INTRODUCTION TO Science by Doing®

Engaging students with science

STUDENT GUIDE

Australian Academy of Science

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Icon					
Meaning	Digital interactive	Hands-on inquiry	Classroom activity	Notebooking	Discussion

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Part 1

Doing science

Part 2

Working in the laboratory

Part 3

The Science by Doing approach

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Part 1: Doing science

Activity 1.1 What is science?
Activity 1.2 What measures up?

PART 1

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Activity 1.1 What is science?

Activity type

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Science...

- Observing
- Wondering
- Inquiring
- Asking questions
- Critical thinking
- Predicting
- Experimenting
- Testing
- Finding answers

Can you think of more?

Scientists and science students use many different approaches

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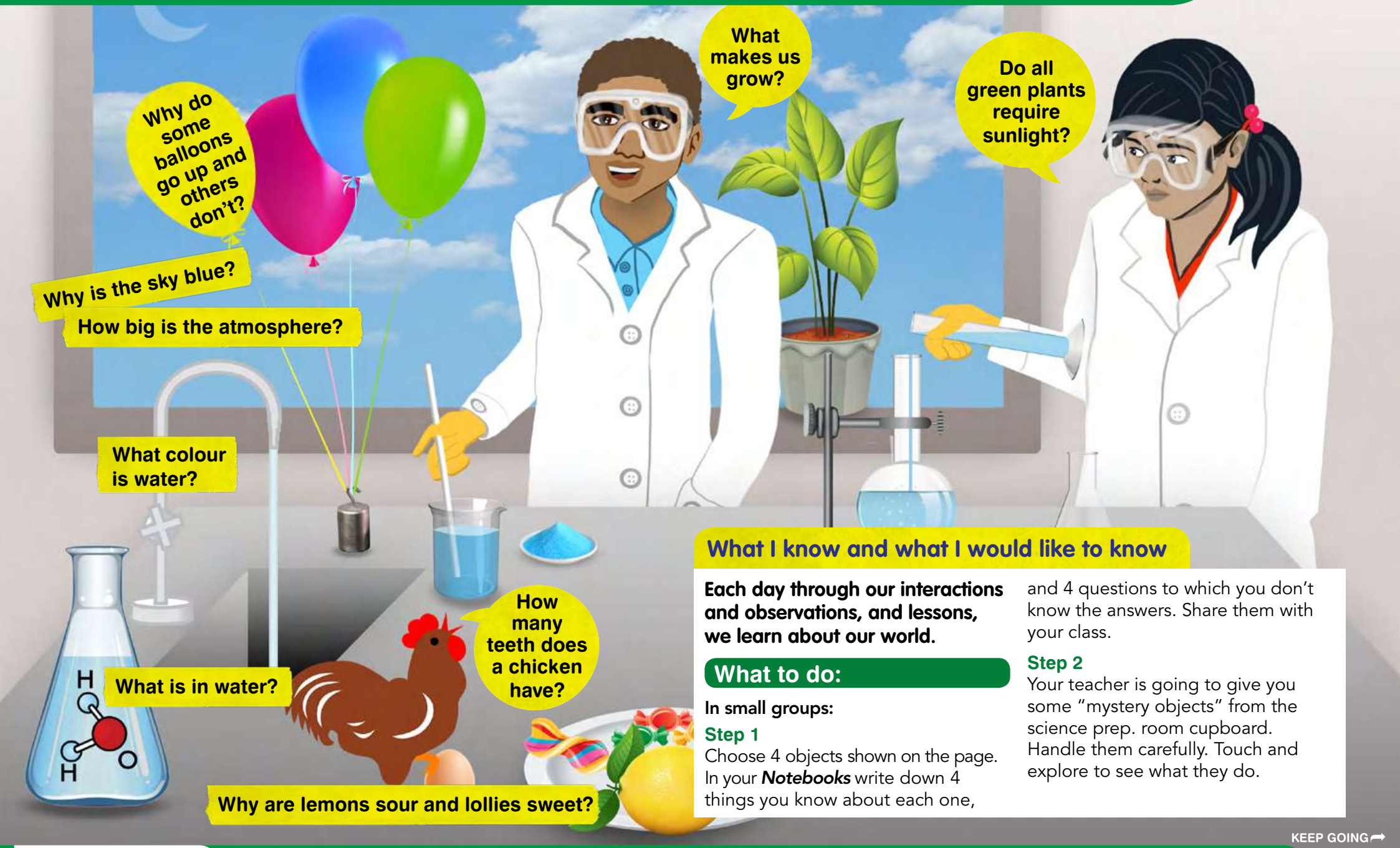

What I know and what I would like to know

Each day through our interactions and observations, and lessons, we learn about our world.

What to do:

In small groups:

Step 1
Choose 4 objects shown on the page. In your ***Notebooks*** write down 4 things you know about each one, and 4 questions to which you don't know the answers. Share them with your class.

Step 2
Your teacher is going to give you some "mystery objects" from the science prep. room cupboard. Handle them carefully. Touch and explore to see what they do.

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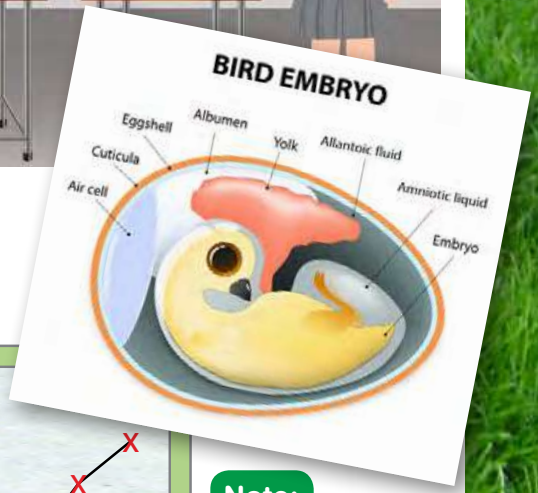
Observation study

What to do:

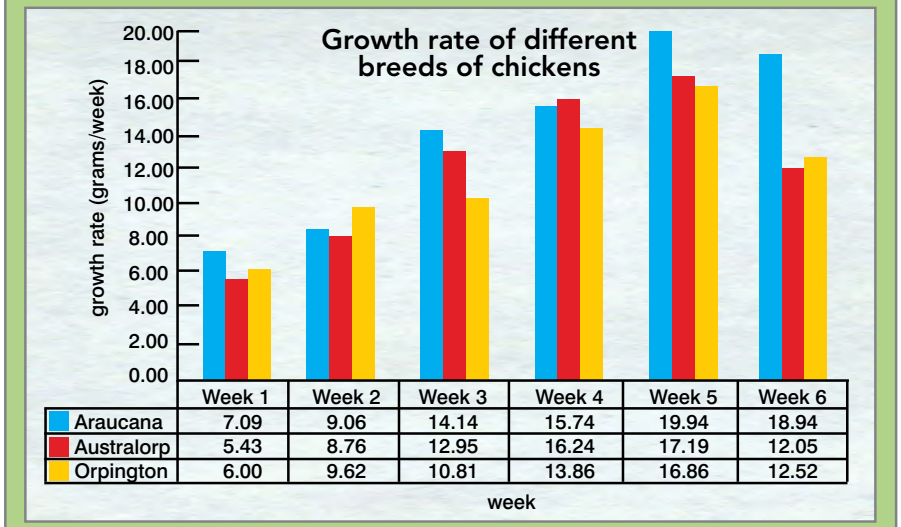
Your teacher will help you find an animal to observe either in the classroom or at home. What questions do you have about the animal? Choose just one question that could be answered by observation studies.

In a small group, consider how and what data to collect in order to learn more about the animal. How will you record your data? How will you graph and present the findings?

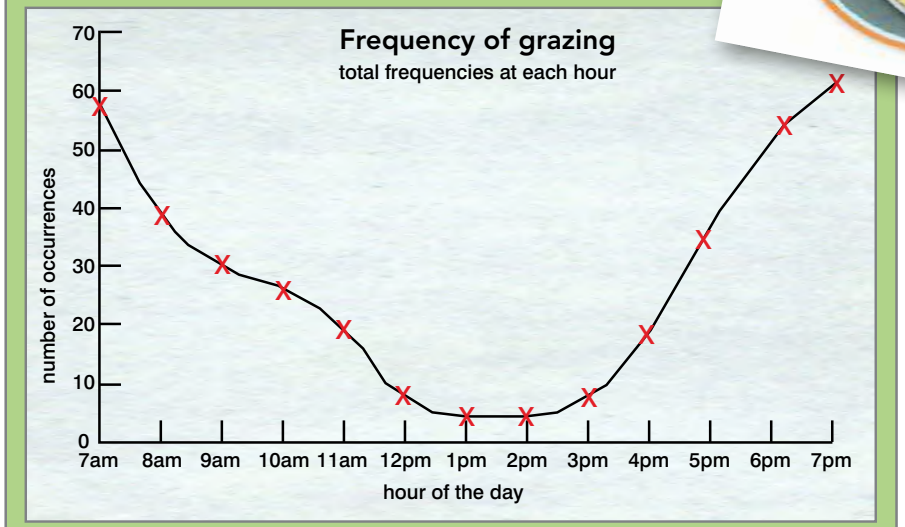


Scientists use graphs and tables to summarise their findings and illustrate trends. What do the graphs below tell you? What don't they tell you? How are they different? What data will you graph from your animal observation study?

Activity sheet 1.1 Interpreting graphs provides some more practice to help you interpret different types of graphs.



	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Araucana	7.09	9.06	14.14	15.74	19.94	18.94
Australorp	5.43	8.76	12.95	16.24	17.19	12.05
Orpington	6.00	9.62	10.81	13.86	16.86	12.52



Note:

Having trouble finding chickens to observe? -try observing earthworms, or your family pet.

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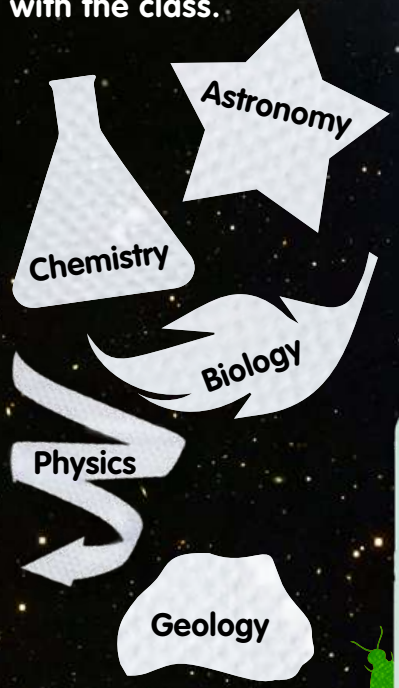
Observation

Scientists learn by watching, measuring and recording "the world" around them.
For each of the areas of science below, describe four examples how scientists undertake observations to learn more?
In pairs, use a table and dot points to complete this task before sharing your answers with the class.



An entomologist studies insects.
How do they do this?
Insects are animals too.
Why are they so important?
What can insects tell us?
In what science field would you expect to study insects?

Does your inference explain how something works?
Could your inference be tested?
If you answer yes to both questions your inference is also a hypothesis.

Observation and inference

Sometimes scientists can't observe directly what has taken place – but they can infer from their observations. This happens at home too. For example, what is the response at home to the following observations;

- your room is messy
- the car has a dent in the bumper bar
- all the biscuits have been eaten
- there isn't any petrol in the lawnmower.

Observation	Inference
Lights are on	Power is working

What to do:

Write in your ***Notebook*** a definition for observation and inference and use a table like the one above to record paired examples. Your observations and inferences could relate to the animal you have been observing in this activity.

Hint: Have you explored the ***Science by Doing* Glossary** for this unit yet? What does the **Glossary** say for **Inference**?

Click here to learn more about science and the scientific approach.

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Activity 1.2 What measures up?

Activity type

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All scientific experiments have to be carefully controlled. Why, and what does this mean?

Many experiments require special instruments to make measurements. Why?

Learning by observation and measurement

What to use:

Each PAIR will require:

- equipment as described in their experiment plan.

Each STUDENT will require:

- *Science by Doing* ***Notebook***.

What to do:

Step 1
There are seven statements on this page. Are they true?

Jot down which of the seven you think are true.

Step 2
In pairs, design a quick experiment to test one of the statements. Write an aim and method for your experiment in your ***Notebook***.

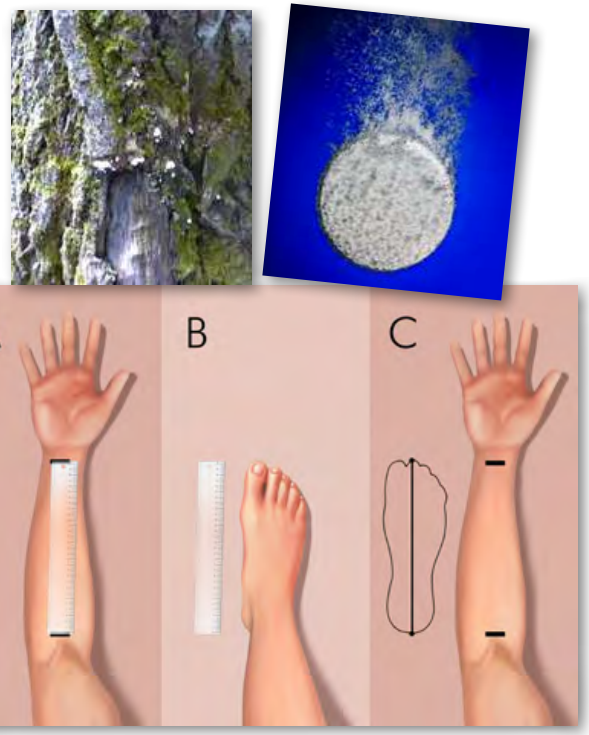
Step 3
Conduct your experiment and record your results in your ***Notebook***. These could be in a table or graph.

Discussion:

1. Did your results support the statement?
2. If your results did not support the statement do you think you have enough evidence to say that the statement is wrong?

Are these statements true?

- People with longer forearms have bigger feet.
- Students can predict when 35 seconds has passed.
- Heavy objects fall to the ground quicker than light objects.
- Tablets dissolve quicker in warm water.
- Mosses and lichens grow on the shady side of trees.
- Children remember phone numbers better than adults.
- Science labs are bigger than other classrooms.



Record all experiments in your ***Notebook***.

This includes your ideas and your experiment plan.

This should include;

- **The aim:** why you did the experiment and what you hoped to achieve
- **Method:** how you did the experiment. This often includes simple diagrams
- **Results:** these are often presented first in a table. They might also be graphed.

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Summary

PART 1

Science is a way of **asking questions** about the world around us and finding answers to these questions that are supported by **evidence**. Scientists create new ideas, or **hypotheses**. They test these by doing **experiments**, observing and measuring.

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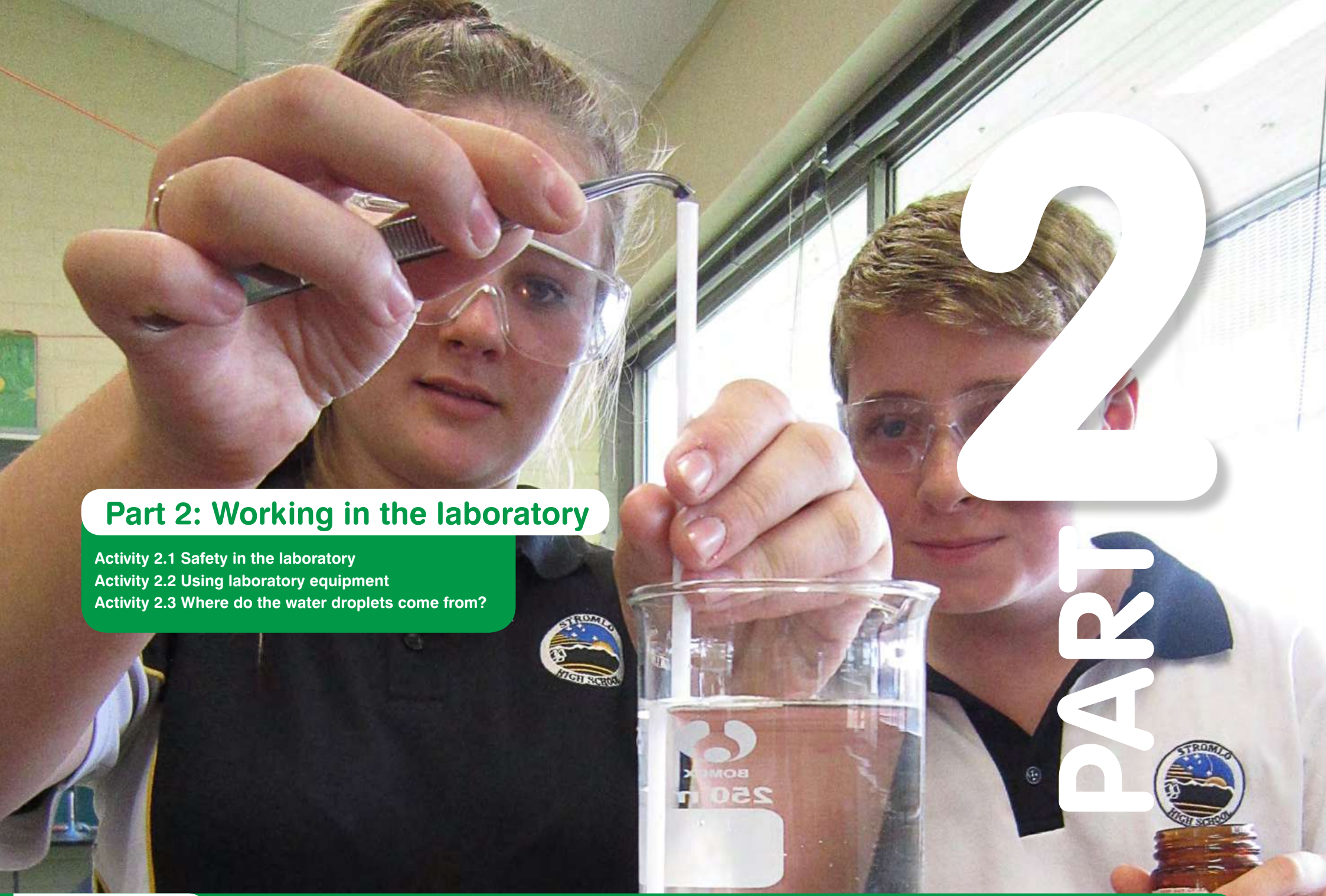

PART 2

Part 2: Working in the laboratory

Activity 2.1 Safety in the laboratory
Activity 2.2 Using laboratory equipment
Activity 2.3 Where do the water droplets come from?

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Activity 2.1 Safety in the laboratory

Activity type

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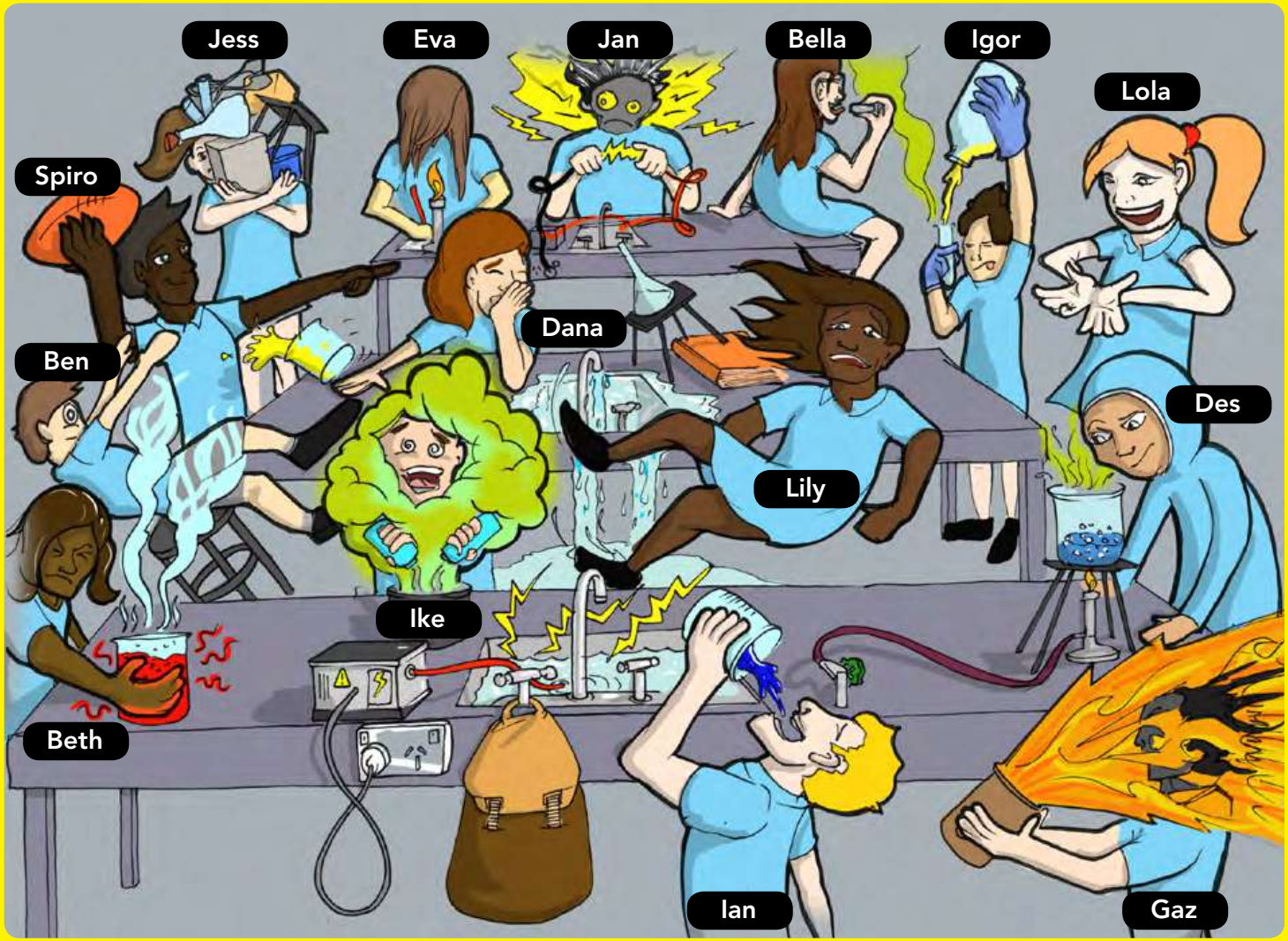
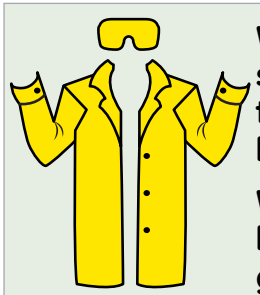
What's wrong with this picture?



Lab safety



Why do many scientists undertake their work in the laboratory?

Why do they wear lab coats and safety glasses?

Some experiments use chemicals and equipment that can be dangerous if used the wrong way.

A laboratory typically provides the following:

- **A controlled environment**
- **Safety equipment and procedures to keep the scientist safe**
- **Specialised equipment.**

What to do:

Step 1
Examine the characters in this image. Make a note of the appropriate safety precaution or required behaviour in your ***Notebooks*** for these students.

Step 2
Look around your school laboratory. What features does it have that allow you to "do science" safely and effectively? Make a note of these in your ***Notebook***.

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Safety in the lab.

As a class, write a set of safety rules for your lab. Your teacher will help you put your different ideas together. How should these rules be displayed so that they can be easily referred to?

WHEN YOU HANDLE CHEMICALS YOU NEED TO ASSESS RISKS AND TAKE PRECAUTIONS. REVISE LAB SAFETY WITH YOUR TEACHER AND FAMILIARISE YOURSELF WITH CHEMICAL SAFETY WARNINGS. KEEP AN EYE OUT FOR THIS SIGN AS YOU PROGRESS THROUGH THE UNITS.

REMEMBER LAB SAFETY STARTS WITH YOU!

? Have you seen these warning signs?

Tripping hazard

Slipping hazard

Radiation

Biohazard

Fire (flammable)

Corrosive

No eating or drinking

High voltage

Am I working safely?

? Where would your safety in the lab be most at risk?

Create your own safety symbols for your laboratory

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Risk assessment

Risk assessment

How will I keep myself and my friends safe?

Each time you start laboratory work, your teacher will conduct a risk assessment to keep you and everyone else safe. A risk assessment takes into account student age and behaviour, laboratory rules and the risks associated with the experiment.

What to use:

Each STUDENT will require:

- *Student Guide*
- ***Activity sheet 2.1 Risk assessment***

What to do:

Step 1

In your ***Notebook***, draw a diagram of your lab (to scale):

Use pictures and labels to identify the following:

- Exits
- Fire extinguisher and safety blanket
- Fume cupboard
- Eye wash
- Chemical storage
- Heating apparatus
- Glassware
- Tongs

Step 2

Read ahead about **Activity 2.3 Where do the water droplets come from?** What equipment and chemicals are going to be used? Identify potential risks in that experiment. Use ***Activity sheet 2.1 Risk assessment*** to write a draft risk assessment.

Click here to check your understanding of warning signs.

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Activity 2.2 Using laboratory equipment

Activity type

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Robert Bunsen
(1811 – 1899)

We use a capital letter for Bunsen burner after Robert Bunsen, the first person to use this apparatus. He was teaching in Germany when gas powered street lighting was first introduced in 1855.

Learning to use a Bunsen burner

Teacher demonstration

Bunsen burners provide heat by burning a flammable gas.

In your laboratory, the gas used is probably propane.

Your teacher will demonstrate how to light a Bunsen burner safely. What happens when the hole is opened or closed?

What to use:

Each GROUP will require:

- Bunsen burner, heat mat, matches

Each STUDENT will require:

- *Student Guide*
- Internet access
- ***Notebook.***

What to do:

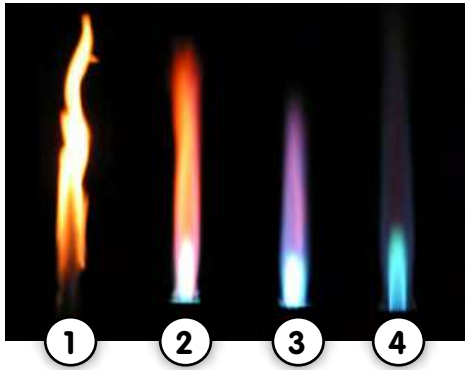
Step 1
Observe both Bunsen flames. Which flame is best for heating? Which flame is cooler and more visible to use as a safety flame? Explain why one flame is hotter than the other.

Step 2
Draw and label the Bunsen burner (heat flame) in your ***Notebooks*** followed by instructions for the safe use of this apparatus. What other possibilities for heating are there in your lab? How do they work?

Step 3

Watch this video of students lighting a Bunsen safely.

Step 4
Practise lighting your Bunsen safely.



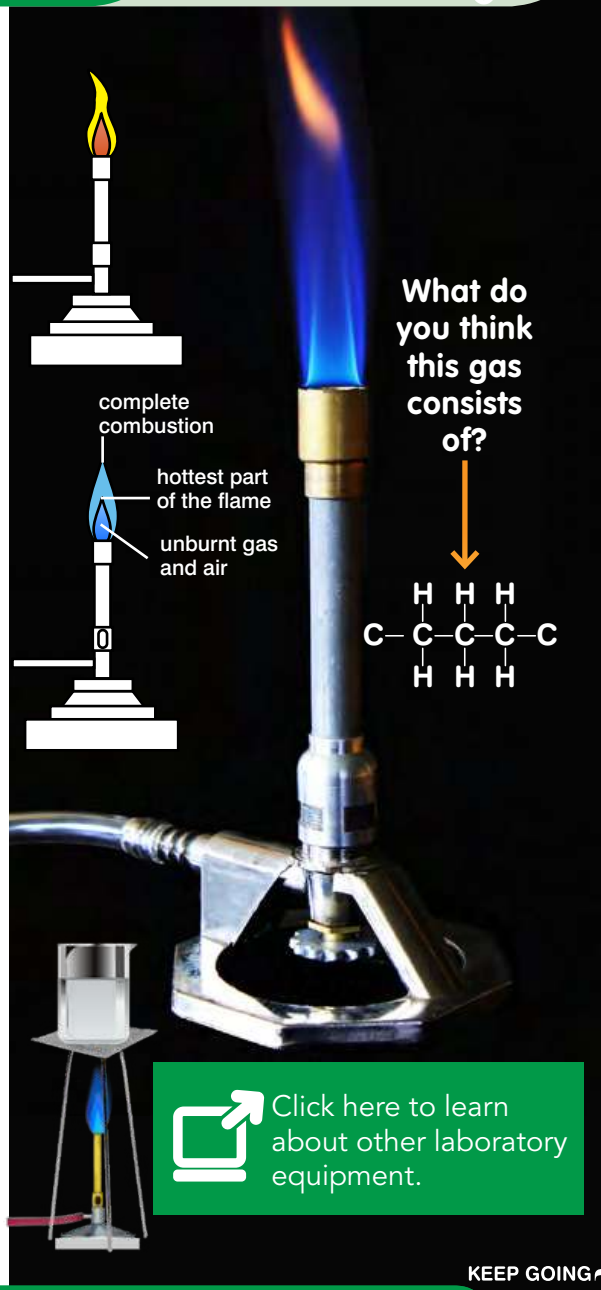
Bunsen burner flames depend on air flow in the throat holes (just above the base):

1 Air Hole closed (safety flame used for lighting). It is easily visible.

2 Air Hole slightly open.

3 Air Hole half open.

4 Hole almost fully open (roaring blue flame). This is the hottest and cleanest flame but is hard to see.



Click here to learn about other laboratory equipment.

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Scientists often use two dimensional representations and labels to illustrate their observations and apparatus used

Hint: Use realistic proportions and neat pencil lines.

Drawing apparatus

What to use:

Each STUDENT will require:

- ruler
- sharp HB pencil
- eraser
- *Science by Doing* ***Notebook.***

What to do:

Here is a photograph of an experimental set-up involving the heating of water.

Draw a diagram in your ***Notebook*** illustrating this.

Diagrams should be accurate, to scale and in proportion.

Apparatus labels should be clear and where possible, written horizontally beside the identifying line.

A new scientific term: Apparatus is another word for equipment.

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Activity 2.3 Where do the water droplets come from

Activity type

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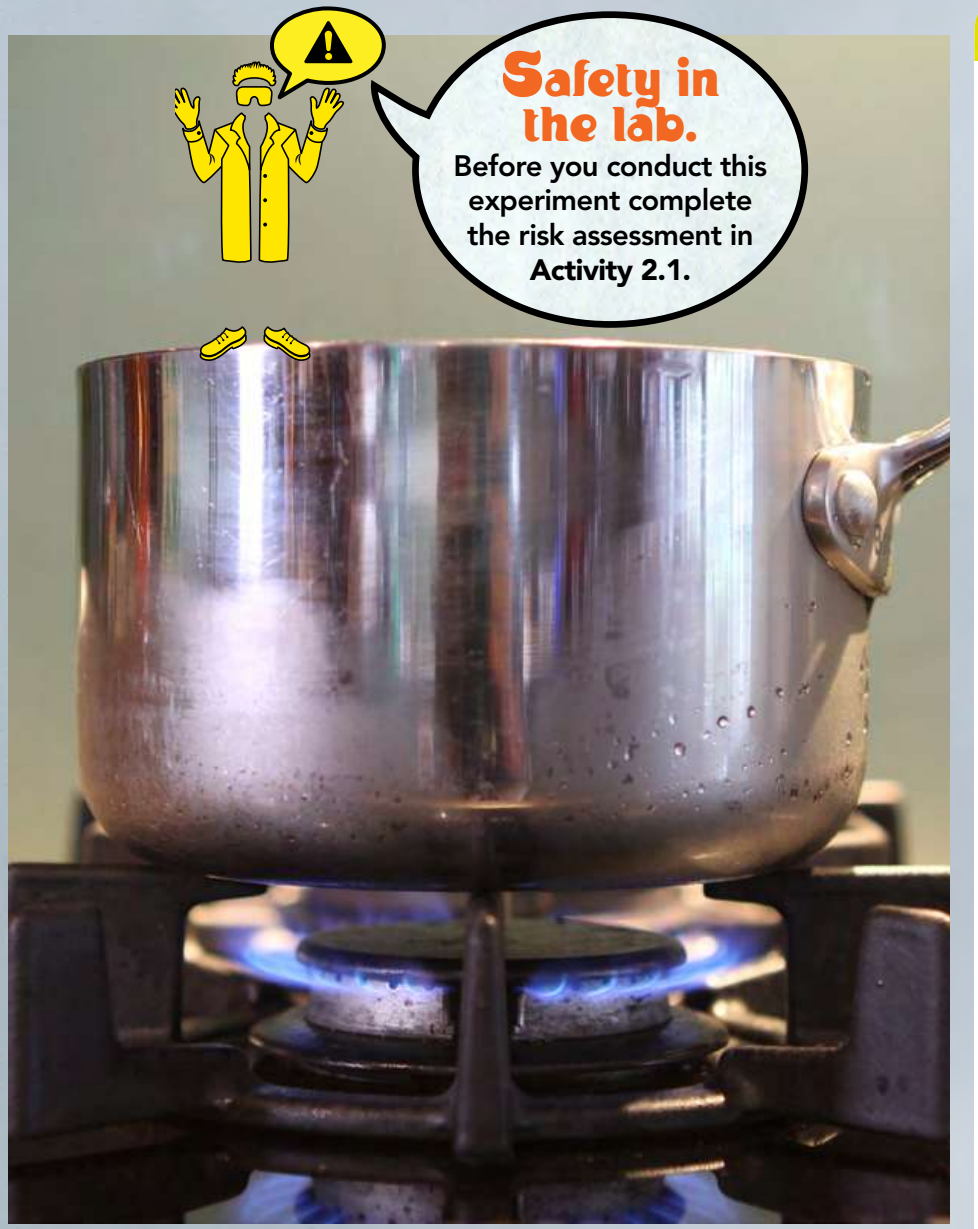

Can you infer where the water droplets come from?

What to use:

Each GROUP will require:

- two beakers of cold water
- Bunsen burner, tripod, gauze mat
- electric hotplate.

Each STUDENT will require:

- ***Notebook.***

What to do:

Step 1
Light your Bunsen burner, being careful to follow the safe procedure you have learnt. Set up the tripod and gauze mat.

Step 2
Place one of the beakers of cold water on the gauze mat over the Bunsen burner. Observe carefully what happens on the sides of the beaker.

Step 3
Now turn on the hotplate. Once it has heated up place the other beaker of cold water on it. Observe carefully what happens.

Step 4
Record this experiment in your ***Notebook***. Follow the guidelines provided by your teacher.

Discussion:

Observations

What did you observe on the side of the beaker heated by the Bunsen burner?

Did you make the same observation for the beaker heated on the hotplate?

Inferences

Where do you think the water droplets came from? You might be able to think of several possible explanations.

Based on what you observed what do you think is the most likely explanation?

Click here to find some more inferences and hypotheses. Did any of these agree with yours?

What would a scientist do?

A scientist decides which inference or hypothesis is the most likely, and then carries out experiments to test this.

A scientist will also try to explain what has been observed. During the following units you will learn some of the scientific ideas that are used to explain this mysterious water-droplet phenomenon.

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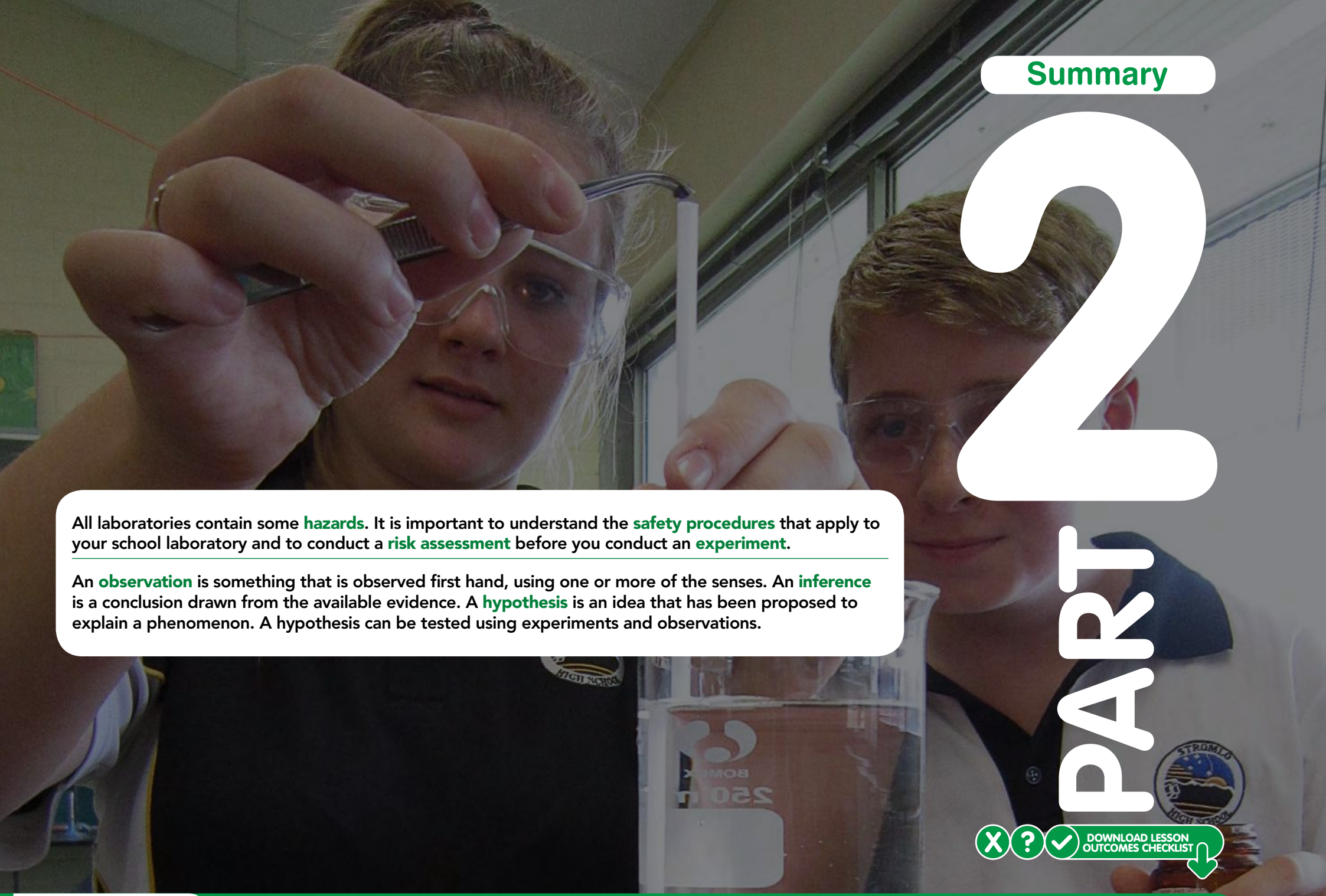

Summary

PART 2

All laboratories contain some **hazards**. It is important to understand the **safety procedures** that apply to your school laboratory and to conduct a **risk assessment** before you conduct an **experiment**.

An **observation** is something that is observed first hand, using one or more of the senses. An **inference** is a conclusion drawn from the available evidence. A **hypothesis** is an idea that has been proposed to explain a phenomenon. A hypothesis can be tested using experiments and observations.

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PART 3

Part 3: The *Science by Doing* approach

Activity 3.1 How do you learn best?
Activity 3.2 Inquiry science

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Activity 3.1 How do you learn best?

Activity type

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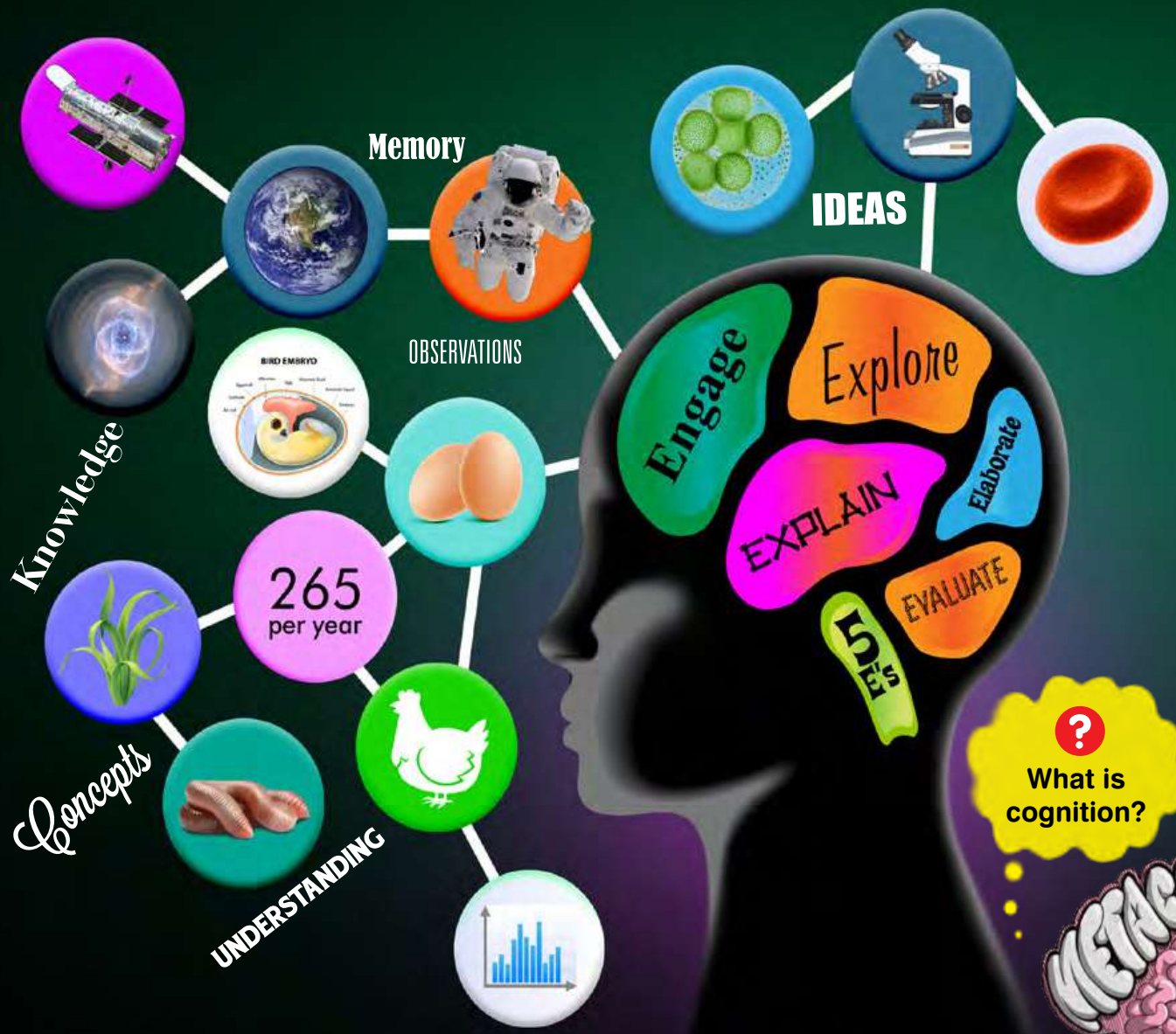
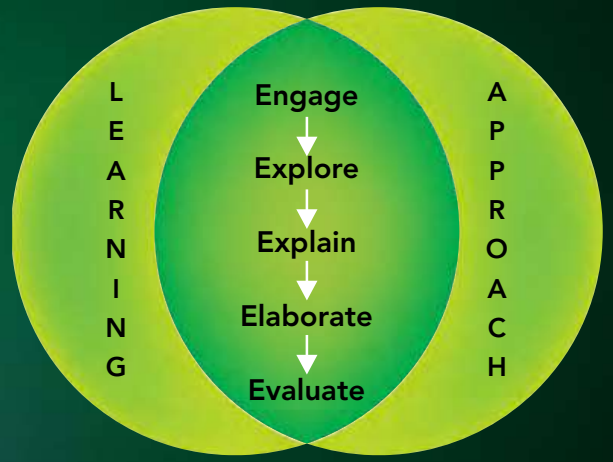


The *Science by Doing* learning approach is inquiry based learning.

This relies on the 5E's:



Brainstorm as a class what each means.

What is your responsibility as a learner and your contribution to the five E's using this approach?

Hint: Think like a scientist and observe, then describe, the behaviours of an engaged learner.

? What is cognition?

Did you know that when you start to think about your own thinking, this is called **metacognition**?

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What is in your brain that enables you to learn?

Your brain is full of cells called neurons. The neurons talk to each other through connections called synapses. These "conversations" produce the knowledge and memories you experience.

Is your brain a learning machine?

Sometimes when you are trying to learn something difficult it feels like "cogs and wheels" are struggling to turn. Why do you think this is the case? What is actually happening?

Quick memory test:

Write down the initials of everyone in your Kindergarten class.

What technique did you use to help you remember?

Apparatus memory test:

Your teacher will conduct another memory test. How does this compare to the one above?

Click here to find out more about memory and your brain.

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Notebooking

In *Science by Doing*, you can document your ideas and learning through text, image and collage. There will be opportunities to write formal answers to Notebook questions and summarise concepts. More importantly, you are encouraged to sketch ideas, use digital technologies and write down your thinking during each lesson.

What to do:

Take a look at this example from Maya's Notebook page on measurement. What do you observe? What can you infer from your observation of this page?

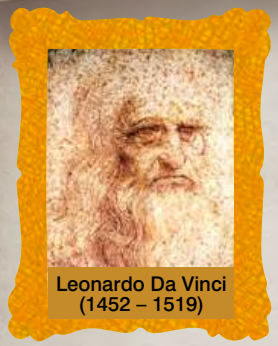
Click here to learn more about ***Notebooking***.

Capturing the moment.

It is not always possible to take a quick photo – but why not draw it, or caption it in a bubble? This will make it easier for you to recall it later.

Remember that your brain likes to use visual clues.

Every time you make a note of something in your *Notebook* it will help your brain recall and remember.


Leonardo Da Vinci (1452 – 1519)

Leonardo Da Vinci's notebooks documented his ideas, explorations and learning in many forms. To keep many of his ideas private he wrote backwards so that the notes had to be read in a mirror.

What sort of notebooks and diaries do we keep today?

? How does Maya's Notebook compare to Leonardo's?

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Activity 3.2 Inquiry science

Activity type

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Asking questions

What to do:

Step 1
In your ***Notebook***, cut and paste the six images of students completing investigations. Create a question and answer (cartoon style) for each of these pictures.

Step 2
Your teacher will allocate the following questions to small groups. Be prepared to share your responses with the class.

Question 1
Why do we ask questions?

Question 2
What types of questions help us to learn?

Question 3
What ways can you ask questions? Who could you ask?

Question 4
How will your teacher know what you know, and what you want to know?

Question 5
How will your class support all students to ask questions?

What do blood cells look like? How can we find out?

A science journey of discovery.

In pairs, visit the learning stations set up by your teacher. For each, summarise what you observed, what you did, what you learnt, and what you would like to know. Before you get started, how will you convey the essence of this experience in your *Notebook*?

Click here to learn more about the inquiry approach.

Microscope investigation

Litmus test

Mystery object

Animal observation

Spinning top prediction

Balloon lift

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Summary

PART 3

Learning in science, like all subjects, is a very active process. As you think about a problem you form new memories that are stored away for future use. The *Science by Doing* program uses an approach called the **5-E's**: which stands for **Engage**, **Explore**, **Explain**, **Elaborate**, and **Evaluate**.

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Summary

PART 1

Science is a way of **asking questions** about the world around us and finding answers to these questions that are supported by **evidence**. Scientists create new ideas, or **hypotheses**. They test these by doing **experiments**, observing and measuring.

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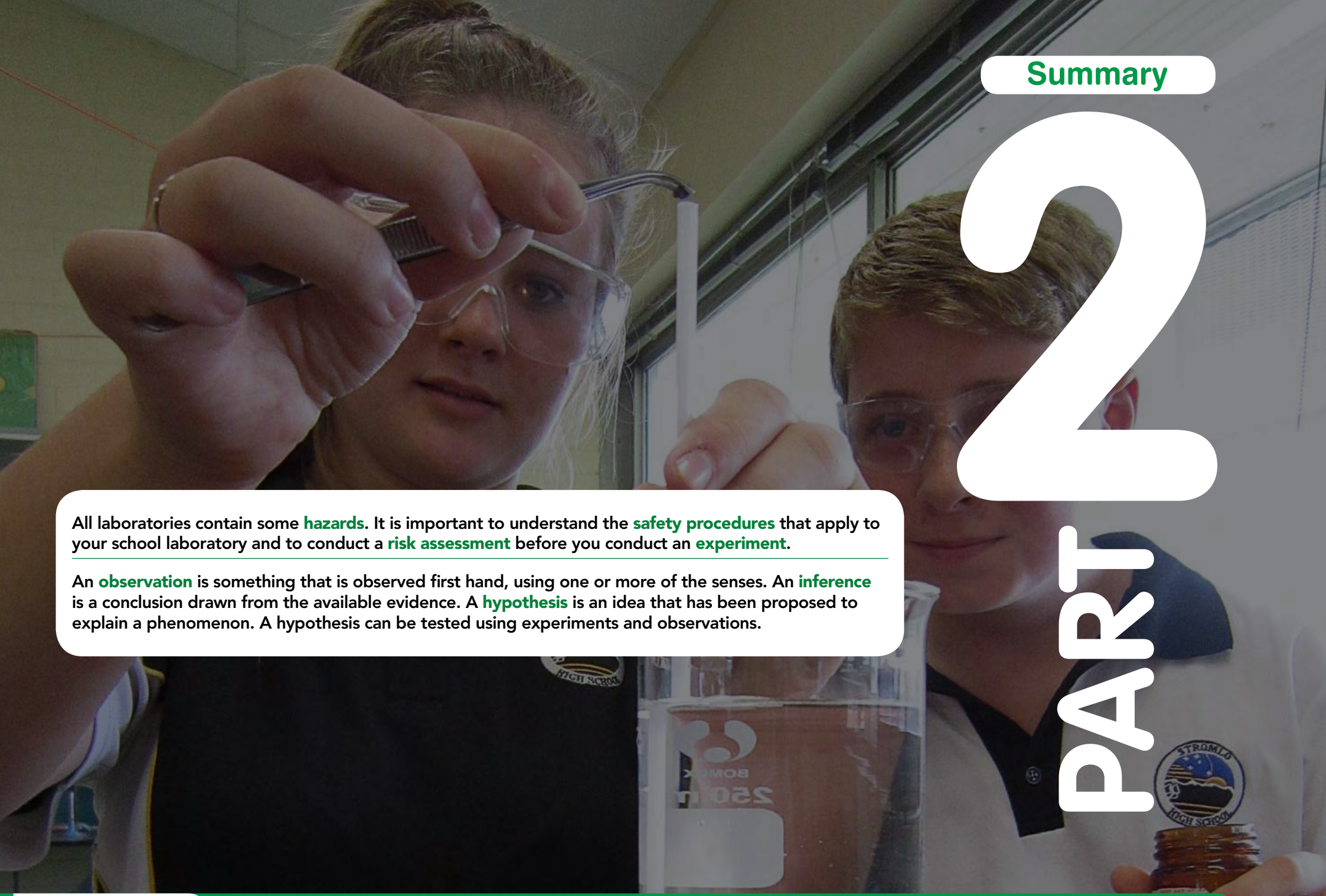

Summary

PART 2

All laboratories contain some **hazards**. It is important to understand the **safety procedures** that apply to your school laboratory and to conduct a **risk assessment** before you conduct an **experiment**.

An **observation** is something that is observed first hand, using one or more of the senses. An **inference** is a conclusion drawn from the available evidence. A **hypothesis** is an idea that has been proposed to explain a phenomenon. A hypothesis can be tested using experiments and observations.

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Summary

PART 3

Learning in science, like all subjects, is a very active process. As you think about a problem you form new memories that are stored away for future use. The *Science by Doing* program uses an approach called the **5-E's**: which stands for **Engage**, **Explore**, **Explain**, **Elaborate**, and **Evaluate**.

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Glossary

Term	Description
Aim	The first part of the record in a scientific Notebook; describes the reason for carrying out an experiment.
Attention	The brain being focussed on a particular event.
Beaker	A glass container used to hold chemicals.
Boss head	A clamp that can be attached to a retort stand.
Bunsen burner	A piece of equipment that provides a flame for heating; usually burns propane (bottled gas) or methane (natural gas).
Clamp	A metal device for attaching pieces of equipment to a retort stand or other supporting structure.
Condensation	Liquid formed as droplets from a gas as it cools down; usually of water.
Conical flask	A glass container with a conical shape, used to mix chemicals.
Crucible	A small ceramic bowl with a lid used to heat chemicals to very high temperatures.
Evaporating basin	A ceramic dish used to dry out and evaporate liquids, usually by heating.
Filter funnel	A cone shaped device made of glass or plastic used to run a liquid through filter paper to separate materials.
Gauze mat	A metal mat placed on a tripod over a Bunsen burner. It can be used to support glassware such as a beaker or flask containing a liquid for heating.
Hypothesis	An idea that has been proposed to explain a phenomenon. A hypothesis can be tested using experiments and observations.
Inference	A conclusion drawn from the available evidence.
Inquiry	A mode of learning that involves asking questions and exploring a topic through a variety of experiences.
Long term memory	A part of your brain that holds memories for a long time; up to many years.
Measuring cylinder	A cylinder of glass used for accurately measuring the volume of a liquid.
Meniscus	The surface of a liquid, usually water, in a container. It curves up slightly where it makes contact with the sides of the container.

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Glossary

Term	Description
Metacognition	Thinking about how you think and learn.
Method	A section of a science report that explains how an experiment was done.
Observation	Something that is observed first hand, using one or more of the senses.
Plausible	Something that is possible or believable based on your current knowledge.
Reagent	A chemical used in an experiment.
Replication	A repeat, usually of an experiment, under identical conditions to check whether the results are consistent.
Results	A section of a science report that provides the actual data collected.
Retort stand	A metal stand for supporting equipment.
Risk assessment	A document that identifies any risks in carrying out an experiment and how these risks can be minimized.
Scientific test	An experiment or series of observations that is designed to test a hypothesis.
Stirring rod	A glass rod used to stir chemicals, usually in a beaker.
Test tube	A glass tube used to mix and heat chemicals.
Test tube holder	A wooden or metal peg used to hold a test tube over a Bunsen burner flame.
Thermometer	An instrument for measuring temperature.
Tripod	A 3-legged metal stand for placing things over a Bunsen burner.
Watch glass	A glass dish: so named because it has the same shape as an old fashioned wrist watch.
Working memory	A part of your brain that holds new information that you are thinking about now.

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Acknowledgements

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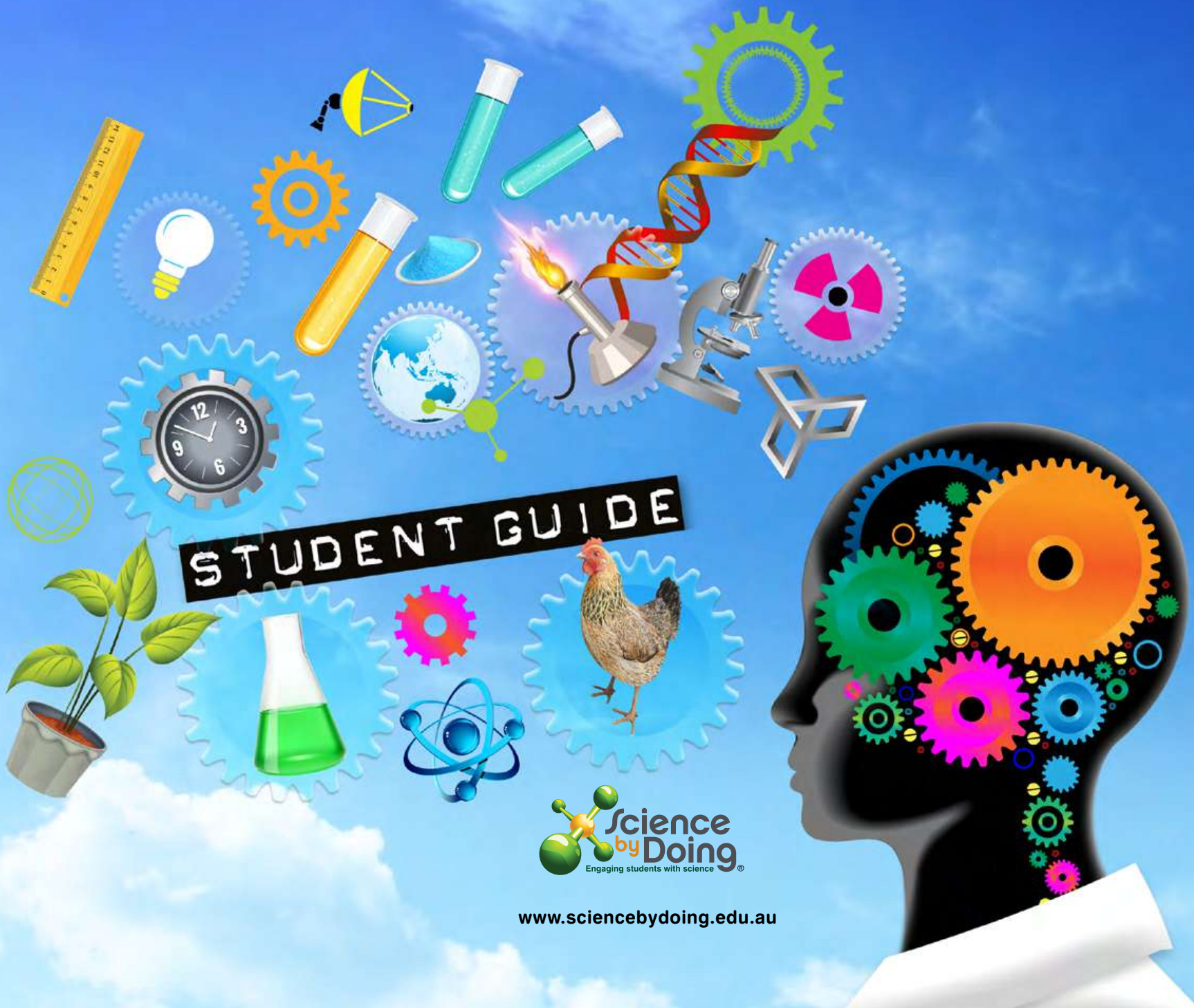

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