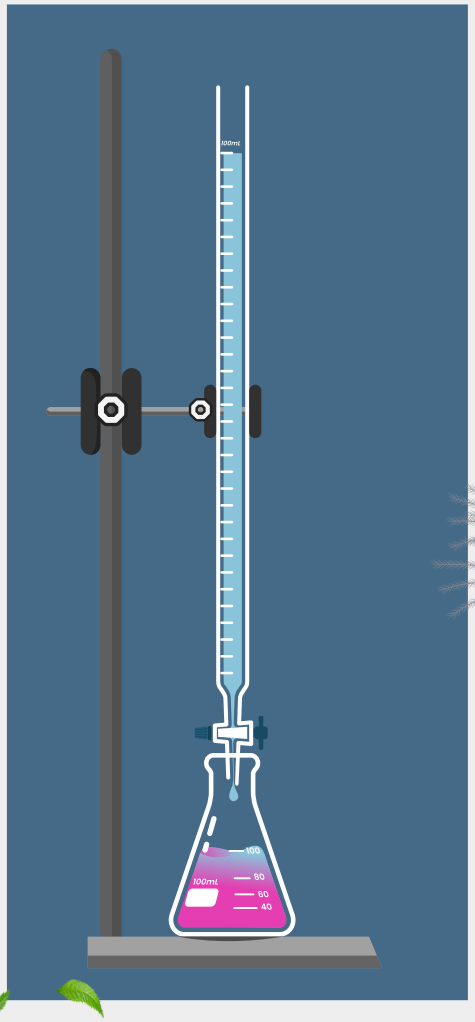
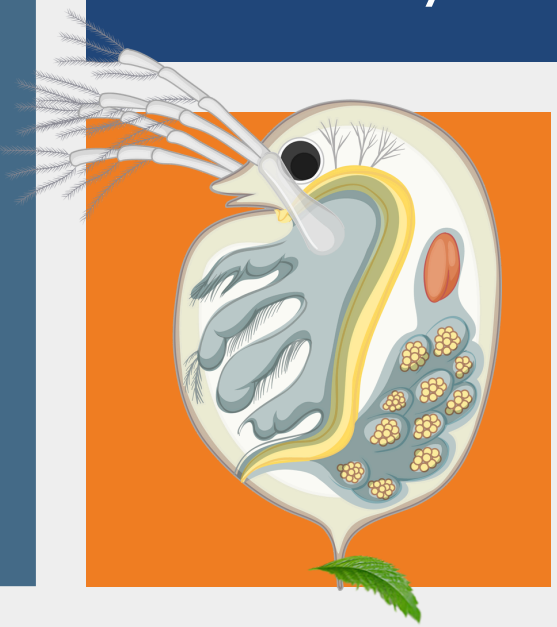
AH BIO PROJECT

Worth 30 marks

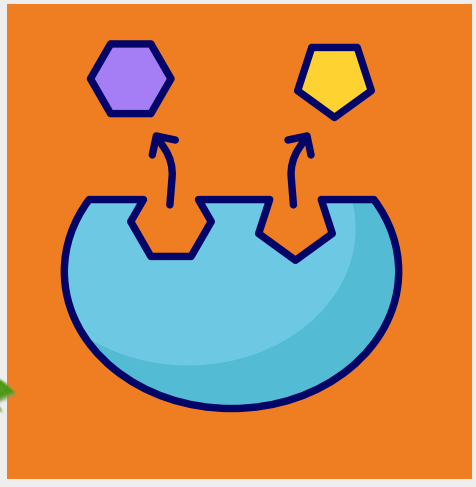
Scaled to 40

25% of your overall mark





IDEAS TO GET YOU STARTED



CFE ADVANCED HIGHER BIOLOGY INSTRUCTIONS FOR CANDIDATES PAGES 20-29

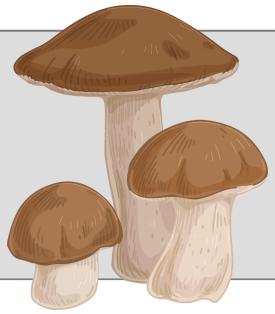
STARTING YOUR PROJECT

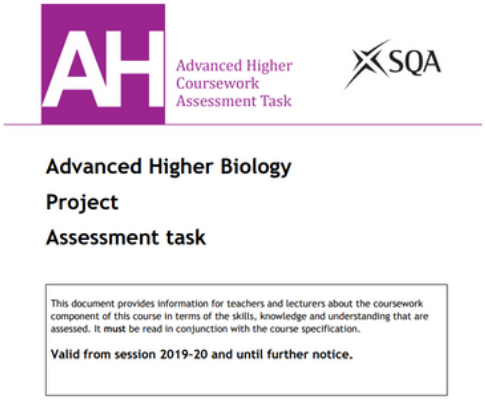
WHERE DO I START?

WHAT MAKES A GOOD PROJECT?

WHERE DO I FIND A PROTOCOL?

What area of Biology interests you? It is not always possible to carry out a project directly related to a personal interest, but it is a good place to start. I had a pupil who was interested in mushrooms - she found this protocol and built her investigation around this.





Look at the Instructions for Candidates (page 18 - 29) or the Marking Instructions (page 9 - 17) - this should guide your planning. Look at the **Procedures** section - what will your protocol look like? What will be a suitable sample size - how will you know? How long will this take? You also have to carry out a Pilot Study and Independent Replicate - this adds to the time and resources needed.

Keep your aim straight-forward, if possible - an aim with one independent and one dependent variable is sufficient. Then consider how all confounding variables can be controlled (in a lab) or controlled/monitored (in the field).

TO INVESTIGATE THE EFFECT OF X ON Y

Keeping going back to the Instructions for Candidates (page 18 - 29) as you progress with your project, e.g. for the Evaluation section, read the Questions (page 24) that are presented and try to answer these in your report; for References and Citations (page 25-27), follow the guidance to the letter (and comma, and full stops!)

The SQA Understanding Standards website for AH Biology provides some guidance on projects. Projects from candidates and marker commentary can be read, which can support your understanding of what is required.
Caution: do not copy these projects as your own.

What can I investigate?
PROJECT IDEAS

This resource contains a collection of experimental protocols that might support the **initial planning** of your Advanced Higher Biology project.

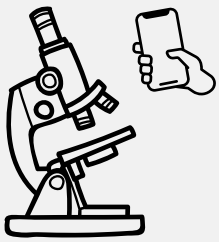
This is not an exhaustive list - and **these are not suggested projects**. They should **not** be repeated exactly as outlined. Instead, they might serve as a **starting point** from which your planning can build. Refer to the Instructions for Candidates and consider:

- a suitable aim that can be tested experimentally or in the field
- a method that is appropriate to your chosen aim
- appropriate controls
- confounding variables that could influence your dependent variable and how will you control/monitor them
- what will be a suitable sample size for your investigation?
- what time and resources will be needed to complete sufficient repeats and an independent replicate?
- what questions do you have that could be addressed in an initial pilot study?

Health & Safety: Your safety and wellbeing, and that of others around you, is of paramount importance. Risk assess the work you intend to do. Projects involving microbiology, living organisms, or human participants, for example, should be carefully planned to ensure the risk of any potential hazards has been minimised - do your research and discuss your plan with your teacher.

INVESTIGATING THE EFFECT OF CAFFEINE CONCENTRATION ON THE HEART RATE OF DAPHNIA MAGNA.

A wide range of different substances have been shown to have an effect on heart rate, including caffeine, various medications such as paracetamol, and alcohol.



CLICK FOR PROTOCOL

INVESTIGATING THE EFFECT OF SODIUM CHLORIDE AS AN INHIBITOR OF CATECHOL OXIDASE IN APPLES

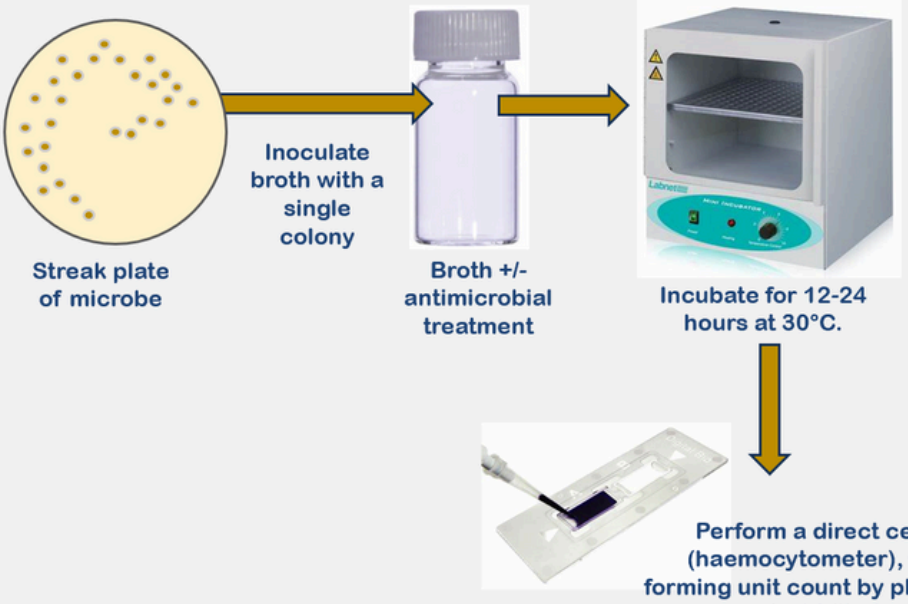
The browning of fruits is caused by polyphenoloxidases that convert polyphenols to melanin in the presence of oxygen. Various substances and processes can inhibit this process, prolonging the life of fruits and vegetables. Sodium chloride might be one potential inhibitor. This linked resource might provide you with some additional ideas.

CLICK FOR PROTOCOL

INVESTIGATING THE EFFECT OF ANTIFUNGAL MEDICATION ON THE GROWTH OF YEAST

This is an example of a microbiology project title that can be adapted in many ways. At Advanced Higher Biology level, consider carefully the confounding variables that need to be controlled to allow a valid conclusion to be drawn. This will guide you to a suitable protocol. The SSERC YouTube Microbiology channel provides a range of techniques to help.

SSERC TV MICROBIOLOGY



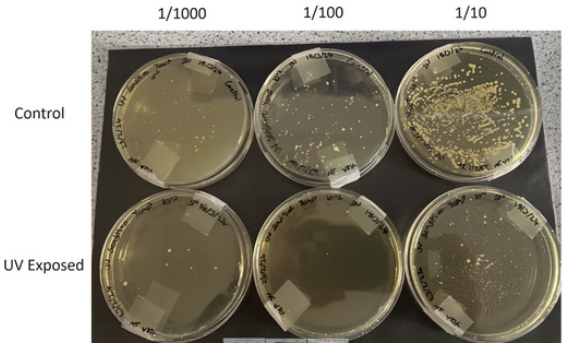
INVESTIGATING THE EFFECT OF NITROGEN CONCENTRATION ON THE GROWTH OF ALGAE.

Types of fertiliser and the concentration of various elements that are vital for plant growth can be investigated using algae. Cultures of algae can be grown in school under various conditions and then growth monitored using colorimetry (indirect) or using a haemocytometer (direct cell count). This links to eutrophication and the effect this can have on aquatic biodiversity and the stability of these ecosystems.

ALGAE SUPPLIER | **USING A HAEMOCYTOMETER** | **COUNTING ALGAE**

INVESTIGATING THE EFFECT OF SUN SCREEN ON THE GROWTH OF YEAST UNDER UV LIGHT

The effect of UV light on cell survival can be explored using a mutated strain of yeast that are sensitive to UV light. The cells are treated with UV light while "protected" using different types of sun screen or sun screen with different SPF ratings. Cultures are transferred to agar plates and the number of colonies growing can be counted.



YEAST SUPPLIER | **PRACTICAL PROTOCOL**

INVESTIGATING TRYPSIN ACTIVITY

Trypsin is an enzyme, secreted by the pancreas, that hydrolyses proteins into smaller, more soluble peptides. It is an important digestive enzyme. Milk can be used as a source of protein and different variables that affect enzyme activity can be investigated. The protocol linked below will provide a starting point for your planning.

PRACTICAL PROTOCOL

INVESTIGATING DOPA OXIDASE ACTIVITY

Enzyme inhibition studies are an interesting choice for an Advanced Higher Biology project. They are often straight-forward to repeat, with reproducible results. Be very careful to plan your project carefully so all confounding variables are controlled. Dopa oxidase is an enzyme, easily extracted from bananas, that converts L-dopa to a red/orange product called dopachrome. The enzyme is positioned within an interesting part of wider metabolism, which you should explore as part of your Introduction. The protocol linked below will provide a good starting point for your planning.

PRACTICAL PROTOCOL

INVESTIGATING CATALASE ACTIVITY

I'm sure you are all familiar with catalase. You've probably used potato or liver as a source of catalase, submerged it in a test tube of hydrogen peroxide, and measured the height of the foam produced using a ruler. Catalase is a fantastic enzyme responsible for the degradation of hydrogen peroxide into oxygen and water. There are many ways of measuring its activity and many independent variables you could investigate. For Advanced Higher Biology, it is good to explore these alternative methods. The protocol linked below will provide one alternative option.

PRACTICAL PROTOCOL

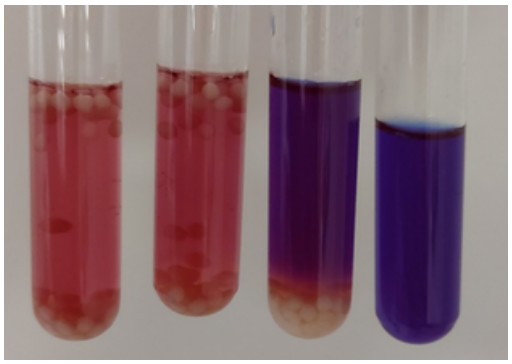
INVESTIGATING PHOSPHATASE ACTIVITY

Phosphatase enzymes are involved in a range of metabolic reactions; they release phosphate groups into the metabolic pool increasing their availability for use in a range of processes including ATP synthesis and membrane construction. The protocol linked below provides a method for how to investigate phosphatase activity. While the enzyme is easily extracted from mung beans or bean sprouts, the substrate (PPP) can be quite expensive so check if your school has this available prior to planning.

PRACTICAL PROTOCOL

INVESTIGATING DEHYDROGENASE ACTIVITY

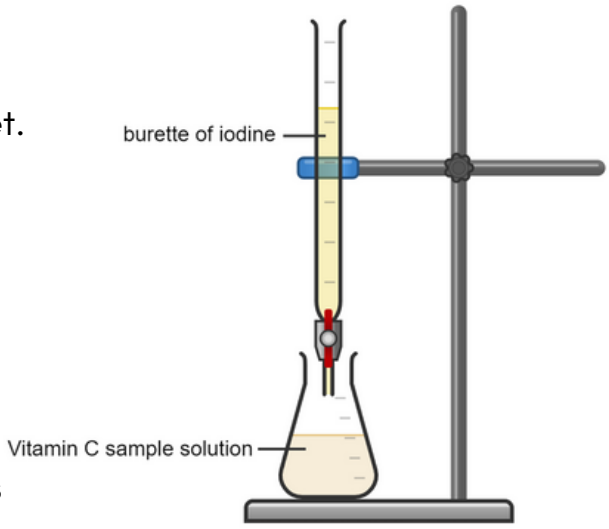
The protocol linked below provides a method for monitoring the action of dehydrogenase enzymes as a measure of respiration rate. Yeast is used as a model organism, which is immobilised so that colorimetry can be used. During glycolysis, glucose is broken down to pyruvate in the cytoplasm. Dehydrogenase enzymes remove the hydrogen ions, in a process called oxidation, and transfer the hydrogen ions to a coenzyme. In this experiment, resazurin dye is used to pick up the hydrogen. As resazurin is reduced, it changes colour, which can be monitored by colorimetry.



PRACTICAL PROTOCOL

MEASURING THE VITAMIN C CONTENT OF FRUITS

Over the course of evolution, humans have lost the gene that supports the biosynthesis of vitamin C. As such, we need to obtain this particular vitamin directly from our diet. Being able to make informed choices about the food we eat to provide us with correct nutrition is important. This protocol provides a method to measure the vitamin C content of fruits, firstly requiring you to generate a standard curve using solutions of known vitamin C concentration and, subsequently, to use this curve to estimate the vitamin C concentration in unknown samples (e.g. fruit juices). The protocol linked opposite will provide a starting point for your planning.



PRACTICAL PROTOCOL

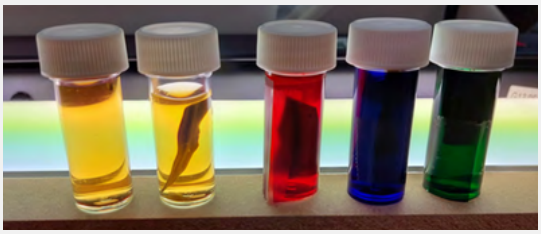
INVESTIGATING BETA AMYLASE ACTIVITY

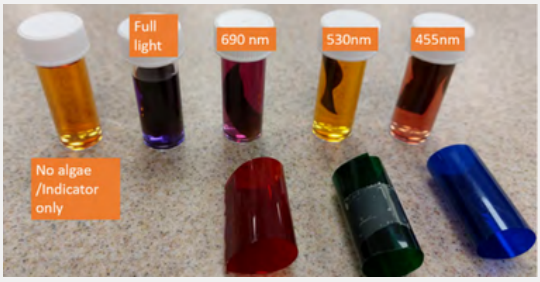
Starch is an important source of energy for many organisms. Beta-amylase, found in yeasts, bacteria, and plants, breaks every second bond of starch to leave 2 glucose monomers joined together - this molecule is called maltose. This reaction can be monitored, through the addition of iodine, by colorimetry. The protocol linked below provides an initial starting point for a wider investigation.

PRACTICAL PROTOCOL

INVESTIGATING PHOTOSYNTHESIS

Various researchers have investigated the influence of lighting of defined spectral characteristics on the growth of plants. This has wider implications for the global food chain, upon which there are significant demands as the human population continues to increase. The protocol linked below investigates the effect of wavelength of light on photosynthesis activity in immobilised algae or seaweed. A note of caution here - coloured filters are used to alter the wavelength of light that reaches the plant material; however, each filter transmits a different percentage of visible light, affecting overall light intensity. This must be taken into account in your planning to control confounding variables.

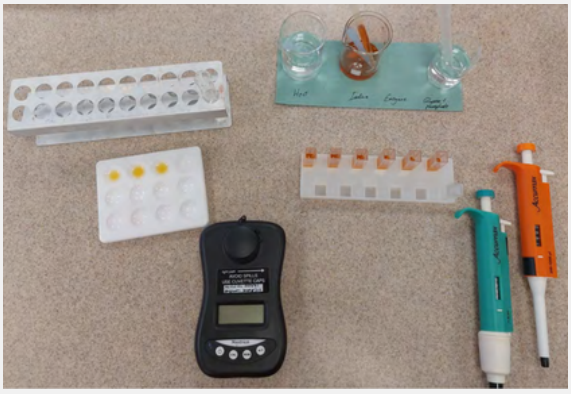




PRACTICAL PROTOCOL

INVESTIGATING PHOSPHORYLASE ACTIVITY

Back in N5 Biology, you might have looked at synthesis reactions using a practical activity - glucose-1-phosphate was mixed with phosphorylase (extracted from potatoes) to synthesise starch, detected using iodine. The protocol linked below builds on this knowledge and extends the approach to include a standard curve so the concentration of starch synthesised in the reaction can be estimated. This might provide a starting point for your planning to address the particular aim you are interested in.



PRACTICAL PROTOCOL

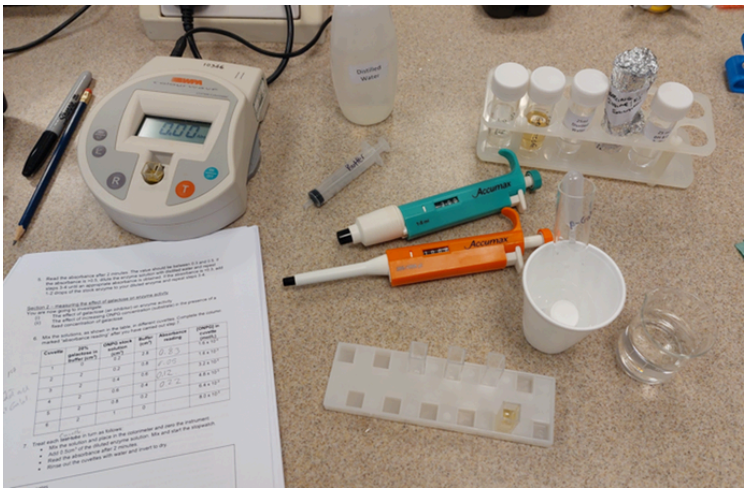
INVESTIGATING RESPIRATION IN YEAST USING CO2 PROBES

Data logging apparatus can be hard to find in school but occassionally this is possible. They can be used in a range of different experiments, including respiration and photosynthesis. One example of this would be measuring the rate of respiration in yeast, using a carbon dioxide probe, in the presence of different respiratory substrates. A good choice of potential substrates might include glucose, sucrose, lactose, and starch.

PRACTICAL PROTOCOL

INVESTIGATING LACTASE ACTIVITY

Lactase, also called beta-galactosidase, catalyses the breakdown of lactose into glucose and galactose. The chemical ONPG can also act as a substrate for the enzyme, resulting in the products ONP and galactose. ONP is yellow in colour - this means the reaction can be monitored using colorimetry. The end product, galactose, acts as a competitive inhibitor of lactase. This can be investigated using the protocol linked below. This protocol could be adapted to investigate an aim of your choice.



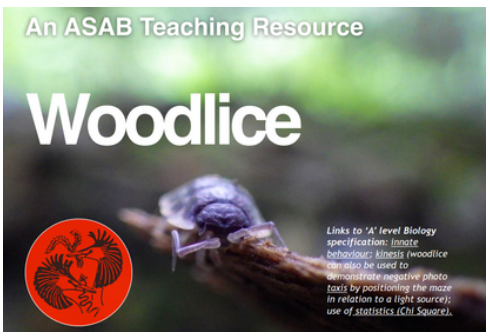
PRACTICAL PROTOCOL

MEASURING REDUCING SUGARS IN SOLUTIONS

The protocol linked below provides a basis from which to build your own investigation. It might be that you are interested in measuring reducing sugars in vegetable extracts or different sports drinks, for example. The dependent variable, sugar concentration, is determined by measuring time for a solution to decolorise. However, this could be adapted to use colorimetry instead. This protocol involves the production of a set of glucose standard solutions, construction of a standard curve, and using the standard curve to estimate the concentration of sugar in unknown samples.

PRACTICAL PROTOCOL

INVESTIGATING TURN ALTERNATION IN WOODLICE



The protocol linked below is available from ASAB and presents 3 different experiments. If you are interested in animal behaviour, this might be for you. Research has shown that woodlice, after being forced to turn in one direction, will turn in the opposite direction at the first opportunity to do to, thus maintaining an overall straight line.

PRACTICAL PROTOCOL

INVESTIGATING MOVEMENT IN SEED BEETLES

The linked protocol is available from Practical Biology and investigates the speed of seed beetles during horizontal and vertical movement. The seed beetle is a pest of legumes, e.g. beans and peas, and results in loss of mass, reduced seed quality, and germination success. Understanding factors that affect their movement would have implications for food production and security.

PRACTICAL PROTOCOL

INVESTIGATING THE RESPONSE OF CALLIPHORA LARVAE TO LIGHT

The linked protocol is available from Practical Biology and investigates the response of Calliphora to light. This, like any animal inivestigation, will require application of your knowledge of scientific ethics in animal studies and the 3Rs. When working with animals, careful consideration of sample size is needed - this should reflect the variation you observe in the data.

PRACTICAL PROTOCOL

INVESTIGATING PECTINASE ACTIVITY

Pectinase is used in juice making, to optimise the volume of juice that can be extracted and has been shown to play a role in clarifying juice as well. The original protocol for this came from University of Reading NCBE and this has been adapted by SSERC. Both protocols are linked below and might provide a starting point if you were interested in this project.

SSERC PROTOCOL

NCBE PROTOCOL

The National Centre for Biotechnology Education (University of Reading) has a number of different protocols, ranging from photosynthesis, respiration, microbiology, and enzymes. Click the link below to explore.

NCBE WEBSITE

FIELDWORK INVESTIGATIONS

SSERC do have some protocols for fieldwork investigations. The following websites might also be worth visiting if you are interested in exploring this type of project:

- The Field Studies Council: Sampling - The Basics
- The Field Studies Council: Sampling - Methods
- Royal Geographical Society - Sampling Techniques
- Barcelona Field Studies Centre

Some interesting ideas might include:

- Investigating the abundance / diversity of lichen in a native deciduous woodland.
- Investigating the abundance / diversity of lichen in a coniferous forest plantation.
- Investigating the abundance / diversity of moss in a native deciduous woodland.
- Investigating the effect of tree type on plant diversity / abundance.
- Investigating the effect of tree type on fungi abundance.
- Investigating the effect of river flow rate on aquatic invertebrate diversity / abundance.
- Investigating the effect of urbanisation on the diversity of aquatic invertebrate diversity / abundance.
- Investigaitng the effect of water quality on aquatic invertebrate diversity.
- Investigating the effect of tree planting density on soil porosity.
- Investigating the effect of time of year on sugar content of grass.
- Investigating the effect of height up the shore on the diversity of seaweed species.

Some interesting marine research questions can be found here.

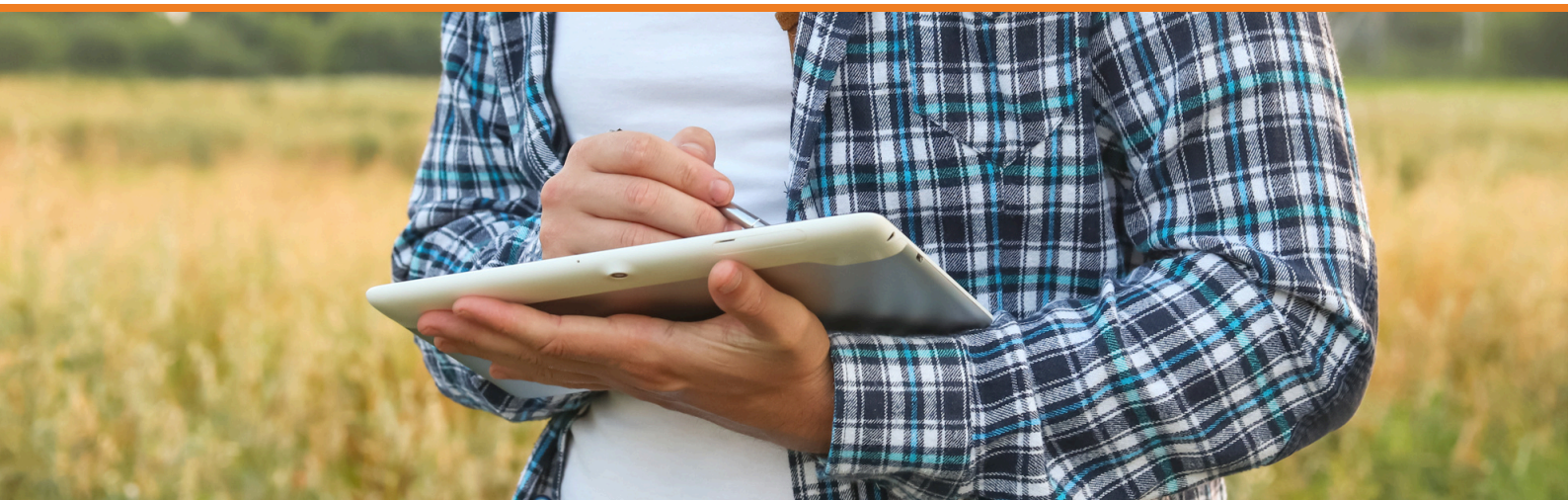
LICHEN ABUNDANCE PROTOCOL

SOIL PROTOCOLS

SUGAR IN GRASS

AQUATIC INVERTEBRATE DIVERSITY

SEAWEED DIVERSITY

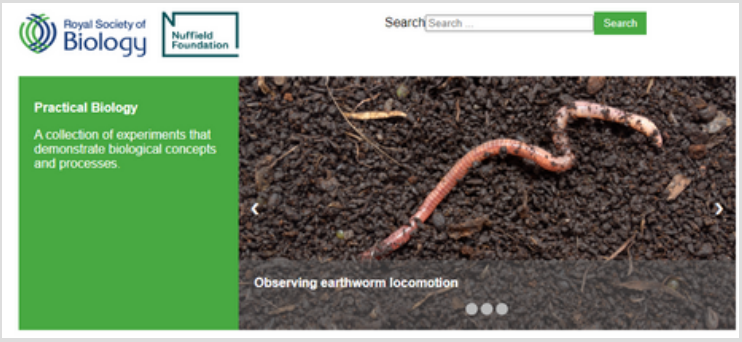


RZSS
THE WILDLIFE CONSERVATION CHARITY

ADVANCED HIGHER BIOLOGY PROJECTS

Edinburgh Zoo and the Highland Wildlife Park welcome applications to carry out a behavioural, observational research study on some of their endangered species. They have an education team who can provide support and advice, alongside your own teacher.

Click here for full details.



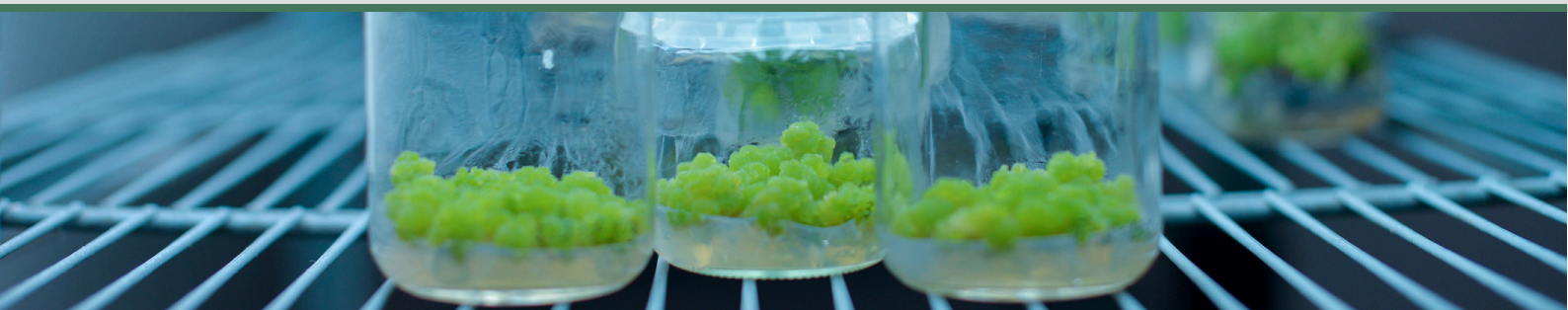
There are a wide variety of potential investigations available on this website.

PRACTICAL BIOLOGY WEBSITE

If you are particularly interested in plant biology, SAPS might have a protocol to guide your planning. Click on “Teaching Resources”, “Secondary & Post-16 Teaching Resources”, then filter by “Practical” under Resource Type.

Science &Plants for Schools

SAPS WEBSITE



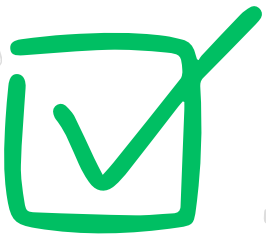
WRITING UP YOUR PROJECT

LEARNING FROM EXPERIENCE

SQA COURSE REPORTS

Every year, SQA provides a "course report", summarising areas where candidates performed well and areas that candidates found demanding. We can learn important things about how to improve by reading the course report. Key points are highlighted below.

INTRODUCTION



- Your introduction needs to show **breadth** and **depth** of understanding of your chosen topic. The account needs to have sufficient depth to support your discussion section later on.
- Highlight the biology that is fundamental to your project.
- Do not include information that is not clearly linked to your specific aim, i.e. don't copy in your course notes – **be specific**. For example, do not copy out all your notes on protein structure if you are investigating amylase activity – this would be too general. Your introduction should help you and your marker make sense of your results.
- Use reliable sources of information to avoid using inaccurate biology.
- You should not limit yourself to theory covered in the course – reading beyond the scope of the mandatory knowledge is necessary for your project.

PROCEDURES

- Apply your knowledge of the Investigative Biology unit to develop sound protocols with appropriate controls.
- Include **all key information** required to repeat the procedure.
- Identify all **confounding variables** and control these in your experiment – explain how you have done this. This is very important to achieve **validity**. It is not enough to simply acknowledge that confounding variables exist – you need to do something about it.
- You need to carry out an **independent replicate** and explain **how** this was achieved. What made it **truly independent**?

RESULTS

Spend time thinking about how to present your results - the presentation chosen must clearly show the trend or pattern of the data. There is a total of 6 marks here.

Remember: tables and graphs must have clear headings/labels with appropriate units. Graphs must have appropriate scales and accurate plots as well.

Ideally, your results section will have a table + graph for Data Set 1 and another table + graph for your Independent Replicate. The data from the first data set and independent replicate should then be combined into a summary table and a mean calculated (where appropriate). This overall set of data should be presented in a graph (see below for example).

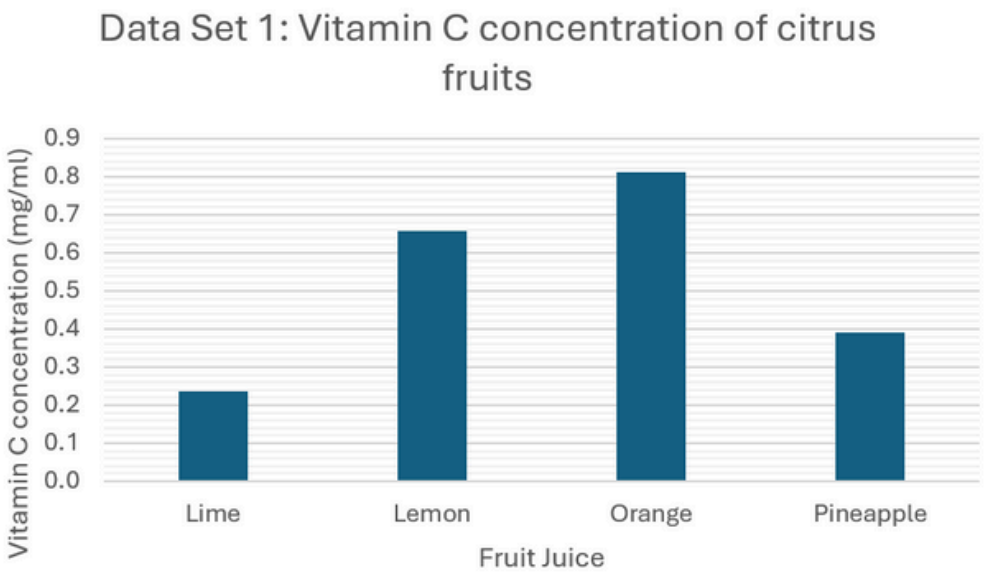
Think about the level of accuracy implied by your data. If you were using a ruler to measuring length, you wouldn't claim an average length of 1.143 cm - a ruler simply could not achieve this level of accuracy. A general rule is to present mean values with the same number of decimal places as the raw data.

Example: Investigating the vitamin C concentration of citrus fruits

There is not a "one-size-fits-all" approach to presenting your results. This is an example of how you might choose to present the data in your project. Graphs are supported by data in a table, which includes raw data and calculated mean values.

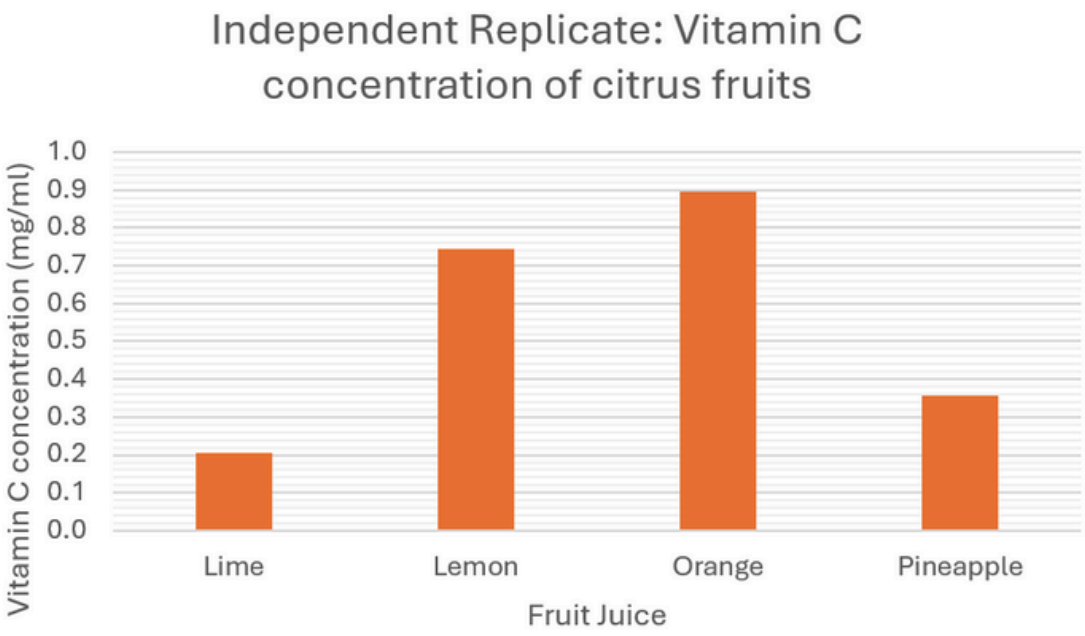
Data Set 1

Fruit Juice	Titre required to reach end point (cm^3)				Vitamin C concentration (mg/ml)
	1	2	3	Mean	
Lime	3.2	3.5	3.3	**3.3**	0.2
Lemon	9	9.3	9.3	**9.2**	0.7
Orange	11.5	11.2	11.2	**11.3**	0.8
Pineapple	5.5	5.4	5.5	**5.5**	0.4



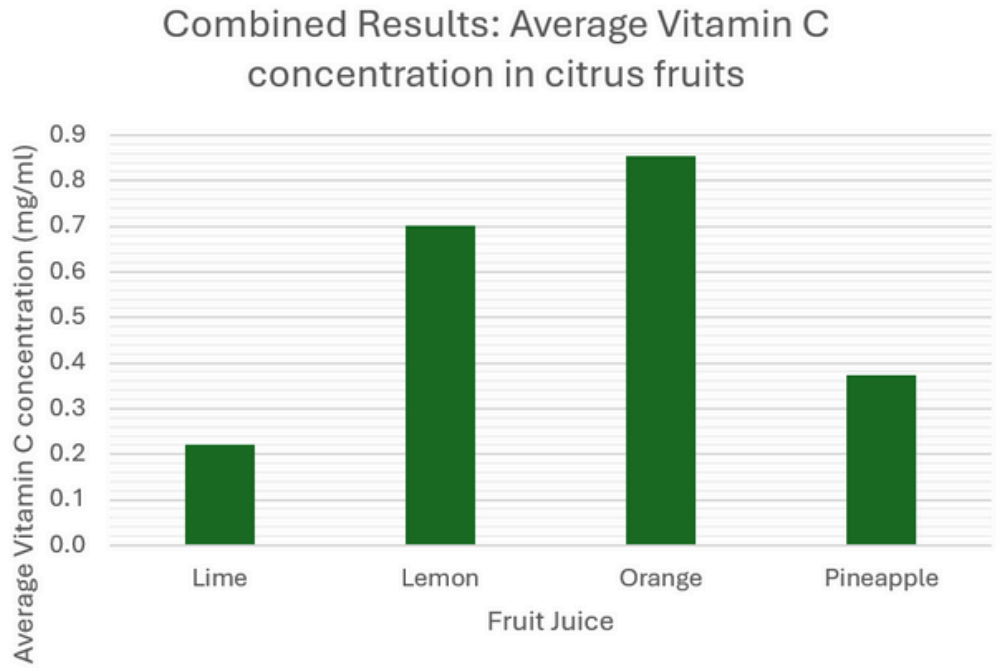
Independent Replicate

Fruit Juice	Titre required to reach end point (cm^3)				Vitamin C concentration (mg/ml)
	1	2	3	Mean	
Lime	2.9	3.0	2.8	**2.9**	0.2
Lemon	10.2	10.4	10.5	**10.4**	0.7
Orange	12.4	12.6	12.4	**12.5**	0.9
Pineapple	5.1	5	5	**5.0**	0.4



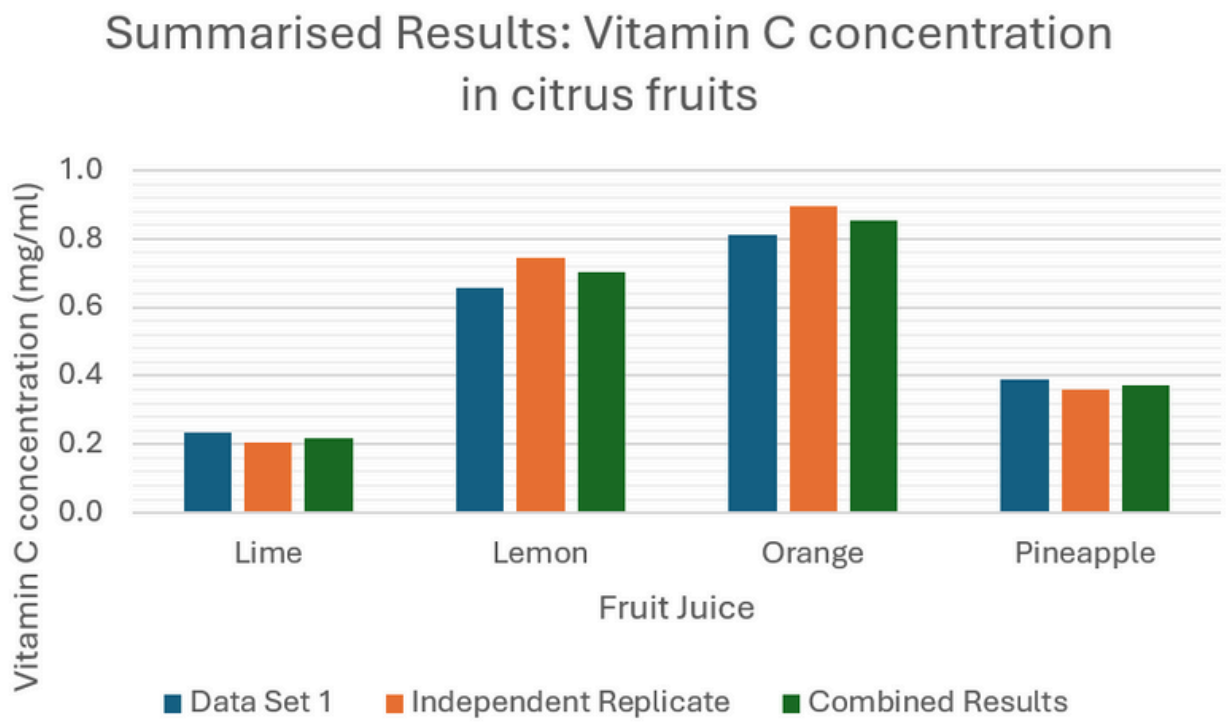
Combined Results

Fruit Juice	Titre required to reach end point (cm^3)			Vitamin C concentration (mg/ml)
	Data Set 1	Independent Replicate	Mean	
Lime	3.3	2.9	**3.1**	0.2
Lemon	9.2	10.4	**9.8**	0.7
Orange	11.3	12.5	**11.9**	0.9
Pineapple	5.5	5.0	**5.3**	0.4



Summary of Results

Fruit Juice	Vitamin C concentration (mg/ml)		
	Data Set 1	Independent Replicate	Combined overall result
Lime	0.2	0.2	0.2
Lemon	0.7	0.7	0.7
Orange	0.8	0.9	0.9
Pineapple	0.4	0.4	0.4



When you refer to the Marking Instructions for the AH Biology project, you can see the data above:

- is relevant to the aim – i.e. it shows the vitamin C concentration in citrus fruits
- the raw data is recorded and within the limits of accuracy of the burette (that would be used in this protocol). The mean values are presented to the same level of accuracy.
- the tables and graphs clearly show the pattern in the data, i.e. you can see which fruit contains the most and least vitamin C.
- Overall results have been calculated and presented based on repeats and replicate measurements. There is a table and supporting graph.
- The tables and graphs have got appropriate and accurate labels and units, the graphs have been plotted accurately, and the scales are suitable. The trend is clearly displayed in both the tables and graphs.

Computer or hand-drawn graphs are both appropriate for your project and equally accepted. Make your choice based on what you feel most confident in producing to the highest standard.

DISCUSSION

DEMANDING SECTION OF THE REPORT-7 MARKS

Explain the key issues that affect the validity and reliability of conclusions that you present.

To achieve a valid conclusion, you must:

- state a conclusion that is accurately reflect in the data you present
- adequately control or monitor key confounding variables
- include appropriate controls
- have a suitable sample size and a true independent replicate.

THIS HIGHLIGHTS WHY PLANNING YOUR PROJECT WELL, FROM THE START, IS SO IMPORTANT.

EVALUATING PROCEDURES

Don't simply state the equipment you have used and possible errors associated with using them - instead, link your statements to **validity** and **reliability**. This should be a **positive** discussion. In N5 and H Biology, an evaluation is often "I used a syringe; I should have used an automatic pipette as it would be more accurate" - this isn't enough at AH level. At the planning stage, think about accuracy, validity, and reliability and plan the appropriate equipment to use - and then talk about these decisions in your evaluation.

Controls - Explain the importance of these - why did you need to include the control?

Discuss your **pilot study** - how did it influence your final experimental design?

Be positive about the decisions you made about your procedure - **try not to highlight flaws** and what you would do next time if you have more time.

Discussion of **reliability** - At N5/H level, you often say "the experiment was repeated to improve reliability of results". This is not sufficient at AH level. Look at your measurements and the variability in these values. How did this inform your **sample size**? Can you include a **boxplot** to further discuss this variation? What is the purpose of an **independent replicate**? What did your independent replicate demonstrate in your own project?

EVALUATING RESULTS

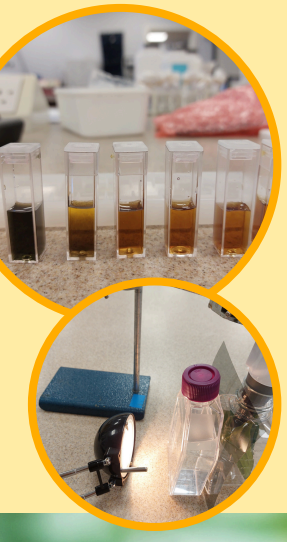
Try to make sense of the results you have collected. What do they mean? Integrate biological details from your introduction here to make sense of the data you have presented.

Discuss variation in the results between repeats and replicates. If variation was observed, was this due to error in laboratory practice, intrinsic variation in the biological samples studies, or the treatments that have been planned?

If you decide to analyse your results using statistical tests, discuss the meaning of these tests and what the outcome shows about your data. If you plot range bars on graphs, discuss accurately what this shows about your data.

Relate your findings to relevant biology. This "relevant biology" would, ideally, be in your introduction or might be from additional published work. Think about your project as a self-contained book and whoever reads it requires all the information to make sense of the results and your conclusion. This highlights the importance of keeping your introduction specific, with suitable depth and breadth of biological background. How do your results and conclusion compare to published findings?

PRESENTATION



- Include clear headings, as outlined in the Instructions for Candidates.
- Choose a title that is descriptive and outlines what you are investigating, e.g. *Effect of garlic on lipase activity*.
- You must cite at least 3 (use more than this!) references correctly in your report, and list the same references correctly at the end. You must use Harvard OR Vancouver for this - use the Instructions for Candidates - put all the information in the correct order, include commas, full stops, brackets, italics, etc.
- Be careful with online research papers or reviews - in the majority of cases, these should be referenced as the printed version. Include all necessary details - not the webpage link.