Module 1: Enzyme activity depth study

## Inquiry question: How do cells coordinate activities within their internal environment and the external environment?

This is an inquiry based depth study for Year 11 that teachers developed at the 2019 Teaching the Year 12 Modules workshops. It may take 5 hours of class time.

## Working scientifically outcomes:

* **Questioning and Predicting – BIO11/12-1**

A student develops and evaluates questions and hypotheses for scientific investigation.

Students:

* + develop and evaluate inquiry questions and hypotheses to identify a concept that can be investigated scientifically, involving primary and secondary data (ACSBL001, ACSBL061, ACSBL096)
	+ modify questions and hypotheses to reflect new evidence
* **Planning Investigations – BIO11/12-2**

A student designs and evaluates investigations in order to obtain primary and secondary data and information.

Students:

* + assess risks, select appropriate materials and technologies when designing and planning an investigation (ACSBL031, ACSBL097)
	+ justify and evaluate the use of variables and experimental controls to ensure that a valid procedure is developed that allows for the reliable collection of data (ACSBL002)
	+ evaluate and modify an investigation in response to new evidence
* **Conducting Investigations – BIO11/12-3**

A student conducts investigations to collect valid and reliable primary and secondary data and information.

Students:

* + employ and evaluate safe work practices and manage risks (ACSBL031)
	+ use appropriate technologies to ensure and evaluate accuracy
* **Communicating - BIO11/12-7**

A student communicates scientific understanding using suitable language and terminology for a specific audience or purpose

Students:

* + select and use suitable forms of digital, visual, written and/or oral forms of communication

## Rationale

This depth study aims to provide students with the opportunity to plan and conduct investigations, as well as process data and information. Focus will be placed on the development of skills related to planning and conducting investigations, as well as processing and communicating information. Students will be given feedback about the development of their investigative skills.

Students will be provided with a model procedure to investigate the effect of temperature on activity of the enzyme – renin. Students will then develop a hypothesis and plan and conduct a practical investigation to test the effect of substrate concentration or change in pH on an enzyme.

## Activity A – How can we model the effect of temperature on enzyme activity

### Background information

An enzyme is a substance which alters the rate of a specific chemical reaction without itself forming part of the final product. One easily observed example of this activity is the effect of the enzyme rennin on milk.

Rennin is an enzyme that acts on the milk protein, casein, causing it to clot and form a curd. This has the effect of keeping liquid foods in the stomach for long enough so that some digestion can take place. Rennin is found in the stomachs of babies and young children whose diet is mainly milk. Another source of rennin is junket tablets which are used in setting milk into a solid. Junket tablets are used as a source of rennin in this experiment.

**Develop an aim and hypothesis for this investigation and write it below.**

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### Method

**Teacher note:** divide the class into eight groups. Each group will prepare and maintain a water bath set at one of the following temperatures by adding hot or cold water as required. (Start with the bath half filled).

10ºC, 20ºC, 30ºC, 35 ºC, 40ºC, 45 ºC, 50ºC, 60ºC

Each group to do the following:

1. Using a 10mL measuring cylinder, place 5mL of milk into two test tubes, one test tube marked ‘A’ and one marked ‘B’. Then place both test tubes in the water bath.
2. Using a clean 10mL measuring cylinder, place 1mL of rennin (junket) solution in a test tube, and then place it in the water bath along with the other two test tubes.
3. Wait 10 minutes, in order to allow for the contents of the three test tubes to come to the temperature of the water bath.
4. When the test tubes have reached the correct temperature add 1mL of rennin (junket) solution to test tube ‘A’ only. Gently swirl the test tube and place it back into the water bath. Start the stopwatch.
5. Examine test tube ‘A’ (by gently tilting), every minute for 20 minutes. Record the time taken for the contents of each test tube to clot. If no clotting has occurred after 20 minutes record a negative sign in the results table.
6. For the test tubes that clotted within 20 minutes calculate the reciprocal of the clotting time (1/clotting time) and record in the results table. Use this as the measure of the activity of the enzyme.

### Results

1. Draw up a table of results, so it includes the following column headings: volume of substrate, volume of enzyme solution, temperature, clotting time, enzyme activity (1/clotting time).
2. Graph the results by plotting enzyme activity (1/clotting time) against temperature

### Discussion

1. Identify the independent and dependent variables in this experiment.
2. Explain the purpose of test tube ‘B’ in this experiment?
3. At which temperature was the enzyme most active? What is the evidence to support this conclusion?
4. Describe the results shown on the data graph (make sure to use the term optimum temperature).
5. From the knowledge gained throughout this experiment and your research on the enzyme renin, outline what might be happening to the enzyme rennin at:
	1. low temperatures,
	2. high temperatures
6. Annotate your graph to explain the changes in the behaviour of the enzyme at different temperatures.
7. Justify the use of variables and a control to ensure the validity of this investigation.
8. Suggest one modification to the procedure that could extend this investigation.

### Conclusion

1. Write a conclusion for this experiment (make sure to refer to the relationship between the independent and dependent variables).
2. **Self-mark your report using the Marking Criteria on last page. (Some reports will be peer reviewed together by the class).**

## Activity B – Student investigation

### Background information

Catalase is an enzyme present in all living things. It is responsible for catalysing the breakdown of hydrogen peroxide (H2O2). Hydrogen peroxide is produced as a result of cellular respiration within the cell. If it is allowed to accumulate it will be toxic to the cell and cause its death. When hydrogen peroxide is broken down it forms the non-toxic substances oxygen and water:

Hydrogen peroxide (liquid) → water (liquid) + oxygen (gas)

$$2H\_{2 }O\_{2}(l)\rightarrow 2H\_{2}O(l)+O\_{2}(g)$$

### Task information:

You are to work in groups to plan and conduct a practical investigation to test the effect of one of the following on the activity of the catalase enzyme:

* Substrate concentration or
* Change in pH

For your investigation the source of catalase is potato tissue. The activity of the enzyme is estimated according to the amount of oxygen gas produced and is measured by looking at the height of bubbles in the test tube. The more gas produced, the faster the rate of reaction of the enzyme catalase.

### You will plan, collect data and present the following information:

* Develop an inquiry question related to the factor investigated
* Aim
* Hypothesis
* Method
* Risk Assessment
* Results table
* Graph
* Discussion
* Conclusion
* Evaluation of your inquiry question

### How will you present this information?

You will work in groups to plan and conduct the investigation. You will then work individually to write a final report that will be peer evaluated.

### How much time will you have to work on this?

You will be given one lesson to plan your investigation, one lesson to conduct the experiment and two lessons to graph your results and prepare your final report.

### Planning your investigation

**In groups**

* Read the task information above
* Identify your variables
* Write your aim and hypothesis
* Develop an equipment list needed for your method
* Check the method with your teacher and design a table of results. Feedback will be given before conducting experiment.
* Conduct the investigation and collect data

**Individually**

* Graph your results including a correct scale, data points, axis labels and trend line. Annotate your graph, showing changes in enzyme behaviour
* Discuss the trend in your results and explain the relationship using your research on enzymes
* Write a detailed critical review of the validity/reliability of your procedure and suggest valid improvements
* Write a conclusion that states the relationship between your variables
* Check the marking criteria before submission
* The report will be peer marked by students

### Formative assessments

Students will generate an initial draft report for Part B based on their inquiry activity. This will be reviewed by the teacher and feedback will be provided to improve the method if needed. The report should contain the following elements:

* Inquiry question
* Aim and hypothesis
* Method

### Summative assessment

A written scientific report on the investigation conducted. Students must provide arguments in the discussion that are based on the data gathered in this unit of work. They should also reflect on the inquiry question, including the information that they have collected.

## Peer review - marking criteria

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| --- | --- | --- | --- | --- | --- |
| **Criteria** | **1 mark** | **2 marks** | **3 marks** | **4 marks** | **Total marks** |
| Inquiryquestion | Some attempt at inquiry question | Appropriate inquiry question related to testing factor |  |  | /2 |
| Aim & hypothesis | Either an aim OR hypothesis  | Both aim and hypothesis stated but no mention of relationship between IV and DV | Both aim and hypothesis are clearly stated and includes relationship between IV and DV |  | /3 |
| Variables  | One variable correctly identified | Two of IV, DV and CV identified | Both IV & DV identified and some CV  | All variables are correctly identified.  | /4 |
| Scientific method | Problems in design that produce invalid result | Method has some steps; a simple design which can produce some results related to the aim | Method is well planned in ordered steps; valid design which can produce results related to the aim | Method shows outstanding planning, ingenuity and precision in its design and can produce results related to the aim (validity) | /4 |
| Results | Numerical data is unlikely/ doubtful/ unreliable; no table; no units | Data in simple table includes only one correct heading or no units | Reliable data is in table with correct headings with some units included | Reliable data is in table with IV and DV as headings, includes correct units | /4 |
| Clear presentation of graph | 1 of: axes correctly labelled with units included, data points correct, scale even, curve/trend line | 2 of: axes correctly labelled with units included, data points correct, scale even, curve/trend line | 3 of: axes correctly labelled with units included, data points correct, scale even, curve/trend line. | Axes correctly labelled with units included, data points correct, scale even, curve/trend line. | /4 |
| Graph annotation | Some annotations on graph, showing some enzyme behaviour | Correct annotations on graph, clearly showing all changes in enzyme behaviour |  |  | /2 |
| Discussion 1: description & explanation of results | An attempt to discuss a pattern, relationship or trend. Description may be incorrect | Some description of results. Attempts to explain relationship or trend. Limited or no scientific explanation | Correct description and explanation results. Some scientific understanding of general enzymes | Correct description and explanation of results. Shows scientific understanding and reflects research on specific enzyme and factor tested | /4 |
| Discussion 2: reviewed method | An attempt to review reliability/validity of method | Some valid review of validity/reliability. Limited suggestions of improvement | Detailed critical review of validity/reliability. Suggests valid improvements |  | /3 |
| Conclusion is valid and related to the aim | Conclusion not related to aim | Conclusion only includes one variable (IV or DV) | Valid conclusion states relationship between IV and DV succinctly |  | /3 |
| Evaluation of inquiry question | Basic evaluation of inquiry question | Detailed and valid evaluation of inquiry question |  |  | /2 |

**Total marks= /35**