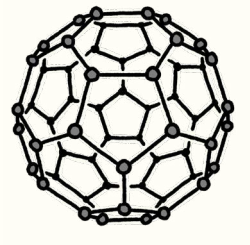
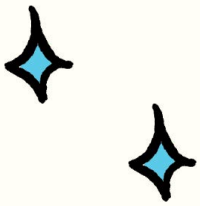
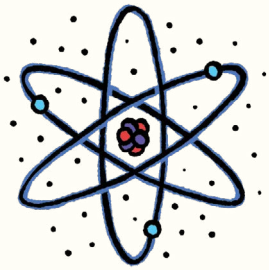


QUARKS, SPARKS and QUANTUM MYSTERIES



A COSMIC GUIDE TO THE BUILDING BLOCKS OF OUR UNIVERSE



Written by

LISA HARVEY-SMITH

AND ILLUSTRATED BY AIDAN RYAN

Teachers' Notes prepared by Christina Wheeler

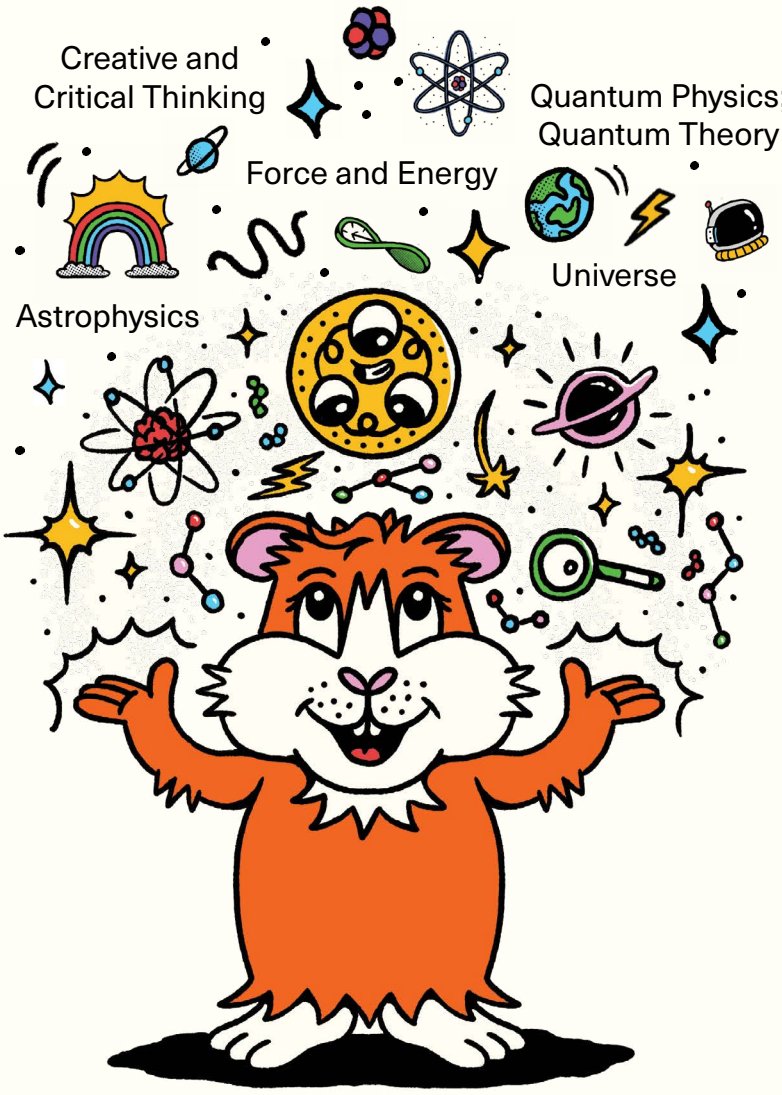
Thames & Hudson Australia acknowledges the Traditional Owners of the land on which we work. We recognise the continuing connection to culture and story passed down through generations of Indigenous Australians that unite people, environment and ways of seeing, and we pay our respects to their Elders past and present and to First Nations people everywhere.

Synopsis

Quarks, Sparks and Quantum Mysteries is an illustrated non-fiction book that delves into the weird and wonderful world of quantum physics. From microscopic atoms and their quirky particles to exploding supernovae and gluttonous black holes, this book is a fascinating insight into the world of astrophysics and other mysteries of the universe.

Cleverly written with detailed explanations, intriguing facts and digestible information, astrophysicist Professor Lisa Harvey-Smith piques curiosity, answers questions and leaves readers with an inexorable desire to ponder 'what if'.

Themes



Writing style

In *Quarks, Sparks and Quantum Mysteries*, the foundations of quantum physics are not only well explained, but they are also expanded upon in a way that makes the text accessible to a range of readers, from those with an innate interest in quantum physics to those new to this field. With valuable features including contents, glossary, index and high-quality illustrations, each chapter is both easy to navigate and highly engaging. The writing style feels almost conversational at times, speaking directly to the reader and making connections between the content and its real-life contexts. The inclusion of Biscuit the guinea pig to help illustrate theories and explanations is also a clever way of helping readers feel a sense of connection with the information. This text is stimulating, thought-provoking and inclusive. It is suitable for readers aged 9+.

Author motivation

I wrote *Quarks, Sparks and Quantum Mysteries* as a gateway to curiosity for learners aged 9+. At this age the mind is receptive to new and challenging ideas, so it has always puzzled me why quantum concepts are not introduced until high school or even university. Quantum physics is all around us – in our bodies, in the light that colours our world and in the food we eat. Quantum physics powers the machines that help us learn, guide us to navigate the world and heal us when we're sick. I first learned about quantum physics as a teenager from a wonderful book, written as a cartoon. Although that book was based around the history and the lives of the people who developed quantum theories, it gave little explanation of how the science was relevant to our everyday lives. *Quarks, Sparks and Quantum Mysteries* is my attempt to offer readers an introduction to this fascinating topic and help root their understanding in the practical applications of quantum physics. I hope you enjoy exploring this wonderful branch of science.

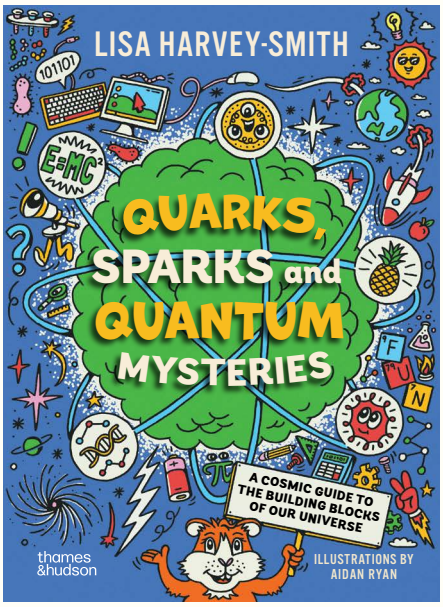
Links to the Australian curriculum

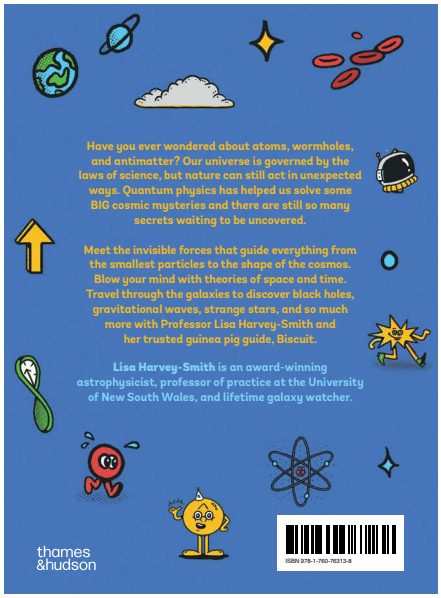
This book and the learning experiences provided are primarily relevant to the following areas of the Australian Curriculum:

Learning area	Year level
Science	Years 3-7

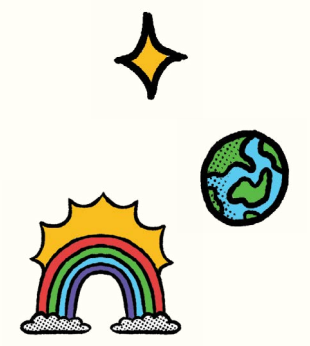
Introduction

- Before reading, spend time looking at the front and back cover of the text. What sparks your interest? What are you hoping to find out by reading this text?





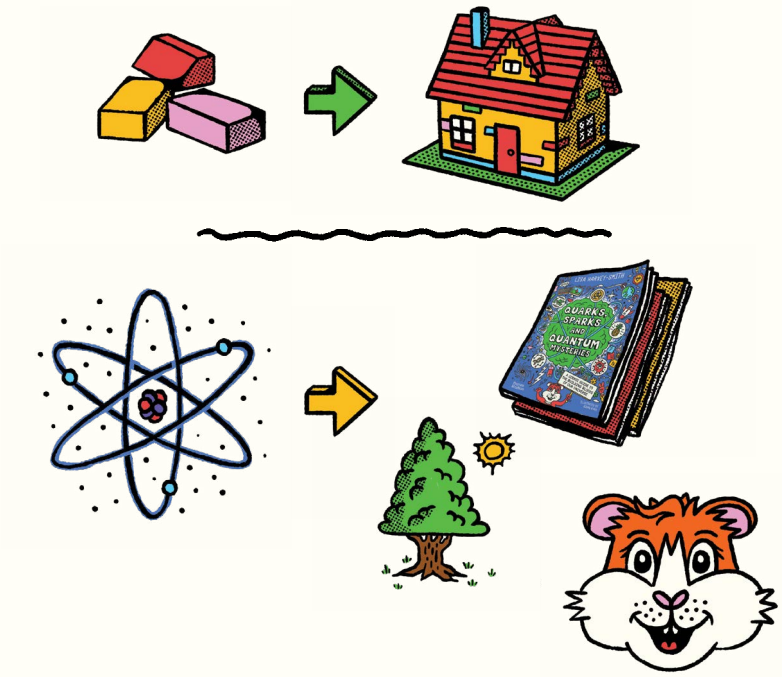
- Using the Contents page, discuss the titles of each chapter. What sort of information might you expect to find in each chapter?
- As a class, read the introduction. As you read, highlight vocabulary to add to your class Word Wall. Consult the Glossary for the definitions. Use this vocabulary as you work with this text.
- The Introduction shares the author's childhood curiosity about the natural world. What are you now curious about having read the Introduction? Complete a KWL chart (see below) to record your wonderings.



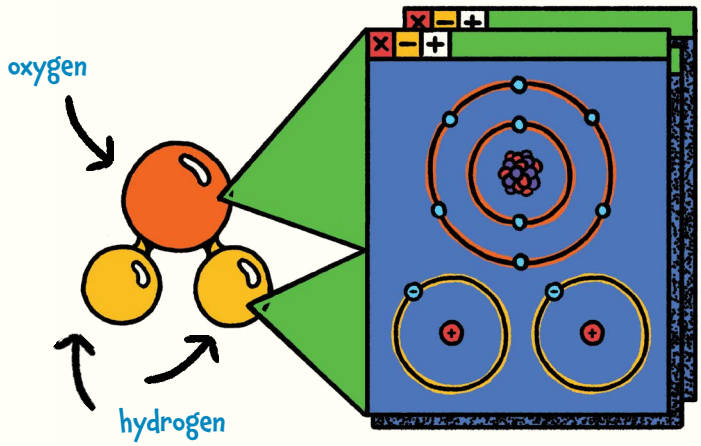
CHAPTER 1

The microscopic world

- Labelling the images below (p. 10), explain what **atoms** are and how they form the building blocks of our universe.



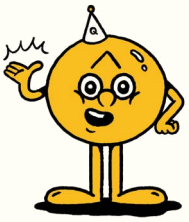
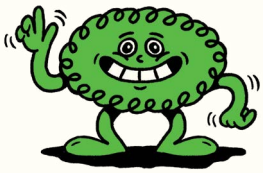
- Sketch an **atom**, showing its **nucleus**, the nucleus' **protons** and **neutrons** and the **electrons** that 'whizz around like a swarm of flies' (see p. 11). Label each of the atom's parts.
- Using Canva or similar app, create a flowchart that shares the history of **particles** (see pp. 14–15). Include elementary particles such as **atoms**, **molecules** and **subatomic particles** in your flow chart.
- To review the content about **particles** shared in Chapter 1, complete this Check for Understanding Slide Deck.
- Using an app such as *Explain Everything*, share your understanding of how **atoms** contain **electrical charges** (p. 16).
- Using the illustration below, explain how **molecules** are created. List some everyday objects that are contain **molecules** (pp. 18–19).



CHAPTER 2

The tiny world of particles

- In Chapter 2, we meet some **elementary particles** including **electrons**, **quarks** and **bosons**. Using the table below, briefly describe the features and role of each of these members of the **Lepton** family (see pp. 23–26).

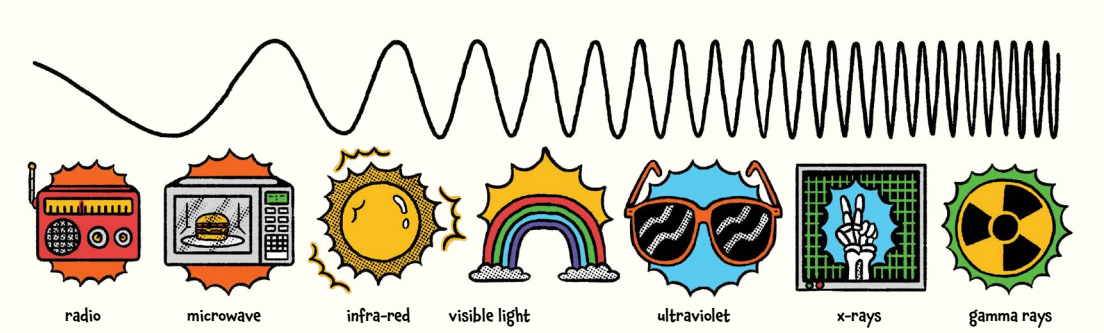
 Electrons
 Quarks
 Bosons

- On p. 27, we learn that many innovative technologies have been made possible through the **standard model of particle physics theory**. With a partner, think of 2–3 new inventions or technologies that could improve life in the future.
- How has your understanding of **particles** strengthened after having read this chapter? Add to your KWL chart as you read.

CHAPTER 3

Quantum quirks

- How would you explain **quantum physics** to your grandparents? What do the terms **quantum**, **photon** and **electron** mean? What has **quantum physics** helped scientists to better understand about **light**, **energy** and **matter** (see pp. 30–31)?
- Define **matter**. Why is it important (see p. 30)?
- What would happen if there was no such thing as **energy**? Why is **energy** vital (p. 30)?
- What are some different forms of **energy** (see p. 30)?
- Use the image below and the information shared in Chapter 3 to explain how **electromagnetic radiation** behaves (see pp. 32–33).



- In your own words, explain what the equation **E = mc2** means. How has this helped scientists understand **energy** more fully (see p. 34)?
- What happens when **photons** are fired into the **nucleus** of an **atom** (see p. 34)?
- How does **quantum physics** drive 'the colours of our modern world'? How do LEDs and **lasers** work (see pp. 37–38)?
- How is **quantum physics** used in cooking (see p. 38)? Try a simple cooking experiment with your class, such as those found on the following websites:

  https://www.kiwico.com/diy/lists/10-food-science-experiments-for-kids?srsltid=AfmBOooOKNQ7s1s_5G8DdNhUsSBVLU_MYQYMyxJsweM_KOE4WA1iORnk

  https://www.fizzicseducation.com.au/category/150-science-experiments/kitchen-chemistry-experiments/?srsltid=AfmBOorLodNYuqMcbcqyqIvs3HKZ6s4relL3O_Fk0WK-FoICFHVZwqR4

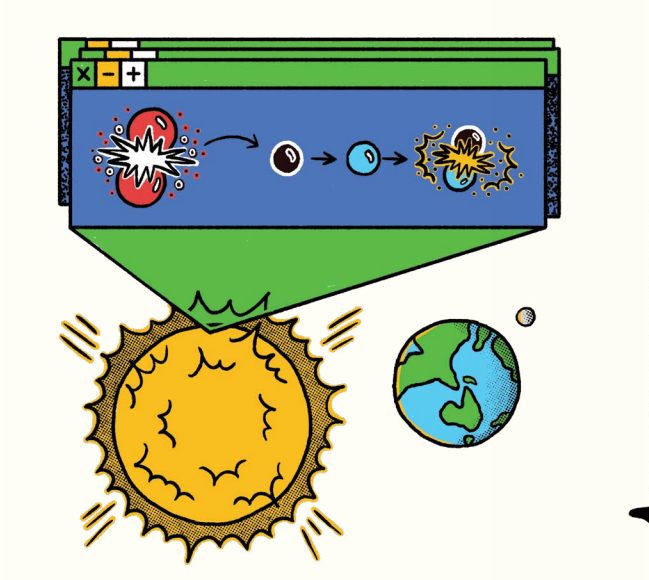
- Using a Makey Makey kit, have students create a simple electrical circuit. Using ideas and theories from quantum physics, explain how this circuit works.

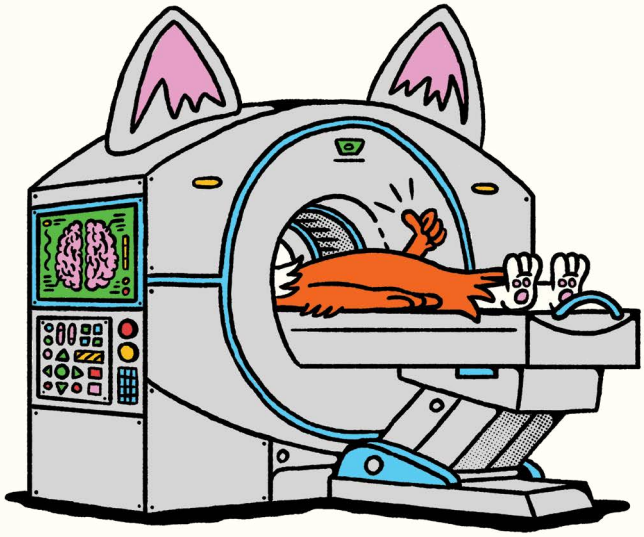
  https://makeymakey.com/blogs/how-to-instructions/lesson-one-simple-circuit?_pos=1&_sid=50ed14a11&_ss=r

CHAPTER 4

The weird world of antimatter

- Using the illustrations below to help, explain how **antimatter** gives heat and light to living things and helps save lives (see pp. 44–45).





- How do scientists make **atoms** from **antimatter** (see pp. 46–47)? How are **antiparticles** stored?

CHAPTER 5

Cosmic rays and other galactic oddities

- Innovate on a board game such as *Snakes and Ladders* to share your understanding of how the following impact human life: **cosmic rays**, **supernovae**, **gamma rays**, **neutrinos** and **cosmic explosions**.

CHAPTER 6

Bizarre forces: Invisible pushes and pulls

- How does the **strong force** help glue everything together, including humans? What allows the strong force to function (see pp. 64–65)?
- Create a comic strip (see template below) explaining the super-powers of the **weak force**. Include **protons**, **neutrons** and their important sidekicks, **W** and **Z bosons** (see pp. 66–67).
- After reading about **electromagnetic forces** on pp. 68–71, create a labelled diagram to explain one or more of the following:
  - How **electric currents** occur
  - How **batteries** and other sources help power our world
  - How **magnetic fields** work

CHAPTER 7

Mass, gravity and relativity

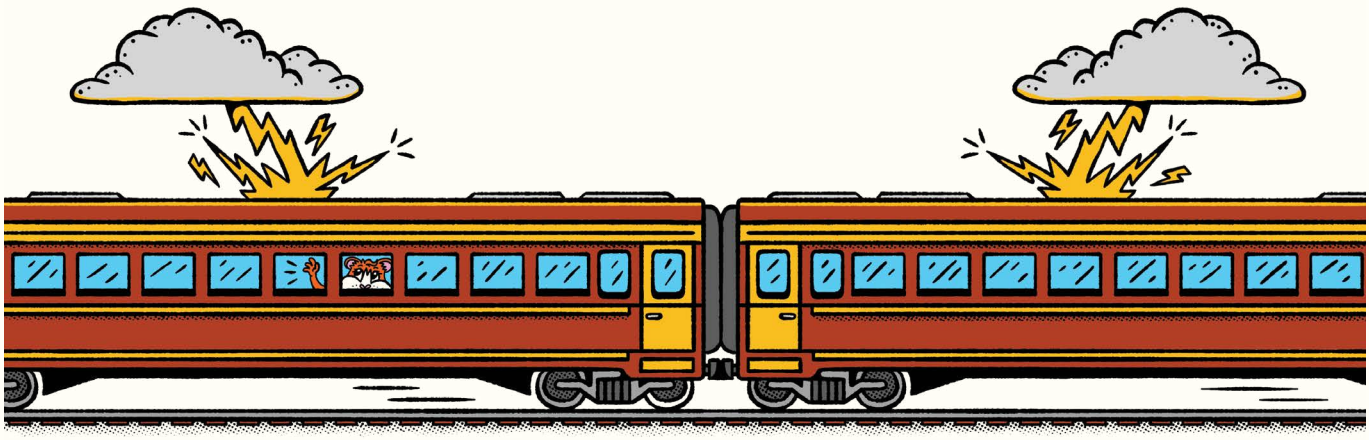
- How is **mass** different from **weight** (see p. 75)?
- In a slide deck or diagram, explain Albert Einstein's **general theory of relativity**, using the analogy of the bowling ball and marble on a trampoline to share how the planets orbit the sun in our solar system (see pp. 76–77).

- See for yourself how **gravitational lenses** work by following the instructions in the Cosmic Fact box on p. 79.

CHAPTER 8

Strange happenings in time

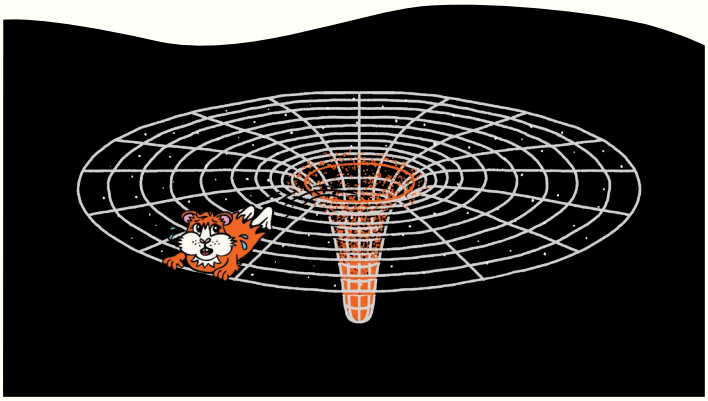
- Explain why if you climbed the highest mountain you can find, **time** would pass faster there (see pp. 84–85).
- Using the example of a moving train given on pp. 86–87, explain Albert Einstein's **special theory of relativity**.

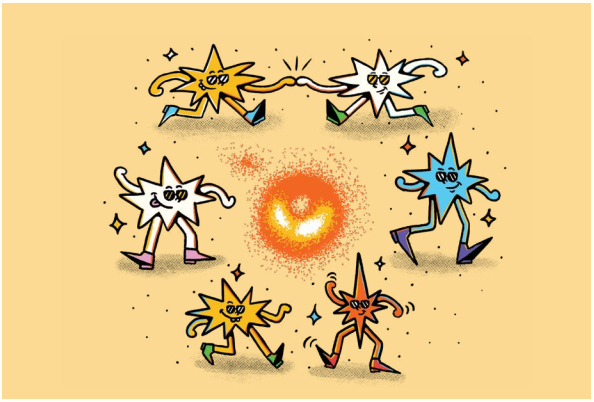


CHAPTER 9

Black holes

- In a medium of your choice (such as a diagram, 3D model, animation or slide deck), share your understanding of **black holes**.

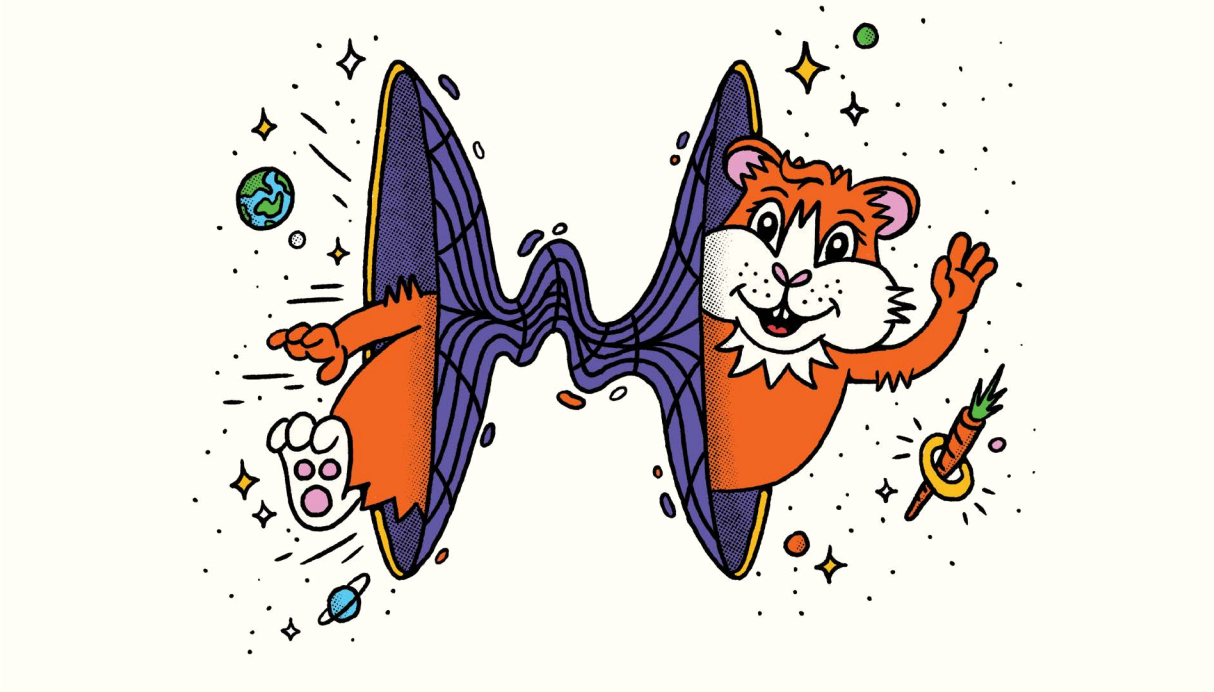




CHAPTER 10

White holes, wormholes, and exotic stars

- Create a Science Fiction story based on **wormholes** as discussed in Chapter 10.

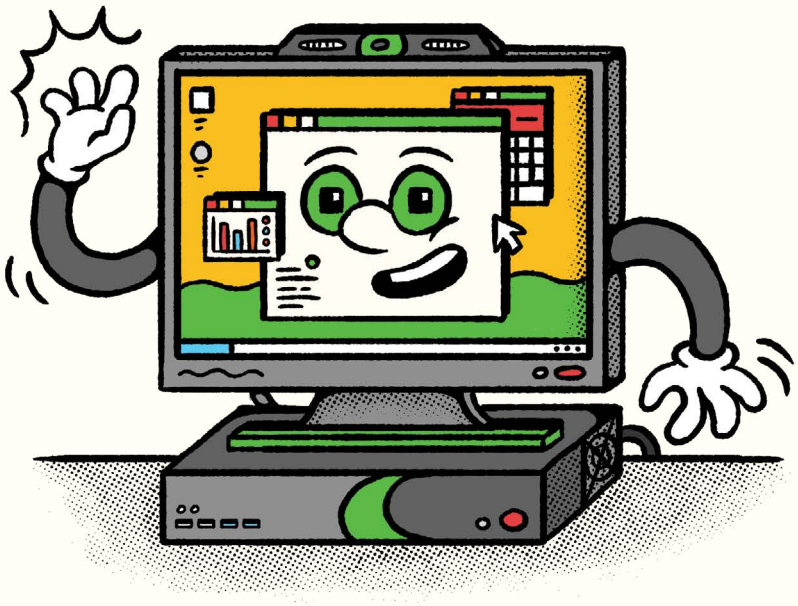


- Why is it important that **theoretical physicists** continue to imagine what might exist? List and explain some of the hypotheses mentioned in Chapter 10 such as **quark stars**, **strange stars** and **boson stars**.

CHAPTER 11

It's a weird quantum world

- In Chapter 11, we are told that '**quantum physics** couldn't be more real' (p. 110). How is **quantum physics** a part of our everyday lives?
- What are the advantages of **quantum computers**? How are they different from regular computers?

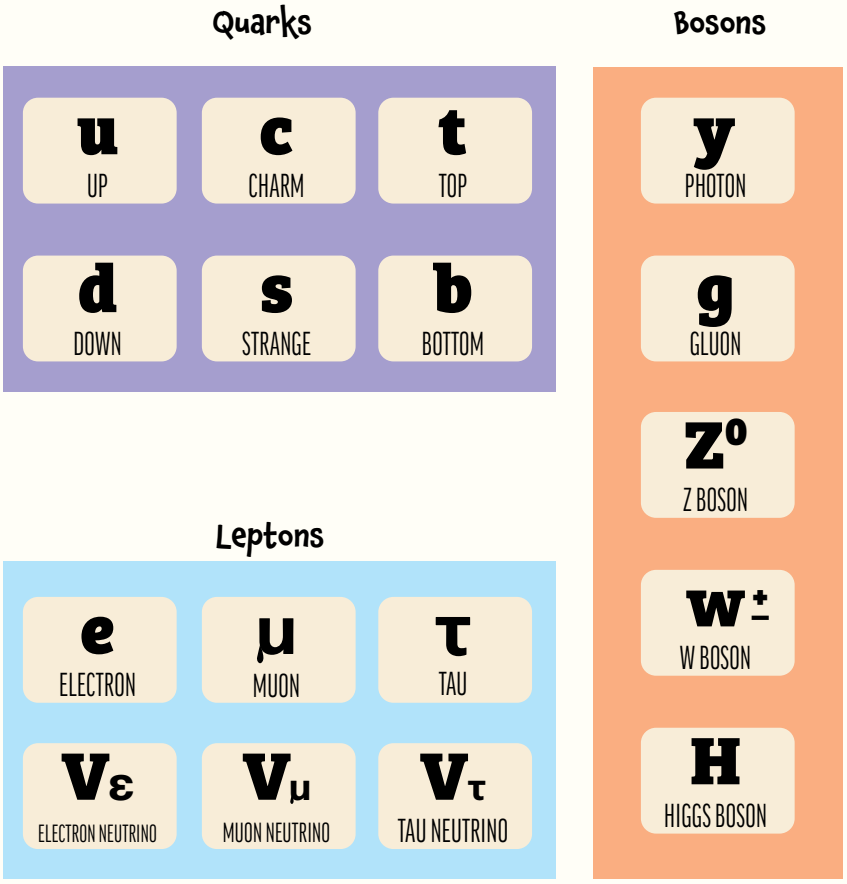


- How has reading *Quarks, Sparks and Quantum Mysteries* inspired you to learn more about science and engineering?
- View short videos that explain **quantum physics**. Alternatively, create your own short videos to explain **quantum physics** to your audience.
  - https://www.scienceabc.com/pure-sciences/what-is-quantum-physics.html
  - https://www.youtube.com/watch?v=AInCqm5nCzw
  - https://www.youtube.com/watch?v=TgH9KXEQ0YU

ELEMENTS 1–20

HYDROGEN 1 **H**							HELIUM 2 **He**
LITHIUM 3 **Li**	BERYLLIUM 4 **Be**	BORON 5 **B**	CARBON 6 **C**	NITROGEN 7 **N**	OXYGEN 8 **O**	FLUORINE 9 **F**	NEON 10 **Ne**
SODIUM 11 **Na**	MAGNESIUM 12 **Mg**	ALUMINIUM 13 **Al**	SILICON 14 **Si**	PHOSPHORUS 15 **P**	SULPHUR 16 **S**	CHLORINE 17 **Cl**	ARGON 18 **Ar**
POTASSIUM 19 **K**	CALCIUM 20 **Ca**						

- To extend learners, discuss the **periodic table** (above) provided on p. 115 and the **standard model of particle physics** (below) on p. 117.



Glossary

- Refer to the Glossary to consolidate your understanding of scientific terms and their definitions. Use this vocabulary in your explanations and discussions.
- Use the Glossary to create a World Wall for your classroom.

General

- How important are learner attributes such as curiosity and creativity? What has most piqued your interest in *Quarks, Sparks and Quantum Mysteries*?
- Choose a chapter from *Quarks, Sparks and Quantum Mysteries* to practise notetaking and summarising.
- Choose an interest area from *Quarks, Sparks and Quantum Mysteries* to inquire into further:
  - Conduct an experiment based on this area.
  - Share the procedure of your experiment in a scientific report (see template below).
  - Share your experiment at a class Science Fair. (Use photos of your experiment or replicate it.)
- Using the template below, create a pictorial sequence that shares information about one of the particles in *Quarks, Sparks and Quantum Mysteries.*

- Which is your favourite fact from *Quarks, Sparks and Quantum Mysteries*. Why is this your favourite? Share with a friend.
- In small groups, design and construct a *Rube Goldberg* machine that uses forces such as gravity, push or pull to work. Share your designs with one another, explaining the theories of quantum physics that are at work.
- Read *The Theory of Hummingbirds* by Michelle Kadarusman (UQP) as a companion novel to *Quarks, Sparks and Quantum Mysteries*. For younger students, share *Albert Einstein* by Vegara Sánchez, Isabel Ma and Jean Claude, and *Stephen Hawking* Vegara Sánchez, Isabel Ma and Matt Hunt from the *Little People Big Dreams* series (Frances Lincoln Children's Books).

SCIENTIFIC METHOD

MY EXPERIMENT

Question

Hypothesis

Materials

Procedure

Results

Conclusion

K	W	L
What do you already **know** about quantum physics?	What do you **want** to learn more about?	What did you **learn** about quantum physics from reading *Quarks, Sparks and Quantum Mysteries?*?