Teacher Notes

Themes

- Scientific method
- Development of theoretical knowledge
- Science career paths

Key learning outcomes

- Science is a way of thinking that produces practical knowledge about the universe.
- Science can be used to understand diverse aspects of the universe on many different scales.
- Australian people and society have contributed a variety of significant discoveries across diverse fields of research.

Key curriculum areas

- **Science:** Science Understanding (Biological sciences, Chemical sciences, Physical sciences, Earth and space sciences); Science as a Human Endeavour; Science Inquiry
- **English:** Literacy
- **Mathematics:** Number, Measurement

Publication details

The Great Australian Science Book

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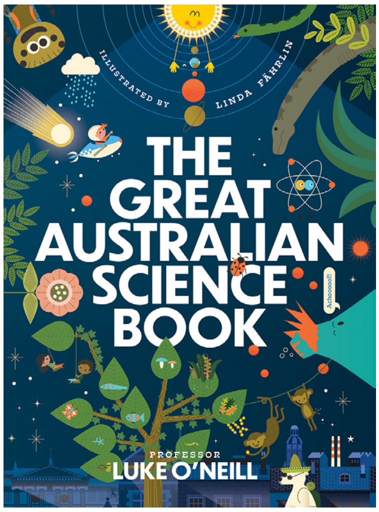

The Great Australian Science Book

Luke O'Neill and Linda Fährlin

About the book

How do we measure the universe? How do our bodies repair themselves when we are ill? What species will exist on Earth in a million years' time?

Discover the answers to these questions and a lot more in *The Great Australian Science Book*. We'll go on an incredible scientific journey from the very, very BIG to the very, very SMALL.

Starting with the universe itself, we will travel through the galaxies and stars, onto our very own planet Earth and across its fabulous features, into our wonderful bodies and all their cells, and on down to the very elements and atoms that make up all things.

Discover how Australia has made huge contributions to science and do a few experiments yourself as you learn to think like a scientist.

Recommended for

Readers aged 8 to 14 (Years 4 to 9)

PUBLISHING

Teacher Notes

About the author and illustrator

Luke O'Neill is Professor of Biochemistry at Trinity College Dublin. He has a PhD in Pharmacology (the science of medicines) and hopes that his research might lead to new treatments for inflammatory diseases.

Linda Fährlin is a visual artist with extensive experience developing artworks and illustrations. Originally from Stockholm, she worked in Australia for many years. Linda often draws inspiration from science and believes that art and science can both change the way we see the world.

Pre-reading questions or activities

Most students will be innately curious about nature and technology. Start a conversation with the class over big questions they'd love answered by sharing your own curiosities. Perhaps you can describe a question you had as a child that was answered, or a question you still have today.

Write the question on a sheet of paper using a marker so it can be easily read.

Invite each student to do the same, writing a question on a sheet of paper using a heavy marker. Their question can be on any topic – encourage them to use their imagination, and not feel intimidated. Explicitly discourage any other student from answering or speculating on another's question.

Once every student has a question, come together to share them as a class. Ask the students whether some questions have features in common. Are some about living things? Are others about space? Are there any about computers or machines? Are some about people?

Discuss how science is a process for discussing answers to these questions. Explain to the students how it is divided into different fields as well, such as biology for studying living things, physics for investigating movement and change, and astronomy to explore the stars and space.

Discussion questions

Science

1. Good science always starts with a good idea. Explain to students that science is a methodology – a way of telling if a method for testing a guess (called a hypothesis) is useful or not. A bad idea is a hypothesis that can't be tested. Invite students to come up with their own 'guess' answers to questions asked in the pre-reading. Ask whether each guess could be tested in some way. Read pages 2 to 3 of the book and discuss how an idea becomes a theory.
2. Invite students to read pages 8 and 9. Two of the big mysteries in physics currently are dark matter and dark energy. Ask the students to explain why we should consider these discoveries as facts about the universe, even if we have no idea what they are (yet!).
3. A lot of astronomy involves searching for signs of life elsewhere in the universe. Invite the students to read page 16, and ask them whether they think it's a worthwhile goal of science to search for life on other planets. Ask them whether such a discovery might benefit human lives here on Earth in any way.
4. Read pages 26 to 27, emphasising the paragraph about the five organisms humans couldn't live without. Invite students to discuss why any environmental crisis that affects a large number of living things puts our current way of life at risk. Invite them to speculate what might happen if flowers couldn't be pollinated, should the world no longer have bees.
5. Ask students to discuss whether humans are still evolving or not. Invite them to read pages 28 to 29, reminding them of how our bodies are also the result of millions of years of natural selection. Invite them to imagine the kinds of changes our bodies might undergo in the future. How will humans evolve over the next few million years?
6. Climate change is a pressing issue in today's world. Ask students to read page 34 and to do the quiz on page 35. Discuss how Earth's climate has changed before, but the speed of change today – combined with the impact it has on us as a species – is significant. Invite students to share their quiz scores, and whether living sustainably is important to them personally.

7. Instruct students to read pages 39 to 59 on the human body. Explain to the students that the human body is like a factory, where each part serves a special role. The brain, for example, is like a board of directors or bosses who take in information and tell others what to do with it. Ask the students to come up with metaphors of people, machines or processes in a factory for other parts of the body.
8. Read pages 67 and 84 and discuss with students how future particle colliders will be bigger and more powerful, while also being very, very expensive. Tell them there's no guarantee they'll be powerful enough to reveal new particles. Should we still spend so much money on big projects in science if there is no certainty that they'll provide big discoveries? Is finding nothing still worthwhile science?
9. Ask students to read 'Be a scientist!' on pages 17, 37, 61 and 85, and to list all of the fields. Remind them this is just a small sample of all of the different areas of research available. Invite them to pick one area of science they would study, if they had to be a researcher. Students can choose a field not mentioned in the book, or even combine fields if they wish. Ask them to discuss why that area of science appealed to them.

English

1. Read page 67, inviting a student to read the words aloud. If they ask how to pronounce 'quark', instruct them to read it as they think it is pronounced. Read them the passage the physicist Murray Gell-Mann borrowed it from:

   "Three quarks for Muster Mark! Sure he hasn't got much of a bark and sure any he has it's all beside the mark. But O, Wreneagle Almighty, wouldn't un be a sky of a lark to see that old buzzard whooping about for uns shirt in the dark and he hunting round for uns speckled trousers around by Palmerstown Park?" (from *Finnegans Wake* by James Joyce)

   Ask them if they can guess what nationality the author of the text might be. How do they think quark was pronounced? Discuss how words and scientific language evolves over time as different uses and cultures borrow and translate words, and even change the way they sound.
2. Read pages 86 to 87, focussing on the motto of the Royal Society: '*Nullius in verba*' (Take nobody's word for it). Discuss how we decide what texts we should trust, and which ones we shouldn't. What signs are important in text that show an author is likely to be knowledgeable and ought to be believed? What signs might indicate an author is confused, wrong or even lying?

Mathematics

1. The universe is a very big place. So big, we need big ways to describe its size. Read pages 5 and 6 and ask students to discuss why light years might be the best unit for measuring vast distances between stars and galaxies. Could we use the same unit to measure the distance between school and home? What about the size of a pencil? Why don't we normally use light years for measures on Earth?
2. Read pages 82 to 83. Ask students to explain what they think the equation $E = mc^2$ might mean. Point out that laws in physics often come in the form of a formula like this. Give force (f) = mass (m) × acceleration (a) as another example. Ask why laws tend to all look very mathematical. What might happen if they rearrange the equations to read differently, such as $m = E/c^2$? Do they think this is still true? How might this be useful to scientists?

Activities

Science

Swinging science

This activity works best if different variables – the length of string, number of washers and angle of the swing – are individually tested by different groups of students in each class.

Safety: Instruct students to stand back while swinging the pendulum.

You will need:

- 70 centimetre length of cotton string
- 50 centimetre length of wooden dowel
- Plasticine or masking tape
- Two chairs
- 5 × large steel washers
- Ruler
- Protractor
- Stopwatch
- Pen and paper

What to do:

1. Measure 10 centimetres on the 70 centimetre length of cotton string. Use those 10 centimetres of string to tie 1 large steel washer onto the string (it's okay if there is some string left over).
2. Measure 10 centimetres from the other end of the cotton string. Use those 10 centimetres to tie the string to the length of wooden dowel. Your 'pendulum' should be 50 centimetres long.
3. Place two chairs back to back, about 30 centimetres apart.
4. Place the wooden dowel on the top of the back of each chair with string and the washer hanging down from the centre. Use masking tape or plasticine to secure it in place if necessary.
5. Using a protractor to measure the angle, pull the string back so it makes an angle of 20 degrees with the dowel.
6. Press 'start' on the stopwatch as you let go. When the pendulum returns to the same side it started for the fifth time (five complete swings back and forth), press stop and record the time.
7. Do this five times. Find the average (add up the times and divide the number by five).

Test some variables:
Conduct the above experiment another five times, with some changes in each 'trial', such as:

A. Increase the number of washers, adding an extra washer in each trial.
B. Decrease the length of string, from 50 centimetres to 40, 30, 20 and then 10 centimetres.
C. Increase the angle between the dowel and the string, from 20 degrees to 30, 40, 50 and 60 degrees.

Before you conduct the trials, form a hypothesis in the following format:

As I increase/decrease [the number of washers/the length of string/the angle of the swing], the average time it takes the pendulum to swing will [increase/decrease/stay the same].

What's happening?

In this experiment, there are a number of things that can be changed, and one thing that can be measured. Things that are changed are called independent variables. The thing that is measured is a dependent variable – the measurement may *depend* on the other changes.

Conducting a number of trials improves the accuracy of the measurement. This is important in science, as any one measurement of the dependent variable might be affected by other things, like the exact starting position, or the speed at which you press the stopwatch, or even a breeze.

The hypothesis is a way to describe an idea so it can be tested. It's easy in the end to then say if your experiment supported your hypothesis, or refuted (disagreed with) it.

By conducting enough different experiments, it's possible to come up with a law that describes something mathematically or theoretically.

Evolutionary Scrabble

You will need:

- Scrabble® letters (1 set per 10 students) – (these can also be written letters on cards, so long as the ratios of letters are similar)
- A bag or box
- A six-sided dice
- Pen and paper

What to do:

1. Divide the class into groups of five students. If there is a group left smaller than five, divide the remaining students across other groups so they each have six.
2. Place all of the letters into a bag or box.
3. Ask each student to draw a single letter from the assortment. Together, they then need to combine letters within their group to form a two, three, four or even five letter word. Tell them to quietly write their words down.
4. Roll the dice. If it comes up with a '1', re-roll. If it is a number between 2 and 5, any groups with those numbers earn a point. If it is a 6, nobody gets points but each group can pick one more letter, after which roll the dice again.
5. After 10 rounds, add up the points to determine a winning team.

What's happening?
Evolution requires two things to work: randomness and selection.

Every organism is built using a genetic 'blueprint' based on a coded sequence constructed using a chemical called deoxyribonucleic acid (DNA).

When a baby is made, this DNA sequence can change slightly in what is known as a mutation. It can also be jumbled, or is combined with a sequence from another parent. These are all relatively random events.

Some changes are then selected in some way. Maybe the DNA sequence doesn't work at all, just like the assortments of letters that didn't make any words. On the other hand, maybe some DNA sequences make features that are selected by the environment, giving them an advantage so they survive where others didn't – much like some sequences of letters 'survived' where others didn't.

English

Is there anybody out there?
Invite students to read The Universe on pages 5 to 16. Have a short discussion about rovers left on Mars (page 16) and the endless journey of the distant Voyager spacecraft (page 13).

Explain to the students how Voyager 1 and 2 are each carrying a 'golden record' of information about humanity. Direct them to search for more facts about the information on these records, which includes details of Earth, humanity and even songs that represent our culture.

Ask the students to come up with their own version of a 'golden record' that could be carried on a spacecraft that is left on another planet or moon, or is destined to fly towards the stars.

What might they want to include on there? What should we tell a distant civilisation in the far future? How should it be communicated? Is it best to include a lot of detail, or just a few important bits of information?

Teacher Notes

Mathematics

Counting big

To measure the universe, you sometimes need some pretty impressive numbers. Hundreds and thousands won't cut it – you need millions, billions and sometimes numbers so big, you need dozens of zeroes to describe them.

Ask students to guess how long it would take them to count to a hundred. What about a million? How about a billion?

Write these numbers on the board. Write after each how many times 10 would need to be multiplied to get to that number (10 × 10 = 100, so you'd write '2'; for a million, it's 10 × 10 × 10 × 10 × 10 × 10, so '6'). Describe this number as a power, showing how it can be written as a smaller number to the upper-right of 10, like 10^2 and 10^6.

Invite students to see how long it takes to count to 100. Tell them to multiply this measurement by 10 to estimate how long it would take for them to count to 1000.

Use this method to estimate bigger numbers, such as 1 million and 1 billion.

Suggest ever-increasing sizes of numbers using the 'power of 10' notation as a shorthand. How long might it take to count to each?

Explain how the universe is around 13.7 billion years old. Use this to compare the time it might take to count some awfully big numbers.

Australian curriculum links (Version 9.0)

Year level	Learning area: Science	Other learning areas
Years 4 to 6	**Science Understanding: Physical sciences** • Identify how forces can be exerted by one object on another and investigate the effect of frictional, gravitational and magnetic forces on the motion of objects (AC9S4U03) • Identify sources of light, recognise that light travels in a straight path and describe how shadows are formed and light can be reflected and refracted (AC9S5U03) **Science Understanding: Earth and space sciences** • Describe the movement of Earth and other planets relative to the sun and model how Earth's tilt, rotation on its axis and revolution around the sun relate to cyclic observable phenomena, including variable day and night length (AC9S6U02) **Science as a Human Endeavour: Nature and development of science** • Examine how people use data to develop scientific explanations (AC9S4H01) • Examine why advances in science are often the result of collaboration or build on the work of others (AC9S5H01 and AC9S6H01)	**English: Literacy – Analysing, interpreting and evaluating** • Use comprehension strategies such as visualising, predicting, connecting, summarising, monitoring and questioning to build literal and inferred meaning, to expand topic knowledge and ideas, and evaluate texts (AC9E4LY05) • Use comprehension strategies such as visualising, predicting, connecting, summarising, monitoring and questioning to build literal and inferred meaning to evaluate information and ideas (AC9E5LY05) • Use comprehension strategies such as visualising, predicting, connecting, summarising, monitoring and questioning to build literal and inferred meaning, and to connect and compare content from a variety of sources (AC9E6LY05)
Years 7 to 9	**Science Understanding: Chemical sciences** • Use particle theory to describe the arrangement of particles in a substance, including the motion of and attraction between particles, and relate this to the properties of the substance (AC9S7U05) **Science Understanding: Biological sciences** • Recognise cells as the basic units of living things, compare plant and animal cells, and describe the functions of specialised cell structures and organelles (AC9S8U01) **Science Understanding: Physical sciences** • Use wave and particle models to describe energy transfer through different mediums and examine the usefulness of each model for explaining phenomena (AC9S9U04) **Science Inquiry: Questioning and predicting** • Develop investigable questions, reasoned predictions and hypotheses to explore scientific models, identify patterns and test relationships (AC9S7I01 and AC9S8I01) • Develop investigable questions, reasoned predictions and hypotheses to test relationships and develop explanatory models (AC9S9I01)	**Mathematics: Number** • Represent natural numbers in expanded notation using place value and powers of 10 (AC9M7N03) **Mathematics: Measurement** • Recognise and use rates to solve problems involving the comparison of 2 related quantities of different units of measure (AC9M8M05) • Solve problems involving very small and very large measurements, time scales and intervals expressed in scientific notation (AC9M9M02)

Teacher Notes

Related books from CSIRO Publishing

- *AmAZed! CSIRO's A to Z of Biodiversity* (https://www.publish.csiro.au/book/7984)
- *Astronomy for Curious Kids* (https://www.publish.csiro.au/book/8163/)
- *Bots and Bods: How Robots and Humans Work, from the Inside Out* (https://www.publish.csiro.au/book/8013/)
- *Computer Technology for Curious Kids* (https://www.publish.csiro.au/book/8162/)
- *How to Survive on Mars* (https://www.publish.csiro.au/book/8011/)
- *Rocks, Fossils and Formations: Discoveries Through Time* (https://www.publish.csiro.au/book/7864/)
- *The Encyclopedia of STEM Words: An Illustrated A to Z of 100 Terms for Kids to Know* (https://www.publish.csiro.au/book/8084)

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There is plenty of free content that can be used at school or home to support learning.

Double Helix Extra

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Other CSIRO resources

CSIRO has developed and delivered a broad range of high-quality STEM education programs and initiatives for nearly 40 years. Our programs aim to inspire the pursuit of further STEM education among students and the community, to equip the emerging workforce with tomorrow's skill sets, and to strengthen collaboration between industry and classrooms across Australia. For more information visit: https://www.csiro.au/en/Education

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