Introduction

This Heinemann Queensland Science Project–Biology: A Contextual Approach Student Activity Pack consists of a Student Activity Manual and eBiology, an interactive student CD.

The pack provides strong support for Heinemann Queensland Science Project–Biology: A Contextual Approach and will assist students develop their practical, research and information and communication technology skills while enhancing their grasp of biological principles and processes.

STUDENT ACTIVITY MANUAL

The Student Activity Manual contains a comprehensive series of activities, experiments and investigations students can undertake to heighten their understanding of concepts. Activities will help students develop a range of manipulative skills, including those required by the syllabus. Students will also have opportunities to collect and analyse both quantitative and qualitative data; use first- and second-hand data; and design their own investigations.

Major features of the manual include:

The key concepts and key ideas related to each activity are listed. Each activity includes a comprehensive list of materials required for the activity. Any potential safety issues are noted in a box labelled ‘Caution’. Key terms used in the activity are listed. Assessment suggestions are listed. Many activities involve the optional use of information and communication technology and computer simulations.

Activities are classified as simple, medium or complex.

Simple activities:
- Generally relate to one Key Concept and a limited number of Key Ideas;
- Contain all the information students need to complete the activity; and
- Tend to be relatively short in duration.

Medium activities:
- Generally relate to one or two Key Concepts and a number of Key Ideas;
- May require students to provide input into the method;
- May require a longer time period; and
- May require students to engage in higher-order thinking.

Complex activities:
- Generally relate to a number of Key Concepts and Key Ideas;
- Will require students to develop aspects of the methodology;
- May require students to undertake extra reading and research before starting or during completion of the task;
- May be extended activities requiring students to record results over a longer time period;
- Will require students to engage in higher-order thinking; and
- Often form the basis for Extended Experimental Investigations.
Activities and assessment

Assessment suggestions are provided for each activity. These can be used for formative assessment or, when used under appropriate conditions, summative assessment. Complex activities may be suitable as Extended Experimental Investigations. Activities in Part One meet the field work requirements of the syllabus. Presenting the results of investigations could be an Extended Response task. If students are asked to write a scientific report of an activity, or answer questions under supervised conditions, the criteria for a Written Task are met. Many of the ‘Further Activities’ at the end of each activity are further opportunities for assessment tasks of all types.

HEINEMANN QUEENSLAND
SCIENCE PROJECT-eBIOLOGY

Major features of eBiology include:

• Interactive Tutorials, which model and simulate key biology concepts. Many are directly integrated with the activities.
• Worksheets to support the activities.
• Data-logging worksheets, which provide an alternative method involving sensors and computers.
• A wide range of information and communication technology support for the activities, including spreadsheets, presentation templates in PowerPoint and Word, webpage templates and more.
• Interactive glossary.
• Exam and test self timer.

eBiology also includes a complete copy of the Student Activity Manual in electronic format, with hyperlinks to all worksheets, templates and tutorials. A direct link is also provided to the Heinemann Queensland Science Project–Biology: A Contextual Approach Website, where internet site URLs relevant to the activity are located, monitored and upgraded as necessary. Icons appear in the activities to indicate where these are available. Simply click on the icon to open the worksheet, template or tutorial.

Provides direct link to relevant websites.
Indicates a worksheet is available that either supports or supplements the activity.
Indicates a spreadsheet is available as an alternative method for recording, graphing and processing data.
Indicates a PowerPoint template is available as an alternative method for presenting your results or findings or as an accompaniment to a class presentation.
Indicates a Webpage template is available as an alternative method to posters and other static presentations.
Indicates a data-logging worksheet is available, which provides an alternative method involving sensors and computers.

Indicates an extra photograph or illustration relevant to the activity is available.

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SCIENCE PROJECT–Biology: A CONTEXTUAL APPROACH TEACHER’S RESOURCE AND ASSESSMENT DISK

The Teacher’s Resource and Assessment Disk supports both the textbook and Student Activity Manual and assists teachers in planning and implementing a course of study and assessment programme.

Major features of the Teacher’s Resource and Assessment Disk include:

- Detailed information relating to the implementation of each of the activities. This includes preparation notes, hints and answers to some of the questions within the activities.
- Sample work programme.
- Units of work for both Years 11 and 12, showing how the requirements of the syllabus could be met using the Heinemann Queensland Science Project–Biology: A Contextual Approach package.
- A sample assessment task for each of the assessment categories.
- Suggested answers to all the review and further questions in the text book.
- A full copy of Heinemann Queensland Science Project–eBiology.
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2.1 Cells—units of life

Introduction

Robert Hooke was the first person to describe cells. In 1665, he observed them for the first time by using a light microscope and wrote that he saw ‘many little boxes’ (cellulae). Our knowledge and understanding of the structure of cells and the functions they perform have progressed significantly since then. Instruments for observing cell structure and techniques for investigating the processes that go on inside a cell are constantly being improved.

Scientists who study cells (cytologists) want to find out what cells do. This generally relates to the location of a cell in an organism, its shape and its organelles (the structures that make up a cell). Living things are made up of cells or the chemical substances that cells make. Consequently, the cells of a living organism depend on, and produce, a large range of chemicals that enable them to make new cell parts (to grow) and to relate to the rest of the organism of which they are a part. Therefore, the functions of a cell can be worked out by determining the range of organelles in a cell and the roles each of the organelles have in the cell.

Pathologists diagnose a range of diseases by looking at changes in the normal structure and function of cells and their organelles (see Biology: A Contextual Approach, p. 177).

By looking at cells in a number of two-dimensional views, we can work out the three-dimensional shape of cells. In most instances, cells are stained to make them easier to see. To see inside a cell, a specialised light microscope, such as a phase-contrast microscope, can be used. To see the fine detail of cellular organelles, however, an electron microscope is necessary.

Purpose

1. To observe, and record in diagrams, the shape of several different plant and animal cells and to relate this to their function.
2. To observe and record the cell organelles that are visible under a light microscope and to relate this to the cell’s function.
3. To observe the effects of staining on cells.
4. To observe and record the structure of the cell organelles that are visible under an electron microscope and to relate this to the cell’s function.

Plant cells

Procedure

1. Take an onion scale and break it as shown in Figure 1. Quickly cut or peel two pieces with sides 1–1 cm long from the thin, transparent epidermal tissue. Mount one in a drop of water on a microscope slide and the other in a drop of toluidine blue or iodine/potassium iodide stain on another slide. If necessary, straighten the tissue using dissecting needles. Add a coverslip to each preparation.
2. Examine the unstained tissue mounted under the microscope, first using low power, then high power. Adjust the iris diaphragm for the greatest clarity at each magnification. Observe the regular shape of the cells and the way they are arranged. Identify the cell wall and any organelles that are visible. Use *Biology: A Contextual Approach*, Figure 7.4 p. 147 as a guide.

Record your observations in a carefully drawn and labelled diagram of several cells. Show the magnification at which the observations were made.

3. Examine the other slide of the same tissue mounted in toluidine blue or iodine/potassium iodide stain.

- Describe any further cell detail or cell structures that can now be observed as a result of staining. Add these to your diagram.
- How many layers of the cells are there in the tissue sample? Suggest what the three-dimensional shape of these cells might be. Give your reasons.

4. Carefully detach a moss or *Elodea* leaf using fine forceps and mount it in a drop of water on a clean slide. Examine the slide first under low power to observe the arrangement of cells and then under high power to observe the structure and contents of an individual cell. Identify the cell organelles you can see.

Draw a leaf cell viewed under high power. Label all structures you can see and state the magnification.

5. Look carefully at several cells under high power for a minute or two. Your observations may be more successful if you first warm the slide gently over the microscope light for a minute.

- Is there any evidence that the cells you are looking at are alive? Explain the evidence you used to answer this question.

6. Cut several thin sections of the stem of a cabbage seedling (or celery petiole) using the method demonstrated by your teacher. Select the two thinnest sections and mount one in a drop of water on a slide and add a coverslip. Mount the other section in a drop of iodine/potassium iodide or toluidine blue on a second slide, and let this slide stand for several minutes before adding a coverslip.

7. Examine the section mounted in water. You will observe a number of different types of cells arranged in different ways. Now examine the section mounted in iodine/potassium iodide or toluidine blue. If you use toluidine blue, cells that lack a thickened wall turn purple and cells with thickened walls turn turquoise (blue–green).

- Have all cells stained the same colour? Is there any pattern to the staining? A sketch diagram may help you to answer this question.

- Explain why staining might be an advantage when examining cells and tissues.

- a. What structures within a cell make it possible to identify those cells that are dividing?
- b. Would it be possible to make this identification without the use of a stain? Explain.
Discussion
During this part of the activity you observed some plant cells. Summarise your findings in a table using the headings:

- cell type
- cell shape
- organelles
- organelle function
- cell functions

You may need to use your textbook or websites to find the function of the organelles that you have seen.

B Animal cells

Procedure
1. Examine the prepared slide of cheek lining cells. Observe the shape of the cells and look for the presence of any organelles.

Make a labelled drawing of a cheek cell under high power.

- What is the likely three-dimensional shape of these cells? Explain.

2. Examine the prepared slides of mammalian blood and frog blood under high power. The most common cells are red blood cells.

Make a labelled diagram of a red blood cell of each species as seen under high power.

- a What are the major visible differences between mammalian and frog red blood cells?
- b Suggest possible advantages and disadvantages to an animal of having red blood cells without nuclei.

3. Search the mammalian blood slide for white blood cells. There will be very few of them in each field of view. Different types of white blood cells can be recognised by the different shapes of their nuclei.

Make a labelled diagram of two different types of white blood cells seen under high power.

4. Examine the prepared slide of motor nerve cell bodies and fibres taken from a spinal cord. Locate a cell body that can be clearly seen, and observe it under low and high power. A motor nerve cell or neuron consists of a cell body located in the spinal cord and a long axon fibre, which extends out of the spinal cord and connects to a muscle.

Draw and label a motor nerve cell body.

- Using a reference book or websites to assist you, draw and label a complete motor nerve cell.

Hydra is a simple, sac-like animal whose body is made up of only two cell layers and a small number of cell types.

5. Examine the prepared longitudinal section of Hydra and, under high power, identify several different types of cells.

Make clear drawings of two different types of cells, showing any organelles present.

- Suggest reasons why all cells on this slide do not show nuclei.

MATERIALS

- Microscope
- Prepared slides:
  - Cheek cells (epithelial or lining cells)
  - Mammalian blood
  - Frog (or chicken) blood
  - Motor nerve smear (nerve cells)
  - Longitudinal section of Hydra (a variety of cells)
- Reference texts such as Biology: A Contextual Approach
- Websites listed on hi.com.au/biol
**Discussion**

During this activity you observed some animal cells. Summarise your findings in a table using the headings:

- cell type
- cell shape
- organelles
- organelle function
- cell functions

You may need to use a text book to find the function of the organelles that you have seen.

**Discussion (for Parts A and B)**

Using a text book and the information from the tables produced in Part A and Part B, draw up a new table to list the organelles that can be seen under a light microscope using the headings:

- found only in plants
- found only in animals
- found in both plants and animals

**Cell organelles**

This part of the activity is based on second-hand data and the Cells and Organelles interactive, and can be done as an out-of-class activity. It can be completed using the PowerPoint template.

Electron microscopy (EM) and scanning electron microscopy (SEM) have made it possible to observe a great deal more in cells (see Biology: A Contextual Approach, pp. 175–7).

Use the electron microscope photographs on pages 66–69, the notes provided in the captions, reference books and websites to produce a table using the headings:

- organelle
- found in plants and animals
- function
- description
- size in micrometres (1 micrometre [1 µm] = 0.001 mm)

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**FIGURE 2**

**Nucleus.** (See Biology: A Contextual Approach, p. 147.) The structure containing the hereditary material, DNA. A double membrane separates the nuclear contents from the cell cytoplasm. Pores occur in the nuclear membrane. Two more dense nucleoli (singular nucleolus) can be seen in (a). The nuclear envelope (NE) and nuclear pores (arrowed) can be seen in (b). (Photo (a) courtesy R. Perry; photo (b) courtesy M. Klemm.)
CELLS—UNITS OF LIFE

FIGURE 3
Endoplasmic reticulum. (See Biology: A Contextual Approach, p. 147.)
A network of two nearly parallel membranes separated by a narrow space. Ribosomes are often visible as dense dots either in the cytoplasm or attached to parts of the endoplasmic reticulum. When ribosomes are associated with the endoplasmic reticulum it is known as rough endoplasmic reticulum (as distinct from smooth endoplasmic reticulum). (Photo courtesy Dr J. B. Kerr, Monash University.)

FIGURE 4
Golgi apparatus (bodies). (See Biology: A Contextual Approach, p. 147.)
Structures that look like a stack of between three and eight flat membrane sacs (cisternae). The arrow points to a small circular vesicle that has pinched off and will move to another location within the cell. (Photo courtesy Dr J. B. Kerr, Monash University.)

FIGURE 5
Mitochondrion. (See Biology: A Contextual Approach, p. 147.) A structure composed of a double membrane. The outer membrane is smooth, but the inner one folds inwards to form finger-like projections called cristae. Mitochondria have their own DNA and ribosomes. (Photo courtesy M. Klemm.)
FUNCTIONING ORGANISMS

FIGURE 6

Chloroplast. (See Biology: A Contextual Approach, p. 147.) Found in green parts of photosynthetic eukaryotes (plants) and in photosynthetic protists. The outer envelope encloses a complex series of membrane stacks (grana). The chlorophyll is bound to protein embedded in the membrane. Chloroplasts contain ribosomes and DNA (see Biology: A Contextual Approach, p. 147). (a) A complete chloroplast (arrowed) in the cell of a mangrove; (b) a close-up of part of a chloroplast shows the grana (G) and stroma (S). (Both photos courtesy J. Carpenter, Monash University.)

FIGURE 7

Cell wall. (See Biology: A Contextual Approach, p. 147.) The rigid outer boundary of plant cells. The cell wall is made up of layers of cellulose microfibrils. The cell membrane, which is normally pressed against the cell wall, has pulled away from it (arrowed). (Photo courtesy G. Jaudzems.)
CELLS—UNITS OF LIFE

FIGURE 8
Cell membrane (plasma membrane or plasmalemma). (See Biology: A Contextual Approach, p. 147.) The cell membrane encloses the cytoplasm and nucleus of all eukaryotic cells. Its double membrane controls what substances enter and leave the cell. The photo shows parts of the membranes that surround two cells (arrowed). (Photo courtesy Dr J. B. Kerr, Monash University.)

FIGURE 9
Plasmodesmata. Cytoplasmic connections between adjacent cells that are observed crossing the cell walls. (Photo source unknown.)

Further activities

1. All cells examined in this activity are classed as eukaryotic. Other cells are prokaryotic. Research the meaning of these two words and list the differences between the two types of cells. Give some examples of each type.

2. It was stated in Part C of this activity that electron microscopes (EM) and scanning electron microscopes (SEM) have enabled us to observe cell structure in greater detail. Research and write a report on:
   a. Why EMs and SEMs are able to show more detail than light microscopes.
   b. How EMs and SEMs work.
   c. The special preparation of material needed for electron microscopy.
   d. The advantages and disadvantages of using EMs and SEMs.
   e. The differences between the two types of electron microscope.

3. a. Form groups of four. Each person is to research a different one of the following types of microscopes:
   • interference microscopes
   • phase contrast microscopes
   • fluorescence microscopes
   • confocal microscopes
   For the microscope you have selected, find out:
   • how it works
   • what materials are viewed using it
   • how specimens are prepared for its use
   • the advantages and disadvantages of using it
   b. Each person is to give a short report and a copy of their research notes on ‘their’ microscope to other members of the group.
FUNCTIONING ORGANISMS

2.5 Useful yeasts

INTRODUCTION

Long before yeasts were identified with the aid of a microscope, their effects were well known. A yeast is a single-celled fungus that is capable of multiplying rapidly in the right conditions. There are a number of different yeast strains. For centuries, they have been used for making alcohol (wine and beer) and bread. In both cases, the enzymes produced by the yeast cells break sugars down into ethanol and carbon dioxide. This process is known as cellular respiration. In wines and beers, the carbon dioxide escapes and the alcohol remains in solution. In bread, the carbon dioxide causes the dough to rise and the alcohol is evaporated off during baking. (For details about aerobic and anaerobic respiration, see Biology: A Contextual Approach, pp. 187–90.)

The relationship between sugars and carbon dioxide in respiration can be demonstrated in an experiment such as the one that is outlined below.

Some carbon atoms are radioactive. They are known as carbon-14 or \(^{14}\)C atoms, and their presence can be detected with a radiation counter.

In an experiment, a mouse was fed water containing a small amount of glucose made with radioactive carbon. The mouse was placed in a large, sealed jar containing air from which carbon dioxide had been removed. After a short time, a sample of the air inside the jar was taken and, using a radiation detector, some of the carbon dioxide was found to be radioactive. The only radioactive carbon atoms present in the jar at the start of the experiment were in the glucose fed to the mouse. At the end of the experiment, they were found in the carbon dioxide exhaled by the mouse. This means that the radioactive carbon atoms had been transferred from glucose to carbon dioxide during the process of cellular respiration.

A mouse respires aerobically. However, in this activity, the link between glucose and carbon dioxide in anaerobic respiration is assumed.

PURPOSE

1. To identify the gas produced when yeast cells respire.
2. To investigate factors affecting the rate of respiration in yeast by measuring changes in gas output.

IDENTIFICATION OF GAS PRODUCED

This part of the activity may be set up as a demonstration for you. So that you can follow what has been done, an outline of the procedure is given. Observe the demonstration and answer Questions 1 and 2.
Procedure

1. Put 25 mL of glucose solution in the 100 mL conical flask and add the cube of compressed yeast. Disperse the yeast into the glucose solution using the stirring rod.

2. Stand the flask in the 500 mL beaker and add warm water to make a water bath at 35–40°C. Do not add so much water that the flask floats. Alternatively, you could hold the flask in the water bath with a retort stand and clamp. Try to maintain the temperature during the experiment by removing cool water from, and adding warm water to, the beaker.

3. Rinse the clean boiling tube with a little limewater and then add more limewater to a depth of 3 cm. Stand the boiling tube in a rack near the water bath.

4. Connect up the stoppers and tubing as shown in Figure 1. Carefully swirl the flask every 2–3 min for 15–20 min.

● Describe what you observed during the 15–20 min that the apparatus was set up.

● Explain how your observations allow you to:
  a. determine that a gas was released
  b. determine the identity of the gas.

**B** Factors affecting respiration rate

Procedure

Work in groups of three. Your teacher will allocate a temperature for your group’s water bath. The temperature ranges are:

- low temperature (less than 5°C)
- medium temperature (15–20°C)
- high temperature (35–40°C)
- very high temperature (greater than 60°C)

Data for all temperatures will be pooled at the end of the activity so that all students have a full range of data to process.
Copy Tables 1 and 2 into your workbook.

### TABLE 1
Yeast respiration rate at ____°C.

<table>
<thead>
<tr>
<th>Time (min)</th>
<th>Number of bubbles per min</th>
<th>Tube 1</th>
<th>Tube 2</th>
<th>Tube 3</th>
<th>Average</th>
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</thead>
<tbody>
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### TABLE 2
Yeast respiration rate at different temperatures.

<table>
<thead>
<tr>
<th>Time (min)</th>
<th>Average gas bubbling rate at different temperatures</th>
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</thead>
<tbody>
<tr>
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<td>Low (temp. ____°C)</td>
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<td>10</td>
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</tbody>
</table>

1. Each member of the group should be responsible for one of the three tubes. Label your test tube with your name and ‘1’, ‘2’ or ‘3’. To each tube, add 12 mL of 20% glucose solution and one cube of yeast. Use the stirring rod to thoroughly disperse the yeast in the glucose solution.

2. Into each test tube insert a stopper with dropper attached. Make sure it is a firm fit (Figure 2). Note: the dropper must not have any liquid in it and the bottom must be above the yeast/glucose suspension.

3. Fill the PET bottle water bath and adjust the water temperature to within your group’s allocated temperature range. Try to maintain the water bath at this temperature throughout the activity by replacing some of the water, if necessary, with ice water or hot water.

4. Submerge the three stoppered test tubes in the water bath. The tubes must be totally under water (Figure 3). If they tend to float, use masking tape to stick a metal ‘weight’ to the bottom of each tube.
tube. Leave the tubes to stand in the water bath for 3 min, then count the number of bubbles released per minute from each tube for 10 min.

Record your data in Table 1. Also record in Table 1 the data for the tubes observed by the other two members of your group. Calculate the average and enter it on the class data sheet. When the class data are complete, copy the details into Table 2.

Dispose of the solution and equipment as directed by your teacher. Draw a graph of the data.

Discussion

- Describe the effect of temperature on the rate of yeast respiration in a glucose solution.
- What is the optimum temperature for the fermentation process investigated?
- Suggest possible reasons why the rate of respiration is affected by temperature. Support your answer by quoting from the data, and referring to Biology: A Contextual Approach, Chapter 9 and references from other sources if necessary.

Further activity

Here are some ideas for you to investigate.

- Investigate the effect of solutions of different \( \text{pH} \) on rates of fermentation. Use the optimum temperature as the temperature at which you carry out the investigations. A thermostatically controlled laboratory water bath would be useful. Make sure that the tubes are clearly identified in some way. Experimental control is important.

Some suggestions are:

- Investigate the effect of solutions of different \( \text{pH} \) on rates of fermentation. Use a standard volume of glucose solution and add a fixed volume of buffer solution. For a control, replace the buffer solution with a similar volume of distilled water.

b Investigate the effect of alcohol on rates of fermentation. Use a standard volume of glucose solution and add a fixed volume of ethanol. For a control, replace the ethanol with a similar volume of distilled water.

c Investigate the effects of carbohydrates other than glucose on rates of fermentation. For example, as well as glucose, choose from 20% solutions of fructose, mannose, galactose, sucrose, maltose and lactose.

Write a report outlining the purpose of your investigation, the procedure you used, the reason for any experimental controls, the results you obtained and a discussion of them. Make suggestions for improving the experimental design and technique.