OCR ADVANCED SUBSIDIARY GCE

IN BIOLOGY (3881)

OCR ADVANCED GCE

IN BIOLOGY (7881)

Teacher Support: Coursework Guidance

This is a revised version of the Teacher Support: Coursework Guidance booklet designed to accompany the OCR Advanced Subsidiary GCE and Advanced GCE in Biology.

This revision was carried out in September 2002 in the light of the moderation of coursework in January and June 2002.

It should be emphasised that there are no changes to the regulations concerning coursework. This booklet has been written to give further guidance to assist the teaching and assessing of the coursework components of the AS and A2 units of the specification.

Sidelines in Section A indicate where passages from the previous coursework guidance booklet have been rewritten. New material has been added to Section A.

There are two significant differences between this edition and the first edition published in September 2000:

- The exemplar materials in appendices 1 to 7 of the September 2000 edition have been removed and replaced with new exemplars. These can be found in section B;
- The list of suggested assessment tasks that was in Section 7.3 has been revised and can now be found in section 6.2.

December 2002

Introduction

This booklet is written to support the OCR AS and A2 specifications in Biology and serves two functions:

- it is a ‘stand-alone’ pack for teachers who are unable to attend any of the OCR Coursework INSET meetings;
- it provides activities to be carried out and discussed at INSET meetings.

For the sake of continuity, this booklet follows the approach taken by the Awarding Bodies on the assessment of coursework skills at GCSE.

Section A gives guidance to Teachers on the teaching, assessment and moderation of experimental skills.

Section B comprises several Activities that are designed to be used at INSET meetings; these may also be used for training within departments.

The Appendices contain **Frequently Asked Questions**, a section on **Ethics and the Law** and a **Mark Scheme** for Activity 3 in Section B.

2803/02 and 2806/02

It should be emphasised that students should be taught components 2803/02 and 2806/02 of the AS and A2 specification. The coursework mark descriptors are designed to facilitate the development of a range of skills that should be part of a student’s education in Biology at GCE.

Contents

Section A: Guidance for Teachers

1 General Introduction

This guide has been written to assist teachers in setting suitable coursework tasks and in assessing candidates' work. The guide should be read in conjunction with the specification itself. However, all sections of the specification relating to coursework assessment are included here. The original coursework guide was revised in September 2001 and a third edition was produced in September 2002 in response to the moderation of coursework carried out in January and June 2002.

While this guide is concerned with the assessment of coursework, it cannot be emphasised too strongly that before candidates are assessed on their experimental and investigative skills, whether by coursework or by practical examination, **these skills must be taught and candidates must have opportunities to practise and to develop their abilities.**

Experimental and Investigative skills may be assessed either **internally** (by coursework, Component 2) or **externally** (by a combination of an externally marked task and a practical examination, Component 3).

Entries are made for Unit 2803 (in AS) or 2806 (in A2). In each of these units, candidates must take two components - a written paper (2803/1 or 2806/1) and one of the above two assessments of experimental and investigative skills, Component 2 or Component 3. Both written paper and skills assessment components must be taken in the same examination session.

Centres may opt to enter candidates for:

- coursework in AS and in A2;
- the practical examination in AS and in A2;
- coursework in AS and the practical examination in A2;
- the practical examination in AS and coursework in A2.

In AS, the marks for Unit 2803 (Components 2 and 3), contribute towards Assessment Objective AO3: Experiment and Investigation.

In A2, the marks for Unit 2806 (Components 2 and 3), contribute equally to Assessment Objectives AO3 and AO4: Synthesis of Knowledge, Understanding and Skills. Assessment of AO4, which is synoptic assessment, is made because:

- candidates are required to use biological knowledge and understanding from other modules of the specification in planning their experimental and investigative work, and in analysing evidence and drawing conclusions;
- in the assessment of all four experimental skills in Unit 2806/2, taken at the end of the course of study, candidates are expected to draw on their experience of such work throughout the course and, in particular, on the outcome of the assessment of these skills in Unit 2803/2.

Practical work provides many opportunities to develop key skills and to collect evidence that may contribute towards the assessment of key skills. Full details are given in Appendix A of the specification and links are identified throughout the content of the specification booklet. Teachers are advised to discuss such opportunities with colleagues and with the students concerned.

2 Coursework Assessment

Unit 2803/2 - Coursework 1 (60 Marks)

Unit 2806/2 - Coursework 2 (60 Marks)

In these components, assessment of candidates' experimental and investigative work is made by the teacher (as coursework) and moderated externally by OCR.

Skills **P** and **A** are each marked out of 8 and Skills **I** and **E** are each marked out of 7. One mark per skill must be submitted for each candidate for Advanced Subsidiary (Unit 2803, Component 2) and for A2 (Unit 2806, Component 2). Hence, a mark out of 30 is initially calculated for each component. The marks are then doubled so that the final mark submitted for each component is out of 60.

When a skill has been assessed on more than one occasion, in Advanced Subsidiary or in A2, the better or best mark for that skill should be submitted. However, Centres are recommended **not** to assess the skills on more than two occasions in each of Advanced Subsidiary and A2 since this may take up time which might better be devoted to other aspects of the specification.

The skills may be assessed at any time during the course using suitable practical activities, based on laboratory or field work, related to, or part of, the content of the teaching course. The context(s) for the assessment of the coursework for Unit of Assessment 2803/2 should be drawn from the content of Advanced Subsidiary Units 2801, 2802 and 2803; the context(s) for the assessment of the coursework for Unit of Assessment 2806/2 should be drawn from the content of A2 Units 2804 and 2805, in which the level of demand of the related scientific knowledge and understanding is higher.

In Advanced Subsidiary and in A2, the skills may be assessed in the context of separate practical exercises, although more than one skill may be assessed in any one exercise. They may also be assessed all together in the context of a single 'whole investigation' in which the task is set by the teacher, or by using individual investigations in which each candidate pursues his or her own choice of assignment.

A similar set of mark descriptors is used for both Advanced Subsidiary and A2. These descriptors have been written to provide clear continuity from the assessment of Sc1 in GCSE Science. The difference in standard of Advanced Subsidiary and A2 is a product of the level of demand of the related scientific knowledge and understanding expected and the complexity and level of demand of the tasks set. Also, the mark descriptors for Skills **P** and **A** at A2 include synoptic elements.

Marks submitted for coursework assessment must have been generated from candidates' individual work. Group work is not suitable for assessment unless the work of the individual candidate can be quite clearly identified both by the teacher and the moderator. In some cases it is necessary for candidates to work collectively in order to collect sufficient data for analysis; in these circumstances, planning and implementing should not be assessed but the work of candidates may be assessed in analysing and evaluating their results, when they are working independently.

The submission of proposed coursework tasks for approval by OCR is not a requirement of the scheme. However, Centres wishing to obtain guidance on whether a coursework task is suitable, should send details to OCR using the Coursework Enquiry Forms in the Coursework Administration Pack. There are separate forms for Unit 2803, Component 2 and for Unit 2806, Component 2. The appropriate form should be used to request advice on the suitability of coursework tasks and specific mark schemes. It can also be used to request feedback and advice on the marking of students' work before marks are submitted to OCR and the Moderator. Details of the task set and any background information should accompany any marked examples of students' work. Teachers are asked not to send large quantities of material at any one time. Feedback will be provided within approximately four weeks.

A programme of INSET meetings is arranged to provide detailed guidance on coursework assessment. Details are circulated to Centres and a contact number for OCR Training and Customer Support is given on page 41.

The skills of planning, implementing, analysing and evaluating should be taught to candidates. This may be done in a variety of ways, for example by using a 'trial' investigation or by studying critically some exemplar material and discussing its strengths and weaknesses and the extent to which the work meets the skills descriptors.

The length of time to be devoted to the assessment of experimental and investigative skills is entirely at the discretion of the teacher. However, it is anticipated that between 5 to 10 hours class time should be sufficient in each of AS and A2. This should include time for initial discussion, preliminary practical work, the main investigation and a discussion of the results. There is no word limit for coursework; however, candidates should be encouraged to write concisely (see FAQ 4 on page 104).

2.1 Standards at AS and A2

A similar set of assessment descriptors is used for the assessment of coursework in both AS and A2. (The mark schemes for the practical examinations are also based on these descriptors).

Assessments at AS and A2 are differentiated by the complexity of the tasks set and the contexts of the underlying scientific knowledge and understanding. In A2, candidates will be required to apply knowledge, understanding and skills from the AS and A2 parts of the specification in planning experimental work and in the analysis of results to reach conclusions.

At AS, experimental and investigative work is likely to be qualitative or require processing in a context that is familiar to candidates.

- **Planning** exercises, although novel, focus on apparatus and techniques which have previously been encountered, based on knowledge and understanding from a limited part of the AS specification.
- **Implementing** involves the manipulation of simple apparatus and the application of easily recognised safety procedures.
- **Analysing and concluding** involve simple data handling, reaching conclusions based on a limited part of the AS specification.
- **Evaluation** expects recognition of the main sources of error and direct methods for improving accuracy.

At A2, assessments will expect a greater level of sophistication and higher levels of skill.

- **Planning** exercises require research to provide a satisfactory solution to a problem which can be addressed in more than one way. The underlying knowledge, understanding and skills are likely to be drawn from different parts of the AS and A2 specifications.

- **Implementing** involves a detailed risk assessment and the careful use of sophisticated techniques or apparatus to obtain results that are precise and reliable.
- **Analysing and concluding** involve sophisticated data handling and the synthesis of several strands of evidence. In developing conclusions, candidates will have the opportunity to demonstrate their skills in drawing together principles and concepts from different parts of the AS and A2 specifications.
- **Evaluation** requires recognition of the key experimental limitations and other sources of error as well as an understanding of the methods that may be used to limit their effect.

The essential difference between AS and A2 is that at A2 candidates should show a wider range of relevant scientific knowledge and understanding than at AS. The context in which investigations are set at A2 should allow candidates to do this. A candidate who incorporates material from the AS and A2 specifications into their coursework may thus satisfy the synoptic descriptors in Skills **P** and **A**.

2.2 Assessment and Moderation

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

Coursework submissions should be clearly annotated by the Centre to support the marks awarded to the candidates.

The sample of work that is submitted to the Moderator for moderation must show how the marks have been awarded in relation to the marking criteria.

2.3 Minimum Coursework Requirements

If a candidate for a coursework component submits no work, the candidate should be indicated as being absent from that component on the coursework mark sheets submitted to OCR. Any work submitted by a candidate should be assessed according to the mark descriptors and marking instructions and the appropriate mark awarded, which may be 0 (zero).

2.4 Authentication of Coursework

As with all coursework, the teacher must be able to verify that the work submitted for assessment is the candidate's own. Sufficient work must be carried out under direct supervision to allow the teacher to authenticate the coursework marks with confidence.

2.5 Special Arrangements for Coursework

For candidates who submit some coursework but are unable to complete the full assessment, or whose performance may be adversely affected through no fault of their own, Teachers should consult the *Inter-Board Regulations and Guidance Booklet for Special Arrangements and Special Consideration.* In such cases, advice should be sought from OCR as early as possible during the course.

2.6 Differentiation

In coursework, differentiation is by task and by outcome. Candidates will undertake assignments which enable them to display positive achievement.

2.7 Some Definitions

Fair test

Candidates should be well aware of the 'fair test' idea from KS2, KS3 and GCSE and this should determine how an investigation is planned and carried out. Candidates should show an awareness of the factors that they can control to ensure that their results are not distorted by those factors.

Factors / Variables

A variable is a factor that is measured or can be controlled. Candidates should identify the variables that may influence their investigation. The most important of these should be listed and described in candidates' plans. For students to identify and manipulate variables they need to know what to change (**independent variable**), and what to measure or judge (the **dependent variable**) for each value of the independent variable. In some studies, especially in ecology and physiology, candidates should show an awareness of factors which they cannot control but which may affect the outcome of their investigation.

Preliminary work

This is work carried out by a student as part of planning which helps to clarify the strategy to be used in the main investigation. At AS, it may well involve a class practical or some preliminary work or a trial investigation carried out prior to the main investigation. It may also be some work carried out at GCSE. Candidates should report on the work that they have done and the results obtained. They should indicate in their reports how the preliminary work influenced their choice of apparatus or the strategy that they have employed. At A2, preliminary work may be any of the above or work done at AS.

Safety aspects

Safety aspects are important features of the planning and the implementing of experimental and investigative work. Candidates should be encouraged to include a risk assessment in their plans. If there are no risks associated with their investigation, then there should be a statement to this effect.

Secondary sources

These include books, articles, web sites, CD-ROMs. It should be clear how these secondary sources have been **used** to develop a strategy and they should be referenced somewhere in the work. Candidates should indicate in their work **exactly** where they have used their secondary sources. Details of the sources may be given at that point in their text or in a footnote or in a bibliography at the end of their work.

Numerical processing

This is assessed in Skill **A.** The descriptors for Skill **A** are given on page 22.

A1.a – simple numerical processing involving calculation of means will satisfy this descriptor.

A3.a – the use of a suitable graph will satisfy this descriptor. If a candidate does not present results as a graph, then some simple comment, such as identifying the range of results without any further calculation would be sufficient.

A5.a – this descriptor requires more detailed processing of results and this will depend on the investigation concerned and may involve any of the following:

- calculation of rates (e.g. cm^3 min^{-1} or cm^3 $s\text{-}^1$)
- standard deviation
- calculation of gradients (e.g. for rates of reaction)
- use of intercepts (e.g. finding water potential of root vegetables)
- use of error bars on the basis of standard error
- statistical tests (e.g. chi squared test, t test)

Mathematical requirements

Appendix D of the specification (pages 114 to 115) lists the mathematical skills which candidates should apply at AS and A2. Several mathematical skills may need to be taught during the AS and A2 courses and teachers should note that the chi squared test is in a learning outcome in Module 2804 (Central Concepts) and that the t-test and confidence limits are listed in a learning outcome in 2805/03 (Environmental Biology). Candidates at A2 may therefore be expected to use appropriate statistical tests in their coursework if they have collected sufficient data and the design of the investigation lends itself to statistical analysis. It should be noted that the chi squared test is very often applied in contexts when it is not appropriate. The use of a statistical test is **not** a requirement for A5.a; however, if a statistical test, such as the chi squared test or the t-test, is used appropriately then this descriptor is clearly satisfied.

Scientific Knowledge and Understanding

At AS, candidates are expected to draw on their knowledge of the relevant learning outcomes from the AS specification when planning investigations and analysing their results. They should also show understanding by applying their knowledge in appropriate ways. At A2, they are expected to use appropriate scientific knowledge and understanding from relevant learning outcomes across the AS and A2 specifications.

Hypothesis / Prediction

An hypothesis is a model, based on scientific knowledge and understanding, proposed to explain a particular problem or a set of observations or measurements. Having devised an hypothesis, it is possible to make predictions based on it, and these can be tested by experiment. The coursework descriptors for planning refer to 'predictions'. It is perfectly acceptable for candidates to make predictions without giving extensive theoretical support in an introduction to their investigation. However, relevant scientific knowledge and understanding should be evident in the planning for the award of descriptors P.3a, P.5a and P.7a. Candidates are advised to investigate the effect of one variable – both at AS and A2 – and to give a crisp prediction that is testable. Candidates should be encouraged to make clear the prediction that they are testing. In some investigations it may be appropriate to give a null hypothesis.

The 'scientific method' is based on the idea that an hypothesis can be disproved by experiment (when predictions are found to be untrue) but can never be proved (since an experimenter may, in the future, disprove it). Thus, an hypothesis which is not disproved remains in place and, when it has general acceptance, may come to be called a theory or law.

Accuracy

The accuracy of an observation or measurement is the degree to which it approaches a notional 'true' value or outcome.

The accuracy of an observation or measurement depends on the experimental techniques used, the skill of the experimenter and the equipment (including measuring instruments) used. Removing or minimising sources of error improves accuracy and the degree of accuracy can be estimated by evaluating sources of error (either qualitatively or quantitatively as appropriate).

Precision is here taken as being that part of accuracy which is wholly in the hands of the experimenter. So, having devised an experimental technique and selected the apparatus, the experimenter may choose to take observations or measurements to different degrees of precision (or may do so through lack of skill or carelessness). Decisions about the precision with which observations or measurements are made may take into account the nature of the investigation and an assessment of the sources of error. For example: a low-power drawing from a microscope may address the task set; there may be little point in measuring a quantity to four significant figures if other quantities are measured to two significant figures.

Reliability

Reliability is a measure of the confidence that can be placed in a set of observations or measurements. The closer a set of observations or measurements approaches to conformity with an underlying model, process, structure etc. (which may be known or unknown), the more reproducible it is likely to be.

If the underlying model, process or structure is known, or a suitable hypothesis can be drawn up, reliability can be judged by reference to this. So, for example, the distance between data points and the line of a graph may provide evidence of reliability and statistical techniques may be used to provide a quantitative assessment of reliability in such cases. If observations or measurements are replicated, then the closeness of the replicates provides another way of judging reliability.

The reliability of a set of observations or measurements depends on the number and accuracy of the individual observations or measurements. Replicating observations or measurements increases the reliability of the set.

Validity

‘Valid’ implies that the outcome of an activity is not being distorted by extraneous factors. In some experiments, one factor is varied whilst other control factors are kept constant (e.g. rates of reaction).

The validity of a conclusion is a measure of the confidence that can be placed in it. The validity of an experiment or investigation depends upon factors such as the range and reliability of the observations or measurements that underpin it, any assumptions made in developing hypotheses or planning the investigation, and the nature of the investigation itself.

A conclusion may relate to whether or not a proposed hypothesis can be rejected or accepted. In such cases statistical techniques may be used to place a value on the reliability of data by generating a probability that the data do conform with the hypothesis. Such techniques should be used where appropriate and in Biology are identified in the specification for work in A2.

Anomalous results

Candidates are expected to **identify clearly** anomalous results in Skill E. They may do this in a variety of ways, for example by highlighting anomalous results in tables, graphs or in the text of their reports. Results that do not ‘fit’ the trend may be regarded as anomalous. If measurements are replicated and one or more of these are different from others, then they may be regarded as anomalous**. In order to satisfy marking criteria E1.b, candidates should state that they have no anomalous results if this is the case.**

Where appropriate

The words ‘where appropriate’ appear in a number of descriptors. It is expected that most investigations at AS and A2 will allow candidates to match the descriptors that follow these words. However, if there are reasons why this is not possible, Moderators will expect to see some explanation on the work submitted. Section 4.1 (see page 14) should be born in mind when choosing an investigation.

3 Introduction to Each Skill

The experimental and investigative skills to be assessed are:

Skill P Planning

Candidates should:

- identify and define the nature of a question or problem using available information and knowledge of biology;
- choose effective and safe procedures, selecting appropriate apparatus and materials and deciding the measurements and observations likely to generate useful and reliable results;
- consider ethical implications in the choice and treatment of organisms and the environmental and safety aspects of the proposed procedures.

For candidates to be able to achieve the highest marks for this skill, tasks set must be sufficiently open-ended to allow more than one solution. The tasks must provide opportunities for candidates to gather information from a variety of sources (including perhaps text books, the Internet, preliminary experiments) to inform their plans and the scientific knowledge and understanding underpinning their work should be of a high standard.

For each task, it is suggested that candidates are asked to complete a preliminary plan which is assessed by the teacher, primarily to ensure that it is practicable and safe. The final mark awarded for planning should, however, take into account any additional work done during the implementation of the plan, i.e. to include any modifications or additions. Planning must be carried out individually and experience shows that candidates achieve higher marks if they carry out their plan. However, Skill P may be assessed as part of a 'whole investigation' or with Skill I and/or Skills A and E.

At A2, there are additional statements that relate to synoptic assessment to take into account in the assessment. Thus, to achieve the highest marks, the tasks set must offer opportunities for candidates to make use, in their planning, of scientific knowledge and understanding from modules in both AS and A2 modules.

Skill I Implementing

Candidates should:

- use apparatus and materials in an appropriate and safe way;
- carry out work in a methodical and organised way with due regard for safety and with appropriate consideration for the well-being of living organisms and the environment;
- make and record detailed observations in a suitable way, and make measurements to an appropriate degree of precision, using ICT where appropriate.

For candidates to achieve the highest marks for this skill, the techniques used should be familiar and well understood. The tasks set should involve techniques that require precision and skill and that make sufficient demands on a candidate's ability to manipulate apparatus.

Skill I may be assessed as part of a 'whole investigation', in isolation, or in combination with Skills P and/or Skills A and E.

Skill A Analysing Evidence and Drawing Conclusions

Candidates should:

- communicate biological information and ideas in appropriate ways, including tabulation, line graphs, histograms, continuous prose, annotated drawings and diagrams;
- recognise and comment on trends and patterns in data;
- understand the concept of statistical significance;
- draw valid conclusions by applying biological knowledge and understanding.

For candidates to achieve the highest marks in this skill, the tasks set must provide sufficient data or information to make the analysis demanding, and allow them to relate their results to scientific knowledge and understanding of a high standard.

Skill A may be assessed as part of a 'whole investigation', in isolation, or in combination with Skills I and/or E.

At A2, there are additional statements that relate to synoptic assessment to take into account in the assessment. Thus, to achieve the highest marks, the tasks set must offer opportunities for candidates to make use, in their analysis, of scientific knowledge and understanding from both AS and A2.

Skill E Evaluating Evidence and Procedures.

Candidates should:

- assess the reliability and precision of experimental data and the conclusions drawn from it;
- evaluate the techniques used in the experimental activity, recognising their limitations.

For candidates to achieve the highest marks in this skill it is advisable that they either carry out the investigation themselves or have seen the techniques demonstrated. Only in this way will they be able to evaluate experimental procedures effectively. The tasks set should be sufficiently complex to allow detailed analysis and the data or information collected should permit evaluation of error and reliability. There should also be the opportunity to suggest realistic changes to the procedures used that would improve the quality of the results.

Skill E is best assessed as part of a 'whole investigation', or together with Skill A, in which case the experimental procedure should have been carried out by the candidates themselves, or demonstrated to them. Where the experimental procedures are such that individual working is not possible, candidates could carry out the investigation working in groups but then be assessed for Skills A and E on their individual work.

4 Notes for Guidance on Coursework Submission and Assessment

These notes are intended to provide guidance for Teachers in assessing experimental and investigative skills, but should not exert an undue influence on the methods of teaching or provide a constraint on the practical work undertaken by candidates. It is not expected that all of the practical work undertaken by candidates would be appropriate for assessment.

It is expected that candidates will have had opportunities to acquire experience and develop the relevant skills before assessment takes place.

4.1 The Demand of an Activity

The demand of an activity is an important feature of the assessment. From the bottom to the top of the mark range in a skill area the activity should involve increasing demands of associated scientific knowledge and understanding, manipulation, precision and accuracy and complexity.

The difference in standard of AS and A2 is a product of the level of demand of the related scientific knowledge and understanding, together with the complexity and level of demand of the tasks set. In A2, candidates will be required to apply knowledge, understanding and skills from the AS and A2 parts of the specification in planning experimental work and in the analysis of data (synoptic assessment).

Teachers should appreciate that the **choice of an activity that is comparatively undemanding** (primarily in terms of the level of the scientific knowledge and understanding that can be linked to the activity, and in the range/complexity of the equipment/techniques used) **may prevent access to the highest marks.**

Teachers should be aware of this feature of the assessment so that, when considering the award of higher marks, the activity should require a sophisticated approach and/or complex treatment. Higher marks must not be awarded for work that is simplistic or trivial.

One of the factors that determine the demand of an activity is the level of guidance given to candidates. The use of a highly structured worksheet, for example, will reduce the number of decisions and judgements required by the candidate and will limit the range of marks available.

4.2 Marking Candidates' Work

A similar set of mark descriptors is used for AS and A2. The descriptors should be used to make a judgement as to which mark best fits a candidate's performance.

The descriptors have been written to provide clear continuity from the assessment of Sc1 for GCSE. This should ensure an effective continuation of the development of candidates' skills from GCSE to Advanced Subsidiary and Advanced GCE.

The mark descriptors within a skill area have been written to be **hierarchical**. Thus, in marking a piece of work, the descriptors for the lowest defined mark level should be considered first and only if there is a good match should the descriptors for the next level up be considered. When a teacher is considering awarding a mark, the work must have demonstrated a good match to all the mark descriptors below the mark to be awarded.

For each skill, the scheme allows the award of intermediate marks 2, 4 and 6 that are between the defined mark levels. An intermediate mark may be awarded when the work of a candidate exceeds the requirements of a defined mark level but does not meet the requirements of the next higher defined mark level sufficiently to justify its award. Thus, an intermediate mark could be awarded if the work meets only one of the two descriptors at the higher defined mark level, or provides a partial match to both descriptors, or provides a complete match to one and a partial match to the other. For clarification of these points see the Activities in Section B (page 46 onwards) and the commentaries on pages 100 to 103.

In Skills **P** and **A**, a mark of 8 should be awarded for work which meets all the requirements of the descriptors up to and including level 7 and is judged to be of exceptional merit in terms of originality, depth, flair, or in the use of novel or innovative methods. Work should be clearly annotated to explain to the moderator why a mark of 8 has been awarded. This may take the form of a check list of items that Teachers considered appropriate for the group as a whole or annotations on each piece of work to indicate where there was material of exceptional merit.

A mark of zero should be awarded where there has been an attempt to address the skill but the work does not meet the requirements of the lowest defined mark level.

The marks awarded should be based on the final written work and, in the case of Skill I, also on the teacher's knowledge of the work carried out by the candidate. In assigning a mark, attention should be paid to the extent of any guidance needed by, or given to, the candidate.

Work should not be marked and then returned to candidates to be improved. However, it may be appropriate to comment, in generic terms, on work in draft form before the final marking. Further guidance about this is given in Activity 3 on page 73.

4.3 Synoptic Assessment

Synoptic assessment involves the explicit drawing together of knowledge, understanding and skills learned in different parts of the Advanced GCE course. Assessment Objective AO4 relates specifically to synoptic assessment and marks from the A2 Experimental Skills (coursework) Unit, 2806/2, contribute to the assessment of AO4.

During experimental and investigative work, synoptic assessment:

- allows candidates to apply knowledge and understanding of principles and concepts from different parts of the specification in planning experimental work and in the analysis and evaluation of data;
- allows candidates to apply skills and techniques learned during the course.

All practical work assessed internally by Centres for the A2 Unit 2806/2 should draw on the range of experience that the candidate has acquired during the AS and A2 courses. It is particularly important that an exercise used to assess planning skills should involve an element of research which goes beyond the repetition of an experiment that simply reflects the use of ideas or techniques met within the module currently being studied. Likewise, an assessment involving analysing evidence and drawing conclusions must require a candidate to use knowledge and understanding acquired outside the confines of a standard experiment recently practised. During the process of moderation, evidence will be sought that such breadth has been achieved.

The assessment descriptors for the skills of Planning (P) and Analysing Evidence and Drawing Conclusions (A), include statements that relate specifically to synoptic assessment. These are shown in bold and should be applied only when assessing A2 work. **Thus, in A2, a candidate will not be able to achieve more than 2 marks in each of Skills P and A without demonstrating aspects of synoptic assessment.** Candidates will also bring to the assessment of Skill I (Implementing) their experience of practical and investigative work from throughout the course. In Skill E (Evaluating Evidence and Procedures), aspects of Skills **P** and **A** are evaluated. Overall, in A2, approximately 15 of the 30 available marks can thus be identified as contributing to an assessment of AO4 (synoptic assessment). Advice about the synoptic element of Skills **P** and **A** is given on pages 80 to 99.

4.4 Quality of Written Communication

Coursework must include an assessment of candidates' quality of written communication. At Level 3, candidates are required to:

- select and use a form and style of writing that is appropriate to the purpose and complex subject matter;
- organise relevant information clearly and coherently, using specialist vocabulary when appropriate;
- ensure the text is legible and that spelling, grammar and punctuation are accurate, so that the meaning is clear.

The mark descriptors for Skills **P** and **A** have been written to include these aspects, and these skills carry an additional mark each in recognition of this.

4.5 Annotation of Candidates' Work

Each piece of assessed coursework must be annotated to show how the marks have been awarded in relation to the relevant skills.

The writing of comments on candidates' work can provide a means of dialogue and feedback between teacher and candidate, and a means of communication between Teachers during internal standardisation of coursework. The main purpose of annotating candidates' coursework should be, however, to provide a means of communication between the teacher and the Moderator, showing where marks have been awarded and why. The sample of work which is submitted for moderation must show how the marks have been awarded in relation to the marking criteria.

Annotations should be made at appropriate points in the margins of the text. The annotations should indicate both where achievement for a particular skill has been recognised, and where the mark has been awarded. It is suggested that the minimum which is necessary is that the 'shorthand' mark descriptors (for example, **P**.5a, **I**.3b) should be written at the point in the text where it is judged that the work has met the descriptors concerned.

For Skill **I**, Implementing, more detail is necessary and the Moderator will require evidence concerning candidates' use of practical techniques and safe working practice. This evidence could take the form of check lists or written notes which are **specific** to the investigation.

A possible convention to use for annotating coursework is as follows:

Annotation	Meaning of annotation
Tick + descriptor, i.e. ✓ P.3(a)ii	*Evidence found here for complete match with the descriptor*
Cross + descriptor, i.e. ✘ P.3(a)ii	*No evidence for this descriptor therefore overall mark for this skill limited at this point*
Descriptor in brackets (P.3(a)ii)	*Partial evidence found for this descriptor at this point in the work*

Brief comments written on the coursework where necessary are also helpful, especially where intermediate marks are awarded.

4.6 Health and Safety

In UK law, health and safety is the responsibility of the employer. For most establishments entering candidates for GCE AS and A level this is likely to be the education authority or the governing body. Employees, i.e. teachers and lecturers, have a duty to cooperate with their employer on health and safety matters.

Various regulations, but especially the COSHH Regulations 1996 and the Management of Health and Safety at Work Regulations 1992, require that before any activity involving a hazardous procedure or harmful microorganisms is carried out, or hazardous chemicals are used or made, the employer must provide a risk assessment. A useful summary of the requirements for risk assessment in school or college science can be found in Chapter 4 of Safety in Science Education (see below). For members, the CLEAPSS guide, Managing Risk Assessment in Science offers detailed advice.

Most education employers have adopted a range of nationally available publications as the basis for their Model Risk Assessments. Those commonly used include:

Safety in Science Education (DfEE 1996 HMSO) ISBN 0 11 270915 X;

Safeguards in the School Laboratory (10th edition 1996 ASE) ISBN 0 86357 250 2;

Hazcards (1995 CLEAPSS School Science Service*);

Laboratory Handbook (1988-97, CLEAPSS School Science Service*);

Topics in Safety (2nd edition 1988 ASE) ISBN 0 86357 104 2;

Safety Reprints (1996 edition ASE) ISBN 0 86357 246 4.

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

(Other publications have sometimes been suggested, e.g. the SSERC **Hazardous Chemicals Manual** or the DES **Microbiology, an HMI Guide for Schools and FE**, but both of these are now out of print).

Where an employer has adopted these or other publications as the basis of their model risk assessments, an individual school or college then has to review them, to see if there is a need to modify or adapt them in some way to suit the particular conditions of the establishment. Such adaptations might include a reduced scale of working, deciding that the fume cupboard provision was inadequate, or that the skills of the candidates were insufficient to attempt particular activities safely. The significant findings of such risk assessment should then be recorded, for example on schemes of work, published Teachers guides, work sheets, etc. There is no specific legal requirement that detailed risk assessment forms should be completed, although a few employers require this.

Where project work or individual investigations, sometimes linked to work-related activities, are included in specifications these may well lead to the use of novel procedures, chemicals or microorganisms, which are not covered by the employer's model risk assessments. The employer should have given guidance on how to proceed in such cases. Often, for members, it will involve contacting the CLEAPSS School Science Service (or, in Scotland, SSERC).

When candidates are planning their own practical activities, whether in project work or for more routine situations, the teacher or lecturer has a duty to check the plans before practical work starts and to monitor the activity as it proceeds.

5 Mark Descriptors for Experimental and Investigative Skills

In defining the various mark descriptors, it is recognised that practical tasks vary widely, both in the experimental procedures used and in the nature of the observations and measurements which may be made by the candidate. The mark descriptors within each defined level are intended to provide guidance to teachers on how to recognise levels of achievement. It is acknowledged that the balance between the statements provided for a particular level of performance will vary with the nature of the activity. Whilst both statements for a particular level must be considered in awarding the marks, it is clear that teachers will need to judge for themselves the relative weightings they attach to each of the statements.

Both statements at a defined level must be satisfied in order that the mark for this level is awarded. All descriptors for lower defined levels must be satisfied before a higher mark is awarded. From the bottom to the top of the mark range the activity should involve increasing demands of related scientific knowledge and understanding, manipulation, precision, accuracy and complexity.

The mark descriptors for the four skills are given on pages 20 to 23. Teachers may also find it helpful when annotating their work to divide the descriptors within their mark schemes to ensure that candidates match all the points covered by each descriptor. The marking grids on pages 24 to 31 are set out in this way. The mark schemes for skills P and A for A2 include descriptors that refer to the synoptic assessment and are given in dark type. Identifying each part of some descriptors using i, ii and iii etc helps in annotating the work to ensure that every part of each descriptor is met in candidates' work.

AS marking grids - pages 24 to 27

A2 marking grids - pages 28 to 31

It is recommended that a tick list is used to assess Skill I. A proforma for such a tick list is on page 32. This should be customised for each investigation.

The synoptic descriptors are indicated in bold type. These should only be used for coursework at A2. In the marking grids on pages 24 to 31, they are indicated separately from the other descriptors at levels 3, 5 and 7. Candidates may use synoptic material in different ways. Teachers are advised to send the moderator a context for each investigation and itemise the learning outcomes from the AS and A2 specifications that they considered appropriate for their candidates to use when planning their investigations and analysing their results.

The relevant descriptors are as follows.

- Level 3: **'……drawn from more than one area of the specification'**. If candidates refer to material from more than one learning outcome then they satisfy this requirement.
- Level 5: **'……drawn from more than one module of the specification'**. If candidates refer to material from two A2 modules (2804 and 2805) then they satisfy this requirement.
- Level 7: **'……drawn from different parts of the AS and A2 specification'**. If candidates use **relevant** material from an AS module (2801, 2802 and/or 2803/01) as well as material from an A2 module (2804 and/or 2805) then they satisfy this requirement and the requirements at levels 3 and 5 **as well**. It is important that the synoptic material is used in the context of the whole descriptor at each level.

Skill P – Planning **Total 8**

Mark		Descriptor
		The candidate:
1	**P.1a**	develops a question or problem in simple terms and plans a fair test or an appropriate practical procedure, making a prediction where relevant.
	P.1b	chooses appropriate equipment**.**
3	**P.3a**	develops a question or problem using scientific knowledge and understanding **drawn from more than one area of the specification**; identifies the key factors to vary, control or take account of.
	P.3b	decides on a suitable number and range of observations and/or measurements to be made.
4		
5	**P.5a**	causes detailed scientific knowledge and understanding **drawn from more than one module of the specification** and information from preliminary work or a secondary source to plan an appropriate strategy, taking into account the need for safe working and justifying any prediction made;
	P.5b	describes a strategy, including choice of equipment, which takes into account the need to produce precise and reliable evidence; produces a clear account and uses specialist vocabulary appropriately.
6		
7	**P.7a**	retrieves and evaluates information from a variety of sources, and uses it to develop a strategy which is well structured, logical and linked coherently to underlying scientific knowledge and understanding **drawn from different parts of the AS and A2 specification**; uses spelling, punctuation and grammar accurately.
	P.7b	justifies the strategy developed, including the choice of equipment, in terms of the need for precision and reliability.
8		

The statements in bold represent additional requirements when assessing A2 work; they are not to be used at AS. See page 19 for further clarification of these statements.

Skill I - Implementing **Total 7**

Mark		Descriptor
		The candidate:
1	**I.1a**	demonstrates competence in simple techniques and an awareness of the need for safe working.
	I.1b	makes and records observations and/or measurements which are adequate for the activity.
2		
3	**I.3a**	demonstrates competence in practised techniques and is able to manipulate materials and equipment with precision.
	I.3b	makes systematic and accurate observations and/or measurements which are recorded clearly and accurately.
4		
5	**I.5a**	demonstrates competence and confidence in the use of practical techniques; adopts safe working practices throughout.
	I.5b	makes observations and/or measurements with precision and skill; records observations and/or measurements in an appropriate format.
6		
7	**I.7a**	demonstrates skilful and proficient use of all techniques and equipment.
	I.7b	makes and records all observations and/or measurements in appropriate detail and to the degree of precision permitted by the techniques or apparatus.

Skill A - Analysing Evidence & Drawing Conclusions **Total 8**

Mark		Descriptor
		The candidate:
1	**A.1a**	carries out some simple processing of the evidence collected from experimental work.
	A.1b	identifies trends or patterns in the evidence and draws simple conclusions.
2		
3	**A.3a**	processes and presents evidence gathered from experimental work including, where appropriate, the use of appropriate graphical and/or numerical techniques.
	A.3b	links conclusions drawn from processed evidence with the associated scientific knowledge and understanding **drawn from more than one area of the specification**.
4		
5	**A.5a**	carries out detailed processing of evidence and analysis including, where appropriate, the use of advanced numerical techniques such as statistics, the plotting of intercepts or the calculation of gradients.
	A.5b	draws conclusions which are consistent with the processed evidence and links these with detailed scientific knowledge and understanding **drawn from more than one module of the specification**; produces a clear account which uses specialist vocabulary appropriately.
6		
7	**A.7a**	where appropriate, uses detailed scientific knowledge and understanding **drawn from different parts of the AS and A2 specification** to make deductions from the processed evidence, with due regard to nomenclature, terminology and the use of significant figures (where relevant).
	A.7b	draws conclusions which are well structured, appropriate, comprehensive and concise, and which are coherently linked to underlying scientific knowledge and understanding **drawn from different parts of the AS and A2 specification**; uses spelling, punctuation and grammar accurately.
8		

The statements in bold represent additional requirements when assessing A2 work; they are not to be used at AS. See page 19 for further clarification of these statements.

Skill E - Evaluating Evidence and Procedures — Total 7

Mark		Descriptor
		The candidate:
1	**E.1a**	makes relevant comments on the suitability of the experimental procedures.
	E.1b	recognises any anomalous results.
2		
3	**E.3a**	recognises how limitations in the experimental procedures and/or strategy may result in sources of error.
	E.3b	comments on the accuracy of the observations and/or measurements, suggesting reasons for any anomalous results.
4		
5	**E.5a**	indicates the significant limitations of the experimental procedures and/or strategy and suggests how they could be improved.
	E.5b	comments on the reliability of the evidence and evaluates the main sources of error.
6		
7	**E.7a**	justifies proposed improvements to the experimental procedures and/or strategy in terms of increasing the reliability of the evidence and minimising significant sources of error.
	E.7b	assesses the significance of the uncertainties in the evidence in terms of their effect on the validity of the final conclusions drawn.

Skill P – Planning for AS Coursework **Total 8**

The candidate:

Mark	General strategy	Level	Choices within plan	Level
0				
1	**P1.a** i. develops a question or problem in simple terms and plans a fair test or an appropriate practical procedure; ii. makes a prediction where relevant.		**P1.b** • chooses appropriate equipment.	
2				
3	**P3.a** i. develops a question or problem using scientific knowledge and understanding; ii. identifies the key factors to vary, control or take account of.		**P3.b** • decides on a suitable number and range of observations and/or measurements to be made.	
4				
5	**P5.a** i. uses detailed scientific knowledge and understanding to justify any prediction made; ii. uses information from preliminary work or a secondary source to plan an appropriate strategy; iii. takes into account the need for safe working.		**P5.b** i. describes a strategy, including choice of equipment, which takes into account the need to produce precise and reliable evidence; ii. produces a clear account and uses specialist vocabulary appropriately.	
6				
7	**P7.a** i. retrieves and evaluates information from a variety of sources; ii. uses information to develop a strategy which is well structured, logical and linked coherently to underlying scientific knowledge and understanding; iii. uses spelling, punctuation and grammar accurately.		**P7.b** • justifies the strategy developed, including the choice of equipment, in terms of the need for precision and reliability.	
8				

Skill I - Implementing for AS Coursework **Total 7**

The candidate:

Mark	Manipulation	Level	Recording	Level
0				
1	**I1.a** i. demonstrates competence in simple techniques; ii. shows an awareness of the need for safe working.		**I1.b** • makes and records observations and/or measurements which are adequate for the activity.	
2				
3	**I3.a** i. demonstrates competence in practised techniques; ii. is able to manipulate materials and equipment with precision.		**I3.b** • makes systematic and accurate observations and/or measurements which are recorded clearly and accurately.	
4				
5	**I5.a** i. demonstrates competence and confidence in the use of practical techniques; ii. adopts safe working practices throughout.		**I5.b** i. makes observations and/or measurements with precision and skill; ii. records observations and/or measurements in an appropriate format.	
6				
7	**I7.a** • demonstrates skilful and proficient use of all techniques and equipment.		**I7.b** • makes and records all observations and/or measurements in appropriate detail and to the degree of precision permitted by the techniques or apparatus.	

See page 39 for guidelines in presenting results in the form of tables.

Skill A - Analysing Evidence and Drawing Conclusions for AS Coursework **Total 8**

The candidate:

Mark		Processing evidence	Level		Drawing conclusions	Level
0						
1	**A1.a**	• carries out some simple processing of the evidence collected from experimental work.		**A1.b**	• where appropriate, identifies trends or patterns in the evidence and draws simple conclusions.	
2						
3	**A3.a**	• processes and presents evidence gathered from experimental work including, where appropriate, the use of appropriate graphical and/or numerical techniques.		**A3.b**	• links conclusions drawn from processed evidence with the associated scientific knowledge and understanding.	
4						
5	**A5.a**	• carries out detailed processing of evidence and analysis including, where appropriate, the use of advanced numerical techniques such as statistics, the plotting of intercepts or the calculation of gradients*.		**A5.b**	i. draws conclusions which are consistent with the processed evidence and links these with detailed scientific knowledge and understanding; ii. produces a clear account which uses specialist vocabulary appropriately.	
6						
7	**A7.a**	i. where appropriate, uses detailed scientific knowledge and understanding to make deductions from the processed evidence; ii. shows due regard to nomenclature, terminology and the use of significant figures (where relevant).		**A7.b**	i. draws conclusions which are well structured, appropriate, comprehensive, and concise and which are coherently linked to underlying scientific knowledge and understanding; ii. uses spelling, punctuation and grammar accurately.	
8						

***A graph which follows all the Institute of Biology guidelines may be regarded as partial matching of A5.a. (See page 39-40 for more information.)**

Skill E - Evaluating Evidence and Procedures for AS Coursework **Total 7**

The candidate:

Mark	Procedures	Level	Sources of error	Level
0				
1	**E1.a** • makes relevant comments on the suitability of the experimental procedures.		**E1.b** • recognises any anomalous results.	
2				
3	**E3.a** • recognises how limitations in the experimental procedures and/or strategy may result in sources of error.		**E3.b** i. comments on the accuracy of the observations and/or measurements; ii. suggests reasons for any anomalous results.	
4				
5	**E5.a** i. indicates the significant limitations of the experimental procedures and/or strategy; ii. suggests how procedures / strategy could be improved.		**E5.b** i. comments on the reliability of the evidence; ii. evaluates the main sources of error.	
6				
7	**E7.a** • justifies proposed improvements to the experimental procedures and/or strategy in terms of increasing the reliability of the evidence and minimising significant sources of error.		**E7.b** • assesses the significance of the uncertainties in the evidence in terms of their effect on the validity of the final conclusions drawn.	

Skill P - Planning for A2 Coursework **Total 8**

The candidate:

Mark	General strategy	Level	Choices within plan	Level
0				
1	**P1.a** i. develops a question or problem in simple terms and plans a fair test or an appropriate practical procedure; ii. makes a prediction where relevant.		**P1.b** • chooses appropriate equipment.	
2				
3	**P3.a** i. develops a question or problem using scientific knowledge and understanding; ii. identifies the key factors to vary, control or take account of; iii. **uses information drawn from more than one area of the specification**.		**P3.b** • decides on a suitable number and range of observations and/or measurements to be made.	
4				
5	**P5.a** i. uses detailed scientific knowledge and understanding to justify any prediction made; ii. uses information from preliminary work or a secondary source to plan an appropriate strategy; iii. takes into account the need for safe working; iv. **uses information drawn from more than one module of the specification**.		**P5.b** i. describes a strategy, including choice of equipment, which takes into account the need to produce precise and reliable evidence; ii. produces a clear account and uses specialist vocabulary appropriately.	
6				
7	**P7.a** i. retrieves and evaluates information from a variety of sources; ii. uses information to develop a strategy which is well structured, logical and linked coherently to underlying scientific knowledge and understanding; iii uses spelling, punctuation and grammar accurately; iv **uses information drawn from different parts of the AS and A2 specification**.		**P7.b** • justifies the strategy developed, including the choice of equipment, in terms of the need for precision and reliability.	
8				

See page 19 for further clarification of the statements in bold type

Skill I - Implementing for A2 Coursework **Total 7**

The candidate:

Mark		Manipulation	Level		Recording	Level
0						
1	**I1.a**	i. demonstrates competence in simple techniques; ii. shows an awareness of the need for safe working.		**I1.b**	• makes and records observations and/or measurements which are adequate for the activity.	
2						
3	**I3.a**	i. demonstrates competence in practised techniques; ii. manipulates materials and equipment with precision.		**I3.b**	• makes systematic and accurate observations and/or measurements which are recorded clearly and accurately.	
4						
5	**I5.a**	i. demonstrates competence and confidence in the use of practical techniques; ii. adopts safe working practices throughout.		**I5.b**	i. makes observations and/or measurements with precision and skill; ii. records observations and/or measurements in an appropriate format.	
6						
7	**I7.a**	• demonstrates skilful and proficient use of all techniques and equipment.		**I7.b**	• makes and records all observations and/or measurements in appropriate detail and to the degree of precision permitted by the techniques or apparatus.	

See page 39 for guidelines in presenting results in the form of tables.

Skill A - Analysing Evidence and Drawing Conclusions for A2 Coursework **Total 8**

The candidate:

Mark	Processing evidence	Level	Drawing conclusions	Level
0				
1	**A1.a** • carries out some simple processing of the evidence collected from experimental work.		**A1.b** • where appropriate, identifies trends or patterns in the evidence and draws simple conclusions.	
2				
3	**A3.a** • processes and presents evidence gathered from experimental work including, where appropriate, the use of appropriate graphical and/or numerical techniques.		**A3.b** i. links conclusions drawn from processed evidence with the associated scientific knowledge and understanding; ii. **uses information drawn from more than one area of the specification**.	
4				
5	**A5.a** • carries out detailed processing of evidence and analysis including, where appropriate, the use of advanced numerical techniques such as statistics, the plotting of intercepts or the calculation of gradients.		**A5.b** i. draws conclusions which are consistent with the processed evidence and links these with detailed scientific knowledge and understanding; ii. produces a clear account which uses specialist vocabulary appropriately; iii. **uses information drawn from more than one module of the specification**.	
6				
7	**A7.a** i. where appropriate, uses detailed scientific knowledge and understanding to make deductions from the processed evidence; ii. shows due regard to nomenclature, terminology and the use of significant figures (where relevant); iii. **uses information drawn from different parts of the AS and A2 specification**.		**A7.b** i. draws conclusions which are well structured, appropriate, comprehensive, and concise and which are coherently linked to underlying scientific knowledge and understanding; ii. uses spelling, punctuation and grammar accurately; iii. **uses information drawn from different parts of the AS and A2 specification**.	
8				

See page 19 for clarification of the statements in bold. See pages 39-40 for guidelines on the presentation of graphs.

Skill E - Evaluating Evidence and Procedures for A2 Coursework **Total 7**

The candidate:

Mark	Procedures		Level	Sources of error		Level
0						
1	**E1.a**	• makes relevant comments on the suitability of the experimental procedures.		**E1.b**	• recognises any anomalous results.	
2						
3	**E3.a**	• recognises how limitations in the experimental procedures and/or strategy may result in sources of error.		**E3.b**	i. comments on the accuracy of the observations and/or measurements; ii. suggests reasons for any anomalous results.	
4						
5	**E5.a**	i. indicates the significant limitations of the experimental procedures and/or strategy; ii. suggests how they could be improved.		**E5.b**	i. comments on the reliability of the evidence; ii. evaluates the main sources of error.	
6						
7	**E7.a**	• justifies proposed improvements to the experimental procedures and/or strategy in terms of increasing the reliability of the evidence and minimising significant sources of error.		**E7.b**	• assesses the significance of the uncertainties in the evidence in terms of their effect on the validity of the final conclusions drawn.	

Suggested proforma for assessing skill I

Experiment title:______________________________________ Date: ____________________

	Competence in Simple techniques	Works safely	Records observations	Competence	Manipulate with precision	Systematic/clear and accurate	Competent and confident	Safe throughout	Ovserves with precision and skill	Records appropriately	Skulful and proficient	Detail and precision
Descriptors	**1ai**	**1aii**	**1b**	**3ai**	**3aii**	**3b**	**5ai**	**5aii**	**5bi**	**5bii**	**7a**	**7b**
Candidates												

25

6 Suggested Tasks for Each Module

6.1 Planning Coursework Tasks

The learning outcomes for each module identify key areas where practical skills are expected to be developed and candidates given the opportunity to carry out practical work. Many of these will provide occasions on which some or all of the four skills may be assessed. However, it is imperative that candidates are **taught** the experimental and investigative skills before they are assessed.

Access to marks depends upon the demand of the activity, which includes the associated increasing demands of scientific knowledge and understanding, manipulation, precision and accuracy and complexity. Teachers should realise that some tasks of a lesser demand may be set for those candidates who are only likely to achieve a low final grade, or for use as training exercises.

One strategy that can be usefully employed to assist in training candidates is to use a prompt sheet or check list, which identifies the key areas that are required to access the full range of marks in each of the four skill areas. Examples of these are given in Section B on pages 33 to 35.

For both AS and A2 assessments the teacher may assess the skills in the context of separate practical exercises; more than one skill may be assessed in any exercise. They may also be assessed all together in the context of a single 'whole investigation' using a task set by the teacher, or by using individual investigations chosen by each candidate. The final four marks (one each for **P**, **I**, **A** and **E**) can be taken from any combination of the preceding practical approaches, e.g. a mark for **P** from a student chosen individual investigation, a mark for A from a teacher set practical task and marks for **I** and **E** from a teacher set 'whole investigation.' In all cases, the candidate's best marks for each skill should be submitted to OCR for moderation.

Pure paper and pencil exercises should not be used for practical work. Due to class sizes and time limitations it may, however, prove necessary on some occasions to provide candidates with additional data in order to assess satisfactorily Skills **A** and **E**. However, the candidates must have carried out relevant experimental work in addition to being supplied with data.

Coursework will provide much scope for the use of ICT. However, both teachers and candidates must ensure that any software used, especially many of the graph-plotting packages, is used with caution, since it may not produce the most appropriate graphs, or graphs which conform to the guidelines published by the Institute of Biology. **Therefore, the use of such software could result in candidates failing to access specific marking descriptors**.

Skill I in particular requires evidence that the candidate has carried out various tasks at a suitable level. Whilst the candidates' results will, in some cases, demonstrate that this has happened, in most cases the Centre will need to provide a tick-list as evidence that these aspects have been assessed. An exemplar tick-list is included (see page 35).

Suggested strategies for AS assessment

The coursework assessment uses skills which cover the same areas as those covered at GCSE and uses a similar form of mark descriptors. Therefore it is to be hoped that candidates will have some prior knowledge of practical work of this type from their work at GCSE. However, candidates will need additional training in order to meet the demands of an AS/A GCE course.

Within the three AS units, there are a number of opportunities for practical work. These can be used for training and formal assessment. Each of the three methods of practical assessment may be used during the AS course; however, a candidate may not have sufficient depth of knowledge to carry out an individual investigation until the later part of the course. As with all investigations, especially in Biology, there is a risk that an investigation may fail for one reason or another, often due to causes outside the candidate's control. Therefore it is strongly recommended that this is not the only route pursued by the Centre in order to obtain a candidate's coursework assessment marks.

With the suitable choice of an individual investigation, it may prove possible to use pilot studies to assess the AS skill areas P, I, A and E. The actual investigation could then be submitted for A2. However, great care needs to be taken with this approach to ensure that all aspects of the requirements are met.

Suggested strategies for A2 assessment

Candidates who carry out statistical methods at A2 clearly meet the descriptor A5.a which requires 'more detailed processing' of results. Candidates can access level 5 and above for skills A and E if they use non-statistical methods as appropriate to their investigations (see pages 9 and 10 for further information).

The A2 assessments will build upon the knowledge, understanding and skills acquired during the AS course. Tasks set by the teacher should normally enable the student to demonstrate knowledge and skills from more than one area of the specification, including the AS specification. This feature is of course also required in any individual investigation followed by a candidate. Candidates will, therefore, need to select any topic they wish to investigate with great care. As previously mentioned, it may benefit the candidates if they are provided with a prompt sheet which identifies the key requirements of the mark descriptors. This will then allow them to check that the investigation has sufficient scope and breadth to allow them to utilise knowledge, understanding and skills acquired from other units, including those taken at AS.

Individual investigations will often be an ecological study, carried out as part of a field course, or work on a topic the candidate wishes to develop further, carried out during the later part of the autumn term or the first part of the spring term of the second year of the course. For ecological work carried out on a field course, the Centre should ensure, if they are not directly involved in the teaching, that the field centre staff are aware of the specification requirements, most notably that A2 investigations must refer back to other AS modules in order to access higher marks.

Types of practical work

A grid of suggested tasks is provided in order to give teachers an idea of the practical work that could be used for assessment and indicating the skill areas they would best address. The choice of practical work is dependent upon the Centre's facilities, the number of candidates undertaking the course, the interests of the staff etc. In all cases, teachers must ensure that the work can be undertaken to a sufficient level of demand. Whilst ecological work can be used by a candidate for an individual investigation, it may also present suitable opportunities for the assessment of the Analysing and Evaluating skills.

Microscopy can be used for assessment of Implementing and, possibly, Analysis. Dissections may be used for the assessment of Implementing.

6.2 Suggested Assessment Tasks Relating to Modules

The following practical tasks can be used for the assessment of the experimental and investigative skills. However, some of these practical tasks may not be sufficiently demanding to allow access to marks for descriptors at the higher defined levels. The list of activities included in the second edition of the Coursework Guidance notes (September 2001) has been revised in the light of the AS and A2 coursework moderated in May/June 2002.

It should be pointed out that these are suggestions. There may be difficulties in using some of these suggestions because of large numbers of candidates or lack of appropriate apparatus or materials. It should also be noted that to satisfy the descriptor I.5b results should be recorded in a table. This means that practical work chosen to assess Skill I should generate numerical data.

Module 2801 : Biology Foundation

Practical task	P	I	A	E
Microscopy t.s. mesophyte leaf plus measuring	✗	✓	✗	✗
Semi-quantitative Benedict's test to produce numerical data (e.g. by using a colorimeter)	✓	✓	✓	✓
Effect of temperature on enzymes	✓	✓	✓	✓
Effect of pH on enzymes	✓	✓	✓	✓
Effect of enzyme concentration	✓	✓	✓	✓
Effect of substrate concentration on enzyme activity	✓	✓	✓	✓
Effects of inhibitors on enzymes	✓	✓	✓	✓
Effect of pectinase concentration on named fruits in the production of fruit juice	✓	✓	✓	✓
Effect of calcium ions on milk coagulation	✓	✓	✓	✓
Effect of copper ions on trypsin	✓	✓	✓	✓
Effect of age of plant tissue on catalase activity	✓	✓	✓	✓
Comparison of biological washing powders, using jelly	✓	✓	✓	✓
Effect of temperature on membrane permeability using beetroot	✓	✓	✓	✓
Effect of bile salts or detergents on membrane permeability	✓	✓	✓	✓
Investigating enzyme activity in apple browning to produce numerical data (e.g. by using a colorimeter)	✓	✓	✓	✓
Effects of osmosis on various tissues	✓	✓	✓	✓
Preparation of mitosis slides	✗	✓	✗	✗
Analysis of mitosis slides	✗	✗	✓	✓

Module 2802: Human Health and Disease

Practical task	P	I	A	E
Investigating the effects of antibiotics on bacteria	×	✓	✓	✓
Setting up and using a spirometer	×	✓	×	×

Module 2803, Component 01: Transport

Practical task	P	I	A	E
Elasticity of artery and vein	×	✓	✓	✓
Heart dissection and drawing	×	✓	×	×
Transpiration experiments	×	✓	✓	✓
Microscopy of xylem, including making slides plus measuring	×	✓	×	×
Analysis of composition of inspired and expired air	×	✓	✓	✓

Module 2804: Central Concepts

Practical task	Synoptic links	P	I	A	E
Effects of temperature on respiration (Q_{10})	enzymes, biochemistry	✓	✓	✓	✓
Effects of alcohol on respiration in yeast	enzymes	✓	✓	✓	✓
Effects of different substrates on respiration rates in yeast	enzymes biochemistry	✓	✓	✓	✓
Determination of RQ values	biochemistry	✓	✓	✓	✓
Effect of temperature on the rate of photosynthesis	enzymes	✓	✓	✓	✓
*Investigations into the distribution of named organisms	photosynthesis, enzymes, ecosystems	✓	✓	✓	✓
Effects of limiting factors on bacterial growth	enzymes	✓	✓	✓	✓
Dihybrid crosses illustrating independent assortment in meiosis	reduction division	×	✓	✓	✓
Effects of environmental factors on the phenotype of bacteria or plants	enzymes, biochemistry, photosynthesis	✓	✓	✓	✓
Effects of auxins on growth/germination	enzymes, protein synthesis, mitosis	✓	✓	✓	✓
*Investigating a succession	ecosystems	✓	✓	✓	✓

Module 2805, Component 01: Growth, Development and Reproduction

Practical task	Synoptic links	P	I	A	E
Measurements of growth of microorganisms or plants	not applicable to Skill I	×	✓	×	×
Factors affecting growth	enzymes, osmosis, mitosis	✓	✓	✓	✓
Microscopy of plant embryo development, including making slides	not applicable to Skill I	×	✓	×	×
Factors affecting germination	mitosis, osmosis, diffusion, enzymes, plant growth substances	✓	✓	✓	✓
Investigating seed dormancy	enzymes, osmosis, respiration, plant growth substances	✓	✓	✓	✓

Module 2805 Component 02: Applications of Genetics

Practical task	Synoptic links	P	I	A	E
Distribution of non-amylase producers in a school population	meiosis and mitosis enzymes	✓	✓	✓	✓
Autosomal linkage in *Drosophila spp*	meiosis, reduction division homologous chromosomes	×	✓	✓	✓
An investigation of genetic variation in *Brassica campestris* plants	enzymes, respiration, meiosis	✓	✓	✓	✓
Effect of environment on fungal growth	enzymes, respiration	✓	✓	✓	✓
Investigating continuous and discontinuous variation	meiosis, homologous chromosomes	✓	✓	✓	✓
Comparing the effects of radiation on seeds	meiosis, mutation homologous chromosomes	✓	✓	✓	✓
Variation in ragwort	meiosis, homologous chromosomes	✓	✓	✓	✓

Module 2805, Component 03: Environmental Biology

Practical task	Synoptic links	P	I	A	E
A comparison of the flora (or fauna) of woods or hedgerows of varying age	photosynthesis populations	✓	✓	✓	✓
Investigating distribution and abundance of a named organism linked to one or several abiotic factors	photosynthesis, enzymes, selection, adaptation	✓	✓	✓	✓
A comparison of soil drainage rates and plant growth	growth, enzymes, anaerobic respiration, mineral uptake, denitrification	✓	✓	✓	✓
Effect of an introduced species on plant species diversity in a named woodland or moorland area	photosynthesis, enzymes	✓	✓	✓	✓
The effects of heavy metal ions on growth of cress seedlings, duckweed or cereal seedlings	photosynthesis, enzymes, mitosis	✓	✓	✓	✓
Study of number of lichen species on buildings across a town (influence of sulphur dioxide)	photosynthesis, enzymes	✓	✓	✓	✓
Effect of nutrient deficiency on plant growth	photosynthesis, enzymes, respiration	✓	✓	✓	✓
* Shell size and/or shape in populations of molluscs e.g. dog whelk, limpet, periwinkle	adaptation, selection, ecosystems	✓	✓	✓	✓
Drying rates of seaweeds related to zonation on the shore	adaptation, selection, ecosystems	✓	✓	✓	✓
* Effect of named factor (e.g. aspect, trampling) on species diversity	adaptation, ecosystems	✓	✓	✓	✓

Module 2805, Component 04: Microbiology and Biotechnology

Practical task	Synoptic links	P	I	A	E
Investigating growth requirements of fungi, bacteria	mitosis, enzymes, respiration	✓	✓	✓	✓
Investigating the effect of enzyme inhibitors on bacterial growth	enzymes,biochemistry, respiration	✓	✓	✓	✓
Investigating immobilised enzymes	enzymes, biochemistry	✓	✓	✓	✓
Comparing the effects of disinfectants and antibiotics on bacteria	respiration, antibiotics	✓	✓	✓	✓

Module 2805, Component 05: Mammalian Physiology and Behaviour

Practical task	Synoptic links	P	I	A	E
Comparison of surface areas of stomach, ileum and colon using microscope slides and photographs/electron micrographs	N/A	✗	✓	✗	✗
Comparison of lipase digestion with and without bile salts	energy and nutrient requirements, enzymes	✓	✓	✓	✓
Learning in human mirror drawings	N/A	✗	✓	✗	✓
Learning in human memory	N/A	✗	✓	✗	✓
Maze learning in rodents	N/A	✗	✓	✗	✓
Territorial behaviour in gerbils	N/A	✗	✓	✗	✓

* Care should be taken when using ecological investigations for planning. There may not be sufficient scope to allow candidates to choose their apparatus. If this is the case then these investigations may not be appropriate for assessing Skill P, but could still be used for assessing the other three skills.

It is difficult to find links between the practical suggestions given for the behaviour topic in Mammalian Physiology and Behaviour (2805/05) and the AS specification. **The suggestion that these investigations could be used for Skills P and A has been removed.**

7 Guidelines for Tables and Graphs

These guidelines are adapted from the Institute of Biology publication:

Biological Nomenclature: Standard terms and expressions used in the teaching of biology. 3rd Edition, 2000, Edited by Alan Cadogan. ISBN 0-900490-36-5

Tables

The following guidelines should be followed when presenting numerical results in tables.

- Numerical values inserted in the table should be pure numbers, i.e. no units.
- Columns should be headed with a physical quantity and appropriate SI unit.
- The slash, or /, meaning per should not be used in the unit symbol, e.g. 100 joules per kilogram can appear in the text as 100 joules per kilogram or as 100 Jkg^{-1}. In a table it should be shown as:

	Energy content / Jkg^{-1}	
	100	

- Note that the slash is here used to separate what is measured from the unit in which it is measured.
- When two or more columns are used to present data, the first column should be the independent variable (i.e. that variable which is chosen by the experimenter); the second and subsequent columns should contain the dependent variables (i.e. the readings taken by the experimenter).
- Tables should be given informative titles.

Bar charts and histograms

These are used when the dependent variable on the y-axis is discrete, i.e. whole numbers; fractions are impossible and the data under consideration deal with frequencies.

Bar charts

Bar charts are used when the independent variable is non-numerical, e.g. the number of different insect species found on trees. These data are discontinuous.

- They can be made up of lines, or blocks of equal width, which do not touch.
- The lines or blocks can be arranged in any order, but it can aid comparison if they are arranged in descending order of size.
- Each axis should be labelled clearly with an appropriate scale.
- There should be an informative title.

Histograms

These are used when the independent variable is numerical and the data are continuous. They are sometimes referred to as frequency diagrams.

- One axis, usually the x-axis, represents the independent variable and is continuous. It should be labelled clearly with an appropriate scale.
- The number of classes needs to be established. This will largely depend on the type and nature of the data. However, five times the log of the number of observations is one approach.
- The blocks should be drawn touching.
- The edges of the blocks should be labelled, so a block might be labelled '7' at the left and '8' at the right; this is expressed as a class range 7 — 8 units, but it is implied that 7.0 is included in this range but 8.0 is not. 8.0 will be included in the next class, range 8 — 9.
- The other axis, conventionally the y-axis, represents the number or frequency, and should be labelled with an appropriate scale.
- There should be an informative title.

Pie charts

These can be used when displaying data that are proportions or percentages.

- Sector angles are calculated by dividing their percentage by 100 and multiplying the answer by 360o (if figures are proportions then just multiply by 360o).
- When comparing two or more pie charts, the sequence of segments should be kept the same.
- The size of the pie circle can be made proportional to the size of the sample.
- Ideally pie charts should not contain more than 6 to 7 sectors, otherwise they become confusing.
- There should be labels or a key.
- There should an informative title.

Line graphs

Graphs are used to show relationships in data which are not immediately apparent from tables.

The term graph should be used to refer to the whole diagrammatic representation. The term curve should be used to describe both curves and lines which are used to join points.

The following guidelines should be followed.

- Only pure numbers are to be used when plotting points.
- Each axis should be labelled clearly with the quantity and SI unit if appropriate, e.g. length of branch from trunk / m.
- Each axis should be marked with an appropriate scale. The data should be critically examined to establish whether it is necessary to start the scale(s) at zero.
- The independent variable should be plotted on the x (horizontal) axis.

- The dependent variable should be plotted on the y (vertical) axis.
- Plotted points must be clearly marked and easily distinguishable from the graph grid lines (dots on their own are not sufficient). Encircled dots or saltire crosses (x) should be used. When multiple curves are being plotted, vertical crosses (+) can be employed; when producing computer-generated graphs, it may not always be possible to impose a particular style of plotted point.
- A smooth curve should only be drawn if there is good reason to believe that the intermediate values fall on the curve, e.g. the effect of light on the rate of photosynthesis. Otherwise, straight lines joining the points should be drawn, thus indicating uncertainty about the intermediate values, e.g. numbers of ground beetles found at set distances from a hedge.
- If a graph shows more than one curve, then each curve should be labelled to show what it represents.
- There should be an informative title.

Scattergrams

These are used when investigating the relationship between two variables of a sample or replicate and observations are in pairs. The data can then be used to establish if there is a relationship between the variables. The relationship can be a positive correlation, a negative correlation or no correlation at all.

- The two axes of the graph are marked out with appropriate scales.
- The two variables are plotted for each sample as a point so that each point on the graph represents an individual.
- There should be an informative title.

7.1 Significant Figures

These guidelines are adapted from the Institute of Biology publication.

Biological Nomenclature. Standard terms and expressions used in the teaching of Biology. 3rd Edition, 2000, Edited by Alan Cadogan. ISBN 0-900490-36-5

No calculated answer should include more significant figures than the least accurate of the figures used to calculate the answer.

8 Coursework Forms

The coursework summary form should be used to record candidates' marks to be submitted to OCR. The marks for each skill should be recorded and the total mark should be transferred to the computer printed mark sheet (MS1) supplied by OCR, or transferred to OCR directly (by EDI). A copy of the coursework summary form should be submitted to the moderator, together with the moderator copy of the MS1 form (or a printout of the EDI submission). A Centre wishing to use a computer to keep a record of marks (for example on a spreadsheet) may submit a printout to the moderator as an alternative to the coursework assessment form, provided that it includes all the necessary information.

The coursework cover sheet should be attached to the front of each candidate's portfolio of work submitted to the moderator. Cover sheets do not need to be completed for candidates whose work does not form part of the sample of work sent for moderation.

The coursework forms are provided in a coursework administration pack. One copy of the pack will be despatched to Centres. The coursework administration pack may also be downloaded from the OCR web site: www.ocr.org

9 Contacts

Subject Officer for A Level Biology (specification-specific queries only)

OCR

1, Hills Road

Cambridge

CB1 2EU

Training and Customer Support (INSET enquiries)

OCR

Mill Wharf

Mill Street

Birmingham

B6 4BU

Tel: 0121 628 2950

Fax: 0121 628 2940

Email: tcs@ocr.org.uk

OCR Information Bureau (other queries)

Tel: 01223 553995

Email: helpdesk@ocr.org.uk

10 Resources for Practical Biology

Books

Cadogan A. and SUTTON R. **Maths for Advanced Biology** (Thomas Nelson and Sons Walton-on-Thames 1994) ISBN: 0-17-448214-0

Clegg C.J. and Mackean D.G. **Advanced Biology Principles and Applications: Study Guide** (John Murray London 1996) ISBN: 0-7195-5358-X

Edmonson A. and Druce D. **Advanced Biology Statistics** (Oxford University Press Oxford 1996) ISBN: 0-19-914654-3

Ennos R**.** **Statistical and Data Handling Skills in Biology** (Prentice Hall Harlow 2000) ISBN: 0-582-31278-7

Freeland P.W. **Problems in Practical Advanced Level Biology** (Hodder and Stoughton, Sevenoaks 1985) ISBN: 0-340-33563-7

Garvin J.W. **Skills in advanced Biology 1: Dealing With Data** (Stanley Thornes, Cheltenham 1986) ISBN: 0-85950-588-X

Garvin J.W.and Boyd J.D. **Skills in Advanced Biology 2: Observing, Recording and Interpreting** (Stanley Thornes Cheltenham 1990) ISBN: 0-85950-817-X

Garvin J.W. **Skills in Advanced Biology 3: Investigating** (Stanley Thornes Cheltenham 1995) ISBN: 0-7487-2048-0

Jones R. and Reed R. and Weyers J. **Practical Skills in Biology** (2nd Ed. Longman Harlow 1999) ISBN: 0-582-29885-7

Powell S. **Statistics for science projects** (Hodder and Stoughton London 1996) ISBN: 0-340-664096

Rockett B. and Sutton R. **Chemistry for Biologists at Advanced Level** (John Murray London 1996) ISBN: 0-7195-7146-4

Siddiqui S.A. **Comprehensive Practical Biology for A Level** (Ferozsons Lahore 1999) ISBN: 969-0-01572-9

Webb N. and Blackmore R. **Statistics for Biologists: A Study Guide** (Cambridge University Press Cambridge 1985) ISBN: 0-521-31712-6

Institute of Biology Booklet

Biological Nomenclature: Standard Terms and Expressions used in the Teaching of Biology (3rd Edition 2000 Edited by Alan Cadogan) ISBN 0-900490-36-5

Web sites

Biozone

http://www.biozone.co.uk/

Science and Plants for Schools (SAPS)

http://saps1.plantsci.cam.ac.uk/

National Centre for Biotechnology Education (NCBE)

http://www.ncbe.reading.ac.uk/

A general search engine may increase the chances of finding appropriate information on the Internet to support practical work in Biology.

http://www.google.com

Section B: Activities for Training

Introduction

There are four different Activities in this section. Three of these involve practicals that are carried out as part of the AS course and one involves two practicals that involve elements of synoptic assessment and are suitable for the A2 course.

Each of the activities is suited for training purposes at INSET meetings, but can also be adapted for use by teachers for internal moderation exercises within their departments. One Activity (No. 3) is designed to be used with students to develop the skills during the AS course.

Activity 1: Coursework Annotation Review

This Activity provides an opportunity for teachers to consider the most appropriate style of annotation to support judgements made in the marking of coursework and the use of a contextualised mark scheme. This Activity also provides an opportunity to consider the application of the hierarchical mark scheme. Teachers may find this Activity useful when training staff new to setting, organising and marking coursework at AS. There is a commentary on the work on page 100.

Activity 2: Coursework Marking Exercise

This Activity consists of a piece of coursework on the same topic as Activity 1, but without any annotation or final mark. Teachers may use this Activity in training within their departments. There is a commentary on the work on page 100.

Activity 3: Formative Assessment

This is an Activity that teachers may find useful for training their students in the requirements of the coursework scheme. It is designed to help students focus on the skills descriptors and see how work of poor quality fails to match those descriptors. Also included are proformas that teachers may like to use or adapt for training their students or to use to provide feedback to their students when they submit their first drafts of coursework. These proformas are on page 77 to 79. There is a commentary on page 101.

Activity 4: Designing Contextualised Mark Schemes for A2 Coursework

Teachers are asked to consider the requirements for students to show elements of synoptic thinking in their coursework. The practicals involve Skills **P** and **A** only. Teachers are asked to complete the proformas. It is expected that issues surrounding the appropriate 'level of demand' for A2 will result from this task. Commentaries on these investigations are on page 102.

Activity 1: Coursework Annotation Review

Context:

The students investigated the effect of enzyme concentration on the rate of an enzyme catalysed reaction using catalase extracted from celery.

Consider the annotation of the coursework and the use of the contextualised mark scheme.

The Task

Use the annotations on the coursework to complete as much as possible of the mark scheme proforma on pages 56 to 59. It is recommended that you carry out this activity for five minutes, and restrict yourself to considering the planning skill only.

Consider the ease and effectiveness of completion of the mark scheme proforma in terms of:

- the structure and logical layout of the student's work
- the ease with which the material to which the annotations referred may be found
- the extent to which careful teaching of the coursework module might improve the structure and logic of the student's work
- the decision to award 6 marks rather than 7 for Skill P.

1. Use the annotations on the coursework to complete the mark scheme profoma for Skills I, A and E. Use the entry for Smith on the tick sheet (see page 60) for assessing the mark for Skill I. It is recommended that if you have attended an INSET course, this part of the task be completed shortly after the course. If you have been unable to attend a course, complete it after tasks 1 and 2.
2. Consider how the hierarchical nature of the coursework assessment has been applied in this case.
3. Do you agree with the final decisions?

( ) = partially met
✓ = fully met

Investigate how concentration of the enzyme catalase in celery tissue alters the rate of reaction with hydrogen peroxide

Skill P — Planning P = 6 I = 7 A = 6 E = 5.

Catalase is an enzyme which breaks down hydrogen peroxide (highly toxic) into water and oxygen in the following reaction:

Hydrogen Peroxide→ (with catalase) Water + Oxygen

Enzymes are protein molecules which can be defined as biological catalysts. A catalyst is a molecule which speeds up a chemical reaction, but remains unchanged at the end of the reaction. Virtually every metabolic reaction which takes place within a living organism is catalysed by an enzyme.
Enzymes are globular proteins. Like all globular proteins, enzyme molecules are coiled into a precise three-dimensional shape. Enzyme molecules also have a special feature in that they possess an active site. The active site of an enzyme is a region, usually a cleft or depression, to which another molecule or molecules can bind. This molecule is the substrate of the enzyme. The shape of the active site allows the substrate to fit perfectly and to be held in place by temporary bonds which form between the substrate and some of the R groups of the enzyme's amino acids. This combined structure is termed the enzyme-substrate complex.

Each type of enzyme will usually act on only one type of substrate molecule. This is because the shape of the active site will only allow one shape of molecule to fit. The enzyme is said to be specific for this substrate.

The enzyme may catalyse a reaction in which the substrate molecule is split into two or more molecules. Alternatively, it may catalyse the joining together of two molecules. Interaction between the R groups of the enzyme and the atoms of the substrate can break, or encourage formation of, bonds in the substrate molecule, forming one, two or more products.

When the reaction is complete, the product or products leave the active site. The enzyme is unchanged by this process, so it is now available to receive another substrate molecule. The rate at which substrate molecules can bind to the enzyme's active site, be turned into products and leave can be very rapid. The enzyme catalase, for example, can bind with hydrogen peroxide molecules, split them into water and oxygen and release these products at a rate of 100000000 molecules per second.

Catalase is present in nearly all aerobic cells, and serves to protect the cell from the toxic effects of hydrogen peroxide by catalyzing its decomposition into molecular oxygen and water without the production of free radicals.

Catalase behaves as a catalyst for the conversion of hydrogen peroxide into water and oxygen. Catalase is an example of a particularly efficient enzyme. Catalase has one of the highest turnover numbers for all known enzymes (40,000,000 molecules/second). This high rate shows an importance for the enzyme's capability for detoxifying hydrogen peroxide and preventing the formation of carbon dioxide bubbles in the blood. Catalase is composed of four subunits. Each subunit contains a haem group. This haem group is responsible for carrying out catalase's activity. Catalase functions to break down hydrogen peroxide into water and oxygen. This reaction is performed by two types of reactions called oxidation (losing electrons), and reduction (gaining electrons). Each of the subunits in catalase uses the energy from electrons to decompose hydrogen peroxide.

(5ai) for detailed sku

The information about the structure of enzymes in the OCR BIOLOGY 1 Textbook was very informative and provided a lot of details about the structure of enzymes, how they break down substrates into products and what factors can affect this. I thought this was a very good source of information. The information found on the website www2.kenyon.edu/depts./biologyBMB/chime/catalase/frames/cattx.htm was specifically about the enzyme catalase, and was a good source of information on how it works in the human body. The information on the website crystal.uah.edu/~carter/enzyme/catalase.htm was very helpful because it actually tells you the process which catalase has to go through in order to break down hydrogen peroxide into oxygen and water. The site also provides information on how fast catalase needs to work in order to keep the body functioning. Overall, this website was a very good source of information.

P7ai Variety of Sources

We are going to carry out an experiment to see how we can affect the rate of the reaction in which catalase catalyses the breakdown of hydrogen peroxide by altering the concentration of the catalase.
To carry out this experiment, we will need:

- 100% catalase (which will be used in the form of liquidised celery)
- 20 vol. hydrogen peroxide solution
- distilled water to make different concentrations of catalase
- gas measuring tube

P1b approp. apparat.

Hydrogen peroxide will be placed in a flask with a stopper. Using a syringe, different concentrations of catalase will be added. At this point a timer will be started. As the hydrogen peroxide breaks down to form water and oxygen. The oxygen will travel up a tube out of the flask, through a beaker of water, and into a gas measuring cylinder filled with water. As time passes, gas bubbles of oxygen will come through the tube, displacing the water in the measuring tube and allowing us to measure how much oxygen has been produced in a certain amount of time. Once the time is up, we can use the graduations on the measuring tube to measure how much the water has been displaced, and this will tell us how much oxygen has been collected. It was decided that a gas measuring tube (or burette) would be used, because this makes it easy for us to see how much oxygen has been produced and therefore enabling us to get a good result.

(P5bi) explains choice of equip.

The variables which could affect this reaction are: temperature, concentration of the catalase, concentration of the hydrogen peroxide and agitation of the catalase-hydrogen peroxide solution (stirring).

Temperature can affect the rate of the reaction, because enzymes catalyse reactions much more quickly at higher temperatures up to about 40 degrees Celsius, when they denature. Denaturing of an enzyme is where the shape of the active site is irreparably changed, meaning that the enzyme cannot catalyse reactions anymore, meaning it is useless. If the temperature of our reaction was increased, the catalase would catalyse the reaction of the hydrogen peroxide much more quickly. To keep this experiment a fair test the temperature of all the reactions carried out must be the same, because temperature is not the variable we are altering in this experiment.

Concentration of the catalase can affect the rate of the reaction, because if there are more catalase enzymes, there are more active sites for the hydrogen peroxide substrate to enter, and so the rate of the reaction would speed up. This is the variable we are altering in this experiment, and so different concentrations of catalase will be used to see what effect they have on the rate of the reaction.

Concentration of the hydrogen peroxide can affect the rate of the reaction, because if there are more hydrogen peroxide substrate molecules, there are more substrate molecules reacting with the enzyme's active sites at any one time, and so the rate of the reaction would speed up. However there is a maximum limit, because when all the active sites are filled with substrate molecules at any one time, this is the maximum rate of the reaction, and from that point the rate of the reaction can only be increased by adding more enzymes. This is not the variable we are altering in this experiment, and so we must make sure that the concentration of hydrogen peroxide is the same in all the reactions we carry out during this experiment.

(P5bi) explains choice

Agitation (stirring) of the catalase enzymes and hydrogen peroxide molecules can affect the rate of the reaction because stirring increases the likelihood that the substrate molecules will come into contact with the active sites of the enzyme, and thus there is more chance that the hydrogen peroxide molecules will be broken down, thereby increasing the speed of the reaction. This is not the variable we are altering in this experiment, and so we must make sure that any agitation of the contents of the flask during the reaction is kept to a minimum in order to make sure that the experiment is a fair test. (P5bi)

Key factors (P3aii)

For each reaction, we will add 10ml of catalase solution to 10ml of hydrogen peroxide solution. Because the concentration of the catalase is the variable that we wish to vary, we add distilled water to 100% liquefied celery to make up the different concentrations. For example, if we want to use 100% concentration, then we simply add 10ml of celery extract to 10ml hydrogen peroxide solution. However, if we want to use 40% concentration, then we add 6ml of distilled water to 4ml of celery extract, then add that to the hydrogen peroxide solution. The concentration of hydrogen peroxide solution will remain at 10ml for each reaction so that the experiment is a fair test. We will be measuring the amount of each liquid using a syringe, thereby trying to minimise human error. We will also be collecting the oxygen product in a graduated gas tube, making it easy to measure the amount of gas which has been produced. A stopwatch will be used to measure the amount of time that has elapsed during each reaction.

✓ P5bi fully met

P7b accurate details for catalase concentration

The concentrations of catalase celery extract which we will use for each reaction will be 100%, 80%, 60%, 40%, 20% and 0% as a control experiment. Each reaction will be allowed to run for 30 seconds, and at the end of that time, the amount of oxygen which has been collected in the tube will be measured and recorded. Each reaction for each concentration will be repeated three times, and an average of these results will be taken in order to reduce inaccuracies. If there are any anomalous results which are a long way out of line when compared to the others, these will be discounted. In the case of an anomalous result, a further repeat of the reaction will be attempted, but only if time permits.

range (P3b)

P3b repeats ✓

✓ P3aii key factors

A preliminary test was carried out, along the same lines as this. Different concentrations of celery extract were added to hydrogen peroxide, and the height of the foam that was produced in 10 seconds was measured.

For (P5aii)

P1ai Suitable method

(P7aii) plan well linked to sku.

not structured so not fully met

Table to show the results of an experiment in which different concentrations of catalase were added to hydrogen peroxide solution

Conc. (%)	Celery (ml)	Water (ml)	H_2O_2 (ml)	Foam height (cm/10s)	Foam height (cm/s)
100	5	0	5	14.50	1.45
80	4	1	5	12.25	1.23
60	3	2	5	8.75	0.88
40	2	3	5	5.25	0.53
20	1	4	5	2.75	0.28
0	0	5	5	0	0

As you can see from this table, the greater the concentration of catalase, the greater the rate of the reaction, which proves that altering this variable alters the break-down of hydrogen peroxide. *Prelim. study (P5a'ii)*

P1a'ii Prediction

My prediction for this experiment is that as the concentration of the celery extract is increased, the rate of the reaction will increase as well. This means that when the concentration is increasing, the amount of oxygen product given off will increase as a result of this, and there will be a greater reading in the gas graduated measuring tubes. Using the results from the preliminary experiment (which were good results) I predict that the concentration of the celery extract is directly proportional to the rate of the reaction. I predict that with the control experiment (adding distilled water to hydrogen peroxide solution) no oxygen (or an extremely small amount) will be given off, and so there will be no reading in the gas measuring tube. *P3ai ✓* *P5a'ii fully met*

P5ai fully met

The reasoning behind my prediction is that as the concentration of catalase in the celery extract increases, there will be more enzymes, and thus more active sites for the hydrogen peroxide substrate molecules to bind with, and so more product will be produced more quickly and therefore the rate of the reaction will increase. As for the control experiment, because there is no catalase in distilled water, there will be no active sites for the hydrogen peroxide substrate molecules to bind with, and therefore the reaction will not take place. There may be a miniscule amount of oxygen collecting in the gas tube during the 30 second reaction for the control reaction, but if there is any, this will be a result of the hydrogen peroxide breaking down naturally in oxygen and water.

I think that this biological knowledge supports my prediction very well, and that according to this biological evidence, the results of my experiment should match my prediction.

As hydrogen peroxide is a very toxic compound, the utmost care must be taken to make sure that it doesn't get swallowed or enter the body in any other way. Safety goggles should be worn at all times when handling hydrogen peroxide and care must be taken that it does not get on the skin. If hydrogen peroxide does get on the skin, it must be washed off immediately. Oxygen is also flammable so therefore there should be no naked flames in the vicinity whilst the experiment is taking place. It must also be checked that the high concentrations of oxygen have dispersed before a naked flame is lit after the experiment taken place. After the reactions have been completed, hands must be washed, especially before eating anything.

P5a'iii Safety considered

Source of knowledge: OCR Biology 1 Textbook,
www2.kenyon.edu/depts/biology/BMB/chime/catalase/frames/cattx.htm
crystal.uah.edu/~carter/enzyme/catalase.htm

P5aii Secondary sources
P7aiii accurate spag

Skill 1 Implementing

P = 6
if subsections used then structured part of 7aii could be ok.

Two changes were made to the planned experiment before it was carried out. Owing to time restrictions, the reaction for each concentration was repeated twice, instead of three times as previously stated. Also, instead of using 10cm^3 catalase solution and 10cm^3 hydrogen peroxide, 5cm^3 of catalase solution and 5cm^3 hydrogen peroxide were used. This was due to the amount of each substance that was available, and also the more of each substance that is used, the more oxygen that will be produced, and this creates the possibility that too much oxygen will be given off for the gas tube to hold, and therefore the amount given off would not be measured correctly. Therefore I decided that using just 5cm^3 of each substance would give a better result.

|| True

No other changes were made to the planned experiment.

The experiment was carried out under the original plan but with the changes stated above. Two results were obtained for each concentration, and an average of both the results was taken and presented as a graph, and in the following table:

Table to show the results of the investigation into how concentration of the enzyme catalase in celery tissue alters the rate of reaction with hydrogen peroxide.

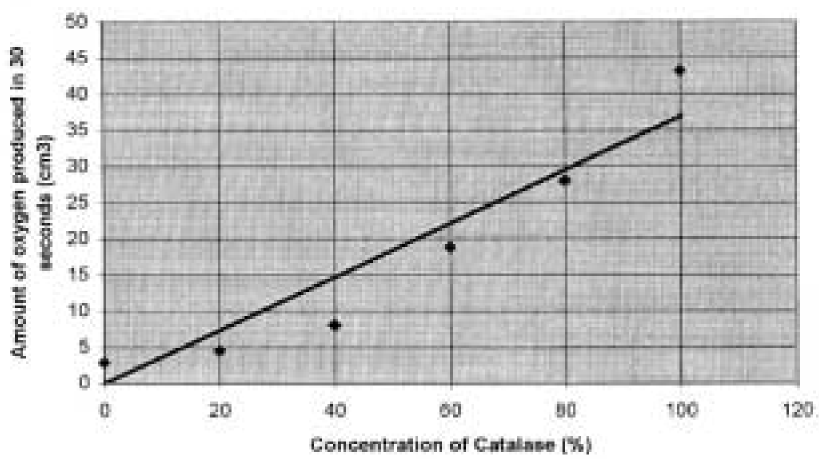
Concentration of catalase (%)	Amount of oxygen released in the 1st reaction (cm^3)	Amount of oxygen released in the 2nd reaction (cm^3)	Average (cm^3)
100	41.5	44.9	43.2
80	29.9	26.2	28.1
60	19.6	18.1	18.9
40	9.2	7.0	8.1
20	4.6	4.6	4.6
0	2.8	3.0	2.9

P7b accurate details

A1a data processed as averages

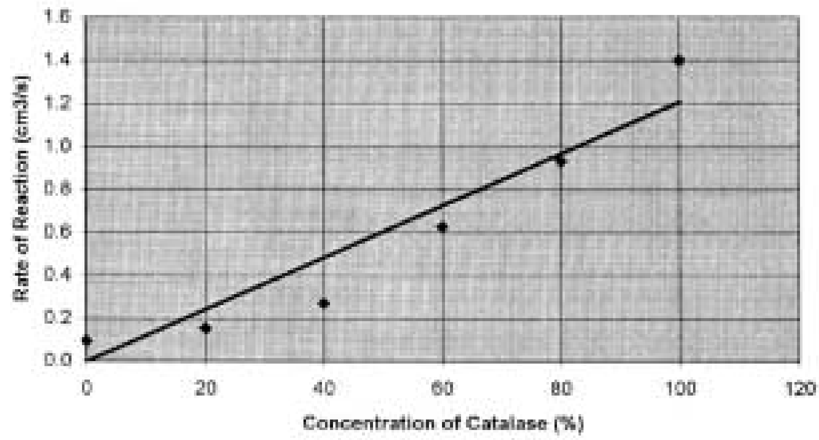
I = 7
using teacher tick list.

Graph to show the results of the investigation into how concentration of the enzyme catalase in celery tissue alters the rate of reaction with hydrogen peroxide



A3a approp. graphs

Graph to show the rate of reaction when different concentrations of catalase are added to hydrogen peroxide.



A5ai follows 10.8 guidelines

(A5aii) rates graphed

Skill A — Analysing Evidence and Drawing Conclusions

A1b Trend Identified

The results of this experiment were significant. As the concentration of catalase solution was increased, the volume of oxygen given off from the reaction increased as well. A table and graph were produced from the results of this experiment. From looking at the graph, you can see that as the concentration of catalase increased, the amount of oxygen produced increased. The results on the graph were shown with a line of best fit which was a diagonal straight line through the origin. When the concentration of catalase was just 20%, the average amount of oxygen produced in 30 seconds was 4.6cm^3. However when the concentration of catalase was increased to 80%, the average amount of oxygen produced in 30 seconds was 28.1 cm^3. This data proves that the amount of oxygen produced increases when the concentration of catalase increases.

The scientific explanation for these results is that catalase is an enzyme. Enzymes are biological catalysts. Enzymes catalyse virtually every metabolic reaction which takes place within a living organism. Enzymes are globular proteins which are coiled into a precise three-dimensional shape. Enzymes also have a special feature in the active site which they possess. The active site is a region, usually a depression in the enzyme to which another molecule or molecules can bind. This molecule is the substrate of the enzyme. The shape of the active site allows the substrate to fit perfectly, and to be held in place by temporary bonds which form between the substrate and some of the R groups of the enzyme's amino acids. This combined structure is termed the enzyme-substrate complex.

Each type of enzyme will usually act on only one type of substrate molecule. For example, catalase will only catalyse the break down of hydrogen peroxide. This is because the shape of the active site will only allow one shape of molecule to fit. The enzyme is said to be specific for this substrate.

The enzyme may catalyse a reaction in which the substrate molecule is split into two or more molecules. Alternatively, it may catalyse the joining together of two molecules. For example, catalase catalyses the reaction where hydrogen peroxide loses an oxygen atom to form water and oxygen. Interaction between the R groups of the enzyme and the atoms of the substrate can break or encourage formation of bonds in the substrate molecule, forming one, two or more products.

A5bi Conclusion consistent with data

When the reaction is complete the product or products leave the active site. The enzyme is unchanged by this process so it is now available to receive another substrate molecule. The rate at which substrate molecules can bind to the enzyme's active site, be formed into products and leave can be very rapid indeed.

By this scientific procedure catalase catalyses the break down of hydrogen peroxide in the following equation:

Hydrogen peroxide → (with catalase) Water + Oxygen

The concentration of the catalase enzyme affects the rate of the reaction because the higher the concentration of catalase, the more enzymes there are in a particular amount of catalase solution. This means that there are also more active sites for the hydrogen peroxide molecules to bind with and be broken down at any one time. This results in more hydrogen peroxide molecules being broken down into water and oxygen in a shorter time period, and therefore more oxygen would be produced in a set period of time than if a lower concentration of catalase was used.

This scientific evidence proves that as the concentration of catalase increases, the amount of oxygen produced from hydrogen peroxide in a set period of time increases as well.

In my prediction for this investigation I predicted that as the concentration of catalase increased, there would be more enzymes, and thus more active sites for the enzymes to bind with, and so more product would be produced more quickly and therefore the rate of the reaction would increase. I also predicted from looking at my preliminary experiment that the concentration of the catalase would be directly proportional to the amount of oxygen produced. A 5bii

I was correct in saying that the amount of oxygen produced would increase along with the concentration of catalase. The concentration of catalase is also directly proportional to the amount of oxygen produced because my graph of the results from this experiment shows a straight diagonal line through the origin. A 7bi
When the concentration of catalase was zero, there was still a small reading in the gas tube even though there would have been no active sites to break down the hydrogen peroxide. Although there was a small reading in the gas tube, no oxygen was released from the breakdown of hydrogen peroxide. The small reading was taken in the gas tube because when the mixture of catalase and hydrogen peroxide was put into the conical flask a small amount of gas in the flask would have been displaced by the liquid and then traveled through the tube out of the conical flask and up into the gas tube. This is why there is a small reading even though no oxygen would have been produced from the hydrogen peroxide. Conclusions well structured concise + compreh.

A 7ai appropr. sku

The rate of reaction was also measured for each concentration of catalase. This is the average amount of oxygen produced per second during the 30-second duration of the reaction. The following table shows the rate of reaction against the concentration of catalase.

<u>Table to show the rate of reaction when different concentrations of catalase are added to hydrogen peroxide</u>

Concentration of catalase (%)	Rate of reaction (cm^3/s)
100	1.4
80	0.935
60	0.628
40	0.27
20	0.153
0	0.0967

✓ A 5aii Rates calculated.
(not sign. figs. so not A 7bii)

A graph was made up of these results, and the best-fit line was at diagonal straight line through the origin. This shows that the rate of reaction is directly proportional to the concentration of catalase used. (The higher the concentration of catalase, the faster the rate of reaction, and vice-versa). Therefore, this data has proved that the higher concentration of catalase you use, the faster the burette will fill up with oxygen and so more will be collected in a shorter time period.

A 7bii accur. spag.

A = 6 as no A 7aii

(not 8 as lacks detail on H bonds etc needed at this level)

anomalies referred to E1b
(E3bii - n/applicable.

Skill E — Evaluating Evidence and Procedures

In my opinion, the method of carrying out the investigation was a good one. There were no anomalous results in the experiment. The method that was carried out was a safe one, and it yielded some good results. The errors of the experiment were that it was very difficult to stop the experiment and take a reading of how much oxygen had been produced at precisely 30 seconds without using expensive electronic equipment. Another error is that maybe not all of the oxygen produced from the hydrogen peroxide may have travelled up the gas tube. Some may have stayed in the conical flask whilst some may have managed to escape. This means that there is a possibility that not all of the oxygen that was given off was measured. Because of this, unless we use expensive electrical equipment to measure how exactly much oxygen is given off in an exact amount of time then the methods have some limitations, like the ones mentioned above. I think that my results were accurate. They were what I expected them to be, and I tried to keep the experiment a fair test as far as I possibly could. I also think that my results are reliable. When the reactions were repeated for a second time, the readings were no more than 3-4cm^3 different each time. Therefore I think that I must have taken accurate, reliable results, and this is backed up by the fact that there were no anomalous results.

E1a suitable

E3a main sources of error

E3bi accuracy

E5ai effect on results

E5bii evaluation of errors

E5bi reliability

I think possible ways in which my method could be improved are: taking more readings over a longer period of time (possibly every 30 seconds for up to 5 minutes), repeating the results more often in order to make it easier to spot anomalies and using more concentrations so that more results can be taken, there would be more points on the graph so the graph would be more accurate and errors could be spotted more easily.

E5aii improvements on method.

I think that overall my conclusion is very safe. I think this because my results were accurate and had a high level of reliability, I had no anomalous results. I realised the limitations of my method, and came up with a conclusion which matched my prediction (i.e. the concentration of catalase was directly proportional to the amount of oxygen produced in thirty seconds). Therefore overall I believe my conclusion to be a very sound one.

E = 5

Skill P – Planning **Total 8**

Candidate name: ______________________________ Number: ____________________

Mark		General strategy	Level		Choices within plan	Level
0						
1	P.1a	(i) Suggests a method that could be used to investigate the effect of concentration on catalase activity (i) Makes a prediction		P.1b	Chooses appropriate apparatus for investigating the effect of concentration on catalase activity	
2						
3	P.3a	(i) Uses relevant scientific knowledge and understanding to attempt to suggest a workable prediction (ii) Identifies key factors to control, vary or take account of e.g. temperature		P.3b	Chooses appropriate number and range of observations and/or measurements e.g. more than three concentrations giving a suitable range, repeats each concentration at least twice	
4						
5	P.5a	(i) Uses detailed scientific knowledge and understanding to justify the prediction e.g. ref to active sites, effect of enzyme concentration on rate of reaction (ii) Uses information from preliminary study or a secondary source (ii) Takes into account the need for safe working, e.g. eye protection; working with H2O2		P.5b	(i) Explains choice of equipment in order to produce evidence which is as precise and reliable as possible (ii) Uses specialist vocabulary to give a clear account	
6						
7	P.7a	(i) Retrieves and evaluates information from two or more sources (ii) Provides a plan, which is well structured, logical and linked coherently to underlying scientific knowledge and understanding (iii) Accurate spelling, punctuation and grammar throughout		P.7b	Provides accurate details of how the amount of catalase will be changed and how volume of oxygen released will be measured to ensure the highest degree of precision and reliability possible with the available apparatus	
8						

Skill I – Implementing **Total 7**

Candidate name: ______________________________ Number: ____________________

Mark		Manipulation	Level		Recording	Level
0						
1	I.1a	(i) demonstrates competence in simple techniques, e.g. gas collection apparatus (ii) shows some awareness of the need for safe working (e.g. eye protection)		I.1b	makes and records observations and/or measurements which are adequate for the activity, e.g. syringe readings and catalase concentration	
2						
3	I.3a	shows competence in conducting experiment by manipulating equipment with precision; technique observed by the teacher		I.3b	(i) makes systematic and accurate observations and/or measurements which are recorded clearly and accurately, e.g. candidate observed to measure and record times and/or volumes (ii) results collected and presented clearly and accurately	
4						
5	I.5a	(i) works carefully and confidently requiring no/limited assistance (ii) adopts safe working practices throughout, e.g. care with glassware, cleaning up any spillages and correct disposal of any chemicals		I.5b	(i) takes readings with precision and skill, e.g. teacher observation of candidates (ii) results recorded in a table using IoB guidelines, containing one or two minor errors	
6						
7	I.7a	skilful and proficient use of all techniques as demonstrated by - the results showing the correct trend		I.7b	(i) records observations with regard to the precision of the apparatus used (0.1cm3) (ii) results recorded in a table using IoB guidelines, no errors	

Using the IoB guidelines, tables should have an informative title, informative column headings, units only in the headings, units correctly expressed and no units in the body of the table.

Skill A – Analysing Evidence and Drawing Conclusions **Total 8**

Candidate name: ________________________________ Number: ____________________

Mark		Processing evidence	Level		Drawing conclusions	Level
0						
1	A.1a	is able to process data to obtain average times and/or volumes		A.1b	is able to identify any trends or patterns in the evidence, giving simple conclusions	
2						
3	A.3a	uses the processed data to present the evidence using the most appropriate line graph(s)		A.3b	links the processed data with a conclusion and links this to knowledge of enzymes (collision theory)	
4						
5	A.5a	(i) graph follows all IOB guidelines (see note below this table) (ii) uses an appropriate numerical technique – e.g. 1/t for rate		A.5b	(i) conclusion(s) are consistent with the processed data (ii) produces a clear account using specialist vocabulary as appropriate	
6						
7	A.7a	(i) uses appropriate detailed scientific knowledge and understanding (at AS) – e.g. effect of enzyme concentration (ii) shows due regard to nomenclature, terminology and the use of significant figures (means to same accuracy as data collected)		A.7b	(i) conclusions well structured, comprehensive and concise (ii) accurate use of spelling, punctuation and grammar.	
8						

Using the IoB guidelines, graphs should have an informative title, fully informative column headings, units correctly expressed and the independent variable on the x-axis, axes correctly scaled and points accurately plotted.

Skill E – Evaluating Evidence and Procedures **Total 7**

Candidate name: ______________________________ Number: ____________________

Mark		Evaluating procedures	Level		Evaluating evidence	Level
0						
1	E.1a	comments, in general terms, on the suitability of the experimental techniques used		E.1b	recognises where the results may be anomalous	
2						
3	E.3a	recognises main sources of error in the techniques used, e.g. problems with downward displacement of water as a means of measuring the volume of gas produced, volume of liquid added displaces air, loss of gas at start		E.3b	(i) comments on the accuracy of measurements made, e.g. use of syringe for measuring volume, use of stopwatch (ii) suggests reasons for any anomalous results	
4						
5	E.5a	(i) recognises how errors in technique will affect the experimental result, e.g. method of gas collection, variability in source of catalase (ii) suggests methods of improvement or precautions to regulate errors		E.5b	(i) comments on the reliability of the evidence, e.g. compares the difference between the two readings for each concentration (ii) evaluates the main sources of error	
6						
7	E.7a	justifies proposed improvements to the experimental procedures and/or strategy in terms of increasing reliability of evidence and minimising significant sources of error, e.g. use of a gas syringe, measuring rate over shorter time span		E.7b	assesses the significance by which any uncertainties in the evidence may affect the validity of the conclusions drawn	

Investigating the effect of enzyme concentration on the rate of breakdown of hydrogen peroxide by catalase

Experiment title:		Date:
	Level	Description of task
1	*I.1(a)i*	*Shows competence using syringes, assembling apparatus*
2	*I.1(a)ii*	*Wears safety glasses*
3	*I.1(b)*	*Adequate number of measurements made and recorded – e.g. 5 different concentrations of catalase and some repeats*
4	*I.3(a)*	*Shows competence in using apparatus to gain results of appropriate level of precision*
5	*I.3(b)i*	*Shows a systematic approach to the measurements that are taken – uses catalase concentrations in systematic manner*
6	*I.3(b)ii*	*Table presented clearly and accurately during experiment* *Table shows concentration and volume of oxygen released*
7	*I.5(a)i*	*Shows confidence in using apparatus to gain results*
8	*I.5(a)ii*	*Safe working practices followed throughout*
9	*I.5(b)i*	*Results taken skilfully – volume of oxygen recorded to nearest 0.5* cm^3
10	*I.5(b)ii*	*All results recorded in a table (one of two minor errors) – title, units, headings etc – see IoB guidelines*
11	*I.7(a)*	*All aspects of the investigation (including prior preparation) carried out skilfully*
12	*I.7(b)i*	*Results taken and recorded to appropriate degree of precision – recorded volume of oxygen to nearest 0.1* cm^3
13	*I.7(b)ii*	*Results recorded in a table, no errors – see IoB guidelines*
Descriptors in italics – recorded by teacher observation during the practical classes		

Candidate Name:	Marking points at various levels														
	1	2	3	4	5	6	7	8	9	10	11	12	13		
Smith	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Jones	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓	✗		

Activity 2: Coursework Marking Exercise

The student carried out the same investigation as in Activity 1. This piece of coursework has not been annotated. Teachers may use this for internal moderation within their departments.

The Task

1. Mark the piece of coursework using the mark schemes on pages 69 to 72.
2. Come to a final decision on the award of marks for all four skills based on the evidence provided. Use the entry for ‘Jones’ on the tick sheet for assessing the mark for Skill I (see page 60).
3. Compare your decision with the commentary on page 100.

Investigation into how the concentration of the enzyme Catalase affects the rate of reaction with Hydrogen Peroxide

This investigation will look into how the concentration of the enzyme Catalase in celery tissue affects the rate of reaction when breaking down hydrogen peroxide (H2O2)

Enzymes are protein molecules which act as catalysts in biological reactions. Enzymes have an active site which is specifically shaped to receive a certain substrate, the substrate binds to the active site whilst the reaction takes place. When complete, the enzyme remains unchanged and can receive another substrate. Enzymes can react with substrates very rapidly, in the case of Catalase and hydrogen peroxide the rate is l07 molecules a second for each enzyme. Therefore if the number of enzymes is increased (increasing the concentration of Catalase) then the reaction will happen more rapidly as there are a greater number of active sites and therefore more molecules of hydrogen peroxide can be broken down at one time.

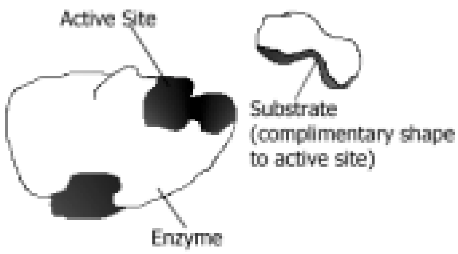
It is the job of the liver to break down any harmful poisons that may be absorbed with food or produced as a waste product by the body. The liver contains a large number of enzymes, each capable of detoxifying one particular poison one such enzyme is Catalase. Catalase breaks down the highly toxic hydrogen peroxide into harmless water and oxygen.

Catalase + Hydrogen Peroxide → Water + Oxygen

Hydrogen peroxide is an active chemical that is formed continually as a by-product during chemical reactions in living cells. It is highly toxic and if it was not broken down by the cells immediately then it would destroy them that is why Catalase is an important enzyme, it is the fastest known enzyme.

Catalase can be found within the liver of mammals and within celery. Celery will be used for this experiment, as it is less messy to handle and can be liquidised to yield a high proportion of Catalase extract.

I predict that as the concentration of Catalase increases, the rate of reaction will also increase e.g. the amount of oxygen produced in a given time will be greater for the reactions with a higher concentration of Catalase than the reactions with a lower concentration of Catalase. I predict that this will be the case as enzymes are complimentary to the substrates that they break down, they have an active site that is usually a cleft. As the enzymes and substrate move around, their interactions are purely random and the substrate will lock into the active site of the enzyme forming a complex. This is known as the lock and key method. When in the active site the substrate will bind with the R groups of the amino acid, e.g. –CH2. Whilst combined with the enzyme the substrate is broken down, in this case the hydrogen peroxide is broken down into oxygen and water.



Therefore if there are more enzymes in the reaction then there are more available active sites onto which a hydrogen peroxide molecule can attach and be broken down, the increase in enzymes also increases the random collisions that occur, which will also speed up the rate of reaction.

N.B. the final amount of oxygen produced will be the same as the same amount of hydrogen peroxide is being used in each.

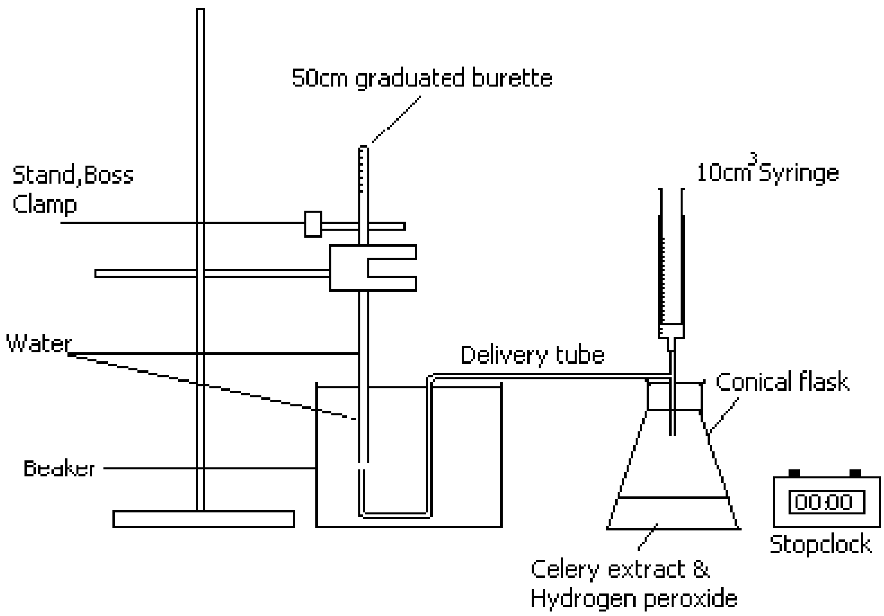
The Apparatus to be used in this experiment is as follows:

- Graduated Burette — for collecting the oxygen that will be given off during the experiment. A 50cm3 burette will be used, as this was sufficient during the pilot experiment.
- Conical Flask — For containing the celery extract and hydrogen peroxide during the experiment. Useful apparatus as a hung can be placed in the top with a delivery tube to stop oxygen escaping.
- Syringe — To accurately measure the amount of celery extract and hydrogen peroxide being used in the experiment.
- Stand, Boss and Clamp — For holding the burette in place during the duration of the experiment.
- Stop Clock — For measuring the time taken for the experiment, which will be one minute.
- Beaker — to contain water and the burette filled with water so that none of the water from the burette is displaced.

Method:

Apparatus set up:

- The apparatus will be set up as shown in the diagram.



- The celery extract will be made up into the required concentration using the 100% celery solution. This was prepared by firstly bomogenising the celery and then draining it through muslin.
- The 100% solution will be mixed with distilled water to make the necessary concentrations.
- A selected concentration will then be added to the conical flask
- A bung with the delivery tube in it will be placed in the top of the conical flask with an additional tube for the attachment of a syringe.
- The burette and a large beaker will then be filled with water and the burette placed in the beaker so as not to displace any of the water. A boss and clamp will hold the burette in place.
- The conical flask and delivery tube will then be arranged so that the end of the delivery tube enters the burette slightly so as to allow the oxygen to displace the water within it.
- The syringe will then be used to accurately measure 10cm3 of hydrogen peroxide.
- The syringe will then be placed in the tube entering the conical flask, as soon as it is depressed the stopwatch will be started.
- The experiment will be stopped after exactly one minute and the amount of oxygen collected will be recorded in a table, so that the results can be plotted on a graph.
- Once all of the concentrations have been tested, the experiment will be repeated a further two times so that an average result can be obtained.

The concentrations and ranges that will be used in the experiment are as follows:

The celery extract concentrations will range from 2% to 10% in 2% intervals.

2% concentration
4% concentration
6% concentration
8% concentration
10% concentration

It is important to consider safety during the experiment, as hydrogen peroxide is being used, Safety goggles must be worn at all time and precaution will be taken to avoid spilling or splashing the hydrogen.

During the experiment there are a number of other variables that could affect the results and therefore will need to be kept constant.

- Stirring/Agitation. This will aid the random movement of the substrate and enzymes within the solution and so will need to be kept constant, I have decided not to stir the solution, as this is the best way to keep it constant.
- The amount of Hydrogen peroxide will need to be kept constant, as varying this would dramatically alter the results. Therefore an accurate syringe will be used to measure out exactly 10cm3 of hydrogen peroxide every time.
- The temperature must be kept constant as temp influences the activity of enzymes; the rate will increase up to a certain point until the enzyme becomes denatured. In order to keep the temperature constant it will be conducted at room temperature.
- Pressure will affect the results of the experiment, this is difficult to keep constant, but the experiment will be carried out at room pressure, which will not be subjected to any large pressure changes.

Obtaining Results

Experiment 1

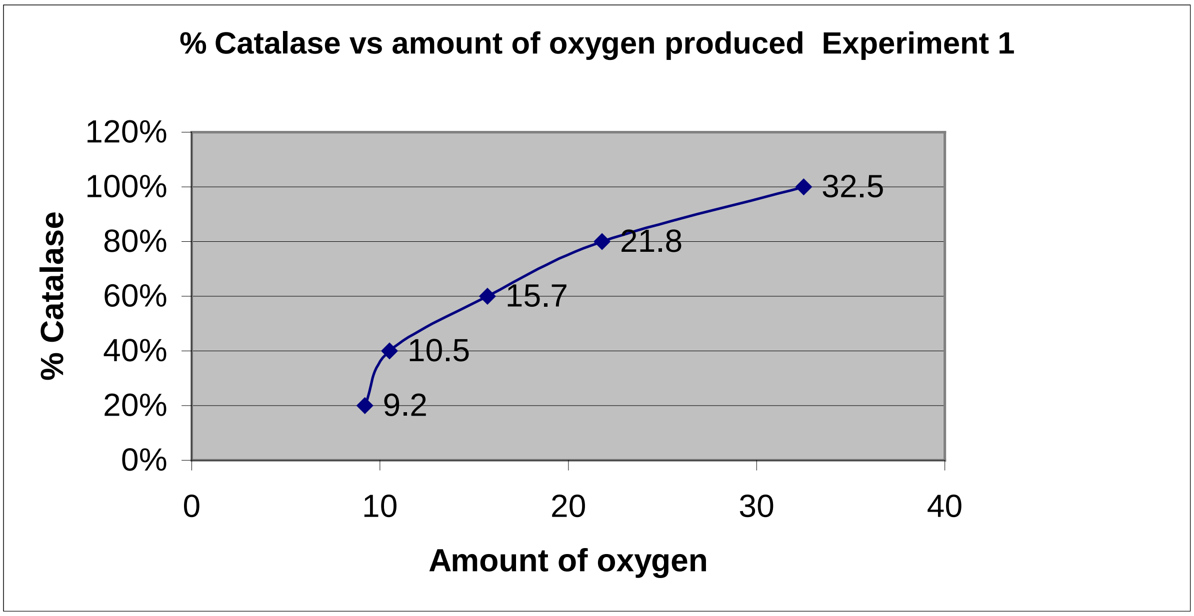
% catalase	Amount of water at start	Amount of water at finish	Amount of oxygen produced
20%	49.3	40.1	9.2
40%	49.0	38.5	10.5
80%	49.2	27.4	21.8
100%	49.3	16.8	32.5

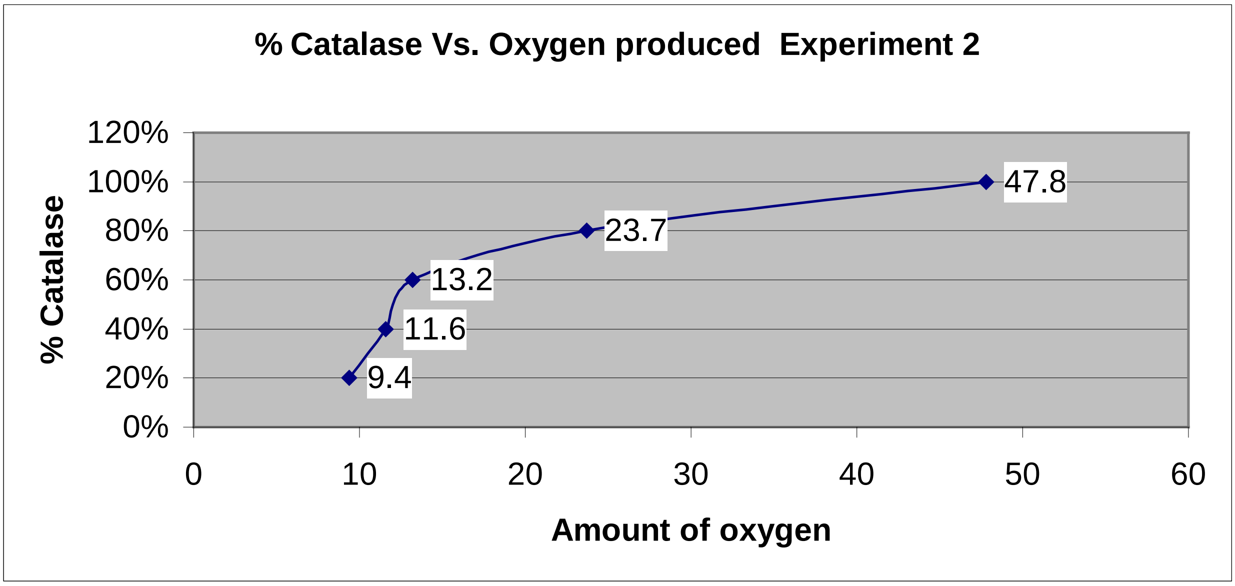
Experiment 2

% catalase	Amount of water at start	Amount of water at finish	Amount of oxygen produced
20%	49.8	40.4	9.4
40%	49.5	37.9	11.6
68%	49.2	36.6	13.2
80%	49.9	21.2	23.7
100%	49.7	1.9	47.8 – anomalous

Average

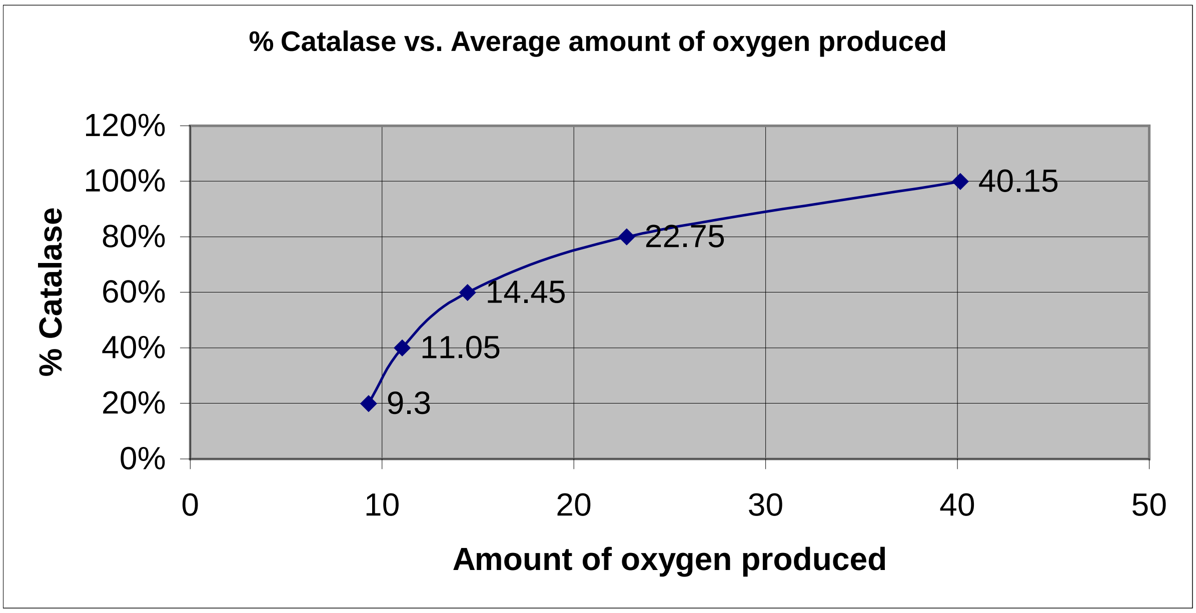
% catalase	Amount of water at start	Amount of water at finish	Amount of oxygen produced
20%	N/A	N/A	9.3
40%	N/A	N/A	11.05
60%	N/A	N/A	14.45
80%	NA	NA	22.75
100%	NA	NA	40.15





One anomalous result was obtained as identified for 100% catalase in experiment 2. This was obtained because when the experiment reached this stage, the homogenized celery ran out and a new batch was used. The new batch proved to be more concentrated than the original and therefore produced a more rapid reaction, releasing more oxygen. For this reason in the Graph of averages below, instead of using an average for the 100% catalase, the result from experiment one will be used to give a more accurate graph.

Originally in the planning section I decided that I would run each experiment for one minute, but during the experiment I found this to be too long as the amount of oxygen produced was too much to measure. I therefore reduced the time that each experiment was run to 25 seconds.



As can be seen from the graph, as the concentration of catalase increases so does the rate of reaction and therefore the amount of oxygen produced in the time that the experiment was left to run. The rate of reaction increases more greatly with the lower concentrations, e.g. 20%, 40% and 60% and the curve of the graph becomes less steep with the higher concentrations, due to the fact that there may be more active sites than substrates and so rate of reaction cannot increase.

The results displayed in the graph show a strong positive correlation between the concentration and rate of reaction. This was what was originally predicted in my hypothesis. As the concentration increased, so did the amount of oxygen produced, the greatest amount of oxygen produced was 32.5cm3 for the 100% catalase. The graphs produced and the tables in the previous section of this write up show clearly this statement and it can be seen that the amount of oxygen produced for 20% was barely anything compared to the 100% catalase.

The reaction rate increased with the concentration because there was more of the enzyme catalase available to react with the substrate; therefore there were more active sites and a greater chance of collisions between the enzyme and substrate as the concentration increased. Enzymes lower the activation energy needed for a reaction to take place and therefore aid the rate of reaction. As more enzymes are present, more active sites are also present, allowing a greater number of reactions to take place at one time.

These factors would have an obvious effect on the rate of reaction this is supported by the increase in the amount of oxygen produced increasing for overtime the percentage of catalase increases. It can therefore be taken to be true that a higher concentration of catalase results in a greater rate of reaction

Evaluating Evidence and Procedures:

The experiment was performed to the best of my ability and everything possible was done to maintain a good operating procedure in order to gain accurate results. However there were unseen problems in the method of the experiment and the apparatus used.

- When pouring the catalase from the boiling tube into the conical flask some of the catalase may have been left behind if it adhered to the sides of the tube. This would affect the results, as different amounts would be left each time and therefore affecting the volume and concentration being used.
- When inserting the delivery tube into the beaker and under the burette water entered the end of the delivery tube and the oxygen had to displace this water before it could begin displacing the water in the burette. This would therefore affect the results, as the correct amount of oxygen being produced would not be measured.
- When using the syringe to insert the hydrogen peroxide through the insertion tube, some of it was left in the insertion tube and the end of the syringe; this was noticed as when the syringe was removed the oxygen pushed the hydrogen peroxide up and out of the insertion tube. This would mean that a uniform amount of hydrogen peroxide would not be being used each time and therefore would affect the rate of reaction.
- When timing the reaction, it was hard to stop the reaction exactly on 25 seconds, sometimes as the timer reached 25 seconds, there were numerous bubbles in the burette, and it is hard to take the rending on the burette as the level of water in it is decreasing rapidly. Therefore sometimes the exact measurement was not clear and had to be estimated, which would have affected the line of best fit on the graph if the results were not exact
- Between each experiment, the apparatus was washed, to prevent any contamination, but the conical flask could not be dried and therefore some water was left inside it and inside the delivery tube, this may therefore have diluted the solution and affected the results.

- During the experiment it was possible that with all of the movement around the laboratory, that the table on which the experiment was taking place may have been jogged, which would therefore agitate the solution and increase the possibility of collisions between the enzymes and substrate, so biasing the results.

One anomalous result was obtained; this is identified in the table in the obtaining evidence section. This was obtained because during the experiment, the celery extract ran out and had to be replaced. The second lot of celery came from a different batch and was noticeably different in colour and it was alot more concentrated, as the amount of oxygen produced was too much to measure.

Bibliography:

Letts — Revise AS — Biology   Letts 2000

Advanced Sciences — Biology 1 OCR Cambridge 2000

Skill P – Planning **Total 8**

Candidate name:________________________ Number: ________________

Mark		General strategy	Level		Choices within plan	Level
0						
1	P.1a	(i) Suggests a method that could be used to investigate the effect of concentration on catalase activity (i) Makes a prediction		P.1b	Chooses appropriate apparatus for investigating the effect of concentration on catalase activity	
2						
3	P.3a	(i) Uses relevant scientific knowledge and understanding to attempt to suggest a workable prediction (ii) Identifies key factors to control, vary or take account of e.g. temperature		P.3b	Chooses appropriate number and range of observations and/or measurements e.g. more than three concentrations giving a suitable range, repeats each concentration at least twice	
4						
5	P.5a	(i) Uses detailed scientific knowledge and understanding to justify the prediction e.g. ref to active sites, effect of enzyme concentration on rate of reaction (ii) Uses information from preliminary study or a secondary source (ii) Takes into account the need for safe working, e.g. eye protection; working with H2O2		P.5b	(i) Explains choice of equipment in order to produce evidence which is as precise and reliable as possible (ii) Uses specialist vocabulary to give a clear account	
6						
7	P.7a	(i) Retrieves and evaluates information from two or more sources (ii) Provides a plan, which is well structured, logical and linked coherently to underlying scientific knowledge and understanding (iii) Accurate spelling, punctuation and grammar throughout		P.7b	Provides accurate details of how the amount of catalase will be changed and how volume of oxygen released will be measured to ensure the highest degree of precision and reliability possible with the available apparatus	
8						

Skill I – Implementing **Total 7**

Candidate name: ________________________________ Number: ____________________

Mark		Manipulation	Level		Recording	Level
0						
1	I.1a	(i) demonstrates competence in simple techniques, e.g. gas collection apparatus (ii) shows some awareness of the need for safe working (e.g. eye protection)		I.1b	makes and records observations and/or measurements which are adequate for the activity, e.g. syringe readings and catalase concentration	
2						
3	I.3a	shows competence in conducting experiment by manipulating equipment with precision; technique observed by the teacher		I.3b	(i) makes systematic and accurate observations and/or measurements which are recorded clearly and accurately, e.g. candidate observed to measure and record times and/or volumes (ii) results collected and presented clearly and accurately	
4						
5	I.5a	(i) works carefully and confidently requiring no/limited assistance (ii) adopts safe working practices throughout, e.g. care with glassware, cleaning up any spillages and correct disposal of any chemicals		I.5b	(i) takes readings with precision and skill, e.g. teacher observation of candidates (ii) results recorded in a table using IOB guidelines, containing one or two minor errors	
6						
7	I.7a	skilful and proficient use of all techniques as demonstrated by - the results showing the correct trend		I.7b	(i) records observations with regard to the precision of the apparatus used. (0.1cm3) (ii) results recorded in a table using IOB guidelines, no errors	

Using the IoB guidelines, tables should have an informative title, informative column headings, units only in the headings, units correctly expressed and no units in the body of the table.

Skill A – Analysing Evidence and Drawing Conclusions **Total 8**

Candidate name: ______________________________ Number: ____________________

Mark		Processing evidence	Level		Drawing conclusions	Level
0						
1	A.1a	is able to process data to obtain average times and/or volumes		A.1b	is able to identify any trends or patterns in the evidence, giving simple conclusions	
2						
3	A.3a	uses the processed data to present the evidence using the most appropriate line graph(s)		A.3b	links the processed data with a conclusion and links this to knowledge of enzymes (collision theory)	
4						
5	A.5a	(i) graph follows all IoB guidelines (see note below this table) (ii) uses an appropriate numerical technique – e.g. 1/t for rate		A.5b	(i) conclusion(s) are consistent with the processed data (ii) produces a clear account using specialist vocabulary as appropriate	
6						
7	A.7a	(i) uses appropriate detailed scientific knowledge and understanding (at AS) – e.g. effect of enzyme concentration (ii) shows due regard to nomenclature, terminology and the use of significant figures (means to same accuracy as data collected)		A.7b	(i) conclusions well structured, comprehensive and concise (ii) accurate use of spelling, punctuation and grammar	
8						

Using the IoB guidelines, graphs should have an informative title, fully informative column headings, units correctly expressed and the independent variable on the x-axis, axes correctly scaled and points accurately plotted.

Skill E – Evaluating Evidence and Procedures **Total 7**

Candidate name: ______________________________ Number: ____________________

Mark		Evaluating procedures	Level		Evaluating evidence	Level
0						
1	E.1a	comments, in general terms, on the suitability of the experimental techniques used		E.1b	recognises where the results may be anomalous	
2						
3	E.3a	recognises main sources of error in the techniques used, e.g. problems with downward displacement of water as a means of measuring the volume of gas produced, volume of liquid added displaces air, loss of gas at start		E.3b	(i) comments on the accuracy of measurements made, e.g. use of syringe for measuring volume, use of stopwatch (ii) suggests reasons for any anomalous results	
4						
5	E.5a	(i) recognises how errors in technique will affect the experimental result, e.g. method of gas collection, variability in source of catalase (ii) suggests methods of improvement or precautions to regulate errors		E.5b	(i) comments on the reliability of the evidence, e.g. compares the difference between the two readings for each concentration (ii) evaluates the main sources of error	
6						
7	E.7a	justifies proposed improvements to the experimental procedures and/or strategy in terms of increasing reliability of evidence and minimising significant sources of error, e.g. use of a gas syringe, measuring rate over shorter time span		E.7b	assesses the significance by which any uncertainties in the evidence may affect the validity of the conclusions drawn	

Activity 3: Formative assessment

Students often find it hard to appreciate what is required of them when they start a piece of coursework. AS coursework was designed to lead on from GCSE, so students may understand the hierarchical nature of the scheme, but will not appreciate how the different descriptors will influence how they plan, carry out, analyse and evaluate their work.

This Activity is designed to be used with students before they start their AS coursework. Often it is useful for students to read and criticise a piece of coursework before they start their own. This helps them to understand what is expected of them. In the example on page 74, a student has completed an investigation on water potential, but does not score well. A mark scheme is provided in Appendix 3.

The Task

1 Set the students the task of checking the coursework using the check list on pages 77 to 79.

2 Discuss with the students ways in which the candidate could have improved the work to gain higher marks.

3 Consider how this exercise has improved each student's understanding of what he or she is required to do in order to reach a higher standard.

The check lists on pages 77 to 79, together with the skills descriptors for Skills P, A, I and E, could be used at a later date to give candidates feedback on their work at a draft stage. Such feedback should only be of a generic nature. Candidates could be set the task of reading through their work and ticking the appropriate boxes in the check lists. Teachers could check the work against the candidate's own assessment.

There is a commentary on the work on page 102.

Contextualised mark schemes for this activity were published in the first edition of these Coursework Guidance notes and are included in Appendix 3. Candidates should not see these contextualised mark schemes until their work is returned after marking.

It should be emphasised here that work should not be marked and returned to candidates for further improvement (see FAQ 19 in Appendix 1).

AS Biology Practical

Water potential

Aim

To find out which water potential is the same as the water potential in the potato.

Water potential is the chemical potential of water and is a measure of energy available for reaction or movement. Water will move by osmosis into and out of cells due to the differences in water potential between the cell and it surroundings.

- Water always moves from high water potential to low water potential.
- Distilled water has a water potential of 0.
- When you add more solute the water potential decreases.
- When there is more pressure it increases the water potential.

Osmosis

Osmosis is regarded as a special type of diffusion involving water molecules or other solvents through a semi-permeable membrane. Remember that:

Solute + solvent = solution

In a sugar solution for example the solute is sugar and solvent is water. Although the plasma membrane of a cell is fully permeable to respiratory gases it's by no means permeable to all substances. In cells, water moves by osmosis to an area where water potential is lower from an area of higher water potential.

The formula for water potential is

Water potential = osmotic potential + pressure potential

How this works in a plant cell

Water will move by osmosis into and out of the cells due to the differences in water potential between the cell and its surroundings. Water potential is especially important in plant cells. Unlike animal cells plant cells are surrounded by cell walls which are very strong and rigid. If the water potential in the solution than in the plant cell the water will enter through a partially permeable membrane by osmosis just like the animal cell the volume of the cell increases but the plant cell the protoplasts start to push on the cell wall. Pressure starts to build up rapidly. This is known as the pressure potential and it increases the water potential of the cell until it equals the water potential outside the cell. The cell wall prevents the cell from bursting.

The variables that affect osmosis and how they affect it.

- The concentration of the solution - as the water moves from a high water potential to a low water potential. If the potential of the solution is higher than the water potential in the cell the water will move until the potential in the cell is equal to the potential in its surroundings.
- Time left in the solution - if it has a short time in the solution then it will have less time to change the water potential. Therefore this cannot be a fair test as it will not show clear results due to the fact osmosis has not had time to occur.

Variables that need to stay the same

- Weight of potato cylinders - weigh them before the experiment to ensure they are all the same weight. This way it is easier to compare the changes in weight after the experiment.
- Time left in the solution - start the whole of the experiment at the same time so they have all been in the solutions the same amount of time. This way you can get clear results.
- Apparatus - keep the same apparatus to make it a fair test. That way the results can not be effected by the apparatus being different.

Variables that need to change

- Concentration of solution - use different solutions each time.

What you will need to record

- You will need to measure the weight of the potato before and after the experiment.

Prediction

I predict that the potato with the least rise will have the higher water concentration. As the solution is has equal water potential to the cell therefore the change in weight will be minimal as the water potentials are equal so no water will have to move.

I found that by using a range of concentrations the experiment would make it a clearer 3 times. I decided to do each concentration three times as this made it a fairer test. I also put three potato cylinders in each test-tube.

Method

The apparatus are:

test tubes
bungs
test tube rack
potato cylinders
solutions

1 Get apparatus ready.

2 20cm of the different solutions put into test tubes ensure that test tubes are labeled so different concentrations are not muddled.

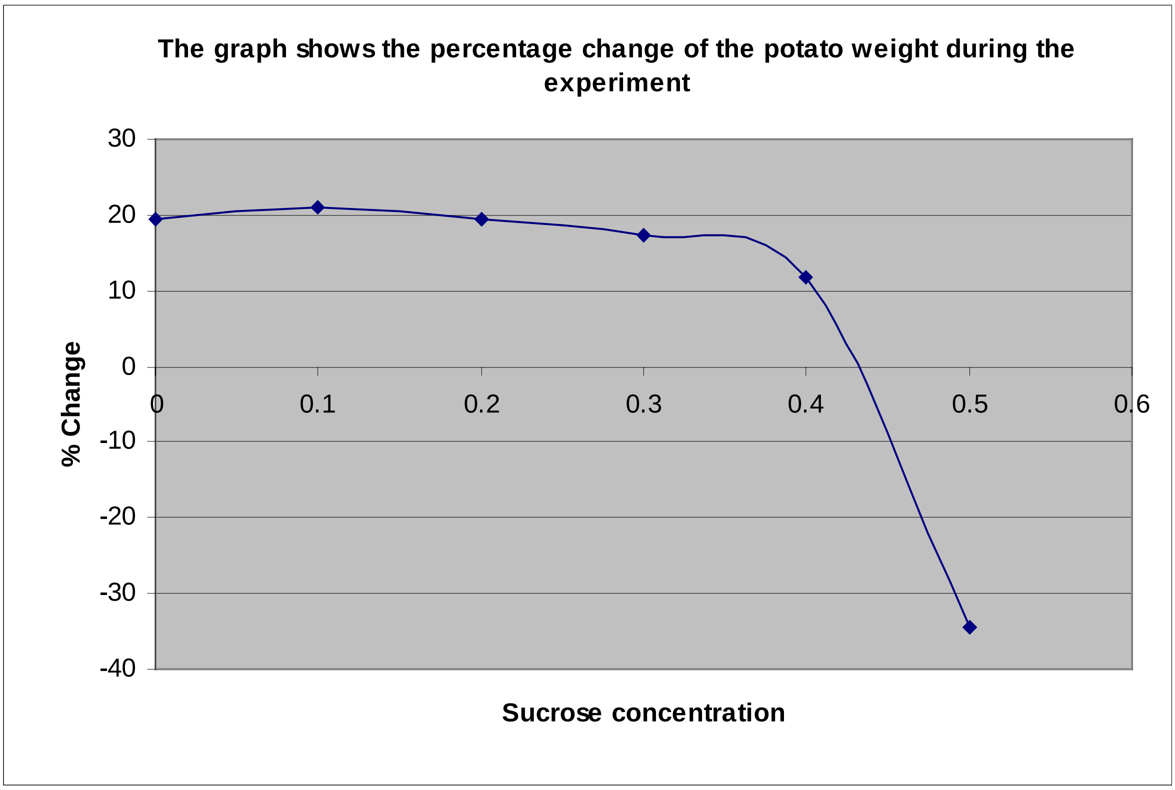
3 Cut 44 potato cylinders. Weigh all the potato cylinders to ensure they are all the same weight and size and put 3 in each test-tube.

4. Put bungs on test tubes.

5. Leave potato cylinders in solution for 24 hours.

6. Weigh potato cylinders again.

	The potato cylinders weight in grams (g)				
Concentration of solutions	Experiment 1	Experiment 2	Experiment 3	Average	Percentage change
0.0	1.49	1.51	1.46	1.49	19.5
0.1	1.58	1.48	1.51	1.52	21.1
0.2	1.53	1.48	1.45	1.49	19.5
0.3	1.48	1.42	1.44	1.45	17.2
0.4	1.39	1.33	1.35	1.36	11.8
0.5	1.18	1.16	1.15	1.16	-34.5



Conclusion

The graph shows that as the concentration of the sucrose decreases the amount of weight increases. This is showing that the water potential is decreasing. On most of the concentrations there is weight gained except for 0.5 as this has lost weight, which shows that the water potential is low. This is showing that the concentration of the 0.5 solution was very low which then caused the water potential in the cell to lower to equal the water potential of its surroundings. My results fit my conclusion as the weaker the solute the higher the water potential.

Evaluation

The method I chose was suitable for the information I needed to find out as I conducted each experiment three times which enabled me to be able to create a fair test. Most of the points on my graph are following a descending line except the second point (0.2) as this shows there may have been an error due to it not running in the pattern. The points on my graph basically follow the line of best fit. We could reduce the effect of experimental errors by doing each experiment more than three times that way there are more of a range of results to find the average results from. I could improve the accuracy of my results by using more potato cylinders when it comes to weighing them at the end so there would be more of a range which would show a clearer test and it therefore would be more accurate.

Student Check list for Planning

Descriptor	What you think the descriptor means for this investigation	Is this completed?
Designed a strategy that will give suitable results	*Put potato cylinders into water and several different sucrose solutions*	
Designed a fair test		
Made a Prediction		
Supported the prediction with appropriate AS K&U		
Given a method which someone else could follow		
Identified variables and stated how these are controlled		
Done a risk assessment		
Given a suitable range of values for your input variable		
Given a suitable number of values for your input variable		
Explained how you will obtain reliable results		
Written about and used your preliminary work in your plan		
Explained how you will obtain precise results		
Explained how results will be taken and recorded		
Explained how results will be analysed / treated mathematically		
Used and given details of secondary sources		
Justified the design of your plan and choice of apparatus		

Teacher's Comments

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Student Check list for Analysing

Descriptor	What you think the descriptor means for this investigation	Is this completed?
Processed your results	*Calculated means from results*	
Given a trend and a simple conclusion		
Presented your results (e.g. in form of a graph)		
Quoted selected results in your conclusions		
Used appropriate AS K&U in making conclusions		
Used a mathematical method (other than means) to process results		
Given conclusions that agree with results		
Used detailed K&U in explaining results		
Used appropriate terms in conclusions		
Made some deductions from processed results		
Used significant figures appropriately throughout		

Teacher's Comments

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Student Check list for Evaluating

Descriptor	What you think the descriptor means for this investigation	Is this completed?
Made a comment on how suitable your procedure was for the investigation		
Identified anomalous results (on table, graph or in text) or stated that there are no anomalous results		
Identified some limitations in experimental procedure		
Explained how limitations may have led to errors		
Made a comment on accuracy, e.g. precision of results taking		
Suggested reason(s) for anomalous results		
Suggested improvements (linking these to limitations)		
Commented on reliability of results by checking all replicates		
Explained which are important sources of error	Most of the error in the results is caused by poor cutting and trimming of potato cylinders and poor measuring	
Explained how suggested improvements will increase reliability		
Explained effect of limitations and errors on validity of conclusions		

Teacher's Comments

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Activity 4: Designing contextualised mark schemes for A2 coursework

In this exercise you are asked to consider two practical exercises and 'contextualise' the marking descriptors by deciding what you would look for in each exercise. This activity is designed to consider the skills descriptors in Skills P and A at levels 3, 5 and 7 that are of a synoptic nature.

The Task

Read the information provided for each practical exercise.

Skill P - Lipase investigation
Complete the right hand column for Skill P on page 89 to give examples of the type of response expected for each of the descriptors, especially those at levels 3, 5 and 7.

Skill A – Dogwhelk investigation
Complete the right hand column for Skill A on page 99 to give examples of the type of response expected for each of the descriptors, especially those at levels 3, 5 and 7.

Exercise 1.

Investigating the effect of a chosen factor on the activity of lipase.

(Skill P only)

Context:

The candidates had been taught Section 5.9.1 of the Mammalian Physiology and Behaviour Option (2805/05). They carried out a class practical on the digestion of fat involving lipase and bile salts. They were reminded about how to use a pH meter. They were then set the task of planning an investigation into the effect of one factor on the activity of lipase in digesting fat. It was expected that candidates would draw on information from Sections 5.1.2 (Biological Molecules), 5.1.3 (Enzymes), 5.1.4 (Cell Membranes and Transport) of Module 2801 when writing their plans. The activity is set in the context of learning outcomes 5.9.1 (b), (c), (f) and (i).

(b) explain what is meant by the terms…..digestion.

(c) distinguish between mechanical and chemical digestion.

(f) describe the structure of the ileum and its function on digestion and absorption.

(i) state the site of production and action and explain the functions of….lipase and bile salts.

The candidates were expected to use this information from the A2 Module in their plans.

Exercise 2

Studying the dogwhelk population on a rocky shore.

(Skill A only)

Context:

The candidates attended a field course in South Wales and studied rocky shore ecology. They carried out several investigations following instructions provided by the field centre. They were then set the task of carrying out a project on one organism. This candidate chose to study the relationship between shell length and aperture in the dogwhelk populations on two shores: an exposed shore and a sheltered shore. It was expected that candidates would draw on information from the following sections of the AS and A2 specifications:

5.1.7 (Energy and Ecosystems) – particularly the concept of niche;

5.4.3 (Populations and Interactions) e.g. predator prey relationships and competition for resources;

5.4.5 (Classification, Selection and Evolution) e.g. adaptation and selection;

5.7.1 (Ecological Fieldwork) e.g. use of statistical tests (5.7.1 (l)).

Action of the concentration of lipase on the digestion of fat

Introduction

The fat in question here is a triglyceride. This consists of three fatty acids chains, each attached at one end to a glycerol molecule. A fatty acid contains a long hydrocarbon chain with a carboxyl group at one end. This carboxyl group is what joins the fatty acid to the glycerol molecule, and it does so with an ester bond. Triglycerides, like all lipids are insoluble in water and are also an excellent energy store, with one gram of fat containing over twice as much energy as one gram of starch or protein. Fat is digested in the small intestine by hydrolysis to give a mixture of glycerol and fatty acids.

As digestion progresses, the pH of the solution decreases as the fat is being broken down into glycerol and fatty acids. This is how the progress of the digestion of fat can be followed, by measuring its pH. Before digestion though, fat is emulsified by emulsifying agents in the bile salts. This is a method of physical digestion where the larger fat molecules are broken down into smaller fat droplets with larger surface areas for digestion to take place on. A word equation for the digestion of fat by lipase is as follows:

$$\text{fat} + \text{3 water} \xrightarrow{\text{lipase}} \text{glycerol} + \text{3 fatty acids}$$

Aim

In this experiment, I shall attempt to investigate how the digestion of fat by lipase is affected by the concentration of lipase.

Variables

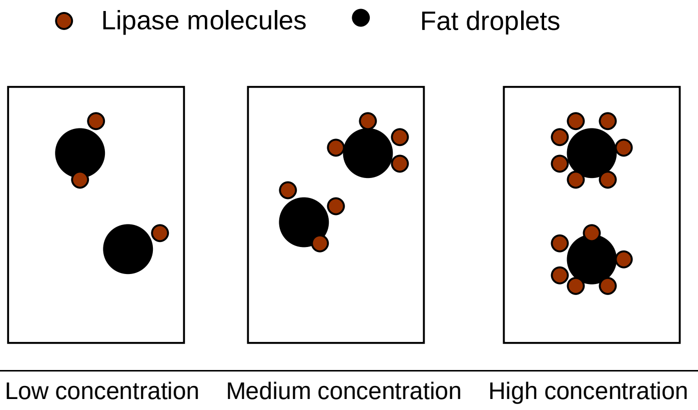
There are five main variables to take into account in doing this experiment, they are as follows:

- temperature
- concentration of fat
- pH
- concentration of bile salt
- concentration of enzyme

pH is very difficult to regulate in this experiment, since as digestion progresses the ph of the solution decreases, so it would be extremely difficult to keep the pH constant.

Hypothesis

I believe that as the concentration of lipase increases, the rate of digestion of fat will increase. This is best explained with the following diagrams:



In the far left diagram, there is a low concentration of lipase molecules, and as you can see there are less fat droplets in contact with the lipase molecules. In the diagram on the far right, there is a much higher concentration of lipase molecules, and thus there are many more fat droplets in contact with the lipase molecules. Therefore in the diagram on the far tight, there is a much faster reaction, since the fat droplet is in contact with far more lipase molecules, and therefore far more active sites of the lipase molecules. Since it is contact with far more lipase molecules and far more active sites of lipase molecules, digestion of the droplet can then happen at every spot where it is in contact with a lipase molecule. This will increase the rate of digestion greatly. Thus an increase in lipase concentration will speed up the digestion of fat by lipase. This is only true while concentration of lipase is the limiting factor. If it is not the limiting factor, then it doesn't matter how high the concentration of lipase gets, the rate will not increase. The product of the breakdown by lipase of a fat droplet are many tiny water soluble fat micelles. The contents of these micelles are then easily absorbed by the villi cells. Micelles also contain the bile salts alter they have finished emulsification, and so once the contents of the micelle has been absorbed, the bile salts are taken back to the liver, recycled and are ready to help with digestion again.

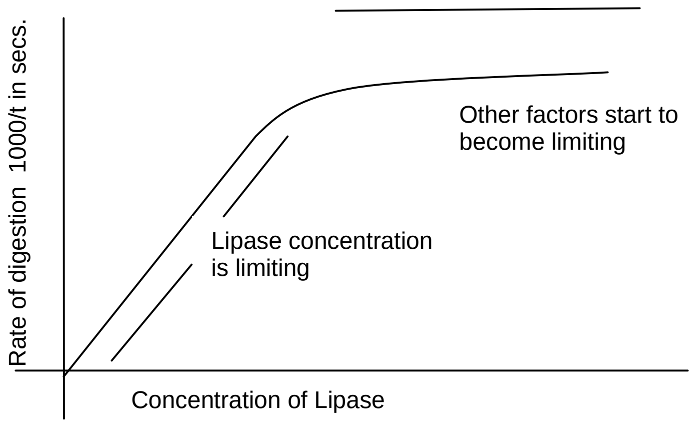
Fat is not, however, presented in the gut in perfect droplets as in the diagram above. It arrives in large globules first, and in order for efficient and fast digestion to take place, these globules need to be broken down physically into smaller parts, so that there is a larger surface area for the lipase to work on. This is the role that the bile salts play. They physically break the fat down into smaller parts, and this is the process of emulsification. In this process, the bile salt molecules which have a hydrophobic end and a hydrophilic end. The hydrophilic end is also negatively charged. When the fat arrives in the gut, it is in a mixture with water. The hydrophobic ends of the molecules push into the centre of the droplet, leaving the hydrophilic end in the watery solution outside of the fat droplet, a bit like a pin cushion. Since the hydrophilic ends are all negatively charged, they all repel each other. This outward force on the fat droplet causes it to break apart forming many smaller fat droplets. These are sufficiently small enough for the lipase to work efficiently and quickly at digesting them simply by coming into contact with the outside edge of the droplets. (1 Advanced Biology. Jones and Jones. CUP.)

This molecule theory is also the reason why temperature and fat concentration must remain the same for all concentrations. An increase in temperature will increase the speed at which the molecules in the solution move about. Thus an increase in temperature will increase the chance of a fat molecule colliding with a lipase molecule and this will increase the rate of digestion. An increase in fat concentration will increase the number of fat molecules in contact with lipase molecules, and thus increase the rate of digestion. (2 Biology 1. Jones, Fosbery and Taylor.)

Prediction

I predict that a graph of rate of digestion against concentration of enzyme would look like this.

A prediction Graph of rate of digestion of fat against concentration of lipase



Preliminary investigation

I carried out a preliminary investigation on the digestion of fat, but did not use concentration of lipase as the variable to be investigated. There was no single variable to be investigated in this preliminary investigation instead it was really used only to find out what different substances are necessary for the digestion of lipase to work. As is proved, it was quite a complex process requiring many different substances, but this shall be explained later. In this preliminary experiment, 7 test-tubes were filled with substances as in the following table:

	Tube Number						
Contents	1	2	3	4	5	6	7
Milk/cm3	5	5	5	5	5	5	5
Sodium carbonate/cm3	7	7	7	7	7	7	7
Phenolphthalein/drops	3	3	3	3	3	3	3
Water/cm3	1	0	0	1	1	2	2
Boiled lipase/cm3	0	1	0	0	0	0	0
Bile salt/cm3	0	1	1	1	1	0	0
Lipase/cm3	1	0	1	0	0	0	0

These test-tubes were then placed in a water bath at 35oC and observations were made every minute until no further change in appearance occurred. When the colour of the solution no longer changes, then that means that the reaction has reached an end point. The results from this are as follows:

	Tube number						
	1	2	3	4	5	6	7
End colour	White	Pink	Yellow	Pink	Yellow	Dark pink	White
Hydrolysis?	Yes	No	Yes	No	No	No	No
Speed of hydrolysis	Slow	-	Quick	-	-	-	-

From this experiment, we can see the factors necessary for the hydrolysis of fat. We can see that the only tubes where hydrolysis occurred were the tubes to contain fresh, unboiled lipase, so this is obviously necessary for hydrolysis. We can also see that hydrolysis took place at a faster rate in tube 3 which contained bile salts as well. As I stated in my hypothesis, bile salts increase the rate of digestion of fat by breaking down the large fat droplets physically into smaller droplets so that there in a larger surface area for the lipase to work on. When there is a larger surface area to work on, the lipase can digest the fat from all angles and sides, rather than just on the outside of a larger molecule. This means that hydrolysis was faster in this tube. In all the other tubes no hydrolysis took place, indicating that the conditions were unsuitable for it in these tubes.

From looking at the colours alone, it seems as if hydrolysis has taken place in tubes 1,3,5 and 7, but I have only acknowledged tubes 1, and 3 as having done hydrolysis. These are the only tubes to have performed hydrolysis as they were the only tubes to have contained the enzyme lipase. Tube 5, although it was yellow this was only because it contained bile salts and no phenolphthalein. The bile salts were yellow in colour so the solution appeared yellow, and there was no phenolphthalein to change the colour of the solution to pink, due to its alkalinity. In tube 7 no hydrolysis took place because there was no lipase. The reason the solution was white was because there was no phenolphthalein to turn it pink. If phenolphthalein was added in this tube, then the solution would have turned pink since no hydrolysis took place and the solution was still alkaline. Tube 1 turned white since when the solution had been neutralised and the phenolphthalein lost its pink colour there were no bile salts present to change its colour to yellow.

Tubes 2,4 and 6 remained pink since they didn't have the required conditions for hydrolysis of fat to take place. None of the tubes contained fresh, unboiled lipase, which is necessary for hydrolysis of fat, and tube 6 contained no bile salts either. These tubes were included to work out which conditions were necessary for hydrolysis to take place.

Apparatus

In this experiment I shall need the following apparatus.

- 10 test tubes
- thermostatically controlled hot water bath
- phenolphthalein
- lipase
- measuring cylinders of assorted sizes
- bile salt solution
- sodium carbonate
- distilled water

- milk
- syringes of assorted sizes
- beakers of assorted sizes

The water bath is used to maintain a constant temperature of the solution in the test tubes, as this, as I have mentioned earlier is one of the variables that needs to be kept constant. The bile salt solution is used as an emulsifying agent in the digestion. This breaks down the large fat droplets physically into smaller droplets which are then suspended in the water as an emulsion. This gives the lipase a much larger surface area to work on when digesting the fat, which speeds up the digestion of the fat. If there was no bile solution, then the digestion would take much longer to complete, much more time than the time available to us in an experiment.

Milk is used as the source of fat for this experiment as it is very readily available, and because it is alkaline. The fat in the milk is in the form of small droplets with a diameter of 5-10 micrometres. Unfortunately it is already emulsified into these small droplets by proteins in the milk3 . However, the results from the preliminary experiment seem to show that the droplets can be emulsified further by bile salts. The alkalinity of milk helps to raise the pH of the solution a little, but really a stronger alkali is needed to raise the pH to a sufficient level for the experiment to work well. This is what the sodium carbonate does. It increases the pH to above 8.3 and turns the solution to a strong enough alkali to turn the phenolphthalein pink. This is necessary for the phenolphthalein to perform its job in this experiment properly. However, I will use a pH meter to check the pH at the start. If the solution starts off a pink colour it is easier to see when it loses this colour as it is neutralised, and when it turns yellow as the digestion progresses and the solution becomes more acidic. When the solution has turned yellow, and is not changing colour any more, then this means that the end point has been reached. I will also use a pH meter to check the final pH.

Phenolphthalein, a pH indicator is used in this experiment to determine how much digestion has taken place. In alkaline conditions it is a light pink colour, and in acidic conditions it is colourless. It can be used to determine the progression of digestion in this experiment by looking at the colour. Where there is no digestion, the solution in the test tube will be pink, due to the alkalinity of the milk, and the alkalinity of the sodium carbonate. However as digestion progresses, the solution shall change to a yellow colour. In the digestion of fat fatty acids are produced which increase the acidity of the solution. This will turn the indicator colourless, but the solution will turn yellow. It will turn yellow however, due to the presence of bile salts. In the initial alkaline conditions the phenolphthalein will be pink and this will be stronger than the yellow of the bile salts, so the solution will appear pink. However, as the phenolphthalein changes to colourless, the yellow colour of the bile salts will start to show through, making the solution appear yellow. To start with, the acid production will neutralise the alkalinity of the solution, but will then turn the solution acidic, and will thus turn the solution yellow because of the presence of phenolphthalein and bile salts. This is why phenolphthalein is such a good indicator for the digestion of fat.

Method

- Set up the test tubes as in the following table, but do not add the lipase until later in the experiment. Instead make up the lipase and water mixture for each of the tubes and have them ready to put into the tubes in syringes.

	Tube Number										
Contents	1	2	3	4	5	6	7	8	9	10	11
Milk/cm3	5	5	5	5	5	5	5	5	5	5	5
Sodium carbonate/cm3	7	7	7	7	7	7	7	7	7	7	7
Phenolphthalein/drops	3	3	3	3	3	3	3	3	3	3	3
Water/cm3	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Bile salt/cm3	1	1	1	1	1	1	1	1	1	1	1
Lipase/cm3	1	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0

- Clearly mark all of the tubes for easy reference.
- Use a pH meter to check the pH in each tube.
- Place all of the tubes without the lipase into a water bath at a temperature of 35oC, and leave them for a few minutes to obtain the same temperature.
- At 30 second intervals starting with tube 1 and finishing with tube 11, add the lipase and water syringes to each of the tubes. This will ensure that there is plenty of time to write down the observations as each tube changes colour. Also mark down the time that each tube took to reach an end point.
- Watch all of the tubes and mark any changes of appearance that happen and write down when they happen in a table.
- Compare the tubes against a standard tube that contains milk and bile salts at the same concentration as the other tubes. This will help decide when the colour has finally changed.
- When the last tube has changed colour, check all the tubes with a pH meter and record the final pH.

- Repeat the experiment with all 11 tubes two more times. Make sure that fresh solutions are used each time and that all test tubes are washed thoroughly if the same tubes are used again.

Precautions

This is quite a difficult experiment to undertake, and so there are many precautions to watch out for even in following the method above.

It may be a good idea to label the syringes as well as the tubes with their respective numbers to prevent any mix ups of lipase concentrations, before the lipase is actually added.

The lipase must not be added until everything is ready, as the addition of lipase is what actually starts the experiment. As soon as the lipase is added, the experiment must begin, as any delays here will produce unreliable results.

Take the temperatures of all of the tubes in the water bath before adding the lipase to ensure that they have all acclimatised to the temperature of the water bath. This will prevent any of them from still increasing in temperature in the course of the actual experiment, as this may cause unreliable, results.

The staggered start will hopefully prevent there from being a rush to put all of the lipase syringes into the tubes in one go, as it is often a cause of mistakes being made. It will also mean that the solutions will change colour in a more spread out time period meaning that there will be less of a hurry to write down any observations. I have started the experiment with the tubes in this order, as if my hypothesis is correct, it will produce the largest spread of times for the tubes to change colour. If I started the tubes off the other way round, i.e. with tube 11 first, and tube 1 last, then all of the tubes would be changing colour at similar times to each other, and this may lead to some confusion.

Safety

- Care should be taken with all glassware to avoid breakages.
- Sodium carbonate can cause skin irritation so care should be taken not to spill any.
- Enzymes, such as lipase, can cause allergic reactions, so care should be taken with the solutions used. No lipase powder will be used in the investigation. Disposable gloves can be worn while handling the solution.
- Protective goggles must be worn at all times to avoid chemicals entering the eyes.
- Lab coat will be worn.

Analysis of results

The results that I obtain from this experiment I shall form into a graph of rate of digestion against time. The rate can be worked out dividing 1 by the amount of time in seconds that it took for each solution to reach an end point. A graph can then be drawn from these results and this can help the formation of any conclusions. From the graph we will be able to see as it levels off, what the optimum lipase concentration is. This will be the point where I would also repeat the experiment as many times as possible in the time available, but depending on the results obtained this would have to be at least two more repeats. If there are any individual anomalous results for any of the concentrations, then it is not necessary to repeat the whole experiment, instead just repeat the experiment for one tube with that one value of lipase concentration. Once are a few replicate sets of reasonable looking results, then an average must be taken from all of the results for each value of lipase concentration. A graph is then drawn of rate against lipase concentration, using these results. The rate is worked out by dividing one by the time in seconds that it took each tube to reach an end point. Another useful thing that can be put onto a graph like this is the range of values obtained for each concentration of lipase. This can easily be represented by drawing a vertical line up and down from each point to the maximum and minimum rates for that concentration. This can be a good aid in drawing conclusions as you can see if there is any overlap between results for each concentration. Anomalous results must not be taken into consideration here either, as otherwise on the point where the anomaly lies, the range will end up very wide indeed giving a false representation of the otherwise good results that were obtained.

References

1. Advanced Biology. Jones and Jones. CUP.

2. Biology 1. Jones, Fosbery and Taylor. CUP.

3. Food Science, Nutrition and Health. Fox and Cameron. Arnold.

1	P.1a	develops a question or problem in simple terms and plans a fair test or an appropriate practical procedure; makes a prediction where relevant.	
	P.1b	chooses appropriate equipment.	
3	P.3a	develops a question or problem using scientific knowledge and understanding; identifies the key factors to vary, control or take account of; uses information drawn from more than one area of the specification.	
	P.3b	decides on a suitable number and range of observations and/or measurements to be made.	
5	P.5a	uses detailed scientific knowledge and understanding and information from preliminary work or a secondary source to plan an appropriate strategy; justifies any prediction made; takes into account the need for safe working; uses information drawn from more than one module of the specification.	
	P.5b	describes a strategy, including choice of equipment, which takes into account the need to produce precise and reliable evidence; produces a clear account and uses specialist vocabulary appropriately.	
7	P.7a	retrieves and evaluates information from a variety of sources; develops a strategy which is well structured, logical and linked coherently to underlying scientific knowledge and understanding; uses spelling, punctuation and grammar accurately; uses information drawn from different parts of the AS and A2 specification.	
	P.7b	justifies the strategy developed, including the choice of equipment, in terms of the need for precision and reliability.	

A comparison of length: aperture ratio of Nucella lapillus on exposed and sheltered rocky shores.

The exposed shore will be Castle Beach: Grid reference SM8 18050, BES Grade 3. The sheltered shore will be Pointwood Beach: Grid reference SM8 22053, BES Grade 4.

Aim

To see if the ratio of length of shell: length of aperture of Nucella lapillus varies on exposed and sheltered rocky shores.

Background Knowledge

Fig. 1

On average fully grown Nucella lapillus, commonly known as Dog Whelks, grow to a length of 20-35mm. This length tends not to vary on exposed and sheltered shores, as the Dog Whelks on both live in similar microhabitats. A habitat is the place that an organism lives, in this case the shore. A habitat can be broken down into a set of smaller microhabitats. These are the specific parts of a habitat on or in which a species live. Dog Whelks usually inhabit crevices and rock surfaces that face away from the sea.

These offer the Dog Whelks protection from both predators, such as gulls, and wave action. What does change is the size of the aperture in the shell. This is significantly larger on Dog Whelks on the exposed shore, as they need a larger and stronger muscular foot with which they attach themselves to the rock surface. This is necessary to allow the Dog Whelks extra support to cope with the increased action of the waves.

If the Dog Whelks on the exposed shore had an aperture as small as those on the sheltered shore then they would be easily washed off the rocks. This adaptation will have occurred as a result of natural selection. On the exposed shore those Dog Whelks with a larger aperture would be able to survive better than those with a smaller aperture. Due to competition for both space and food the Dog Whelks with a larger aperture would survive to breed and would pass on their genes.

Dog Whelks usually inhabit the middle shore. There are a number of reasons for this; the main one being it is the area where their main prey lives. Huge amounts of barnacles populate the middle shore so Dog Whelks always have a large and plentiful supply of food. Due to the abundance of food competition for it is not that fierce. The major limiting factor is availability of suitable microhabitats that will provide protection from predators and the action of the waves.

If there are a large number of crevices between rocks then there will be a much larger population of Dog Whelks, as there will be enough protection for the increased numbers. Dog Whelks also need salt to survive and have a very low tolerance to reduction in salinity levels.

This means that they are unsuited to the upper shore as they will not be covered by the salt water for long enough to survive. Desiccation, or drying out, also restricts Dog Whelks to the middle and lower shore, as they need to be covered by water for long periods of time to avoid death.

Fig. 2

Prediction

I predict that the ratio of length of shell to length of aperture will be greater on the sheltered shore. This means that the aperture will be smaller in relation to length of shell. I think this because Dog Whelks will not need such a large aperture on a sheltered beach, as the wave action will be less than on an exposed shore. On an exposed shore the muscular foot of the Dog Whelk must be larger and more powerful to cope with the increased exposure to wave action, so they therefore need a larger aperture.

Preliminary Work

1. During a study of plant succession on the Gann Salt-marsh (Grid ref SM8 14075) Low water: 2m ACD @ 10:50 (ACD = above chart datum)

   The following has allowed me to select an accurate way of measuring vertical height.

Method for measuring height:

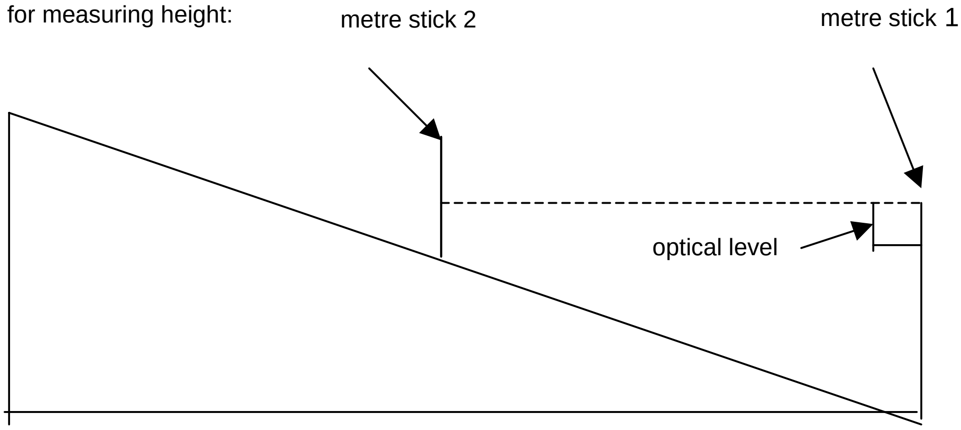


Fig. 3

Place the first metre stick at the water's edge, which will be at a height of 2 m ACD. Place the optical level at the top of the metre stick and look along it. Place another metre stick at the place where you are working and get your partner to run their finger up it until it is at the same level as the optical level. The distance from the finger to the top of the metre stick is the height difference. Add this to 2m to get the height of the site ACD. (See fig 3). This method of measuring the height will be used, as it is accurate and easy. It can also be easily adapted so that I can select a height to work at and find it quickly.

2. A study of the distribution and abundance of organisms on a sheltered rocky shore

Site: Jetty Beach GR: SM823 052 Aspect: NNE Low water: 1.6mACD@ 11:34am

From the results of this study it can be seen that Dog Whelks live predominantly on the middle shore. I will therefore work at a vertical height of 3 m ACD, as this is an area where a large number of Dog Whelks can be found. This will allow me to take a large random sample and gain enough results to draw valid conclusions. If the sample is not random then the results can not be deemed as valid as I will not have a true reflection of Dog Whelks on the entire shore. Getting a large amount of data will also allow me to carry out a valid statistical test and analysis.

This investigation has also been used to select the quadrat size for my project. We were using a 1 m2 quadrat and, at many sites, found over 25 Dog Whelks. A 50 cm2 quadrat will therefore be used. This will reduce errors within the quadrat due to changes in height. This will help to ensure that the majority of Dog Whelks measured will actually be living at 3 m ACD.

3 Effect of exposure on the shell morphology of Rough Periwinkles.

Site:	Pointwood Beach	Castle Beach
BES:	Grade 4	Grade 3
Grid ref:	SM822053	SM821051
Aspect:	NNE	SSE

Low tide: l.3m ACD @ 12:03

BES = Balentine exposure scale

This investigation has provided a sample size to use and which beaches are best to collect data from. The method to measure the shell was also obtained.

The beaches to be used are Pointwood Beach (sheltered) and Castle Beach (exposed). This is because the results obtained provided a good set results and showed a definite difference in shell morphology between the two. The sample size used gave a good set of results and from them a valid conclusion could be drawn. For the investigation the sample size will be increased to 50 Dog Whelks across 5 quadrats, measuring 10 in each. This will help to increase both reliability and accuracy of my results by allowing a statistical analysis of data using a t-test and calculating averages. This will reduce the effect of any anomalies.

Callipers will be used to measure the length of the shell and aperture, as they proved to be very accurate and measured to the nearest 0.5 mm.

Pilot Study

Title: A comparison of Nucella lapillus on an exposed rocky shore of BES grade 3 and a sheltered rocky shore of BES grade 4.

Aim: To see if the ratio of length of shell to length of aperture is different on exposed and sheltered rocky shores.

Hypothesis

H1 = The Nucella lapillus on the sheltered rocky shore have a greater length to aperture ratio than on the exposed rocky shore

Ho = There is no difference in ratio

Apparatus:

- 1m ruler
- Optical level
- Tape measure
- First Aid Kit
- Calculator
- 50 cm2 quadrat
- Veiner Calipers
- Tide table
- Dichotomous key

Safety:

- Rocks will be slippery so be careful when walking on them
- Some rocks may be loose so be aware when you stand on them
- If you get a cut treat it immediately to avoid infection
- Always work in pairs so help can be given in the event of injury
- Incoming tide will cut off site access and leave you stranded, so be aware of time.
- Check safe times using tide table
- Sign out and in at the Field Centre so people know where you are in an emergency.

Tables to show the length of shell, length of aperture and ratio of length: aperture of Nucella lapillus on an exposed and a sheltered beach.

Castle Beach — BES Grade 3

Dog whelk	Quad 1			Quad 2			Quad 3			Quad 4			Quad 5		
	L / mm	ap / mm	L/ap	L / mm	ap / mm	L/ap	L / mm	ap / mm	L/ap	L / mm	ap / mm	L/ap	L / mm	ap / mm	L/ap
1	27	17	1.6	23	17	1.4	29	22	1.3	29	21	1.4	13	10	1.3
2	26	18	1.4	26	18	1.4	30	21	1.4	24	18	1.3	22	18	1.2
3	30	22	1.4	21	16	1.3	28	19	1.5	21	18	1.2	25	21	1.2
4	29	21	1.4	27	19	1.4	24	19	1.3	26	20	1.3	23	19	1.2
5	20	15	1.3	24	19	1.3	24	18	1.3	22	19	1.2	23	18	1.3
6	20	16	1.3	25	20	1.3	27	21	1.3	26	21	1.2	25	22	1.1
7	31	23	1.3	28	19	1.5	26	17	1.5	24	18	1.3	28	21	1.3
8	28	20	1.4	28	21	1.3	28	20	1.4	26	19	1.4	30	22	1.4
9	26	19	1.4	24	16	1.5	27	20	1.4	30	23	1.3	25	19	1.3
10	27	18	1.5	23	16	1.4	29	22	1.3	24	18	1.3	25	20	1.3

Pointwood Beach - BES Grade 4

Dog whelk	Quad 1			Quad 2			Quad 3			Quad 4			Quad 5		
	L / mm	ap / mm	L/ap	L / mm	ap / mm	L/ap	L / mm	ap / mm	L/ap	L / mm	ap / mm	L/ap	L / mm	ap / mm	L/ap
1	29	18	1.6	25	15	1.7	26	14	1.9	26	15	1.7	25	14	1.8
2	27	16	1.7	27	16	1.7	27	17	1.6	29	16	1.8	25	14	1.8
3	20	14	1.4	28	16	1.8	27	17	1.6	25	14	1.8	19	11	1.7
4	25	15	1.7	26	16	1.6	26	17	1.5	27	15	1.8	28	15	1.9
5	27	15	1.8	21	14	1.5	28	16	1.8	27	17	1.6	28	14	2.0
6	22	14	1.6	26	14	1.9	24	12	2.0	29	15	1.9	21	12	1.8
7	28	14	2.0	26	13	2.0	26	13	2.0	28	16	1.8	27	14	1.9
8	26	14	1.9	25	13	1.9	27	15	1.8	25	13	1.9	25	14	1.8
9	26	14	1.9	27	15	1.8	25	14	1.8	27	14	1.9	26	14	1.9
10	25	15	1.9	25	13	1.9	25	14	1.8	21	12	1.8	24	12	2.0

Summary table to show averages

	Castle Beach BES = Grade3	Pointwood Beach BES = Grade4
Length(mm)	25.5	25.8
Aperture(mm)	19.1	14.5
L/a ratio	1.3	1.8

t-test data for ratio of length: aperture of Nucella lapillus on an exposed and a sheltered beach

H_o = There is no significant difference in ratio for Nucella lapillus on exposed and sheltered beaches.

N	Castle Beach: BES 3		Pointwood Beach: BES 4	
	Xl	X12	X2	X22
1	1.6	2.56	1.6	2.56
2	1.4	1.96	1.7	2.89
3	1.4	1.96	1.4	1.96
4	1.4	1.96	1.7	2.89
5	1.3	1.69	1.8	3.24
6	1.3	1.69	1.6	2.56
7	1.4	1.96	1.7	2.89
8	1.4	1.96	1.7	2.89
9	1.3	1.69	1.8	3.24
10	1.4	1.96	1.6	2.56
11	1.3	1.69	*1.5*	*2.25*
12	1.3	1.69	1.9	3.61
13	1.3	1.69	1.9	3.61
14	1.4	1.96	1.6	2.56
15	1.5	2.25	1.6	2.56
16	1.3	1.69	1.5	2.25
17	1.3	1.69	1.8	3.24
18	1.3	1.69	2.0	4.00
19	1.4	1.96	1.7	2.89
20	1.3	1.69	1.8	3.24
21	1.2	1.44	1.8	3.24
22	1.3	1.69	1.8	3.24
23	1.2	1.44	1.6	2.56
24	1.2	1.44	1.9	3.61
25	1.3	1.69	1.8	3.24
26	1.2	1.44	1.8	3.24
27	1.2	1.44	1.7	2.89
28	1.2	1.44	1.9	3.61
29	1.3	1.69	2.0	4.00
30	1.1	1.21	1.8	3.24
31	1.3	1.69	2.0	4.00
32	1.4	1.96	1.9	3.61
33	1.4	1.96	1.9	3.61
34	1.5	2.25	1.9	3.61
35	1.5	2.25	2.0	4.00

36	1.3	1.69	1.9	3.61
37	1.5	2.25	1.8	3.24
38	1.4	1.96	1.9	3.61
39	1.5	2.25	2.0	4.00
40	1.4	1.96	1.8	3.24
41	1.4	1.96	1.8	3.24
42	1.3	1.69	1.8	3.24
43	1.3	1.69	1.8	3.24
44	1.4	1.96	1.9	3.61
45	1.3	1.69	1.9	3.61
46	1.3	1.69	1.8	3.24
47	1.3	1.69	1.9	3.61
48	1.3	1.69	1.8	3.24
49	1.4	1.96	1.9	3.61
50	1.3	1.69	2.0	4.00
Total	67.00	90.24	89.72	161.93

Mean of X 1 = total X 1 = 67 = 1.34

N 50

Mean of X 2 = 89.7 = 1.79

50

Variance (s2) = total X2 - (total x)2/N

N-1

S2 1 = 90.24 - 89.78 = 0.009

49

S2 2 = 161.93 - 160.92 = 0.053

49

‘t’= [mean X 1 - mean X 2] = 0.45

0.009 + 0.053 0.04

50 50

‘t’ calculated = 11.25

Degrees of freedom = 50 + 50 - 2 = 98

Critical taken at 5% significance level to 98 degrees of freedom = 2.00

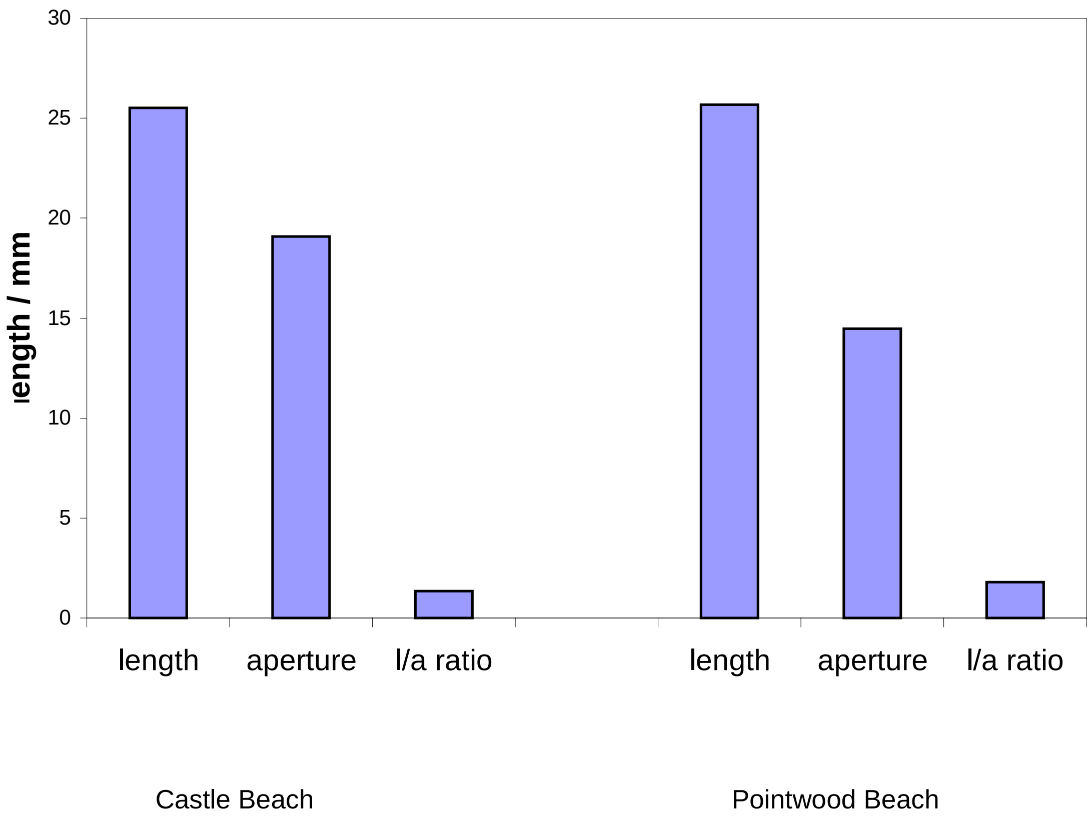
Statistical conclusion

From these results Ho can be rejected as ‘t’ calculated (11.25) is much greater than ‘t’ critical (2.00). This proves at a 95% certainty level that the ratio of length of shell:aperture of Nucella lapillus is significantly greater on a sheltered shore than on an exposed shore. I can also reject Ho at the 0.1% significance level as ‘t’ critical is only 3.46. This means that if I were to carry out the investigation again there is a 99.9% chance that I would come to the same conclusion.

Biological conclusion

From these results Ho can be rejected as ‘t’ calculated (11.25) is much greater than ‘t’ critical (2.00). This proves at a 95% certainty level that the ratio of length of shell:aperture of Nucella lapillus is significantly greater on a sheltered shore than on an exposed shore. I can also reject Ho at the 0.1% significance level as ‘t’ critical is only 3.46. This means that if I were to carry out the investigation again there is a 99.9% chance that I would come to the same conclusion.

Fig. 4. Graph to compare the average length of shell, the average length of aperture and the average ratio between the two of dogwhelks on two shores at different exposure at 3 m ACD.



From the graph I can see that the lengths of the shells of the Dog Whelks on the exposed and sheltered shores were almost identical, the average being 25.5mm on the exposed shore and 25.8mm on the sheltered shore. However, I can also see that the aperture changes greatly between the two shores. The average length is 4.6mm longer on the exposed shore. As a result the length: aperture ratio is greater on the sheltered shore at 1: 1.8, as opposed to 1 :1.3 on the exposed shore. The information in my graph and tables support my initial prediction, that Dog Whelks living on the sheltered shore would have a greater length: aperture ratio.

Discussion

The Dog Whelks on the two shores were very similar in length. They normally grow to a length of 20-35 mm. The reason that I obtained these results is that length is not affected by the different exposure to the sea of different shores. This is because the preferred microhabitat of Dog Whelks on a rocky shore is in cracks between rocks. This provides adequate protection from the action of waves to mean that a change in overall size is not necessary for the Dog Whelks. The cracks also provide excellent hiding places and make it very difficult for predators, such as sea gulls and crabs, to be able to catch and eat the Dog Whelks. Instead of changing overall size of shell to combat the increased wave action on the exposed shore the Dog Whelks increase the size of their aperture. This allows the Dog Whelks to take a much firmer grip on the rocks to avoid getting washed away. They secrete a mucopolysaccharide chemical that sticks them to the rock so that they have more chance of survival. The increased power of waves, brought about by the southerly aspect of Castle Beach, means that the Dog Whelks can be washed off the rocks more easily than those on Pointwood Beach, which faces north. If the Dog Whelks on the exposed rocky shore had an aperture as small as those on the sheltered rocky shore then they would be unable to grip the rocks strongly enough and be washed away. The Dog Whelks on the exposed shore have had to adapt to their harsher habitat by increasing the size of their aperture to allow for a larger, more muscular and powerful foot to prevent this from happening. This therefore means that the ratio of length: aperture will be greater on the sheltered shore. This is because the Dog Whelks are still the same overall size on both shores but have different sized apertures. The smaller the aperture compared to the overall size of the Dog Whelk the greater the ratio. The difference in the populations of Dog Whelks on the two shores could be due to the way young animals grow in response to the wave action and the exposure. Therefore the difference could be due to factors in the environment. The difference could also be due to some difference in the genes between the two groups of Dog Whelks. Maybe the Dog Whelks at Castle Beach have genes for larger apertures. Maybe these Dog Whelks have been selected by abiotic factors, such as exposure. There may also be less predation by gulls and crabs at Castle Beach because it is more exposed. Some people have noticed that the shells of the Dog Whelks were thicker at Pointwood Beach and this maybe to give the animals greater protection against crabs. This may also be something that is selected.

Dog whelks have a niche that is determined by abiotic and biotic factors. In this investigation, I have found that exposure to wave action is an important factor in deciding the niche.

References

(1) Dog Whelks: an introduction to the biology of Nucella lapillus. J.H. Crothers.

(2) Field Atlas of the Seashore. Julian Cremona.

1	A.1a	carries out some simple processing of the evidence collected from experimental work.	
	A.1b	identifies trends or patterns in the evidence and draws simple conclusions.	
3	A.3a	processes and presents evidence gathered from experimental work including, where appropriate, the use of appropriate graphical and/or numerical techniques.	
	A.3b	links conclusions drawn from processed evidence with the associated scientific knowledge and understanding; uses information drawn from more than one area of the specification.	
5	A.5a	carries out detailed processing of evidence and analysis including, where appropriate, the use of advanced numerical techniques such as statistics, the plotting of intercepts or the calculation of gradients.	
	A.5b	draws conclusions which are consistent with the processed evidence and links these with detailed scientific knowledge and understanding; produces a clear account which uses specialist vocabulary appropriately; uses information drawn from more than one module of the specification.	
7	A.7a	where appropriate, uses detailed scientific knowledge and understanding to make deductions from the processed evidence; shows due regard to nomenclature, terminology and the use of significant figures (where relevant); uses information drawn from different parts of the AS and A2 specification.	
	A.7b	draws conclusions which are well structured, appropriate, comprehensive and concise, and which are coherently linked to underlying scientific knowledge and understanding; uses spelling, punctuation and grammar accurately; uses information drawn from different parts of the AS and A2 specification.	

Commentaries

Script Annotation Exercise for candidate ‘Smith’. (from page 47).

Skill P There is no clear use of sub-headings throughout the plan which means that it is not well structured, so P.7(a)ii was not awarded.

This is an important point when teaching the coursework module. It is expected that plans will be concise and well structured.

A mark of 8 cannot be awarded as not all the descriptors for 7 have been met. However, if the work was well structured there is insufficient scientific knowledge and understanding of ‘exceptional merit’ to support an award of 8. P = 6.

Skill I The tick list suggests that a mark of 7 is appropriate. I = 7.

Skill A The candidate has not used significant figures correctly, so level 7 is not awarded. All the descriptors for level 5 are matched, so A = 6.

Skill E All the descriptors for 5 are matched, but not for 7. E = 5.

Marking Exercise for candidate 'Jones' (from page 62).

Skill P

Appropriate method suggested
Prediction made
List given of appropriate apparatus
Relevant scientific knowledge and understanding included
Key factors listed and considered
Appropriate range of measurements suggested; measurements repeated
Detailed AS scientific knowledge and understanding shown

Secondary sources listed but not used or referenced in the planning
Safety comment given – just enough to satisfy the descriptor
Choice of apparatus explained briefly but not sufficiently to award this point
Specialist vocabulary used

Not quite enough to meet P.5 completely, so 4 marks awarded.

Skill I The tick list provided (see page 60) indicates that level 4 is awarded because the table contains a serious error as units (%) are given in the body of the table.

Skill A

Means calculated from the raw data
Trend identified; a simple conclusion given

Not awarded as the graphs are not appropriate as the axes are incorrect
Data linked with conclusion
Accurate use of spelling, punctuation and grammar

No other descriptors are met, so 2 marks awarded for Skill A.

Skill E

Suitability of experimental procedure commented upon
Anomalies recognised in the table and the text
Lists six sources of error, e.g. inaccurate transfer of catalase solution
Accuracy of results commented upon

Reasons for anomalies given
Recognises how the six errors in technique will affect the results e.g. timing

No other descriptors are met so 3 marks awarded for Skill E; 4 marks could be awarded if any of the following were matched as well as E.5(a)i:

E. 5(a)ii or E.5(b)i or E.5(b)ii.

Formative Assessment Exercise (from page74).

Appropriate method suggested
Prediction made
Some apparatus listed, but insufficient detail given for carrying out this experiment – descriptor not awarded
Relevant simple scientific knowledge and understanding included

Some variables identified, e.g. time left in solution, weight of potatoes, but nature of 'solution' not given. It is not clear how these variables are to be controlled, varied or 'taken account of', so this descriptor is not awarded here
Repeats suggested, an appropriate range is given in the table of results, but the nature of the solution in unknown so this cannot be awarded
No detailed AS scientific knowledge and understanding shown
No secondary sources listed
No safety comment given
Apparatus not listed, so no explanation given
Limited use of specialist vocabulary used, so not awarded

As P.1(b) is not met, a mark of zero is given for Skill P.

Without a tick list it is not possible to assess Skill I.

Skill A

Means calculated from the raw data
Trend identified
An appropriate graph has been drawn
Data linked with conclusion

There is just sufficient here to match A.1(a) and A.1(b) and some of A.3 so 2 marks are awarded.

Skill E

Suitability of experimental procedure commented upon
Anomalies recognised in the text

Not sufficient on sources of error so not awarded
Accuracy of results not commented upon
Reasons for anomalies not given

E.1(a) and E.1(b) are matched, but not the descriptors for E.3(a) or E.3(b). A mark of 1 is awarded.

Mark Contextualisation Exercise for A2 from page 82

Lipase planning (Skill P only)

Appropriate method suggested
Prediction made
Appropriate apparatus listed

Relevant simple scientific knowledge and understanding included
Variables identified
Information from more than one learning outcome from the Option Mammalian Physiology and Behaviour used: 5.9.1 (b), (c), and (i).
Appropriate range and number for lipase concentration given. Repeats included in plan
Detailed A2 scientific knowledge and understanding shown to justify the prediction
Preliminary work used in the planning
Safety aspects considered
Information from 2801 included in the planning, e.g. enzyme action; structure of triglycerides

Strategy explained in terms of pH change; pH meter included to check on decrease in pH so a method given that will give precise results; repeats included
Clear account; good use of specialist vocabulary
References used to provide background information for the planning and to justify the use of milk as source of fat
Strategy is well structured and logical – good links to underlying scientific information
Good spelling, punctuation and grammar
AS material used in development of the plan – enzymes and biochemistry from 2801
The need for the pH meter is not explained in terms of precision, and problems with using a colour end point are not recognised – so this descriptor not fully met

All descriptors are met except P.7(b), so 6 marks are awarded for planning

Ecology Analysing (Skill A only) from page 90

Details of the method were included in the exemplar to give an idea of the context in which the exercise was carried out. Some parts of the candidate's plan work are omitted so it is not fair to mark this as a planning exercise as well.

Means calculated from the raw data
Trend identified; a conclusion given
Appropriate bar chart included to summarise the date; histograms of the data for each shore would also satisfy this descriptor
Conclusion linked with processed results
Conclusions linked with scientific knowledge and understanding from more than one area of the specification – adaptation (5.4.5 (k)) and predator-prey (5.4.3 (d) from 2804
Graph follows IoB guidelines for bar chart
Appropriate stats test (t test) carried out on the data
Conclusions are consistent with the processed data

Clear account – uses specialist vocabulary
Information from 2 modules – 5.1.7 (a) from 2801 and 5.4.5 (k) and 5.4.3 (d) from 2804
Some limited deductions made from the processed evidence
There are no errors in nomenclature, terminology and significant figures
The material from 2801 is not developed in making deductions – more use could be made of concept of niche, for example
Conclusions are well structured, but not comprehensive
Spelling, punctuation and grammar are used accurately
Only limited use is made of the synoptic material to match this descriptor

Appendices

Appendix 1 Frequently Asked Questions (FAQs)

1. Can a single coursework exercise be used to assess more than one skill?

Yes, skills may be assessed separately or in combination. All four skills can be tested at any one time, in a 'whole investigation'. However, it is the responsibility of candidates and their centres to ensure that it is clear where each skill is being covered. This should be achieved by the use of titles and sub-titles.

2. Is it advisable to test more than one skill in any one exercise?

This depends very much on the nature of the task and how it is set up. Generally, candidates achieve higher marks for planning if they are able to perform their investigation since this gives them opportunities to revise the plan in the light of experience. Thus, Skills P and I are often assessed together. Similarly, candidates who have not planned and carried out an investigation (or at least seen it demonstrated) will find it difficult to evaluate the investigation. Skill E may therefore be better assessed in a whole investigation. If all four skills are to be tested in one 'whole investigation', it is essential that it is clear to moderators, by means of titles, subtitles, teachers' comments, etc., which are being tested where.

3. Is it better to do fieldwork or laboratory work?

Assessment exercises can be based on either approach. In practice, many centres may find that a mixture of the two will offer greater flexibility.

4. Is there any size or word limit on coursework submissions?

No, but there is absolutely nothing to be gained by submitting particularly large volumes of work for each assessment, especially where the same technique is repeated several times. Moderators will be looking at the quality of the work rather than the quantity and clear evidence that candidates have achieved the criteria listed under each skill.

5. Do centres need to show evidence of marking on candidate's work?

Yes; the minimum requirement is that the 'shorthand' mark descriptors (e.g. P.3b or A.5a) are written in the margin of the script at the point where the work has met the descriptors concerned. However, the more comments clearly written on submitted work, the easier it is for moderators to judge whether candidates have been fairly assessed.

6. Do centres need to submit copies of the worksheets, exercises and resources given to students?

Yes; moderators need to know exactly what candidates were asked to do, and what help they received.

7. Do centres need to submit mark schemes?

The general descriptors given in the specification (and in Section 5) may be used directly by centres to mark candidates' work. However, centres may choose to develop specific sets of descriptors for particular tasks, to allow consistency of marking from year to year, and from teacher to teacher. If such 'contextualised' descriptors are used, they must be very closely based on the standard descriptors and they must be sent to the moderator with the sample of work. It should be noted that the moderator will mark using the general set of descriptors (given in the specification), to ensure that the standard of work is the same from centre to centre. For Skill I, teachers should provide details of the aspects of the work that were scrutinised, in the form of check lists or written notes.

8. Some candidates find coursework very difficult. What advice can you offer which will increase candidates' prospects of achieving good marks?

It is clearly important that candidates are taught the skills and given opportunities to practice, before being assessed. Candidates may find it helpful if staff go through a worked exemplar showing how they themselves would tackle a particular topic, provided that candidates are not allowed to produce work on the same topic for submission. Candidates should be made aware of the descriptors used to assess their work, so that they can ensure that all aspects of the descriptors are addressed. Worksheets clearly give considerable assistance to candidates, but if they are too specific, the help which they give may prevent candidates making choices and so limit access to the highest marks, so they should be used carefully.

9. Do all candidates have to do completely different topics for Skill P assessments?

No; a single task may be set by the teacher for all candidates, but they must work individually.

10. How can Skill P be used with fieldwork exercises when the candidates may not have been to the specific field location before?

Teaching staff can give their candidates information about the field location in advance of the trip, e.g. maps, photographs, background information etc. The only proviso is that candidates are not given answers, interpretations, etc., to possible areas of investigation.

11. In Skill P work, do candidates have to put their plans into action and examine the results in order to evaluate and modify their plans?

No, but candidates who do not have the opportunity to carry out their plans and modify them in the light of experience will be at a considerable disadvantage.

12. I am having trouble deciding whether my exercises properly address the demands of the skills listed in the specification. What advice is available?

A proposed task may be submitted to OCR and a response on its suitability will be provided. Copies of the relevant form may be obtained from OCR in Cambridge and should be sent to the subject officer (a contact address is given in Section 10). INSET courses are provided each year; details are sent to centres, and a contact address for the Training and Customer Support section is also given in Section 10.

13. None of my candidates have produced work that is as good as the best exemplars in this guide. Does this mean they cannot achieve full marks for their assessments?

No. As long as candidates' work meets all the mark descriptors, including the top band, there is no reason why full marks should not be awarded. There can be a big range of performances within the top band. If you have one or two brilliant students, do not let this persuade you that those who are only 'very good' must be worth less than full marks. Conversely, if all your candidates are of more limited ability, do not be misled into giving the best of them full marks.

14. Can candidates use the Internet during their investigations?

Yes; there is some excellent material available and the highest mark descriptors for Skill P require candidates to draw together material from several sources. All URLs should be listed (with any other sources) in a bibliography. It should be noted that unless this information is processed or modified in some way and used in the development of the strategy, it is unlikely to be worthy of credit.

15. Will candidates improve their chances of achieving high marks by making extensive use of Information and Communication Technology in their reports?

Computer generated material is not in itself worth any more marks than hand-written work. However, if the use of I.C.T. enables the mark descriptors for any of the skills to be more effectively addressed, then candidates could gain extra credit. It should be noted that many graph-plotting packages, if not used expertly, may not produce the most appropriate graphs and therefore that the use of such software may actually penalise candidates.

16. My candidates have completed several assessments in a field notebook that includes some unassessed work. Can I submit the book to the moderator?

No; only assessed work should be sent. Centres should avoid this practice because it adds to the cost of postage and makes unnecessary extra demands on moderators.

17 Does all coursework have to be carried out under the direct supervision of the teacher?

No; in order to meet the requirements of the descriptors, particularly for Skills P and A, candidates will need to carry out research which may require the use of library facilities, the Internet etc.. Also, it may not be possible to devote sufficient time in the laboratory/classroom to allow candidates to write up their work. However, sufficient work must be completed under direct supervision to allow the teacher to authenticate the marks awarded, and this is left to the discretion of the Centre.

18 How much help can I give students with their coursework?

This is a difficult question to answer. In general terms, direct help in the form of suggesting to a student how to carry out an investigation, or how to interpret the results, is unacceptable, while it is acceptable to draw the attention of the student to aspects of the assessment descriptors that he or she has not addressed.

In some circumstances it may be necessary to give direct help to students, for example to ensure that they are working safely or to get them through a difficulty. Such help should be taken into account in the award of marks and details must be provided to the moderator.

If students are to be given the opportunity to choose their own coursework tasks, guidance should be given by the teacher to ensure that that the tasks are of appropriate demand and likely to generate results capable of analysis. In a whole investigation, or if students are to be asked to carry out an investigation that they have planned, it is suggested that the draft plans are submitted to the teacher for an initial assessment to be made of the suitability of the strategy. Such assistance is acceptable without penalty provided that candidates are not given direct guidance about what to do.

19. Can I take in the work of my students, mark it, and then give it back to them for any errors to be corrected before taking it in again for a final mark to be awarded?

No; once the work has been handed in for marking, the marks awarded should stand. Assistance can be given to students while they are carrying out their work provided that it is limited to the identification of aspects of the assessment descriptors that have not been addressed. However, it is suggested that work for Skill P should be collected in for an assessment of its suitability to be made before any practical work has been carried out, though Skill P should not be marked until the whole assessment has been completed.

20. Can I use worksheets to set the tasks that my students are to carry out?

Yes; worksheets are very helpful, particularly if students are not being asked to plan the investigation themselves. However, a worksheet used to set a planning task which gives too much guidance as to the method to be used or the number of readings to be taken etc. may reduce the level of demand of the task and so limit the marks which can be awarded to candidates.

21. Where more than one skill is being assessed on a single piece of work, for example in a whole investigation, is it acceptable for the skills to be given widely differing marks?

It is unlikely that skills will be awarded marks that differ by more than two. If the level of demand of the task is limited, this will have an effect on all four skill areas. The marks awarded for Skill P will relate closely to the other skill areas since it is unlikely that a poor plan will generate a good set of data and that such data can be analysed or evaluated to generate high marks. However, a good plan may produce good results but the analysis and/or evaluation may be poor. Where marks do differ widely, they should be scrutinised carefully and if a teacher feels that widely differing marks can be justified, information must be provided to the moderator to support the marks awarded.

22. Can work completed in the AS year be submitted for assessment for A2?

Yes; though the work submitted for AS must be set in the context of AS units and work for A2 must be in the context of A2 units. This means that candidates will need to draw on the knowledge and understanding of the appropriate units in order to plan and/or analyse the experiment/investigation. However, there are some topics that relate to work in both AS and A2 but teachers should be aware of the need to provide tasks of appropriate demand for A2.

23. If Units 2803 or 2806 are re-taken, can the coursework marks be carried forward?

Yes; an entry for one of these units is for the written paper and either the coursework component or the practical examination. Entry options for these units are provided for coursework marks to be carried forward, but it should be noted that marks for the written paper and the practical examination components may not be carried forward.

Appendix 2 Ethics and the Law

In the Specification Aims, Section 2.1 covers Spiritual, Moral, Ethical, Social and Cultural Issues.' In addition, in planning an investigation it is important that the candidate 'considers ethical implications in the choice and treatment of organisms' as well as 'the environmental and safety aspects of the proposed procedures.'

Much biological practical work will involve ethical considerations. It is strongly recommended that appropriate guidance should be sought before working on any living organism. The following issues should be considered by Centres, as well as being discussed with candidates.

Plants

Whole plant specimens should not normally be removed from their natural environment; this applies to all ecological studies. Most wild plants are protected by various Acts of Parliament and should not be 'harvested'. Various biological work requires the use of leafy stems, flowers etc. These should be obtained from commercial or private sources, or bred for the purpose.

Animals — invertebrates

No experiments should be carried out which may cause harm or suffering to these animals. In no circumstances should the animals be subjected to such extreme conditions that they are killed. For example: experiments on the effect of alcohol on Daphnia should use concentrations that do not kill the organism; experiments on the effect of temperature on barnacles should not exceed normal environmental temperatures; it is not acceptable to carry out experiments that measure the amount of force needed to dislodge limpets from their habitat; consideration should be given to the effects upon individuals and populations of the use of 'mark recapture' sampling.

Animals — vertebrates (excluding humans)

Experiments should not be carried out using live vertebrates, the only exception to this being, possibly, maze learning in rodents. No experiments should be carried out which may cause any harm or suffering to these animals. In no circumstances should the animals be subjected to such extreme conditions that they are killed. Animals should not be exposed to any unnecessary stresses; these include deprivation of food, water or rest. For example, in experiments using a food reward during maze learning in rodents, the animals must not be starved prior to the tests. Only material from commercial sources or bred for the purpose should be used for dissection; candidates should be made aware of the source of such material and encouraged to discuss the ethics of using it.

In all cases of experimentation on animals, candidates should be given the opportunity to opt out of such work due to their moral or religious standpoint.

Animals — humans

Many biological experiments are carried out in Centres, where the subject is one of the candidates or other pupils in the school.

Most candidates will be aged under 18 during some or all of their course of study. Whilst a person aged 16 or 17 may give consent, without parental permission, to an experiment which will not harm them, either physically or mentally, the Centre and candidates should appreciate that for any experiment, the 16 or 17 year old can only give informed consent. This is dependent upon the competence of the person and the information provided. It is recommended that the Headteacher be informed of all such experiments and that full risk assessments are carried out. In addition, careful consideration should be given before any experiments are conducted where the subjects may be exposed to judgmental comments by their colleagues. This includes exercise experiments, reaction times, memory tests and testing for various genetic phenotypes. In all cases, subjects must be allowed to opt out of such activities. Under no circumstances would experiments where subjects are given cigarettes, alcohol or other drugs be acceptable.

In certain circumstances, candidates carry out experiments comparing different age groups. Again, great care must be taken to ensure that none of the subjects may be upset by the results of the experiment (e.g. slow reaction times or reduced memory in elderly people). All subjects should give their consent to any activities before they are undertaken. Any experiment involving children under the age of 16 must be carefully planned and must not involve any chance of harm. Within a school environment, the staff involved should ensure that the Headteacher or other person or persons acting in loco parentis are prepared to sanction the experiment. A person under 16 is rarely competent to give personal consent.

Any practical work involving questionnaires must ensure that none of the questions are of a personal nature and that there is always an option not to answer any or all of the questions if the person so desires.

Appendix 3 Contextualised Mark Scheme for Activity 3

Skill P – Planning **Total 8**

The candidate:

Mark	General strategy	Level	Choices within plan	Level
0				
1	P1.a i. suggests a method that could be used to investigate water potential of a root vegetable ii. makes a prediction.		P1.b • chooses appropriate apparatus for investigation of water potential.	
2				
3	P3.a i. uses relevant scientific knowledge and understanding to attempt to suggest a workable prediction; ii. identifies the key factors to control, vary, or take account of.		P3.b • decides on a suitable number and range of observations and/or measurements to be made.	
4				
5	P5.a i. uses detailed scientific knowledge and understanding to justify the prediction; ii. uses information from a preliminary study or a secondary source; iii. takes into account the need for safe working and justifying any prediction made.		P5.b i. explains choice of equipment, in order to produce precise and reliable evidence; ii. uses specialist vocabulary to give a clear account.	
6				
7	P7.a i. retrieves and evaluates information from a variety of sources; ii. provides a plan which is well structured, logical and linked coherently to underlying scientific knowledge and understanding; iii. uses spelling, punctuation and grammar accurately.		P7.b • provides accurate details of how molarity of sucrose will be changed and how uptake of water will be measured to ensure the highest level of precision and reliability possible with the apparatus.	
8				

Skill I - Implementing **Total 7**

The candidate:

Mark	Manipulation	Level	Recording	Level
0				
1	I1.a i. demonstrates competence in simple techniques (e.g use of syringes and/or measuring cylinders); ii. shows an awareness of the need for safe working.		I1.b • makes and records observations and/or measurements which are adequate for the activity, e.g. syringe readings and mass of cylinders.	
2				
3	I3.a • demonstrates competence in producing dilutions;		I3.b • makes systematic and accurate observations and/or measurements which are recorded clearly and accurately, e.g. measure and record correct cylinders for each solution.	
4				
5	I5.a i. demonstrates competence and confidence in the use of practical techniques, e.g. carefully removes, dries and weighs cylinders; ii adopts safe working practices throughout(e.g. care with glassware, cleaning up spillages etc.		I5.b i. makes observations and/or measurements with precision and skill; ii. results recorded in a table using IoB guidelines, containing one or two minor errors..	
6				
7	I7.a • skilful and proficient use of all techniques as demonstrated by the results showing the correct trend.		I7.b i. makes and records all observations and/or measurements with regard to the precision of the apparatus used; ii. results recorded in a table using IoB guidelines, no errors.	

In the Centre's mark scheme, the precision acceptable will be dependent on the apparatus available, e.g. balance used.

Using the IoB guidelines, tables should have an informative title, informative column headings, units in the headings, unit symbols correctly expressed and no units in the body of the table.

Skill A - Analysing Evidence and Drawing Conclusions **Total 8**

The candidate:

Mark	Processing evidence	Level	Drawing conclusions	Level
0				
1	A1.a • is able to process data to obtain average weights and % change in weights (or equivalent).		A1.b • is able to, identify trends or patterns in the evidence giving simple conclusions.	
2				
3	A3.a • uses the processed data to present the evidence using the most appropriate graph(s).		A3.b • links the processed data with a conclusion and links this to knowledge of osmosis.	
4				
5	A5.a i. graph follows all IOB guidelines; ii uses the intercept from the processed experimental data and the reference curve to give the correct water potential for the tissue.		A5.b i. conclusion(s) are consistent with the processed data; ii. produces a clear account using specialist vocabulary as appropriate.	
6				
7	A7.a makes deductions from the processed evidence using detailed scientific knowledge and understanding; shows due regard to nomenclature, terminology and the use of significant figures.		A7.b i. conclusions well structured, comprehensive and concise; ii. accurate use of spelling, punctuation and grammar .	
8				

Skill E - Evaluating Evidence and Procedures **Total 7**

The candidate:

Mark		Procedures	Level		Sources of error	Level
0						
1	E1.a	• comments, in general terms of the suitability of the experimental procedures used.		E1.b	• recognises where the results may be anomalous.	
2						
3	E3.a	• recognises main sources of error in the technique used (e.g. the procedure assumes that all excess water is removed and the tissue samples contain the same cell types).		E3.b	i. comments on the accuracy of the observations and/or measurements made (e.g. use of balance, drying cylinders, zeroing, initial measuring material); ii suggests reasons for any anomalous results.	
4						
5	E5.a	i. recognises how errors in technique will affect the experimental result, e.g. inaccurate concentrations would give false results or weighing not as accurate due to poor drying; ii. suggests methods of improvement.		E5.b	i comments on the reliability of the evidence (e.g., compares the difference between the two readings for each molarity); ii evaluates the main sources of error.	
6						
7	E7.a	• justifies proposed improvements to the experimental procedures and/or strategy in terms of increasing the reliability of the evidence and minimising significant sources of error. E.g. making up the solutions using sucrose powder and distilled water, rather than a serial dilution.		E7.b	• assesses the significance of the uncertainties in the evidence in terms of their effect on the validity of the final conclusions drawn.	