



Biology (revised) Advanced Higher

Biology Investigation

Candidate Guidance (for use from Session 2012–2013)

Introduction

The investigation is an individual project undertaken by you with support from your teacher/lecturer to show that you can:

- ◆ come up with a suitable biology topic or idea on which to base a scientific investigation.
- ◆ research the biology background of your topic using various sources to include textbooks, journals and internet websites.
- ◆ come up with questions or hypotheses to investigate and state the aim of your investigation.
- ◆ devise suitable experiments to meet the aim of your investigation.
- ◆ make observations and carry out experiments safely and ethically.
- ◆ collect data accurately.
- ◆ devise further experiments based on initial results.
- ◆ process, present and analyse the collected data.
- ◆ evaluate your experimental procedures and results.
- ◆ submit a scientific report on your investigation.

Your investigation should be based on a topic that is appropriate to the demands of Advanced Higher Biology. It must include experimental or survey work and must not be a technical exercise in statistics or computing. Group work and joint investigations are not permitted. A successful investigation is likely to be in an area in which you have a genuine interest. Early discussions with your teacher/lecturer should take place to ensure that your proposals are practical, realistic and take account of the time and resources available to you.

The investigation cannot also be submitted as an investigation for any other Advanced Higher Course such as Advanced Higher Chemistry, Advanced Higher Physics or Advanced Higher Geography.

You should keep a record of all the work you do on your investigation. You should:

- ◆ keep short notes on the ideas and thoughts you have in the early stages of planning your investigation (including ideas you may later dismiss).
- ◆ keep a brief record of the discussions you have with your teacher/lecturer or other scientists (including any decisions or Outcomes made).
- ◆ keep notes (including a note of references) from your background biology research into the topic of the investigation.
- ◆ keep a record of all your experimental laboratory or field work including experimental methods and procedures, results obtained and an analysis of your results (using calculations, tables, graphs, diagrams or photographs as appropriate).

Although this is not required directly for assessment, your notes will be essential when you prepare the report of your investigation for Course assessment and will be a useful source of evidence when your teacher/lecturer assesses you for the Unit assessment.

Your investigation will be assessed for both Unit and Course assessment.

Unit Assessment

The investigation is part of the Advanced Higher Biology Unit *Investigative Biology*. To meet the standard of this Unit you must meet the Performance Criteria of Outcome 3.

Outcome 3 — Carry out a biological investigation.

Performance Criteria

- (a) The experimental design is appropriate to the aim of the investigation.
- (b) Ethical considerations in the use of living materials, human subjects and the conservation of natural habitats have been taken into account as appropriate.
- (c) Potential hazards have been identified, associated risks assessed and appropriate control measures applied.
- (d) Initial results are used to develop or confirm procedures in the experimental design.
- (e) Consideration is given to collecting data with precision and accuracy.

Your teacher/lecturer will assess your achievement of this Outcome based on evidence gathered during discussion with you and by observing you carrying out the investigation. Your teacher/lecturer will record the evidence of your achievement in a suitable checklist such as the one shown in Appendix 1.

Course Assessment

For Course assessment purposes, you are required to produce an investigation report. This report is submitted to SQA for external marking. A total of 25 marks (approximately 20% of the total marks) are allocated to the investigation report. A summary of the assessment scheme and mark allocation for the investigation report is shown in Appendix 2.

If you follow the guidelines given below, you should be able to score a high mark for this part of the Course.

The investigation process

The three important stages in the investigation are planning, collecting data and producing the investigation report. The key to success is good forward planning: you should set realistic deadlines and stick to them. Keeping a clear and accurate record of your work on a regular basis will help you to produce a good report.

The main stages in the investigation are shown in the table below. You should have regular discussions with your teacher/lecturer to ensure that procedures, safety, resources and timescales are appropriate.

Phase	Tasks	Deadline	Completed
Planning	Select an investigation topic that interests you. Discuss ideas with your teacher/lecturer.		
	Research the biological background to your topic (books, journals, websites etc.)		
	Develop an outline plan for the investigation.		
	Record aims, hypotheses and questions.		
	Outline experimental methods and procedures.		
Collecting data	Complete the experimental work in the time allocated. Allow time for further experiments based on initial results and for replication.		
Producing report	Hand in first draft.		
	Hand in final draft.		

Producing the investigation report

The investigation report submitted to SQA must have a logical structure and must be clear, concise and easy to read.

The report should be around 2,000–2,500 words in length excluding the title page, contents page, tables, graphs, diagrams, calculations, references, acknowledgements and any appendices. It should be written in the past tense and the impersonal voice should be used.

The report must include the following sections:

- ◆ Title page
- ◆ Contents page
- ◆ Abstract/summary
- ◆ Introduction
- ◆ Procedures
- ◆ Results
- ◆ Discussion
- ◆ List of references

Title page

This page should have a title that clearly indicates the subject matter of the investigation. You might start out with a working title and then consider revising the wording of the title as the investigation nears completion. The title page must also have your name and candidate number and the name and number of the centre you attend.

Contents page

The contents page must list the sections within the investigation along with their corresponding page numbers for the purposes of cross-referencing. It is essential that all pages throughout the report are numbered.

Abstract/summary

In your summary you must state the aims and findings of the investigation. The abstract/summary should immediately follow the contents page. Although it appears early in the report, as the abstract summarises the investigation it may be one of the last things you write.

Introduction

Your introduction must include a clear statement of the aims of the investigation (despite the fact that you have already stated these in the summary) together with any relevant hypotheses or questions. The aims need to be clear and explicit since these are key to the overall report.

In this section you must include a concise account of the relevant background theory to the investigation at a level appropriate to Advanced Higher. Take care to use terms accurately and explain ideas clearly. The references you use as sources for the background theory must be cited in the text of the introduction and listed at the end of the report (see Appendix 3 — References).

The purpose of your investigation must be justified and/or its biological importance explained.

Diagrams, formulae and equations should be included as appropriate.

Procedures

The procedures you use must be appropriate to the aims of the investigation.

The procedures must be clearly described in sufficient detail to allow the investigation to be repeated.

The experimental procedures that you use in your investigation must be at an appropriate level of demand for Advanced Higher Biology. Consideration of the following questions will help to assess if your experimental designs are valid and reliable.

- ◆ Have you included necessary controls in your plans?
- ◆ Have you controlled variables that should be kept constant?
- ◆ Are your replicates and sample sizes adequate?
- ◆ How complex is the design of your experiments?
- ◆ Have you modified procedures when this was necessary and/or based further work on initial results?
- ◆ How creative and original have you been?
- ◆ How accurate are your measurements?

The procedures should be presented in a meaningful and coherent way and not as a set of instructions. It would be appropriate in this section to include labelled diagrams or photographs of assembled apparatus. There must be evidence that you have been involved in the planning of the investigation and have not simply followed a given set of instructions.

Results

The results must be relevant to the aims of your investigation.

Readings (raw data) must be recorded and be within the limits of accuracy of measurement. Ensure that average results do not have an excessive number of decimal places.

All your raw and processed results must be presented in a clear and concise manner with appropriate use of calculations, tables, graphs and diagrams. It is essential that you summarise results adequately. Where results are presented graphically, a table containing the relevant processed data must support each graph. Extensive raw data may be presented in an appendix. Where Excel or other software packages are used to present graphs, it is important that axes are adapted to suit the data so that the results are presented in a scientific manner.

You must include a statement of results from tables and/or graphs to show the main trends and patterns observed.

In descriptive components of the work, observations must be detailed and suitably recorded and, where appropriate, quantitative.

Discussion

The discussion section is the most important part of the investigation report and in it you must discuss your findings in a critical and scientific manner. It provides you with an opportunity to show off the depth of your knowledge and understanding relevant to the biology in your investigation. It would be appropriate in this section to include a discussion of experiments that you carried out and which did not produce results or for which results were not presented.

In your discussion section you must include a clear statement of the overall conclusion(s) and a critical evaluation of the investigation as a whole.

The overall conclusions must relate to the aims of the investigation and they must be valid for the results obtained.

The discussion section requires you to review your work in a critical manner. Your evaluation of procedures should include the following where appropriate:

- ◆ accuracy of measurement.
- ◆ sources of error in relation to measurements.
- ◆ adequacy of replication.
- ◆ adequacy of sampling.
- ◆ adequacy of controls.
- ◆ the ways in which problems encountered in the investigation were resolved.
- ◆ ways in which procedures might have been modified to improve the investigation.

In the critical evaluation of your procedures in the discussion it is important to emphasise positive aspects relating to the procedures as well as commenting honestly on any shortcomings.

Your evaluation of results must include as appropriate:

- ◆ analysis and interpretation of the results.
- ◆ suggestions for further work.
- ◆ critical and scientific discussion of the significance of the findings.

The analysis and interpretation of results should include a statement of the results obtained, any trends or patterns observed and a discussion of the relationship between the results of different experiments in the investigation. This should lead to a discussion of suggestions for further work. In discussing the findings as a whole, reference should be made to relevant background theory where appropriate.

List of references

References should be listed alphabetically and must be in the format described in Appendix 3. Within the report, there must be a minimum of three references from different sources.

Appendix 1: Advanced Higher Biology Investigation — Unit assessment checklist

Checkpoint	Suggestions to aid professional judgement	Check (✓)
Stated the aim of the investigation and formulated questions or hypotheses to be investigated.	The candidate has developed ideas for an investigation by reviewing and discussing previous learning and/or researching appropriate sources of information. The purpose of the investigation is clear and/or questions to be investigated and/or hypotheses to be tested have been formulated.	
Devised appropriate experimental, observational and sampling procedures, techniques and apparatus.	The procedures devised are appropriate to the aim of the investigation. The candidate has selected an appropriate procedure after considering or trying alternatives or becoming proficient in the procedure.	
Considered the need for controls and replicate treatments or samples.	Use of negative and positive controls and the control of potential confounding variables has been considered as appropriate. The need for repeated measurements, replicate treatments or samples and repeated experiments has been considered.	
Taken into account the ethical use of living materials, human subjects and the conservation of natural habitats.	The candidate has developed knowledge of and taken into account any ethical issues relevant to the investigation.	
Identified potential hazards, assessed their associated risks and applied appropriate control measures.	The candidate is aware of any potential hazards and has used the appropriate control measures to control risks in carrying out the investigation.	
Initial results have been used to devise further experiments or to confirm the appropriateness of a procedure for further work.	Experimental findings have been reviewed and further steps identified and carried out if appropriate.	
Made observations and recorded measurements with appropriate precision and accuracy.	Observations and/or measurements are recorded in a planned and organised way. Consideration has been given to the precision and accuracy of results.	

Appendix 2: Advanced Higher Biology Investigation — Summary of assessment scheme and mark allocation for the Course report

Assessment category and criteria	Mark	Check (✓)
Presentation <ul style="list-style-type: none"> ◆ appropriate and informative title ◆ contents page and page numbers ◆ brief summary/abstract stating aims and findings ◆ references cited in text and listed in standard form ◆ report is clear and concise (2,000–2,500 words) 	1 1 1 (3)	
Introduction <ul style="list-style-type: none"> ◆ clear statement of aims together with hypotheses/questions ◆ account of underlying biology relevant to aims ◆ biological terms/ideas are clear and at an appropriate depth ◆ biological importance is explained/justified 	1 3 (4)	
Procedures <ul style="list-style-type: none"> ◆ appropriate to aims ◆ clear description with enough detail to allow repetition ◆ include appropriate controls and adequate control of variables ◆ adequate replicates and sample size ◆ appropriate complexity of methods/inputs/outputs ◆ creativity and originality ◆ pilot study or experiments based on previous findings ◆ appropriate accuracy or modifications to improve accuracy 	1 1 1 2 3 (8)	
Results <ul style="list-style-type: none"> ◆ relevant to aims ◆ data recorded within limits of accuracy of measurement ◆ data presented summarise overall results ◆ adequate quality, including headings/Units/scales/labels/clarity 	1 1 2 (4)	
Discussion <ul style="list-style-type: none"> ◆ conclusions relate to aims ◆ conclusions are valid for results obtained evaluation of procedures includes comment as appropriate on: <ul style="list-style-type: none"> ◆ accuracy/sources of error in measurement ◆ adequacy of replication/sampling ◆ adequacy of control ◆ solutions to problems and modifications to procedures evaluation of results includes as appropriate: <ul style="list-style-type: none"> ◆ analysis and interpretation of results ◆ meaningful suggestions for further work ◆ critical and scientific discussion of significance of findings 	1 1 2 2 (6)	
Total marks	25	

Appendix 3: References

A reference is any piece of material to which a writer 'refers' in the text. Each reference must be listed at the end of the report to provide information about the source of the material 'referred to'. This allows the reader of the report to consult the original work if necessary and is also an acknowledgement of the work of other authors. Each reference must also be cited in the appropriate part of the text using the author's surname and the year of publication as in the exemplar below:

There are many different starches whose different properties make them suitable for different uses. Recently, transgenic plants have been used to produce 'designer starches' for use in specific commercial applications (Bowsher, 2007).

When you are citing websites, it is sometimes difficult to attribute the information used to specific authors; in such cases, the citation should use the organisation responsible for the output published on the web pages consulted, as in the exemplar below:

Until the results of badger culling trials are known, it may not be possible to judge whether killing badgers will have a significant impact on the incidence of tuberculosis in cattle (The Mammal Society, 2006).

References should be listed in alphabetical order and must be written in standard form as follows:

Books

Author(s), (surname followed by initials) (Year of publication) Title, Publisher, Place of publication, Page number(s).

For example: Wright, R (2005) Environmental Science: toward a sustainable future, Pearson Prentice Hall, New Jersey, p.446

Journals/periodicals

Author(s), (surname followed by initials) (Year of publication) Title of article, Name of Journal, Volume number (Part number if appropriate), Page number(s).

For example: Bowsher, C (2007) Designer starches, Biological Sciences Review, 19 (3), pp18–20.

Websites

As many of the following items as are available must be given: author, date, title, publisher, the URL and the date you accessed the material (because the 'site' may be updated between the time the writer uses it and the point at which a reader refers to it).

For example: The Mammal Society (2006) Position statement: badgers and bovine tuberculosis. **URL: http://www.abdn.ac.uk/mammal/badgers_tb.shtml**
Visited: August, 2007