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INTERNATIONAL GCSE (9–1)

Biology

for Edexcel International GCSE

Core Practicals Teacher Lab Book

Teacher and technician information

HODDER EDUCATION
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Contents

Asterisks* are used to indicate which practicals are for separate sciences only.

We have carried out a health and safety check of this text and have attempted to identify all recognised hazards and suggest appropriate cautions. However, the Publishers and the authors accept no legal responsibility on any issue arising from this check; whilst every effort has been made to carefully check the instructions for practical work described in this book, it is still the duty and legal obligation of schools to carry out their own risk assessments for each practical in accordance with local health and safety requirements. Suitable blank and model risk assessments are publicly available and can be found readily online.

The text has not been through the Edexcel endorsement process.

For further health and safety information (e.g. Hazcards) please refer to CLEAPSS at www.cleapss.org.uk.

Matching chart

Edexcel Core Practical name	Single Science	Double Award
Investigate the presence of glucose, starch, protein and fat	1	1
Investigate how temperature affects enzyme activity	2	2
Investigate how pH affects enzyme activity	3	–
Investigate diffusion and osmosis	4	3
Investigate how photosynthesis and starch production are affected by light, carbon dioxide and chlorophyll	5	4
Investigate the energy content in a food sample	6	–
Investigate the evolution of carbon dioxide and heat from respiring seeds	7	5
Investigate the effect of light on net gas exchange from a leaf	8	–
Investigate breathing in humans	9	6
Investigate the rate of transpiration from a leafy shoot	10	–
Investigate the conditions needed for seed germination	11	7
Investigate the population size of an organism	12	8
Investigate the distribution of organisms	13	–
Investigate anaerobic respiration by yeast	14	9

How to use this book

This book has been designed to help both teachers and technicians ensure full coverage of the core practicals.

It covers the following specifications:

- Edexcel International GCSE (9–1) Biology
- Edexcel International GCSE Science Double Award (9–1) – Biology component only

The mapping chart on page vi provides a guide to how the practicals are covered. Each practical is also flagged with an indication of whether it is 'Double Award' or 'separate sciences only'.

For details on how you may use and share the content within this book (including photocopying and classroom distribution) please see page ii.

Practical structure

In both the Student and Teacher Lab Book the **aim** of each practical is laid out first. This is followed by a list of **equipment** needed to complete the practical as suggested. The equipment list will prove invaluable in preparing the practical in advance of the lesson.

The method itself is detailed in the **Student Lab Book**, although you will note that at the end of each practical in this Teacher Book there are **possible alternatives**. These can be used if your school has different equipment available or if you wish to take an alternative approach.

Health and safety notes are provided in both Student and Teacher Lab Books so that everyone is aware of the need to take precautions. See the health and safety feature below for more details.

Questions and answers

Students are led through each practical with scaffolded questions to help them with their observations, conclusions and evaluation. They are then provided with **exam-style questions** that relate to the practical and provide exam practice.

These are followed by **further application** questions that apply the science from the practical to a different context to stretch students and consolidate understanding.

Answers to all of the Student Lab Book questions are provided in this Teacher Book, including model data and **unexpected results**. Where applicable, answers are flagged as testing M (maths), QWC (quality of written communication) or EXT (if it goes beyond what most students would be expected to know at GCSE).

As well as the use of QWC in flagging, other common abbreviations used in this book include:

- ECF – error carried forward. This applies to multi-part questions where a student may still pick up marks for calculations, even if they are using incorrect data due to a previous error.
- WTTE – words to that effect. This applies where a student may pick up marks for an answer with similar enough wording to the correct answer. Instances where a particular term or phrasing **must** be used for the mark are also made clear.

The model data sections provide the sorts of data ranges you should expect from the practicals, although actual data will vary based on the equipment used, the environment and so on. You can use this data for checking students' accuracy, and you may wish to provide copies for students to help them evaluate the success of their practicals.

If a student observes results that significantly differ from the model data provided, it is likely that an error in the method has occurred. Each practical has a section for **unexpected results**, which will help you identify the probable error(s) and rectify them.

Related activities

Whilst teachers must teach the core practicals as part of the specification, these practicals should be considered a minimum requirement. The Edexcel International GCSE encourages teachers to provide further opportunities for experimental work throughout the course, to help students improve their ability to work scientifically. To help with this, we have provided **extension questions** and **linked experiments** within this book.

Extension questions provide suggestions for additional work to stretch more-able students. These questions relate to the science behind each practical, and range from smaller, more contained questions to mini-research tasks. They can be set as homework or as follow-up work in class, or could possibly be used for revision.

Linked experiments are optional experiments that can either be demonstrated by teachers/technicians or carried out by students. Some of these are other related core practicals; others are extensions, and some are more loosely linked through shared scientific theory. This section can assist you in planning by helping you think about a teaching order, as well as suggesting other experiments that may help to engage students as you move through the course.

Where page references are provided for the Student Book (as opposed to the **Student Lab Book**), these refer to our accompanying Edexcel International GCSE (9–1) Biology Student Book. Please note that purchasing our student books is not required, and all of the content within the Teacher and Student Lab Books is self-contained and valuable in and of itself.

Features to help you teach

Health and safety

Each practical includes health and safety guidance to help you carry out the experiment safely. However, it is still the duty and legal obligation of schools to carry out their own risk assessments for each practical in accordance with local health and safety requirements.

Maths opportunities

Opportunities to cover the recommended mathematical skills are flagged in these boxes. These will usually only list the mathematical skills most relevant to the practical, and additional minor skills may also be covered. A more comprehensive mapping of mathematical skills to practicals is provided on page v.

Common mistakes

As well as containing the answers to every question in the **Student Lab Book**, this Teacher Book also flags where students are likely to make mistakes. These provide valuable teaching opportunities to address common misconceptions.

Notes

These are used to highlight additional practical notes that needed flagging. For example, if there is a particular recommended way to carry out a practical, or if there are multiple ways a student could answer a question to get the mark.

How students are assessed

In Edexcel International GCSE (9–1) Science, students are expected to complete all core practicals as part of the wider science course, so they may get questions on any of them in the exam. It is important to note that the exams are **not** restricted to asking questions on these specific practicals, and instead are designed to focus on investigative skills. This means the exam board may test students on how well they can apply the practical knowledge to unfamiliar contexts.

The **Student Lab Book** allows students to keep a record of the practicals they have completed, as well as their results and conclusions. This will provide them with a useful resource when it comes to revising the practicals prior to the exams.

Teacher and technician notes

Aim

Investigate how enzyme activity can be affected by changes in pH.

Equipment and reagents (per student)

- 10 × test tubes
- Test tube rack
- Electric water bath, or a Bunsen burner, tripod and beaker, at 35 °C
- Spotting tile
- 5 cm^3 measuring cylinder
- Pasteur pipettes, syringes or 5 cm^3 measuring cylinders
- Stopwatch
- Labels
- Thermometer
- Iodine solution (0.01 mol dm^{-3})
- Starch solution (1%)
- Fungal amylase solution (0.1%)
- Labelled buffered solutions at pH 4, 5, 6 and 7

Alternatives to this practical are suggested on page 14.

Health and safety

- Students must wear eye protection.
- Iodine solution is an irritant to both skin and eyes. Any spills should be mopped up with paper towels. Iodine solution on the skin should be washed off with plenty of water.
- Amylase solution is low hazard once made up.

Notes

- The amylase can be diluted if the reaction is too fast.
- Amylase solution should be prepared fresh for each lesson, as it loses activity. Powdered amylase also loses activity over time (ca. 10% per year).
- Starch suspension should also be made fresh. Soluble starch can be used, heated to dissolve. It is best to use soluble starch that is low in sugars, although that is not especially important for this particular experiment.
- It is best to trial the experiment before students attempt it. At around the optimum pH (4–5), the end-point should be reached within 1–2 minutes, but this can vary.

Common mistakes

- Students often believe that denaturation occurs after 40 °C. For many enzymes that is true, but others remain stable at higher temperatures, even up to 80 °C.
- Students sometimes believe that acid in the stomach will stop pepsin from working. The acid is there to kill bacteria, and pepsin has evolved to work at pH 2 so it can function in the stomach.
- Students often refer to (or imply) a reaction between the enzyme and the substrate. A characteristic property of enzymes is that they are unchanged by the reaction they catalyse. Students also sometimes refer to a successful collision as one that has sufficient kinetic energy. With enzymes, a successful collision relates to the orientation of the collision (substrate to active site) not the kinetic energy.

Further information can be found in the **Edexcel International GCSE (9-1) Biology Student Book** on these pages:

- 27–28: Enzymes
- 30–31: pH and enzyme activity

Maths opportunities

- Using an appropriate number of significant figures
- Understanding and finding the arithmetic mean (average)
- Translating information between graphical and numerical form
- Plotting two variables (discrete and continuous) from experimental or other data
- Determining the slope and intercept of a linear graph

Results

Expected results

The optimum pH of fungal amylase is 5–6. The time taken for complete breakdown varies, but at optimum pH it should be 1–2 minutes.

	Time taken for starch digestion in s			
pH	1	2	3	Mean
4.5	761	805	759	775
5.0	620	604	632	613
5.5	386	380	374	380
6.0	94	87	87	89
6.5	255	267	278	267
7.0	582	583	576	580
7.5	726	718	721	722

Unexpected results

- Amylase activity varies and declines over time.
- Some amylases used in detergents are resistant to denaturation. This is because they have to be functional in hot water. The result of this is that the enzyme doesn't denature at the temperatures used in a school lab (it may need a temperature as high as 80 °C to cause denaturation).
- Some amylases are inhibited by tris buffers. Use alternative buffers where possible.
- Fungal amylase is the most reliable.
- Some fungal amylases have an optimum pH of 4–5. This will be unexpected by students. The result is not anomalous, however. Pancreatic amylase has an optimum of pH 6–7.

Answers

Observations

1 Graph will depend on results.

2 This will depend on individual results. There should be a decline in activity/increase in time between pH 5 and 7. The activity may or may not be less at pH 4 than pH 5.

Conclusions

3 pH 6 (but will depend on individual results).

Evaluation

4 Students should consider the significance of any difference between their chosen optimum and adjacent points; the reproducibility when compared with other groups. The evidence is weakened by lack of repeats and the gap between pH intervals.

5 Any two from: do repeats; use a wider range of pH values (particularly below 4); have smaller intervals between pH values tested.

Exam-style questions

1 **(a)** 2 **[1]**

(b) Test pH values between 1 and 2 or 2 and 3 **[1]**

(c) Possible answers (maximum **[3]**): Temperature **[1]**; Volumes used **[1]**; Enzyme concentration **[1]**; Substrate concentration **[1]**.

(d) Pepsin works in the stomach **[1]** where the pH is low/acidic/2 **[1]**.

(e) The enzyme is denatured (by pH values far from the optimum). **[1]**

2 **(a)** Substrate concentration/volume of enzyme solution/volume of substrate **[1]**

(b) Add a buffer **[1]** to the enzyme/substrate solution **[1]**.

(c) Measure enzyme activity **[1]** at a range of pH values **[1]**.

(d) Bottom of range 10–20 °C **[1]**; top of range 40–50 °C **[1]**.

3 **(a)** Bonds hold the active site in shape **[1]**. If these bonds break, the active site loses its shape **[1]**. The enzyme's active site will no longer be able to bond to the substrate/enzyme–substrate complexes will not be able to form **[1]**.

(b) The active sites of different enzymes have different bonds holding them in shape **[1]**. The effect of a given pH value on the active site will vary **[1]** depending on whether the bonds broken feature in the active site **[1]**.

QWC **4** Indicative content (maximum **[6]**)

- Dissolve albumen in water **[1]**
- Add buffer solution **[1]**
- Add protease solution **[1]**
- Time how long it takes for the solution to clear **[1]**
- Control pH with buffer solution (pH range can be anything but should go up in steps of no more than 1) **[1]**
- Temperature should be controlled with some form of water bath (temperature no lower than 20 °C, no higher than 40 °C) **[1]**
- Concentration of albumen and protease should be controlled **[1]**

Further application

1 **(a)** An enzyme that breaks down protein. **[1]**

(b) High temperatures will denature the enzymes **[1]** by changing the shape of their active sites **[1]**. The bonds between the protein fibres will then be able to form **[1]** and this will allow the jelly to set **[1]**.

(c) Cells (lining the mouth) may be broken down by the bromelain. **[1]**

(d) The stomach contains acid **[1]** and this will produce a pH at which the bromelain enzymes cannot work. **[1]**

2 **(a)** Proteins **[1]**

(b) Idea of enzymes involved in respiration being denatured **[1]**. Link between respiration, energy and growth **[1]**.

(c) The bonds in the active site break **[1]**. The active site changes shape **[1]** and can no longer bond to the substrate/enzyme–substrate complexes cannot form **[1]**.

3 **(a)** They will work on a number of different substrates. **[1]**

(b) The high temperatures involved in the cooking **[1]** will denature the enzymes **[1]**.

(c) At low temperatures the enzymes will work very slowly **[1]** so it will take longer to tenderise the meat **[1]**.

Possible alternatives

- Other enzymes (such as catalase from potato) could be used. There are a variety of experimental setups for using catalase, easily found on the internet. If investigating the effect of pH on catalase, be aware that some commercial hydrogen peroxide (the substrate) contains a buffer. This should be avoided.
- Bacterial amylase could be used instead of fungal amylase. Its optimum pH seems to vary between 5 and 7, presumably dependent on its source. The method is exactly as described here.
- It is possible to set up a series of test tubes with small quantities of the reaction mixture in place of spotting tiles and add iodine to them at 10 second intervals, but this requires many tubes.
- Different groups of students can use one buffer each and then class results can be combined if time or resources are short.

Extension questions

- Students could research the link between the optimum pH values of enzymes and the pH of their normal surroundings (for example, in the digestive system).
- Students could research the effects of enzyme and substrate concentrations on the rate of enzyme-controlled reactions.
  The pattern is the same in both (a rise with a rise in concentration, eventually levelling off). Levelling off occurs when all of the enzyme (or all of the substrate) is being used, so increasing the concentration of the other component has no effect.
- Students could research the types of bonds within an enzyme molecule that might be affected by pH.
  This will be the acid–base connections. They should not be asked to investigate the nature of these acid–base connections, as that is complex.

Linked experiments

- Core Practical 2 investigates the effect of temperature on enzyme activity, but other variables to be tested could include the effect of enzyme concentration and substrate concentration on enzyme activity (for example, using catalase).
- Effect of pH on protease activity, using the clearing of exposed photographic film when the gelatine coating is digested as a measure of activity. The black silver deposit is held in place on the film by gelatine. Protease breaks down the gelatine and the film goes from black to clear. The time taken to clear a given area of exposed film can be used to assay the activity of the enzyme.