About this book

This student workbook provides a **hands-on program of science investigations** developed by SASTA in conjunction with Thomas More College. It has been carefully written to ensure that students can work confidently and independently, developing and enhancing the understandings and skills of the **Australian Curriculum: Science.**

The **22 practical investigations** in the workbook are in four main sections; Biological sciences, Chemical sciences, Earth and space science and Physical sciences. They cover the entire scope and sequence of the Year 9 Australian Curriculum: Science, with an emphasis on the **Science Inquiry Skills, including practical design.**

To reflect the emerging emphasis on **STEM** skills and dispositions, each of the four sections includes one **Engineering Design Challenge.** This challenge asks students to apply their content knowledge and skills to create solutions to real world applications of science.

A Curriculum map is provided on pages 6 and 7.

An assessment rubric has been developed for each practical investigation. This rubric assesses students level of achievement of the Science Inquiry Skills relevant to the practical and has been developed using the Australian Curriculum **Achievement Standards.**

The workbook includes introductory sections that build necessary skills and provide clear guidelines for **scientific literacy.**

Each practical has a **consistent format** with language that reflects that of the Australian Curriculum; Science.

Each investigation has been **tested by teachers and students** to ensure usefulness and feasibility.

Safety is always of upmost concern and we encourage students and teachers to make themselves aware of safety procedures for each practical investigation and wear personal protective equipment at all times.

Contents

Practical 3 – Clear that artery – ENGINEERING DESIGN CHALLENGE

Background

In a correctly working human circulatory system, blood vessels are clean and smooth, however, sometimes material (plaque) coats the interior walls of blood vessels. This plaque, whether it hardens and stays in place, or hardens and gets dislodged, can block or restrict the normal movement of blood through the body, leading to problems such as heart attacks or strokes.

If one of the heart's coronary arteries gets clogged, the heart muscle does not receive sufficient oxygen-rich blood, the muscle begins to die. The result is a myocardial infarction, or heart attack.

Design Challenge

To create a device that could remove or flatten built up plaque material inside artery walls.

Materials:

- 2 model "blocked arteries" per group, made from about 10 cm clear flexible tubing, approx. 3.8 cm in diameter, clogged with play dough (or icing)
- 1 clear piece of tubing 10 cm long per group as a control.
- clown balloons (long and thin)
- air pump, for clown balloons
- straws
- paper clips
- thin wire
- pipe cleaners
- rubber bands
- tape
- other equipment as available e.g. swizzle sticks, bin ties, alfoil.
- water source
- 2 L container (from which to pour the same volume of water)
- large jug, bin or container, to catch poured water

Preparing the blocked arteries:

1. Cut enough tubing so that each group has four 5 cm pieces.

2. Pack the icing or playdough into each of the 5 cm tubes until the icing is approximately 2cm. deep.

3. Tape two of the tubes together with transparent tape so that the icing makes one complete (4 cm) section in the centre of the now 10 cm 'artery'.

4. Chill the "arteries" overnight in a refrigerator.

5. Using a straw, create a narrow opening in each of the "arteries" to allow minimal blood flow.

Defining the problem

- Notice that the icing is packed in the centre of the tubing and not easily accessed.
- What are some of the difficulties doctors might face during the procedure to clear the artery?
- How big would the hole need to be to restore blood flow?
- Could a doctor scrape away all the plaque? What effect would this have on the walls of the arteries? As you saw in the heart-dissection, the arteries are soft tissue and can be easily torn or punctured, causing bleeding.
- Could you push the plaque all the way through the artery? What do you think happens to the plaque that breaks off and is carried away in the bloodstream?

Success criteria:

The device needs to create maximum blood flow through the artery.

The increase in blood flow needs to be quantifiable.

Constraints:

Keep as much plaque as possible in the tube.

Clear a path for blood flow by pushing the plaque to the sides of the artery.

Research

- Collect your blocked arteries and your clear artery.
- Time how long it takes for two litres of water to flow through the clear piece of tubing at a 45° angle versus through a blocked piece of tubing at the same angle.
- Record these measurements in **table 1.**
- Calculate the flow rate in both the clear and the clogged artery.
  Flow rate = Fluid Volume/time

Artery type	Time for 2 L of water to flow through artery (s)	Flow rate
Clear artery		
Blocked artery		

Imagine

- Brainstorm ideas for clearing your clogged arteries. Record your ideas here.

Plan

- Find a consensus design, the idea that you think will work best and decide how you will design it.
- Make a specific design plan, including list of materials and a labelled diagram.

Create

- Build your design prototype.
- This step may not go as planned. You may need to brainstorm new designs and/or create on-the-spot modifications and improvements to your plan.
- Any changes should be documented.

Test and evaluate

- Test your designs and evaluate whether the design works according to the established success criteria. Does it work? Does it solve the problem?
- Measure success by timing how fast 2 L of water flows through your cleared artery after the treatment method. Hold the arteries at 45° angle while the water flows. Record these measurements.
- What percentage increase in flow was there in the cleared artery?
- Did you apply the constraints when creating your design?
- Look at the designs of other groups. What works? What doesn't work?

Evaluate and redesign

- Decide how to improve your design, based on the analysis of the data from the testing stage.
- The data and observations can come from your own testing or from observing other teams.
- Discuss improvements and draw up another design, create and retest.

Communicate

Design a way to share your designed solution and the results. (video, posters, digital representations, photography, story boards……)

What choices did you make? (with regard to materials, construction, shape, sustainability etc.)

- ✦ What were the reasons for your choices?
- ✦ What alternatives did you consider?
- ✦ How did you make your decision?
- ✦ Were there any scientific concepts considered in your reasoning?

Describe how successful you were in meeting the criteria and keeping within the constraints.

- ✦ Did the tests give you the results you expected?
- ✦ Did your choices work as intended?
- ✦ Did you notice anything that you didn't originally think about?

Reflect on the procedure of clearing the artery.

- ✦ Did your procedure mimic real-life surgery?
- ✦ Did you dislodge any of the plaque from the artery?
- ✦ Did you enter the tubes from both sides? How would a surgeon access both ends of an artery?
- ✦ How long did it take to perform your procedures? What effect could this have on the patient? How is blood circulated through the body while a patient's heart is being operated on?
- ✦ What information would inform your next design?
- ✦ What factors would influence your next design choices?

Assessment Rubric – Practical 3: Clear that artery

	Achievement Standard	A	B	C	D	E
Planning and conducting	Students design methods that include the control and accurate measurement of variables.	Constructs a **detailed and logical** step-by-step procedure. .	Constructs a **clear and logical** step-by-step procedure.	Constructs a **simple** step-by-step procedure.	Constructs an **incomplete and/or simple** procedure with some key steps omitted.	If provided, the procedure is **disorganised, unclear and/or omits** large parts.
	Students methods include the systematic collection of data.	Constructs **accurate** and **well-designed methods** of collection for a **variety** of data, using **correct** conventions to record quantitative and qualitative data. **Accurately** performs calculations and clearly identifies anomalous data.	Constructs **appropriate methods** of data collection, using **correct** conventions to record quantitative and qualitative data. **Correctly** performs calculations and **usually** identifies anomalous data.	Constructs **a method** of data collection, using **mostly correct** conventions. **Correctly** performs calculations.	Constructs **a table** for data collection, using **some correct** conventions. Performs calculations **when directed to do so.**	Records results in a **provided table.** **Attempts to** perform calculations when directed to do so, making frequent errors.
Processing and analysing data	Students analyse trends in data.	Summarises results, explaining patterns and trends in the data, **using scientific terminology.**	Summarises results, explaining patterns and trends in the data.	Summarises results, describing **straightforward** patterns or trends in the data.	Summarises **differences** between data sets.	Makes **general,** non-distinguishing comments about data sets.
Evaluating Processes	Students analyse their methods.	**Critically** and **logically** evaluates procedures and describes in detail a **range** of **appropriate** improvements.	**Logically** evaluates procedures and describes in detail **range** of **appropriate** improvements.	Evaluates procedures and describes **some** improvements that are **generally appropriate**.	Has **attempted** to evaluate procedures and **suggests** improvements that may be made.	Has made **little attempt** to evaluate procedures and lists some **basic** improvements.
Evaluating Claims	Students evaluate others' methods and explanations from a scientific perspective.	**Critically and logically** evaluates procedures and claims made by others.	**Logically** evaluates procedures and claims made by others.	Evaluates procedures and claims made by others.	**Attempts to** evaluate procedures and claims made by others.	**Makes little attempt** to evaluate procedures claims made by others.
Communicating	Students use appropriate language and representations when communicating their findings and ideas to specific audiences.	Uses an **extensive range** of appropriate **scientific** language, **conventions** and representations when communicating r findings and ideas to specific audiences.	Uses **a variety** of appropriate **scientific** language, **conventions** and representations when communicating findings and ideas to specific audiences.	Uses **appropriate** scientific language and representations when communicating findings and ideas to specific audiences.	Uses **everyday** language and **simple** representations when communicating findings and ideas to specific audiences.	Uses **unscientific or inappropriate** language and representations when communicating findings and ideas to specific audiences.

Practical 5 – Fuelling the Ecosystem

Background

Energy flow in an ecosystem.

Life on earth is dependent on the flow of energy from the sun. At the base of an ecosystem, primary **producers** are actively converting solar energy into stored chemical energy. This process is called **photosynthesis**. During this process, carbon dioxide combines with simple sugars to form more complex carbohydrates in special structures called chloroplasts.

During plant growth and other processes, sugars are broken down in a series of reactions called **respiration.** Oxygen is consumed in these reactions and energy is released to power the growth of the plant.

Measuring the rate of photosynthesis

A leaf is composed of layers of cells. The spongy mesophyll layer has spaces that are filled with gases including carbon dioxide and oxygen. Oxygen and carbon dioxide are exchanged through openings in the leaf called stoma.

Leaves will normally float in water because of these gases. When these gases are replaced with water the overall density of the leaf increases and the leaf will sink.

Photosynthesis in plants requires a source of carbon dioxide. If a leaf is placed in a solution with a source of carbon dioxide in the form of bicarbonate ions, then photosynthesis can occur in a sunken leaf. As photosynthesis proceeds oxygen is released into the interior of the leaf which changes the buoyancy, causing the leaf to rise.

While this is going on, the leaf is also carrying out cellular respiration, consuming the accumulated oxygen, possibly causing the leaf to sink again.

Using small leaf discs sunken in a solution of bicarbonate ions, we can measure the rate that the discs rise. This rate is an indirect measurement of the net rate of photosynthesis.

PART A:
Purpose

To conduct a procedure that allows you to measure the rate of photosynthesis.

Material

- 2 x 10 ml syringes
- small tweezers
- desk lamps with 18- to 23-w fluorescent or led bulbs
- jumbo plastic straws (all of the same diameter or a hole punch)
- 50 ml beakers
- approx. 20 ml of 0.2 $moll^{-1}$ sodium hydrogen carbonate solution. (4–5 drops of detergent should be added to a litre of solution. this helps prevent the discs from sticking to the sides of the syringe.)
- fresh plant leaves (ivy, spinach or leaves of radish seedlings work equally well, and almost any leaf with a smooth, as opposed to a hairy, surface works)

Procedure

1. Fill the 50 mL beaker with 20 mL of 0.2 $molL^{-1}$ sodium hydrogen carbonate solution.
2. Remove the plunger from a syringe.
3. Use a straw or hole punch to punch out discs from the leaves. The discs should be as uniform in size and mass as possible. Avoid the larger veins of the leaves.
4. As you punch out the leaf discs, put them into the syringe. Continue until you have 20 discs.
5. Use the tweezers to push the discs down as far as they can go. Be careful not to crush or damage them.
6. Once you have all the leaf discs in the syringe, replace the plunger.
7. Put the tip of the syringe in the sodium hydrogen carbonate solution and pull back the plunger to suck up 10 mL of the solution.
8. Tap the syringe to dislodge discs that are stuck to the sides.
9. Hold the syringe vertically, with the tip pointed upwards, and push in the plunger to expel any trapped air.
10. Cover the end of the syringe with your finger, and then draw back on the plunger to create a vacuum and pull the air out of the leaf discs. Alternate drawing back on the plunger and pushing it in (remember to keep the end covered with your finger the whole time). Pushing the plunger in is forcing the carbonate solution into the leaf discs and drawing it out will remove any air from spaces in the leaves.
11. Continue to do this until you see the leaf discs start to sink. Once all your leaf discs have sunk, pour the discs and solution back into the 50 mL beaker.
12. Place under the light source and start the timer.
13. At the end of each minute, record the number of floating discs.

Results:

Plot the number of floating discs against time.

Analysis

1. Would this experiment have worked with normal tap water? Why or why not?

2. What was happening when the leaf discs sunk?

3. What does the slope of your graph represent?

Part B: Design Investigation

Based on your observations and analysis in PART A, design an investigation to explore some factors that may affect the **rate of photosynthesis.**

Identify:

Independent variable

____

Dependent variable

____

Hypothesis

(This is a statement about what you expect to observe for the dependent variable as the independent variable is changed.)

____

____

____

Controlled Factors

____

____

____

Materials

(The following materials will be provided; however, as this is a design investigation you may like to request or bring other materials to your laboratory station.)

- 4 x 50 mL beakers
- various types and sizes of leaves
- 20 mL measuring cylinder
- spatula
- thermometer
- 2 x 10 mL syringes
- desk lamps with 18- to 23-W fluorescent or LED bulbs
- jumbo plastic straws
- 100 mL of 0.2 $molL^{-1}$ sodium hydrogen carbonate solution

Procedure

(Write a detailed step by step procedure of how you will carry out your investigation.)

Hints:

- You will measure the number of discs floating per unit time.
- You will compare **the slope of your new graph** to the one constructed in PART A to determine how your chosen factor affected the rate of photosynthesis**.**
- You will need to clearly identify your controlled factors within the procedure to ensure that you design a “fair test”.

REMEMBER: The procedure needs to have sufficient detail so that someone else could repeat exactly what you did.

Results

(Draw a table for recording the results of your experiment here.)

Table (Title)**:** ____

Plot the number of floating discs against time.

Analysis

1. What do the results suggest about factors that affect the rate of photosynthesis?

2. Use what you understand about photosynthesis in green plants to **EXPLAIN** your results above.

Conclusion

Claim

Evidence

Reasoning

Evaluation

1. Describe some of the details in your procedure that did not work well, and that might have affected your results.

2. Suggest some **improvements** to your design that might improve the validity of your results if you were to do the experiment again.

Assessment Rubric – Practical 5: Fuelling the ecosystem

		Achievement Standard	A	B	C	D	E
Science Inquiry Skills	Questioning and Predicting	Students design questions that can be investigated using a range of inquiry skills.	**Designs original and complex** questions that can be investigated scientifically. **Develops** a **justified** hypothesis, **consistently** linking the independent and dependent variable.	**Designs logical** questions that can be investigated scientifically. **Develops** an **informed** hypothesis linking the independent and dependent variable.	**Designs appropriate** questions that can be investigated scientifically. **Develops** a hypothesis **with reference** to some scientific concepts.	**Constructs simple** questions that can **sometimes** be investigated scientifically. Develops a **plausible** hypothesis.	**Constructs simple but vague** questions that are **difficult** to investigate scientifically**.** **Makes a prediction,** but does not provide a reason.
	Planning and conducting	Students design methods that include the control and accurate measurement of variables.	Constructs a **detailed and logical** step-by-step procedure showing how equipment and quantities are selected in order to control variables. Gives a diagram where required. The procedure is **the most suitable** and can be replicated. **Accurately identifies** the independent and dependent variables and **explains how** they will be changed and measured. Provides a **comprehensive list** of factors that need to be controlled to ensure the reliability of data collected.	Constructs a **clear and logical** step-by-step procedure showing how equipment and quantities are selected in order to control variables. Gives a diagram where required. The procedure is **appropriate** and can be replicated. **Accurately identifies** the independent and dependent variables including their units of measure where appropriate. **Lists a range of factors** that need to be controlled to ensure the reliability of data collected.	Constructs a **simple** step-by-step procedure. Gives a diagram where required. **Identifies** the independent and dependent variables. **Lists several factors** that need to be controlled to ensure the reliability of data collected.	Constructs an **incomplete and/or simple** procedure with some key steps omitted. **Lists a number of variables that can affect the investigation** and inconsistently identifies them.	If provided, the procedure is **disorganised, unclear and/or omits** large parts. Identifies some variables, **with guidance.**
		Students methods include the systematic collection of data.	Constructs **accurate** and **well-designed methods** of collection for a **variety** of data, using **correct** conventions to record quantitative and qualitative data. **Selects and constructs appropriate** graph types for a **variety of data** and displays data using required conventions.	Constructs **appropriate methods** of data collection, using **correct** conventions to record quantitative and qualitative data. **Selects and constructs appropriate** graph types and displays data using required conventions.	Constructs **a method** of data collection, using **mostly correct** conventions. Constructs **appropriate** graph types and displays data using required conventions.	Constructs **a table** for data collection, using **some correct** conventions. Constructs a **simple** graph using **some** required conventions	Records results in a **provided table.** Constructs a **simple** graph with **errors and omissions**

Assessment Rubric – Practical 5: Fuelling the ecosystem

	Achievement Standard	A	B	C	D	E
Processing and analysing data and information	Students analyse trends in data.	Summarises results, explaining patterns and trends in the data, **using scientific terminology.**	Summarises results, explaining patterns and trends in the data.	Summarises results, describing **straightforward** patterns or trends in the data.	Summarises **differences** between data sets.	Makes **general,** non-distinguishing comments about data sets.
	Students identify relationships between variables and reveal inconsistencies in results.	Formulates a **logical and perceptive** conclusion. Provides a **clear and detailed explanation** of how evidence from the investigation supports the conclusion. Makes **clear and detailed** connections with **relevant** scientific concepts.	Formulates a **logical** conclusion. Provides **an explanation** of how evidence from the investigation supports the conclusion. Makes connections with **relevant** scientific concepts.	**Provides a conclusion,** linking it to the results. Makes **a** connection with scientific concepts.	Provides a conclusion **loosely related** to the results.	Provides a conclusion **without linking it to the results.**
Evaluating Processes	Students analyse their methods.	**Critically** and **logically** evaluates procedures and describes in detail a **range** of **appropriate** improvements.	**Logically** evaluates procedures and describes in detail **range** of **appropriate** improvements.	Evaluates procedures and describes **some** improvements that are **generally appropriate**.	Has **attempted** to evaluate procedures and **suggests** improvements that may be made.	Has made **little attempt** to evaluate procedures and lists some **basic** improvements.
	Students analyse the quality of their data and explain specific actions to improve the quality of their evidence.	Identifies a number of sources of uncertainty and **makes specific suggestions** for improvements to increase **accuracy and reliability**.	Identifies sources of uncertainty and **makes specific suggestions** for improving the **reliability** of the data.	Identifies sources of uncertainty and makes **general suggestions** for improvement.	Identifies **general areas** of error sometimes linked to the investigation.	Makes comments that are **not linked** to the investigation.
Communicating	Students use appropriate language and representations when communicating their findings and ideas to specific audiences.	Uses an **extensive range** of appropriate **scientific** language, **conventions** and representations when communicating r findings and ideas to specific audiences.	Uses **a variety** of appropriate **scientific** language, **conventions** and representations when communicating findings and ideas to specific audiences.	Uses **appropriate** scientific language and representations when communicating findings and ideas to specific audiences.	Uses **everyday** language and **simple** representations when communicating findings and ideas to specific audiences.	Uses **unscientific or inappropriate** language and representations when communicating findings and ideas to specific audiences.