect the storage area.

Why store seeds?



African farmer dependent on crop yields
Copyright Board of Trustees, Royal Botanical Gardens, Kew

Scientists in many countries have become increasingly concerned that so many indigenous plant species are being reported as extinct or under severe threat of extinction so something has to be done to stop the genes from these species being lost. So far about 70% of our medicines are derived from molecules first isolated from plants; this suggests they really are an important scientific resource. Farmers are increasing growing only specific types of crop plants so old varieties are being lost to cultivation, if they are lost completely so is the genotype that gave them particular characteristics.

At present there is great concern about climate change, many scientists have reported that some of the most agriculturally productive areas of the world are likely to suffer significant climatic changes. One of our responses will be to develop new strains of crops that incorporate genes from plants derived from seeds only available from seed banks. The potential loss of genetic diversity is the most important reason for any government to invest in seed banks.

Setting up a seed bank

The seeds have to be stored at low temperatures so that the proportion of stored seeds that germinate remains quite high. Some seeds have been found to naturally germinate successfully after a dormancy of many years, while others rarely germinate after only two years' storage. The scientists will have to find the best conditions for each species of seed as there would be no point in storing seed only to find that it could not be made to germinate again.

At Wakehurst Place the seed vault has been designed to last 500 years!

The floor area of the vault is 930 square metres and it has an internal height of about 5 metres. The vault could hold 100 000 000 000 rice grains! Inside the vault there is a prefabricated drying room that is entered via an air lock. When finished, the vault will have six more cold rooms and be able to hold seed from as much as 40% of the world's seed-bearing species.(2)

The store is underground to save energy in the summer. The risk of flooding is overcome by having two emergency pumps and emergency generators.

The walls are so thick they would reduce the effect of penetrating radiation in the event of a nuclear event.

The waste heat from the cold rooms is used to heat a domestic water supply.

Storing seeds

Seeds arrive from all parts of the world. They are left in their cloth or paper collecting bags to dry out in the drying room (15-18 °C, 15% relative humidity). The drying process can take a month before there is no net movement of water in or out of the seed. A hygrometer is used to check for dryness. Meanwhile, some seeds are taken out and germinated to check they are still alive.

The seeds are stored at -20 °C so the biological activity is greatly reduced. Enzymes cannot be denatured at these low temperatures but they have extremely low activity. As most seeds only have about 10% water this would also keep enzyme activity to a minimum.(3)



The cold store at Wakehurst Place
Copyright Board of Trustees, Royal Botanical Gardens, Kew

Seed dormancy

This is the failure of mature, intact seeds to germinate under favourable conditions (usually water, oxygen, light and appropriate temperature).

Dormancy has evolved to protect the seed during seed dispersal. It can be found in five types: (Baskin & Baskin, 2004).

- **Physiological**
A mechanism inside the seed embryo prevents germination – this often breaks with moist storage followed by optimum temperature germination.
- **Morphological**
A seed embryo that is not fully developed at dispersal – the embryo continues to grow after dispersal and will not germinate until it has reached a critical length.
- **Morpho-physiological**
This combines the features of both of the above.
- **Physical**
The seed or fruit coat is resistant to water uptake or there are inhibitors present in the seed. ‘Chipping’ the seed coat usually breaks dormancy.
- **Combinational**
These species have impermeable seed coats and a physiological mechanism.

Dormancy can be a problem for seed conservationists because the germination monitoring can lead to underestimates of seed viability. Seeds might be disposed of as dead when they are not. If seeds cannot be converted back into plants, they will be of no use to scientists.

Germination monitoring

Seeds have to be tested for their ability to germinate. A seed container is removed from cold storage and allowed to warm up to room temperature over 24 hours. Usually between 20 and 50 seeds are used and treated so as to break their dormancy. The seeds are grown on 10 g l⁻¹ water agar in an illuminated incubator with 8 hours of light and 16 hours in the dark.

Germination (when the radicle is 1-2mm long) is recorded each week. To pass, the seeds must reach 75% germination ($p < 0.05$). If the level is below this then re-collection may be required and an alternative regeneration is carried out.(1)

Growing out

This allows some plants to be grown in the glasshouse to allow the production of ‘fresher’ seed to be placed in the bank. This is known as regeneration or multiplication. So far, mainly UK native species have been regenerated to improve stock and in support of English Nature’s Species Recovery Programme. This has also been done for *Silene tomentosa*, a species thought to be extinct in the wild on the Rock of Gibraltar and reintroduced.(1) This successful research will lead to other examples in the future if viable seed is kept in seed banks. Some species that lose viability quickly will have to be repeatedly grown out to keep stocks fresh.



Is it justified to encourage seed bank developments?

One of the main aims of the MSBP is to educate other scientists from around the world as to how they can set up a seed bank in their own country. This will make humans less reliant on a few banks; no one knows how genetic rights to biological material might change in the future. If a country supplied seed to Wakehurst Place and did not have its own seed bank, then it would cause great problems if that country then found it did not have rights of access to its own seeds.

At present there are funds to keep the MSBP going until 2010 – after this its future is uncertain. This explains why so many countries are sending scientists for training and setting up their own seed banks.

Recently Norway has set up a seed bank underground on the island of Sptizbergen where the permafrost will keep the stock cold. It is going to become a genuinely international bank that any country can use. Even if the UK project does not last, it will have helped the creation of many other seed banks and it seems to be a race against time as biodiversity is being lost at an increasing and alarming rate.(4)

Bibliography

1 <http://kew.org/mspb>

2 Notes from personal communication during my visit

3 *Biological Science 1 &2* Green, Stout and Taylor

4 <http://news.bbc.co.uk/1/hi/sci/tech/4605398.stm>

Exemplar B: Examiner's comments

Seed banks

1. Biological methods and processes used.

The problem of storing seeds effectively is identified and explained briefly (3). There is a good description of the methods used, although there could have been more data as part of this explanation (3). The methods used are regarded as appropriate and some data is given on seed storage and also germination monitoring just in case viable seeds are discarded mistakenly. (2)

(8 marks)

2. Applications and implications of the biology encountered

Notice that this part is to with applied biology but in this case, only the social aspects are briefly touched on (1). There is no discussion of advantages or disadvantages of these methods (0) and a brief mention of the alternative strategy in Norway. (2)

(3 marks)

Evaluation of source material

There were four sources, web based and non web based, one being a personal communication (4). The bibliography was partially correct and sources were referred to in the text (3). There was no attempt at evaluating the validity of the source material. (0)

(8 marks)

Communicate clearly, concisely and logically

Spelling, punctuation and grammar are good and the report is well set out (2). Technical language is fine but there is not much use of 'visuals' as part of the argument. (1)

(3 marks)

Overall mark – 22 marks out of 40, possibly a grade 'C'

Exemplar C: Asian vultures on the road to extinction



Figure 1

Source: Asad Rahmani, *The Peregrine Fund*

Groups of these oriental white-backed vultures (*Gyps bengalensis*) are now a rare sight across Eastern Asia.

The crisis

The white-backed vulture (*Gyps bengalensis*) was a common bird of prey with a global population of over 10 million.¹ Since the early 1990s, bird conservationists in India, Nepal and Pakistan have noticed the populations of these birds has been declining dramatically.

One study put the drop in population levels at 95%,² the most rapid decline in the total population of a bird species ever recorded³. This is a greater rate of decline than the Dodo. While this rate of decline seems colossal, the source of the information must be considered. Reference 1 is a website not affiliated with a university or other reputable source. Because

of this it must be treated cautiously as it could be presented without peer review as would be the case for biological literature in a science journal. References 2 and 3 are more like to be valid as they are published reports by respected scientists. Green and Hirons have also published work on flamingos, and reference 3 was published in *Nature*.

There are three species of vultures in crisis. The oriental white-backed vulture (*Gyps bengalensis*), the long-billed vulture (*Gyps indicus*) and the slender-billed vulture (*Gyps tenuirostris*) have all been added to the IUCN Red List of threatened species. The IUCN (International Union for the Conservation of Nature and Natural Resources) works to help conserve the environment by sharing information.

The cause

Although the problem of the declining vulture population was identified as early as 1987 when the number of nesting pairs in the town of Bharatpur, India, dropped from 353 to 20, the cause of the problem was not identified until 2004 when a report was published in the journal *Nature*. A team of conservationists from the US-based Peregrine Fund led by J. Lindsay Oaks from Washington State University collected dead vultures and examined their bodies. The team found that of 259 birds investigated, 85% showed evidence of gout.

Gout is a systemic disease (a condition that affects more than one part of the body) that is caused by crystals of uric acid becoming deposited when it cannot be properly metabolised (processed). A symptom of gout in humans is intense pain in the joints where the crystals collect, such as the big toe.

In vultures gout is caused by kidney failure, which leads to strong concentrations of uric acid collecting on the surface of the bird's organs such as the heart. Kidney failure in birds can be caused by:

- disease
- toxins
- nutritional deficiencies
- metabolic diseases.

In humans, gout occurs when there is a high level of uric acid in the blood. This is known as hyperuricemia and happens when the kidneys cannot filter excess uric acid from the blood and excrete it as urine. Hyperuricemia could be caused by a diet high in red meats, beer and red wine, or by medication such as aspirin. It can also be inherited. Gout affects 1 in 200 adults in the UK, mainly men between the ages of 40 and 60.⁴ This figure is from the NHS website, but no source is given, so the estimate cannot be checked.

If the condition were not treated (in humans) it would reduce the size of the country's workforce, reducing profitability in business as well as the country's gross national output. More people unable to work would also cost the country money in terms of benefits paid to these disabled people, and could lead to an increase in taxes or a decrease in government spending in other areas.

There is also a social issue involved. Gout is affected by alcohol consumption and is made worse by high blood pressure and obesity. Obesity (which leads to high blood pressure) and alcohol consumption is increasing in the UK and so it is likely that gout occurrences will increase too unless the causes of gout are controlled or prevention measures such as changes in diet and reducing alcohol consumption become widespread. If these issues in society are not addressed, the health of the people within the UK will suffer.

The cause of vulture deaths

The next step in solving the vulture crisis was to identify what was causing the kidney failure found within the birds investigated. Samples were collected from 42 freshly dead vultures and the cause of death was investigated. The results suggested the cause of the vulture's death was due to a toxin. Toxic substances such as DDT, the controversial pesticide used widely in the 1960s, were tested for and in some cases found, but not in substantial enough quantities in the brain or liver to suggest they were the cause of death.

The team observed that vultures in Pakistan fed exclusively on domesticated livestock and so identified drugs that were commonly used to treat cattle. The anti-inflammatory drug diclofenac was identified as a potential problem and further tests showed a 100% correlation between residue of the drug in the vultures and death caused by gout. There was no other common factor between all the gout deaths.⁵ This suggested that the drug diclofenac was causing the decline in the vulture population. This theory was proved by further testing where vultures were fed both diclofenac-treated and untreated flesh. The vultures fed with the treated meat died, while the others survived.

The information above is taken from a report published by a charity aiming to raise money to help its causes. While this information is likely to be correct, it is important to consider that the report may have been intended to shock or prompt people into donating to the Peregrine Fund. The report may have been focused on the areas worst-affected by Diclofenac poisoning, so may not give an overall impression of the situation.

Diclofenac

Diclofenac is a non-steroidal anti-inflammatory drug (NSAID) very similar to Ibuprofen. This class of drug affects the production of hormones that carry nerve impulses across synapses (conductive gaps between nerve cells or a nerve cell and a muscle). NSAIDs have also been proven to cause kidney damage in studies on baboons. The drug is popular in the Indian sub-continent because of its cheap price and widespread distribution. The drug is used on cattle that are often kept for work rather than food, because of this when the cattle die their diclofenac-contaminated bodies are left for the vultures to feed on. This is how diclofenac enters the vultures' food chain.

The future for vultures

In 2004, meetings were held and a resolution was passed recommending that diclofenac would be banned. In 2005, the Indian government announced its intent to phase out the veterinary use of diclofenac within six months. A good-value alternative for the drug has been found and it is hoped that this will eventually become as commonly used as diclofenac. If use of the drug diclofenac was phased out and replaced with this alternative, the implications would be positive – a reduced death rate for the vultures in the areas benefiting from the reduction in diclofenac use. However, for the alternative drug to replace diclofenac it would have to offer equal or superior properties at a lower cost in order to achieve widespread distribution and use.

Captive breeding centres have been set up for the vultures to help increase their populations. It is estimated in a Journal of Applied Biology report that the vulture declines could have been caused by only 1% of livestock carcasses being contaminated with the drug, so vultures bred in these centres will be kept in captivity until the threat of diclofenac is removed. While it may be considered inhumane to keep the birds in cages, it is ultimately for their own safety as if they were released they would be likely to die as a result of diclofenac poisoning. If captive breeding is widely adopted then the future for vultures would be more promising. Early breeding results are promising and when the Eurasian Griffon vulture's levels dropped in Western Europe captive breeding was successfully used to reintroduce the species into a region of France. It is hoped that over time diclofenac use will be removed and the same can be done for the Asian vultures with regards to reintroduction of the species.

	Diclofenac traces	No diclofenac
Gout	14	0
No gout	0	14

Table 1.1 The relationship between vulture death caused by gout and the presence of diclofenac residues. These data suggest that the majority of vulture deaths (78%) in the area investigated were caused by diclofenac.

generated income through tourism.⁶ The value of each vulture at each station was calculated and then compared to the figure spent on conservation, divided by the increase in population observed. The figure spent on conservation per vulture was lower than the value of the vulture, showing that vulture tourism is economically viable. However the information from this source is only partially valid in the context of the Asian vulture crisis. This study was carried out in Israel where there are likely to be more tourists than in the areas of India, Nepal and Pakistan affected by diclofenac poisoning, and ecotourism involving vultures will not be possible without enough visitors. Also, the costs involved in increasing Israel's vulture population may be less than the cost of increasing Asia's vulture population, as Israel does not suffer from the diclofenac contamination. As a result of these differences, the validity and strength of argument of this source is limited. Despite this, protecting the vulture population for tourists is still a viable argument for the conservation of the vultures.

Another possible development would be to promote vultures as a tourist attraction to help pay for and support conservation efforts. Vultures are graceful birds and people enjoy watching the birds soaring above their heads. A study carried out in Israel where vulture-watching stations have been established, showed that it was economically viable to spend money conserving vultures as they

Should the vulture be saved?

“Vultures have an important ecological role in the Asian environment...their loss has important economic, cultural and health consequences”

Dr Munir Virani

The Peregrine Fund
Press Release, 2004

As well as the potential revenue generated by vulture watching, there are other reasons to save the Asian vultures. Vultures have a significant affect on the environment in which they exist. Vultures feed on rotting corpses, so with fewer vultures more corpses are being left where humans can become exposed to them. This increases the chances of infection with tuberculosis or anthrax. In Africa, vultures consume more than 70 percent of zebra, wildebeest and other hoofed animal carcasses – not lions or hyenas though.⁷ (This information is unreliable as it came from a National Geographic news item, and no source was cited.) Vultures quickly stripping corpses can also prevent the spread of animal-to-animal diseases such as foot and mouth disease. The reduction in the number of vultures has also led to an increase in the feral dog and crow populations. These species are known to spread rabies and West Nile disease, respectively. The loss of the Asian vulture poses a health risk to humans so this also a social issue.

There are also other important social issues involved. The Parsi communities of Pakistan and India have a tradition of leaving their dead in the open in ‘towers of silence’ where their bodies are devoured by vultures. Their religion includes a belief in the sacred vultures releasing the spirits of their dead. With lower vulture numbers, the Parsi traditional culture is becoming threatened.

The Indian government banned the manufacture and sale of diclofenac in September 2006.

(1991 words)

References:

- 1 Vultures, dying faster than the Dodo..., Edward Teague. www.williambowles.info/env/vultures.html
- 2 Gilbert *et al.* (2002)
- 3 Green & Hirons (1991)
- 4 Gout, NHS Direct Online Health Encyclopaedia. www.nhsdirect.nhs.uk/en.aspx?ArticleID=180
- 5 Oaks J.L. *et al* (2004) Diagnostic investigation into vulture mortality, Punjab Province, Pakistan, *The Peregrine Fund*.
- 6 Becker N. *et al* (2004) A bio-economic valuation of protecting vultures: Estimating the economic benefit of viewing vultures (*Gyps fulvus*) and some policy implications of valuation techniques, *Tel-Hai College, Israel, University of Haifa, Israel*.
- 7 Mystery disease stalking vultures in India (2003), Trivedi P.B., *National Geographic News*.



Exemplar C: Examiner's comments

Vultures

1. Biological methods and processes used.

The problem of decline in vulture numbers is outlined clearly and described in some detail (4).

There is then an account of how to address this problem together with data on how the problem had been identified together with some possible solutions (3). The appropriateness of these potential solutions is considered but not enough data is given to back the argument up. (2)

(9 marks)

2. Applications and implications of the biology encountered

Environmental and social issues are identified and discussed well (4). There is some discussion of the advantages or disadvantages of the solutions (3) but not much on alternative strategies. (1)

(8 marks)

3. Evaluation of source material

There were a good number of sources, web and non web based and they were acknowledged in the text (4). The bibliography was perfectly adequate (4). At least two sources were investigated well for their validity but more evidence could have been given. (3)

(12 marks)

4. Communicate clearly, concisely and logically

Spelling, punctuation and grammar are good and the report is well set out although it could have done with more data or illustrative material (2). There is good use of technical language. (2)

(4 marks)

Overall mark — 32 marks out of 40, a possible 'A' grade'

Unit 6 Individual experimental investigations

Managing the investigation

The investigation is a chance for students to identify an area of personal interest and undertake an experimental investigation. Here are some points that will help you manage the investigation effectively:

- All student's work must be individual. Whilst it is inevitable that, in larger groups, there may be some overlap between titles, centres are strongly advised not to use a similar approach for all candidates.
- Reviewing initial plans suggested by students and discussing them individually will often help to avoid major pitfalls.
- Previous experience has shown that successful investigations have the following characteristics in their plans:
 - (a) A short, unambiguous hypothesis that does not seek to investigate multiple variables
 - (b) A consideration of how the data are to be analysed is included in the initial plan. Ideally this is incorporated into the hypothesis. For example, 'There is a significant difference/correlation/association between...'
 - (c) Research and background theory is very closely linked to the hypothesis and has a sound A-level biology basis. (This is often a section where word count rises without gaining marks.)

The individual investigation checklists provided for students should help them to organise their work effectively (see pp. 57-59).

Unit 6 student exemplars

There are two exemplars of student investigations:

Exemplar A

An investigation into the factors affecting the distribution of sand couch grass *Elytria juncea* on a sand dune system

Exemplar B

Investigating the antibacterial effects of fluoride and non-fluoride toothpastes

Each exemplar starts with an abstract. The student work is then provided, along with moderator's comments at various points in the work so that you can see the standard required.

Please note that the students used photographs from the internet to illustrate their work and that the reproduction of these images is not allowed under copyright laws, so we have described the images used in the appropriate places.



Exemplar A: An investigation into the factors affecting the distribution of sand couch grass *Elytria juncea* on a sand dune system

Abstract

The main aim of the investigation was to determine the most important factors affecting the distribution of sand couch grass *Elytria juncea*. Initial research indicated that moving inland from the sea would result in decreasing salinity and this would be the major factor in limiting the distribution of the sand couch. Interrupted belt transects were used to record percentage cover of sand couch and soil samples were taken to measure salinity. The results showed that whilst there was some correlation between salinity and distribution, this was not significant at the 5% confidence level. It is suggested that the interaction between sand couch and other biotic and abiotic factors in the dune ecosystem is more complex and would require further investigation.

Rationale for the investigation (1)(2)(4)(5)

Sand dunes are an example of ecological succession. Bare sand is a poor medium for plants to grow, water drains through very quickly and hence leaches out mineral ions, but they are often very saline because of the effects of direct contact with sea water or salt spray. Dunes are often in very exposed positions making them liable to strong winds as well as wave action and tidal currents. Sand has no humus content so is easily blown around in such conditions, meaning that plants cannot anchor themselves.

Primary colonisers of sand must therefore be able to grow in such conditions. They often have long root systems and xerophytic adaptations such as thick cuticles, rolled leaves and protected stomata. In addition, they must also have some way of combating the high salinity in the sand. Provided that they have evolved these features. They gain the advantage of being able to live in a habitat with low levels of competition. Such colonisers are found on the dunes nearest to the sea and around the strand line which indicates the level of the highest tides.

As primary plant colonisers develop they help to stabilise the dunes with their roots, trap sand so that it builds up, and as they die and decay small amounts of humus can begin to form. This allows other species of plants to begin to grow and form fixed vegetation which further stabilises the dunes. Finally small shrubs and trees are able to grow and the formation of woodland would be the final stable stage of succession which is called a climax community. However, because each area has slightly different conditions and many other factors that can affect succession, the final stages of succession make never take place or be delayed a long time. With sand dunes this can often be because of human influences since they are often close to popular holiday areas.

Plants typical of the embryo dunes are marram grass, lyme grass and sand couch. In the grey dune area plants such as ling (*Calluna vulgaris*) become dominant along with gorse and dwarf birch species. Larger shrubs of birch and alder begin to grow along with oak or Scots pine saplings as more permanent woodland forms if the succession is undisturbed.

(521 words)

The position of sand couch in the sand dune succession

Sand couch (*Elytria juncea*) is a grass-like plant that is found at the beginning of the succession in embryo dunes and above the strand line. Whilst it produces seeds by sexual reproduction, its main method of colonising new areas of the dune is by producing horizontal underground stems called rhizomes. These grow beneath the sand surface and produce new shoots at intervals. If the rhizomes break, two new plants are formed. This long network of underground stems helps to bind the sand together and build up the first dunes.



Sand couch plants on an embryo dune © AJSilverside www-biol.paisley.ac.uk



**Sand Couch starting to form embryo dunes
at the top of the beach**

Source: www.sandsoftime.hope.ac.uk

The leaves of sand couch are thin and have a thick cuticle giving them a small surface area and a low rate of transpiration. Both of these are useful adaptations to embryo dunes which drain any available water very quickly and are subject to very strong winds. Their leaves also have stomata which are well-protected from the air flow and this allows gas exchange without losing too much water. The embryo dunes also have a high salt content and therefore sand couch must have adapted to tolerate these conditions too. Although it has some competition from plants such as marram grass and lyme grass which have similar adaptations, sand couch is a common feature of embryo dunes. Further away from the sea the dunes become dominated by other species and the main purpose of my investigation is to try to find which factor is the most important in determining the distribution of sand couch.

Using the information from my research and initial observations from the dunes to be studied, it was obvious that a number of plants on the dunes had xeromorphic adaptations but that the cover of sand couch did decrease as the distance from the sea increased.

My initial hypothesis therefore is that there will be a significant correlation between percentage cover of sand couch and salinity of the soil. In order to plan my method, I researched the best way to test this idea and to analyse my results.

Research and rationale

Moderator's comments

The rationale is clear but not particularly well justified (8). The biological background is developed but it is still not clear what the point of the investigation is. Perhaps a more detailed look at human influences on this sort of environment would help. A good number and variety of sources has been used. (12)

Overall mark = 10

Of the statistical tests available I chose a Spearman's Rank correlation test because I was trying to analyse a link between two continuous variables and gather support for the idea that salinity was an important factor in determining the distribution of sand couch.

My null hypothesis therefore will be: There is no significant correlation between the percentage cover of sand couch and the salinity of the sand on which it is growing.

In order to carry out this test effectively I need to collect 7-30 samples which are at the ordinal level and do not show a U-shaped relationship. (8)

Trial investigation

In order to finalise my plan I paid an initial visit to my chosen site to check the details of my actual method.

The database (3) showed that sand couch had been recorded at this site from 1936, so this seemed a sensible choice of plant to investigate.

At the site I found that I could use the top edge of the strand line indicating the most recent high tide as my base line. I laid out a 50m tape from this point directly inland over the dunes. I then used my field key (7) to check that I could correctly identify sand couch. On inspection I could find no more sand couch beyond the 33m mark, so this determined the range of my measurements.

It was obvious that I would not be able to take measurements along the whole tape and the cover of sand couch did not seem to change rapidly, so I decided to take measurements every 3m along the tape as an interrupted belt transect since this would give me 12 measurements which was well above the minimum for my Spearman's Rank test.(6)

Given that I also had only a limited time, I also tested my basic method to see how long this might take.

First of all I laid out three 1m rulers to form a square on one side of the tape and tried to estimate the % cover of sand couch. This proved very difficult in such a large square and my estimates by eye seemed very inaccurate. I then moved the rulers to form a 0.5m x 0.5m square quadrat. This was much easier to estimate but still seemed to be very inaccurate. I decided that to improve accuracy I would need to tie some strings on the smaller quadrat to form a smaller grid to make assessment quicker and more accurate. I tied string to my quadrat to make up 25 10cm x 10 cm squares.

(1304 words)

Taking samples of the soil for laboratory analysis was easy but I would need to decide on exactly where and how deep I took each sample. This was also a protected site, so any samples would need to be very small and have a minimal effect on the environment.

As I moved from the embryo dunes to the more established dunes the plant cover became more dense and it was also necessary to keep to clear pathways in order to prevent further trampling damage.

Back in the laboratory I tried out the methods I was going to use to determine salinity and other tests on the soil samples. To measure salinity I used a salinity meter that measured the conductivity of water. The small probe of this meter easily fitted into a 25ml beaker and by adding water I found I would need 10ml of solution to cover the probe. Using some sand I had collected I found that I could make up the required solution using only 5ml of sand with 15ml deionised water and pouring the solution through coarse filter paper. To speed up this sampling I collected 15 identical small specimen tubes with a volume of 5ml to fill with sand at each site.

**Control of main variables**

- 1 Select start point for transect by taking a random number from a calculator as the distance from the main path to the beach.
- 2 Sampling area = 0.5m x 0.5m every 3m along the transect
- 3 Percentage cover estimated using 0.5m x 0.5m quadrat divided into 25 equal squares. Cover was estimated to a half of one square (2%).
- 4 Soil samples taken by pushing identical 5ml specimen tubes into the sand until they were exactly level with the soil surface. The inshore corner of the quadrat touching the tape was always used for this sampling.
- 5 This exact volume of sand was mixed with 15ml of deionised water for 5 minutes before filtering and testing with the salinity meter until a constant reading was obtained.
- 6 All sampling was carried out within a 2-hour period in which there were no changes in the weather such as rain showers which could affect salinity readings.

Safety issues

- The weather forecast was checked carefully beforehand and suitable clothing taken to the shore.
- Tide tables were checked to note times of high water.
- At least four other students investigating other features of the dune were in sight at all times.
- All students had mobile phones with the number of the supervising teacher programmed in.
- A first aid kit was available on the dunes.
- A simple risk assessment showed no important hazards in either apparatus or procedures.

(1756 words)

Details of final method



I carried out my investigation at Studland Bay, Dorset. (see map below; grid ref. 642451).

I began on the strand line 187m from the edge of the fenced area of conserved dunes as indicated by a random number generated from my calculator. I placed a 50m tape on the top edge of the strand line and laid it at right angles to the beach across the dunes. I placed my 0.5m x 0.5m quadrat, divided up into 25 squares by strings, with its bottom edge on the zero mark. To assess % cover I used the key (7) to make sure I could identify the sand couch and then looking down on the quadrat I counted the number of squares that were mainly covered in leaves of sand couch. Those which were not fully covered I counted if they had more than half covered; those which were less than half covered were not

counted. At the top corner next to the tape I pushed an empty specimen tube into the sand until it was level with the surface and completely full. To prevent the sand falling out I slid a small piece of card under the mouth of the tube as I lifted it out. I then labelled it with the quadrat number and screwed on the plastic top. This was then repeated every 3m along the tape to a distance of 36m.

Back in the laboratory I poured each sand sample into a small beaker and added 15ml of deionised water, using some of it to rinse out the tube if any sand was stuck to the side. I then stirred it for one minute before filtering the mixture and putting the salinity probe into the solution until it was just covered and waiting until the reading was constant. I also tested the pH of the solution with a pH probe for the samples from 0, 9, 18, 27 and 36m.

(2074 words)

Planning

Moderator's comments

There is a good discussion of variables (9), a good description of possible risks (10) and thorough trial investigation but the investigation as a whole is not particularly original and so doesn't qualify for any more than 9 marks.

Overall mark = 9

Results

Distance from strand line (m)	Cover of sand couch (%)	Salinity (arb units)
0	2	6.0
3	22	2.5
6	32	5.5
9	23	4.5
12	14	7.0
15	40	2.5
18	32	2.5
21	30	2.0
24	38	2.0
27	36	1.5
30	6	0
33	0	2.0
36	0	1.0

Distance from strand line (m)	pH
0	7.4
9	7.2
18	8.1
27	7.8
36	7.9

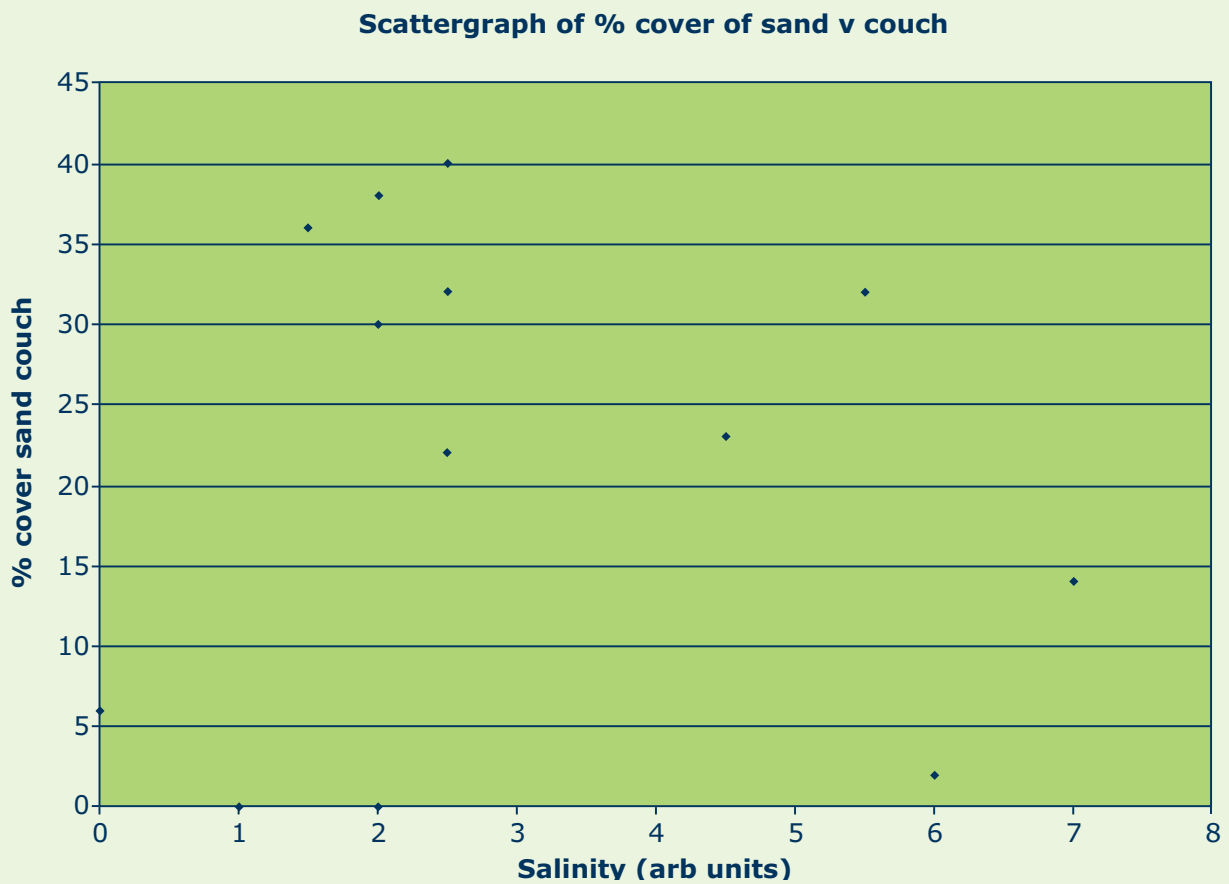
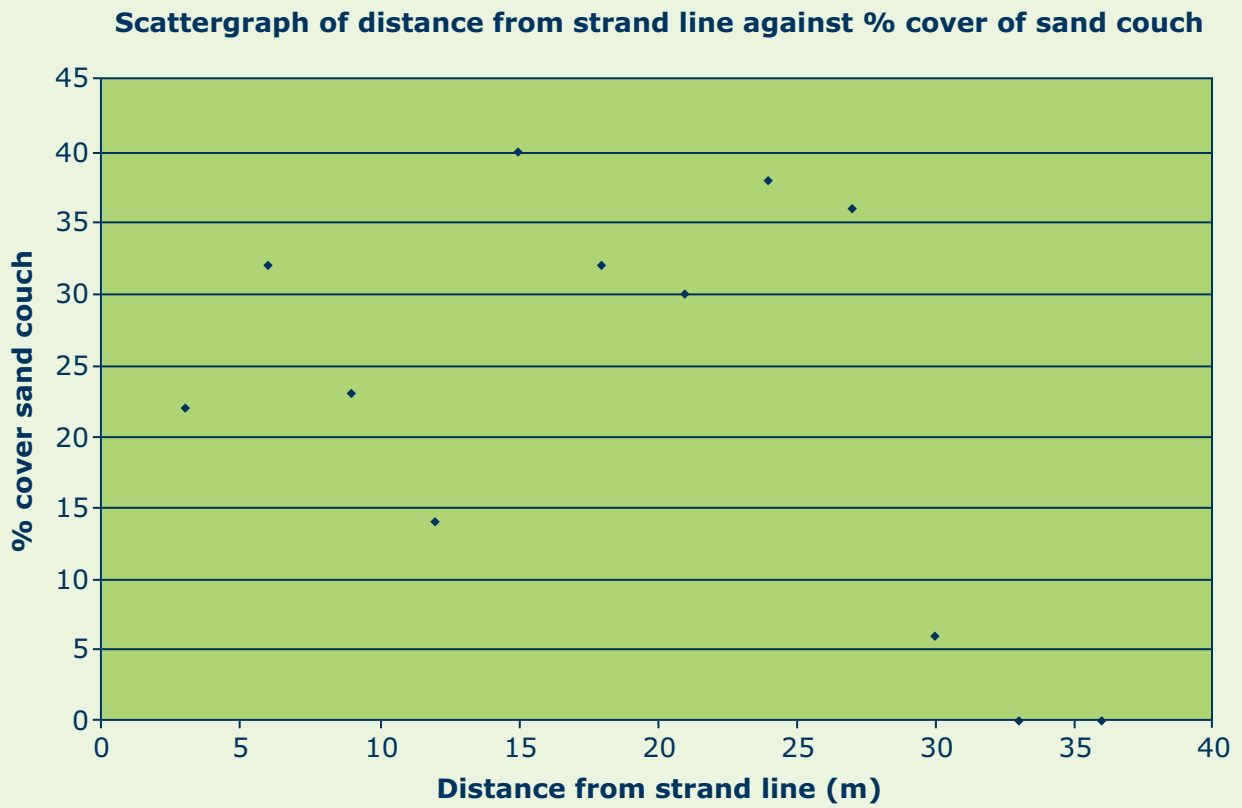
(2143 words)

Observing and recording

Moderator's comments

Observations and measurements deserve the maximum mark (8) due to the thoroughness of the teacher annotation. However, there were not enough replicates taken and there is no discussion of anomalous data (0).

Overall mark = 4





Statistical analysis

Null hypothesis: There is no significant correlation between the % cover of sand couch and the salinity of the soil.

Distance from strand line (m)	Cover of sand couch (%)	Rank 1	Salinity (arb units)	Rank 2	D(1-2)	D ²
0	2	11	6.0	2	9	81
3	22	8	2.5	6	2	4
6	32	4.5	5.5	3	-1	1
9	23	7	4.5	4	3	9
12	14	9	7.0	1	8	64
15	40	1	2.5	6	-5	25
18	32	4.5	2.5	6	-1.5	2.25
21	30	6	2.0	9	-3	9
24	38	2	2.0	9	-7	49
27	36	3	1.5	10	-7	49
30	6	10	0	13	-3	9
33	0	12.5	2.0	9	3.5	12.25
36	0	12.5	1.0	12	0.5	0.25

$$\Sigma D^2 = 314.75$$

$$r_s = 1 - \frac{6\Sigma D^2}{(n^2 - 1)}$$

$$6 \Sigma D^2 = 6 \times 314.75 = 1888.5$$

$$n = 13$$

$$n^2 = 169$$

$$n^2 - 1 = 168$$

$$n(n^2 - 1) = 2184$$

$$6 \Sigma D^2 / (n^2 - 1) = 1888.5 / 2184 = 0.8647$$

$$r_s = 1 - 0.8647 = 0.1353$$

From the tables I used (8), the nearest critical value for r_s with 14 pairs of measurements at the 5% confidence level is 0.544. My calculated value of r_s (0.1354) is well below this level and therefore I must accept my null hypothesis – there is no significant correlation between salinity levels and the % cover of sand couch.

Trends and patterns

The % cover of sand couch increases as the distance from the strand line increases but only up to a certain point at 15m. From here to 27m there is the highest percentage cover but beyond this point the cover of sand couch falls quickly to zero. It appears from these readings that sand couch tends to be distributed in a preferred zone rather than a smooth change along the transect.

The trend of salinity is that it decreases as you move away from the sea but this is not consistent and there is a great deal of variability. Without further investigation it is not easy to explain why salinity is 7.0 at the 12m point and therefore higher than the strand line or why salinity was only 2.5 at 3m from the strand line.

Comparing salinity with % cover of sand couch shows that there is again a lot of variability which does not support my hypothesis. The area with highest salinity level of 7.0 has only 14% cover of sand couch, whilst an area with low salinity level of 1.5 at 27m has a 36% sand couch cover.

Not surprisingly therefore my statistical test showed only a very weak correlation between salinity and % cover which was well below the 5% significance level.

My monitoring of pH showed that there were changes from neutral to slightly alkaline along the transect, but again there was not a consistent pattern.

Conclusions

It was suggested that sand couch was adapted to withstand high levels of salinity allowing it to out-compete other species in these areas. It is obvious that this is too simple an explanation for the distribution recorded.

My limited data indicate that salinity levels decrease across the dune system as you move inland and this might be a factor affecting sand couch. However when carrying out my investigation it was obvious that when moving over the dunes there were many other factors which might affect sand couch. In particular the stages of succession had many other plants some of which were quite dense. At the start of the yellow dunes there was a dense growth of marram grass (*Ammophila arenaria*) and lyme grass (*Elymus arenarius*) which were much taller than sand couch and could shade it. As I moved inland the sand became much darker indicated some humus content and there were large tufts of ling (*Calluna vulgaris*) which again could change the overall level of competition. The dunes were not level so again it's possible that the water table was much closer to the surface in the dips.

My data show clearly that sand couch is an important part of the succession on the dunes and that it is common only on embryo and yellow dunes. This does support the idea that the stages of succession are determined by which organisms are best adapted to the sequence of changing conditions and sand couch is part of this pattern.

(2860 words)



Evaluation

The selection of sites and the random sampling appeared to be as good as I could make them in the circumstances. I tried to focus on one abiotic factor to investigate but this meant I did not record everything in my quadrats and if time permitted this would have given me a better picture of competition at each stage. My methods of analysing salinity were very simple. Taking samples from the top few cms of sand could have meant that readings would easily be affected by rain dissolving the salts in the surface layer. My meter worked by measuring the current passing through the solution, so I do not know if it was just sodium chloride I was measuring. This might explain the big variations in the salinity readings.

Although recording % cover to an accuracy of 1-2% was optimistic since it was often difficult to assess the thin leaves this would not give errors larger than the obvious differences between many quadrats although it might affect the correlation calculations.

Given more time I would amend my methods as follows:

- Given the variability of my readings, I would carry out two more transects.
- Taking photos of each quadrat on my digital camera might allow me to work out a more accurate way of assessing % cover and to identify all species in each one.
- It would be interesting to check how rain affected salinity readings and take samples from deeper levels that matched the level of sand couch roots.
- Finally, it is obvious that other abiotic factors such as humus content, aspect and position on the dune could also be investigated to see if there was one major influence which would give a strong correlation.

(TOTAL WORD COUNT = 3139)

Interpreting and evaluation

Moderator's comments

The correct statistical test is used and the trends and patterns observed (9) but there is not enough discussion of the biology associated with these conclusions (4). Limitations are recognised and some modifications are suggested. (8)

Overall mark = 7

Bibliography

- 1 *www.sandsoftime.hope.ac.uk* (Hope University Liverpool) accessed 12/10/06
- 2 *www.biol.paisley.ac.uk* (University of Paisley) accessed 11/10/06
- 3 *www.searchnbn.net* (National Biodiversity Network) accessed 12/10/06
- 4 *Biology for Advanced Level* 4th ed. Toole & Toole, Stanley Thornes
- 5 *A Field Atlas of the Seashore* Julian Cremona, CUP
- 6 *Biological Sciences Review* Vol 6, Jan 94 Philip Allan
- 7 *A key to plants common on sand dunes* Edmundson & Roberts, FSC
- 8 *OU Project Guide* Chalmers & Parker, FSC

In selecting my resources to consult I have tried to use only those which are linked to a well-known source.

Both of my background website resources are from universities and the National Biodiversity Network is a Government-funded body containing data from reliable sources.

My journal resource (5) is composed of articles from well-known scientists. My other references are Field Studies Council publications which are nationally known in ecology and well-known A-level texts.

Communicating

Moderator's comments

There is a clear scientific structure to the report (6), data is effectively presented in tables, graphs or diagrams (6), spelling, punctuation and grammar are accurate (6) but perhaps there could have been a more thorough evaluation of the validity of the source material (4).

Overall mark = 6

Summary

This is a very good investigation with an overall mark of 36 marks out of 45. It would probably be awarded an A grade.



Exemplar B: Investigating the antibacterial effects of fluoride and non-fluoride toothpastes

Hypothesis – Toothpaste containing fluoride will kill more bacteria than a toothpaste without fluoride

Abstract

The ability of two types of toothpaste, one containing fluoride and the other without, to kill bacteria was tested. Equal volumes of toothpaste were added to holes in agar plates containing the bacteria (*Bacillus subtilis*). After incubation the size of the clear zone around the toothpaste was measured and the two toothpastes were compared. A Mann-Whitney U test showed that the toothpaste containing fluoride killed more bacteria than the one without fluoride.

Theory behind my hypothesis

Tooth decay is caused by bacteria in the mouth feeding on sticky sugary foods. They form a layer on teeth called plaque and as they use up the sugar they produce an acid which dissolves the enamel to form holes in the tooth called caries.

Fluorine is a very reactive element and forms many compounds. Calcium fluoride is used to prevent tooth decay by adding it to drinking water, although many people have objected to this. Fluoride is thought to work by strengthening the enamel and helping it to remain in good condition by absorbing calcium which forms an important part of its structure.

Fluoride is also thought to kill the bacteria which cause tooth decay. These bacteria are called *Streptococcus mutans*.

Research and rationale

Moderator's comments

The rationale is very limited with hardly any attempt to discuss why this investigation is worth carrying out (2). The biological background is not well developed, only a few sources are quoted and it is not obvious how they have been used to justify this investigation (6).

Overall mark = 4

Plan

I am going to test the hypothesis by taking equal samples of each toothpaste and placing them in holes cut in agar plates which have been covered with bacteria. I will then leave them for the same time and measure the size of the clear zone around the toothpaste which shows where the bacteria have been killed.

(279 words)

Variables I will keep constant:

1. I have chosen two types of toothpaste of the same brand, 'Boots', one that contains fluoride and one that does not. I have checked the ingredients lists on the packets which show they are identical except for the fluoride.
2. I will place exactly 0.2cm³ of each toothpaste in a hole in the centre of the agar plate. This hole will be cut with the same diameter cork borer each time.
3. Each plate will contain exactly the same volume of the same nutrient agar spread with the same volume of the same bacteria (*Bacillus subtilis*) as described in my method.
4. I will incubate all my plates at 30°C overnight.
5. I will use the same ruler to measure the diameter of the clear zone on each plate.

Actual method

Before starting work, all surfaces were swabbed with a disinfectant. One tablet of nutrient broth was added to 20cm³ of distilled water in a small bottle and then sterilised in an autoclave for 45 mins. After it was cool a small loop was flamed and used to take a sample of *Bacillus subtilis* from a pure slope culture and inoculate the broth. This was then incubated at 30°C for 24 hours.

30 bottles containing 20cm³ of standard nutrient agar were then sterilised in the autoclave for 45 mins and cooled in a 45°C water bath.

The cap was removed from each bottle in turn and the rim flamed to prevent contamination as it was poured into a sterile Petri dish. The lid of the dish was held just open to prevent contamination. All the plates were allowed to cool and set. A sterile micropipette was then used to add 0.1cm³ of the *Bacillus subtilis* broth to each Petri dish, again being careful to open the lid just enough to squirt in the broth.

A T-shaped glass rod was then dipped in alcohol and flamed to sterilise it so that it could be used to spread the bacterial broth evenly over the surface of the agar.

Then for each plate a cork borer was flamed and cooled so that it would not melt the agar and a hole of exactly the same diameter was cut in the centre of each dish of agar. Finally, a sterile micropipette was used to add 0.2cm³ of non fluoride Boots toothpaste to 15 of the holes in the agar plates and this was repeated adding 0.2cm³ of the fluoride-containing Boots toothpaste to the other 15 plates. Each plate was sealed with sellotape and carefully marked with a permanent marker.

All the plates were left in an incubator at 30°C for 24 hours and then the diameter of the clear zone around each toothpaste was measured.

I then carried out a Mann-Whitney U test to see if there was a difference between the two toothpastes.



Safety precautions

All normal microbiology precautions were taken.

All the plates were sealed and not opened after incubation. They were then collected for autoclaving before being disposed of.

I chose *Bacillus subtilis* because it is not harmful to humans and can be used in the school laboratory.

I was careful to wash the bench with disinfectant before and after my experiment, and to wash my hands thoroughly before leaving the lab.

(546 words)

Planning

Moderator's comments

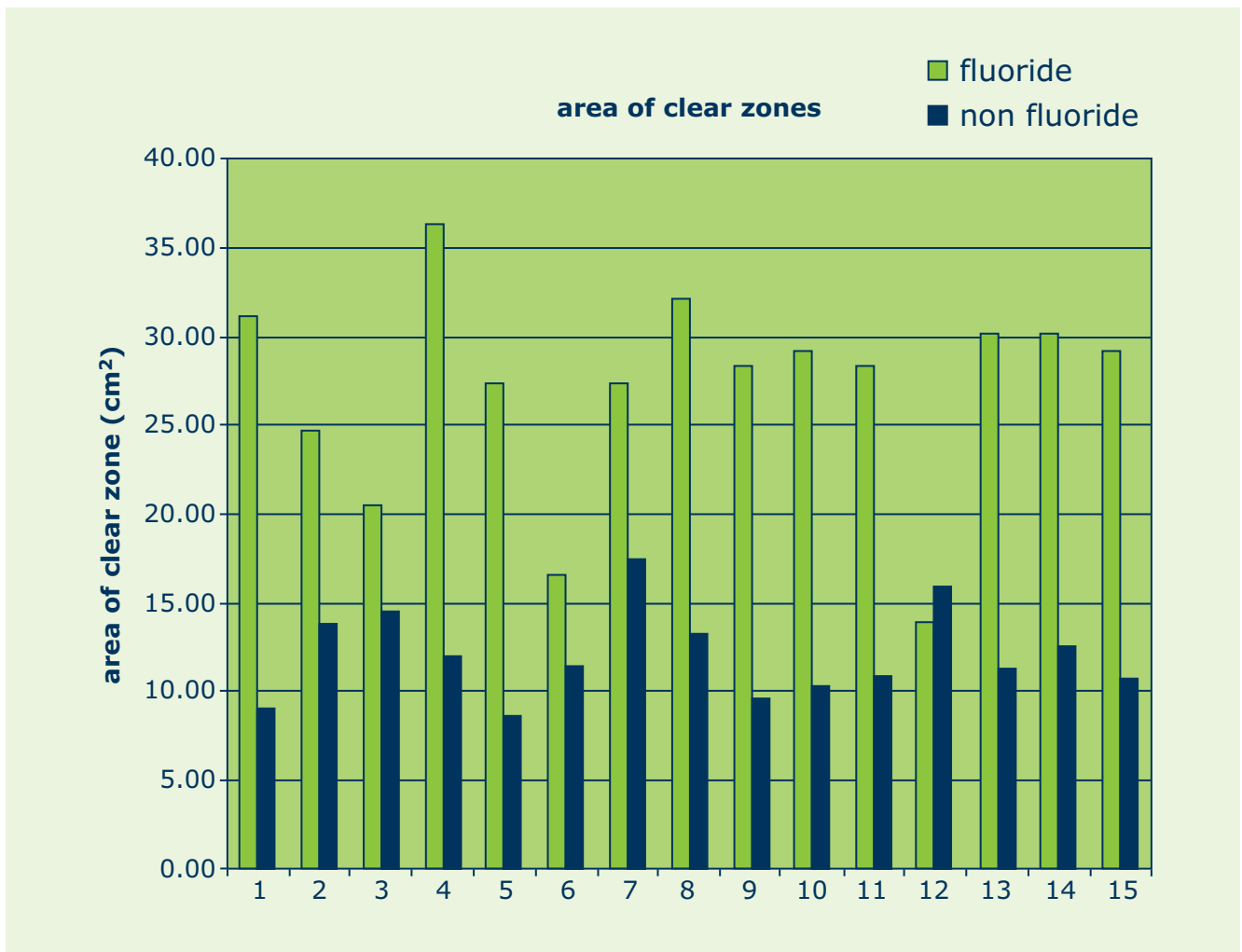
There is some discussion of variables together with details of apparatus (4) and a reasonable description of some risks (8). However, no preliminary work was carried out as part of the planning. (0)

Overall mark = 4

Results

Size of clear zones on agar plates with *B. subtilis*

Plate no.	Fluoride toothpaste		Non fluoride toothpaste	
	Diam cm	Area cm ²	Diam cm	Area cm ²
1	6.3	31.17	3.4	9.08
2	5.6	24.63	4.2	13.85
3	5.1	20.43	4.3	14.52
4	6.8	36.32	3.9	11.94
5	5.9	27.32	3.3	8.55
6	4.6	16.62	3.8	11.34
7	5.9	27.32	4.7	17.35
8	6.4	32.17	4.1	13.20
9	6.0	28.27	3.5	9.62
10	6.1	29.22	3.6	10.18
11	6.0	28.27	3.7	10.75
12	4.2	13.85	4.5	15.9
13	6.2	30.19	3.8	11.34
14	6.2	30.19	4.0	12.57
15	6.1	29.22	3.7	10.75
Mean		27.01		12.06

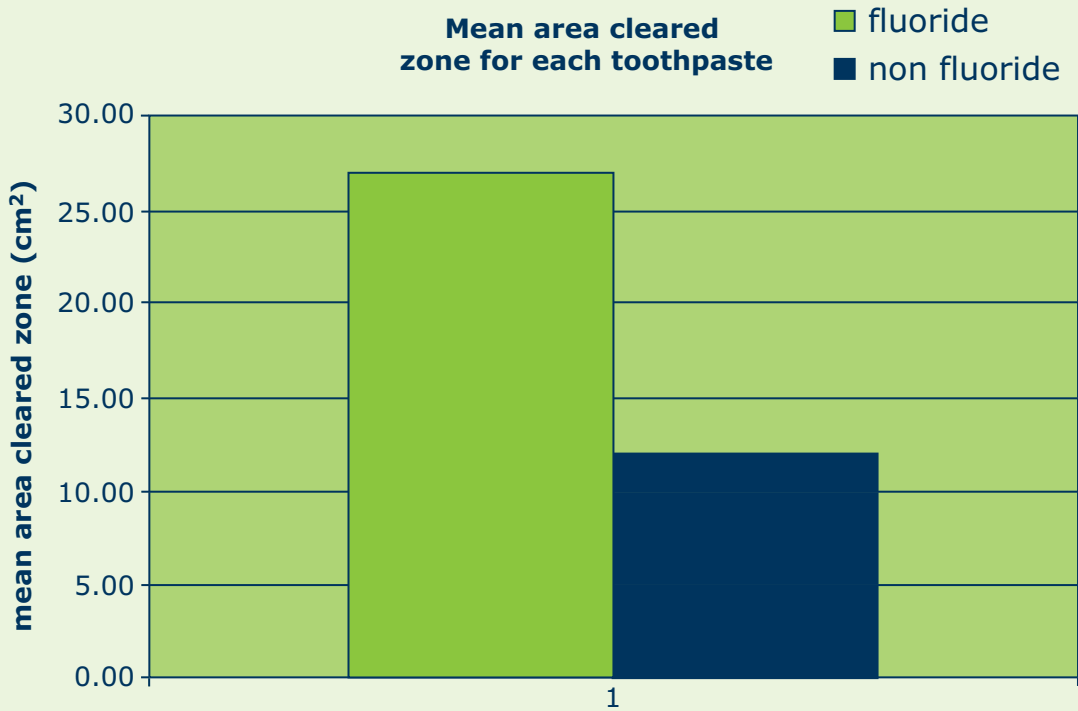


Observing and recording

Moderator's comments

Teacher annotation suggests that recording was methodical and carried out with some precision (6). Although plenty of replicates were made, there is only a little consideration of anomalous data and there is no suggested modification of the procedure. (6)

Overall mark = 6



Mann-Whitney U test

Rank data from each

Find values of U1 and U2:

$$U1 = n_1n_2 + \frac{1}{2} n_1(n_1+1) - \sum R_1$$

$$U2 = n_1n_2 + \frac{1}{2} n_2(n_2+1) - \sum R_2$$

where $\sum R$ = sum of ranks of each set of readings and

n_1 and n_2 = sample numbers of each test

Comparing ranks of diameters of inhibition zones:

Plate no.	Fluoride toothpaste diam (cm)	Rank R1	Non fluoride toothpaste diam (cm)	Rank R2
1	6.3	28	3.4	2
2	5.6	19	4.2	12.5
3	5.1	18	4.3	14
4	6.8	30	3.9	9
5	5.9	20.5	3.3	1
6	4.6	16	3.8	7.5
7	5.9	20.5	4.7	17
8	6.4	29	4.1	11
9	6.0	22.5	3.5	3
10	6.1	24.5	3.6	4
11	6.0	22.5	3.7	5.5
12	4.2	12.5	4.5	15
13	6.2	26.5	3.8	7.5
14	6.2	26.5	4.0	10
15	6.1	24.5	3.7	5.5
		$\Sigma R1 = 340.5$		$\Sigma R2 = 124.5$

$$U1 = 15 \times 15 + 7.5(15+1) - 340.5 = 4.5$$

$$U2 = 15 \times 15 + 7.5(15+1) - 124.5 = 220.5$$

The critical value for 15 sample pairs at $p=0.05$ is **64**.

To compare with this I must use the lower value of U from my calculations.

The lower value of U is 4.5, which is well below the critical value, so I can say at this level of confidence that fluoride-containing toothpaste is a lot better at killing off bacteria than the non fluoride toothpaste.

Trends and patterns

It is obvious that the results show clearly that there is a big difference between the cleared zones in the fluoride toothpaste and the non fluoride toothpaste. The mean area cleared by the fluoride toothpaste is 2.25 times bigger than the mean of the non fluoride toothpaste. The Mann-Whitney U test also shows that the difference between the two is statistically significant.

Looking at the data I can see that most of the bars for the non fluoride toothpaste are well below those of the non-fluoride. However, plate 12 is obviously an anomaly because the non fluoride toothpaste gives a bigger clearance zone than the fluoride.

Overall, my results agree with my hypothesis and show that fluoride in toothpaste kills off bacteria as well as helping to strengthen enamel.

Explaining my results

Fluoride in toothpaste is clearly poisonous to bacteria in some way so that instead of just cleaning teeth by brushing it stops them growing and therefore making acids which would damage the enamel. Tests have shown that fluoride gets into bacterial cells and inhibits enzymes so preventing them growing. This would explain the difference between my results since the fluoride in the toothpaste must spread out from the centre and kill off the bacteria to form a clear zone.

Limitations

Because it is not allowed, I could not use *Streptococcus mutans* which is the main bacteria found on teeth, so I do not know if these bacteria would behave in the same way as the *Bacillus subtilis* that I used.

My results showed quite a bit of variation. Diameters varied from 4.2cm to 6.0cm for the fluoride toothpaste and from 3.3cm to 4.7cm for the non fluoride toothpaste. This means that there must be some other things which were affecting my results that I did not control.

I did use exactly the same agar and incubated them for exactly the same time but it was sometimes difficult to see exactly where the edge of the cleared area was. Several clear zones were not round, so it was difficult to decide which diameter to measure.

The only other thing that could have been different was the number of bacteria growing on the plate which would have been difficult to measure.

If I did this again I would do more repeats to get a better average and I would measure the diameter at exactly the same point on each one.

Total 1356 words

Interpreting and evaluation

Moderator's comments

The correct statistical test is used but there is a limited discussion of its significance (4). There is hardly any discussion of the biology associated with these conclusions (1) but some basic limitations are recognised. (3)

Overall mark = 3



References

www.crest.com-dental_hesth-pdf-fluoride

http://en.wikipedia.org/wiki/Dental

www.colgate.com/app/Colgate/us/oc

Jensen & Kehout. The effect of fluoridated dentifrice on root and coronal caries in an older adult population.

J Am Dental Assoc 1988: 117.

Communicating

Moderator's comments

The report is quite well set out (5) but the data is not presented effectively. The graph of inhibition for each plate is inappropriate although others are (4). Spelling, punctuation and grammar are reasonable (4) but there is no evaluation of the validity of the source material which is itself limited. For example, it is not obvious how the one professional journal has been used. (2)

Overall mark = 4

Summary

This is a reasonable investigation with an overall mark of 21 marks out of 45. It would probably be awarded an E grade.

Student guide

What do I need to know, or be able to do, before taking this course?

The qualification builds on the knowledge, understanding and practical skills that you gained in GCSE Science and GCSE Additional Science, or GCSE Biology (to at least a grade C). You should also have at least a C grade in GCSE Mathematics, as numerical and mathematical skills are important in biology. You will also need to be able to communicate effectively, be able to plan and carry out research and think critically about problems.

What will I learn?

In biology you will develop practical skills, by planning experiments, collecting data, analysing experimental results and making conclusions. You will also learn how scientific models are developed, the applications and implications of science, the benefits and risks that science brings and the ways in which society uses science to make decisions.

Unit 1: Lifestyle, transport, genes and health

Heart disease is one of the UK's biggest killers — what makes it so common? You will learn more about the circulatory system and the kinds of lifestyle choices, such as diet and exercise, that put you more, or less, at risk of suffering from heart disease.

You will find out how some parts of the body work, for example, about the lungs and how materials are transported around the body, and the role of enzymes.

You will also learn about genetics and what can happen if errors occur during the replication of DNA, considering the social and ethical issues raised by genetic screening and gene therapy.

Unit 2: Development, plants and the environment

Do you know how you came to have your natural hair colour? You will learn that your physical characteristics have been determined by your genetic makeup and influenced by the environment. In doing so, you will learn some cell biology, about the two main types of cell division and the purpose of each type, and about sexual reproduction.

Have you also ever wondered how there came to be so many different types of organisms in the world, ranging from microscopic organisms such as viruses to huge mammals such as whales? This unit explains the term biodiversity, and also the concept of natural selection and how it can lead to adaptation which drives evolution.

In this unit you will also learn about plants and their structure, and how the properties of some plants may be used to tackle issues such as sustainability.

Unit 4: The natural environment and species survival

Global warming and climate change are buzzwords that appear in media headlines and have been the source of much controversy and political divide. So which side are you on and why? You will learn about the different types of evidence for global warming and the possible causes of it, and the effect it will have on animals and plants. You will also learn about ecology, photosynthesis and speciation.

This unit covers the fascinating area of immunology – the war that goes on between our immune system and pathogens. You will learn what defences the body has against invading pathogens and how some micro-organisms, such as *Mycobacterium tuberculosis*, can get the better of us by attacking our defences.

You will have the opportunity to look into the world of the forensic scientist and appreciate the application of scientific knowledge in this context.

Unit 5: Energy, exercise and coordination

All mammals, including humans, have similar physiologies that facilitate movement. Why is it rare to find an athlete who is both a sprinter and a marathon runner? In this unit you will build on your knowledge about joints and movement, and learn more about the precise mechanism of skeletal muscle contraction, respiration and homeostasis in the context of exercise.

The brain is the most complicated, and probably least understood organ in the body. It has the complex task of coordinating our bodily functions and movement, making sense of all the sensory information it receives, as well as storing our thoughts, emotions and memories. As the brain is such a complicated and vital organ, there is a lot of potential for it to go wrong which can have drastic effects on the health of the person. You will also look at the effects of disease and drugs on the brain and how these effects, in turn, affect the body and the mind.

How will I be assessed?

Assessment at AS Level

Units 1 and 2 are externally assessed written examination papers, each lasting 75 minutes. The papers will contain objective questions, short questions and longer questions.

Unit 3 is a practical assessment. During the course your teacher will observe you carrying out practical work to verify your practical skills. You will receive a mark for producing a report on an application of biology seen during a visit or an area of personal interest.

Assessment at A Level

Units 4 and 5 are externally assessed written examination papers each lasting for 90 minutes. The papers will contain objective questions, short questions and longer questions.

Unit 6 is a practical assessment. You will use the skills that you have gained to plan an investigation and carry out an experimental investigation based either in the laboratory or an ecological study of your choice.

Is this the right subject for me?

AS and A level Biology is suitable if you:

- have an interest in, and enjoy biology and want to find out about how things work in the biological world by the application of imaginative, logical thinking
- want to use biology to progress onto further studies in Higher Education or support other qualifications or enter biology-based employment
- are taking A levels in the other sciences and/or mathematics or other relevant courses such as Physical Education and want to take another course that will support those studies.

What can I do after I've completed the course?

Biology leads on to a wide range of courses and careers. This could include:

- an undergraduate degree in a life sciences, medicine, environmental science, forensic science and related courses or a BTEC Higher National (HNC and HND)
- employment, for example in the areas of biological testing, biotechnology, independent research and the food industry.

To find out more talk to your biology teacher and visit your careers office or www.iob.org for further information on careers and courses in biology. For the full specification check www.edexcel.com



Individual investigation: Student checklist

While working on your project and before finally submitting your coursework you may find it useful to use the checklist below to ensure you have covered everything that is required.

It is essential that you are familiar with the assessment criteria against which your report will be marked. Your investigation will be given marks under these headings:

- Research and rationale
- Planning
- Implementing
- Observing and recording
- Interpreting and evaluation
- Communication.

It is very important that you attempt to address every sub-section of each criterion. If you do not, then your possible mark for that criterion will be severely limited. The best way to avoid this is to follow the advice given below about organising your report and using sub-headings where possible.

Research and rationale

Have you:

- chosen your hypothesis so it is soundly based on an A-level biology theory?
- discussed your choice of investigation with your teacher?
- chosen a hypothesis that is clear, simple and does not attempt to investigate multiple variables?
- looked at a range of sources of information, not just websites?
- chosen the information carefully so that it helps to explain why you formed your hypothesis? (Remember you have a 3300-word limit so keep it relevant.)
- found an academic source of information?
- listed your sources of information accurately and included the date you accessed the websites?

Planning

Have you:

- described the apparatus you propose to use and explained why you chose it?
- considered the level of accuracy of any methods or apparatus you propose to use?
- described exactly what you are going to measure?
- considered how your results are to be analysed?
- explained why the number and type of measurements you propose to take is suitable?
- listed the variables that might affect your investigation?
- explained how you propose to control or monitor these variables?
- carried out a short pilot experiment?
- reviewed your plan using information from your pilot study?

Observing and recording

Have you:

- designed and drawn a table of results labelled clearly with suitable units?
- recorded at least five sets of measurements?
- repeated measurements if appropriate?
- used a consistent and suitable number of significant figures?
- explained any changes to your planned procedure?



Interpreting and evaluation

Have you:

- processed your data to make it easier to identify trends and patterns?
- carefully identified trends and patterns in your data?
- carried out a suitable statistical test that is matched to your hypothesis?
- set out the calculation of your statistical test clearly?
- interpreted the results of your statistical test using a null hypothesis and a 5% ($p=0.05$) confidence level if appropriate?
- drawn overall conclusions from your data and expressed them in writing or numerically where possible?
- used A-level biology to explain your actual results?
- commented on limitations of your experimental design and suggested modifications or further development?

Communicating

Have you:

- organised your report in the form of a scientific paper?
- used sub-headings to organise your report in a logical order?
- numbered each page?
- included a word count page by page?
- checked to make sure you have not exceeded 3300 words (including any appendices)?
- plotted a graph to help you to compare two sets of data?
- chosen the correct form of graph which is clearly labelled with units?
- made sure your graph is large enough to be clear and show all the plotted points, has accurately labelled axes and a clear key to identify your plots?
- read through your work and checked you have attempted to address all the criteria?
- listed all your sources in a bibliography and made it clear in your report where you have used the information?
- made some attempt to assess the scientific credibility of your chosen source.

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