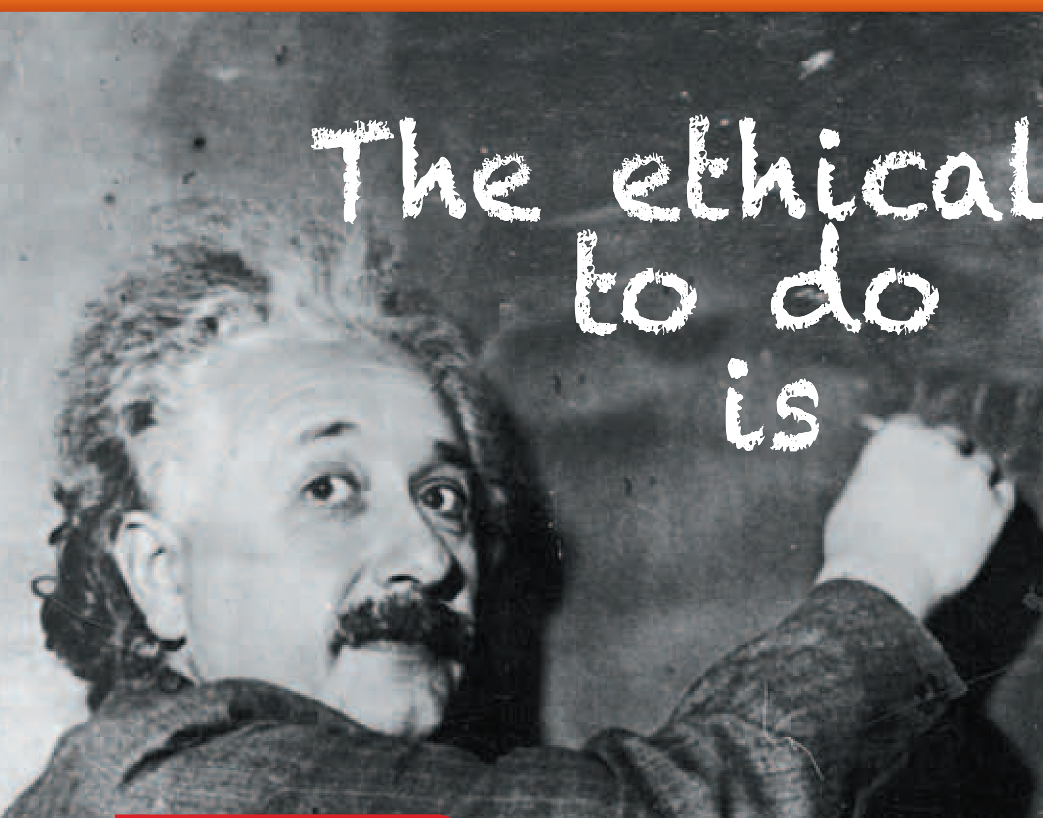

Sometimes I think we're alone in the universe, and sometimes I think we're not. In either case the idea is quite staggering.
Arthur C. Clarke

1 Think quest

Are you ethical? Does it matter? What influences your opinions, values and beliefs? How do your attitudes affect when, how and why you learn? How and why do you think the way that you do? Is it ever worth changing your mind? Why doesn't everyone think the same way as you do? Who are you and who are you yet to become?



THINK ABOUT THESE

- What are the ABCs of attitude?
- Are you obeying the proximate rules of others?
- What are four key ways of knowing?
- What have Socrates, Karl Popper and Thomas Kuhn got to do with thinking about knowledge?
- What scientific event occurred the year that Einstein was born?
- Is all news about radioactivity bad?
- Can unethical behaviour ever be justified?
- Who owns genetic material?
- Should the government be able to control what and how much you eat and drink?

OVERARCHING IDEAS

- Patterns, order and organisation
- Form and function
- Stability and change
- Matter and energy

SCIENCE UNDERSTANDING

The transmission of heritable characteristics from one generation to the next involves DNA and genes.

The theory of evolution by natural selection explains the diversity of living things and is supported by a range of scientific evidence.

SCIENCE AS A HUMAN ENDEAVOUR

Scientific understanding, including models and theories, are contestable and are refined over time through a process of review by the scientific community.

Advances in scientific understanding often rely on developments in technology, and technological advances are often linked to scientific discoveries.

People can use scientific knowledge to evaluate whether they should accept claims, explanations or predictions.

Advances in science and emerging sciences and technologies can significantly affect people's lives, including generating new career opportunities.

The values and needs of contemporary society can influence the focus on scientific research.

YOUR QUEST

What makes you, you?

Who are you? What do you need? Why do you react in the ways that you do? Possible answers to questions about the essence of who you are may be related to:

- the chemical instructions in the DNA that you inherited from your parents
- your experiences and the environment in which you live
- a combination of both of these.

Are you a product of your genes and your environment, or do they both contribute to make you who you are? Scientists have been involved in this 'nature versus nurture' debate for many years. Which do you think is the key contributing factor to why you are you?

Bombarded by the media

We are in an age of information. In fact, you are continually being bombarded by it! How can you begin to make sense of it all? How can you better evaluate it? How can you incorporate this new information into what you already know to develop a better understanding of the world in which you live?

To effectively evaluate articles in the media you need to be able to determine what the facts are, and consider the type of journalism, the quality of writing and the article's ability to effectively present its message.

THINK, ANALYSE AND INVESTIGATE

What makes good news?

Read the article headlines and opening paragraphs at right, and then answer the questions below.

1 For each article, consider the following.
  (a) What do you think the article is about?
  (b) What type of article do you think it is? Is it:
    (i) sensational
    (ii) informative
    (iii) entertaining
    (iv) thought provoking?
  (c) Use the internet to find further content from each article and find out more about the story by using search parameters such as the article headline, newspaper source and publication date.
  (d) Analyse the language and style of writing used in the article. What kind of audience do you think this article was written for?
  (e) Do you think you need to be a scientist to understand what the author is writing about?
  (f) Did the article headline grab your attention and make you want to read more? If not, how could it be improved?
  (g) Research one of the events or issues mentioned and write your own article about it. Collate the class articles into a journal or newspaper.

2 One of these articles was written almost ten years ago.
  (a) What types of environmental and scientific problems do you think people faced at the time?
  (b) Are they similar or different to those we face today?
  (c) Use the internet to find out more about the following issues mentioned in the articles:
    (i) carbon tax
    (ii) China syndrome
    (iii) nuclear power
    (iv) millennium bug.
  (d) How do you think people's opinions of the above issues have changed in the past ten years? Justify your answer.

THAT WHITE-HOT BALL-BEARING IN THE SKY
Our supposedly middle-aged sun has been behaving like an adolescent of late, hurling huge clouds of particles at us after its face broke out in spots.
Sydney Morning Herald, 2 December 2003

'Bang' when a nuclear reactor fails
There is no such thing as failsafe nuclear power, science commentator Karl Kruszelnicki said yesterday.
'Nuclear reactors are not failsafe. They won't fail in a safe way. They can go bang as Chernobyl did,' Dr Kruszelnicki said.
Herald Sun, 14 March 2011

Nuclear crisis is no longer fiction
The nightmare scenario for Japan's crippled nuclear power plants is the so-called China syndrome.
The Hollywood movie *The China Syndrome* portrayed a near-meltdown of nuclear fuel rods in a US reactor.
Herald Sun, 15 March 2011

Millennium bug melee misses the true degree of our challenge
Tim Flannery's 1000-year carbon concession is a straw man that will no doubt burn brightly throughout the highly contested carbon tax debate.
The Australian, 29 March 2011

1.1 SCIENCE AS A HUMAN ENDEAVOUR

ABCs of attitude

eBook*plus* **eLesson**

Meet Professor Veena Sahajwalla

Meet an engineer who is also a television presenter on *The New Inventors*.

eles-1071

Sitting on the fence can be boring! It's okay to have an attitude. In fact, you can have lots of attitudes.

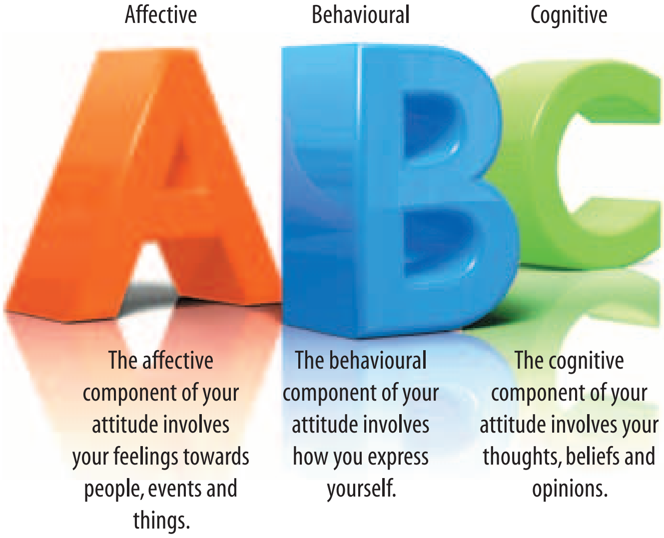
Who are you?

ATTITUDES

Who you are, or your sense of identity, is a result of your **attitudes**, opinions, values and beliefs. Attitudes are a combination of feelings, beliefs and actions. These may be negative or positive and may be towards an event, object or person.

Social psychologists generally agree that there are three main components to any attitude:

- **A**ffective
- **B**ehavioural
- **C**ognitive.



The ABCs of attitude

COLOURED GLASSES

Opinions, values and attitudes involve making **judgements** about the desirability of something, whereas beliefs usually do not. Your **values** may involve making personal judgements and represent a deeper commitment than an attitude would. Values also act as standards in your decision making. **Opinions** can be expressed as a point of view that is based on known facts or available information.

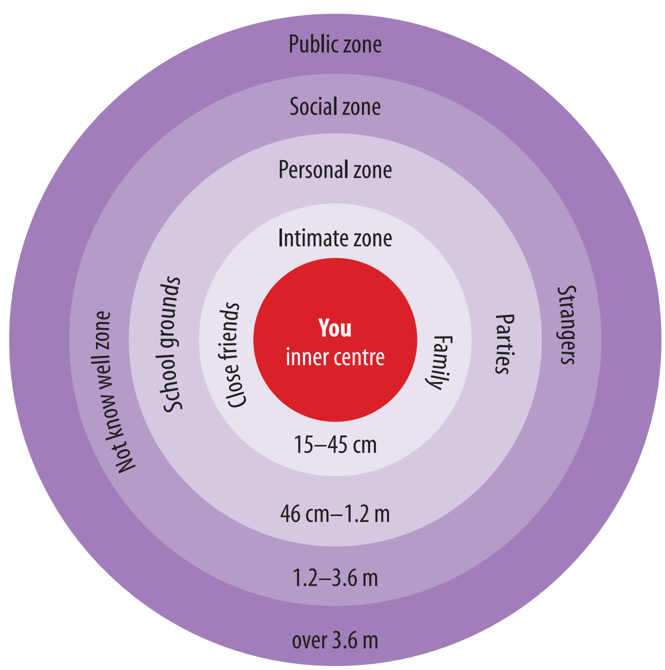
Although **beliefs** reflect what we think and know about the world, they do not have to be based on fact. While you may see the world through the lenses in your eyes, your perceptions are filtered through your beliefs and assumptions.

OTHER LENSES

Your family, cultural and social environments also play a part in how you perceive the world. Your attitudes, values and beliefs may be quite different due to the influence that these factors have on how you shape and organise your understanding of what happens around you. The time that you live in is also important. Imagine the effect this has had on scientists throughout different times in history.

Showing an attitude

Attitudes can be communicated both verbally and non-verbally. We express them in the words that we speak, our posture, our use of space, gestures, facial expressions, and the tones, inflections, volume and pauses in our speech. Another way of



Proximate rules: think of specific examples of how they apply to you and others around you.

communicating our attitudes may be through the use of **paralanguage**. Paralanguage is communicating your specific meaning through the way that you speak, as well as what you say.

NOT TOO CLOSE!

Our attitudes can also be expressed by the distance that we place between ourselves and others. **Proximate rules** determine the physical distance (in zones) that is comfortable between people depending on their relationships.

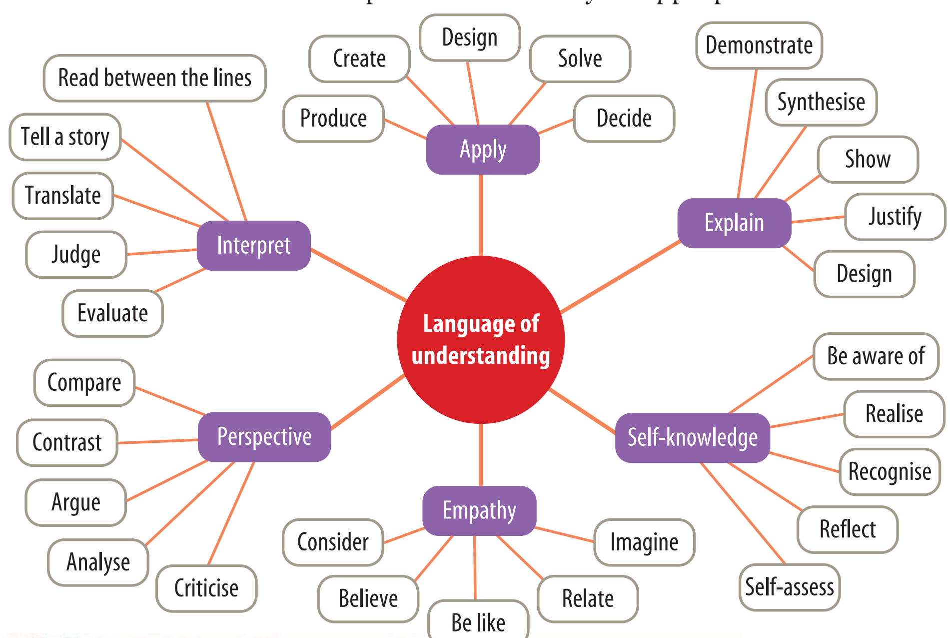
The language of understanding

Who are you and who are you yet to become? How can your use of language and non-verbal communication give the right impression about who you are? How do your attitudes affect when, how and why you learn? Can you remember different types of learning in different ways? How can you make your learning and understanding more effective?

TO LEARN . . . OR NOT TO LEARN?

Learning often involves taking a risk. Taking risks can make you feel uncomfortable and take you out of your comfort zone. There are times when it is necessary to sacrifice competence and control, and to tolerate frustration and confusion. Imagine how far a scientist would get if they took only the easy, well-trodden path. How many amazing discoveries would remain hidden and out of reach?

There are other times when the risks and potential learning are not to your advantage. At these times you need to protect yourself. Can you think of examples when this may be appropriate?



What sorts of questions do you ask yourself to decide whether you should take on new learning?

UNDERSTANDING AND INQUIRING

THINK AND DISCUSS

1 Think about your reactions over the last week. Is there anything that makes you feel uneasy or uncomfortable? If so, ask yourself:
- Is this how I really want to behave?
- Is this who I am or who I want to be?
- What are my core values?
- What can I do to realign my actions with my values?

2 (a) Create your own cartoon that could be used to promote thinking about attitudes.
(b) Share your cartoon with others in the class in a class gallery.
(c) As a class, select four cartoons from the class gallery.
(d) Individually, write a background story for one cartoon to describe what has led to the attitude shown.
(e) Share your stories with your team.
(f) Share and discuss your stories with others who have written for the same cartoon. Comment on any similarities or differences in the stories.

3 List three things that you value. Give reasons why you value them.

4 A bias is a preference that may inhibit your impartial judgement.
(a) Give an example of how you are biased.
(b) Bias may be revealed by comments that are exaggerations, generalisations, imbalanced opinions stated as facts and emotionally charged words. Look through a newspaper and select two articles that show examples of bias. Bring these articles to school and discuss the bias with members of your class.
(c) Suggest why it is important to know your biases.

5 Discuss the following statements with your team, then summarise your discussions in a PMI chart.
(a) Teenagers between the ages of 14 and 16 should be isolated from the rest of the community and schooled in live-in camps.
(b) Abortion for any reason should be illegal.
(c) Vaccinations against measles, whooping cough and meningitis should be compulsory for all Year 10 students.

6 Think of examples of cues (what it looks and sounds like) that convey:
(a) a positive attitude
(b) a negative attitude
(c) disbelief
(d) agreement.

7 A stereotype is a collection of beliefs that are held about people belonging to a particular category. While they can help us make sense of the world, they can also lead to discrimination and self-fulfilling prophecies. Suggest a stereotype for:
(a) a physicist
(b) an environmentalist
(c) a chemist
(d) a psychiatrist.

8 What do you think is meant by a *self-fulfilling prophecy*? Give an example.

9 It has been said that 'Our beliefs and values are hard to think about because they are what we think with' (K. Egan). What is your opinion on this statement? Share your opinion with your team. Use a cluster or mind map to summarise your discussion.

10 (a) Use a target map to sort the words below. Show the positive words in the centre circle and the negative words in the outer circle.
accept, harmful, undesirable, like, believe in, agree with, morality, disagree with, tolerate, desire, dislike, ethics, important, unethical, desirable, beliefs, virtues
(b) Share your target map with your team. Comment on any similarities or differences.

11 Suggest ways in which you can use language positively when you are communicating with others.

12 For each of the questions below, provide a response and suggest which type of understanding it belongs to.
(a) What are some common misconceptions about spiders?
(b) What does your language reveal about your self-confidence?
(c) How and when could you use a toothbrush?
(d) What are the different points of view about stem cell research?
(e) What would it be like to be a genetic engineer?
(f) What are my strengths and weaknesses in science?

13 Sketch your own 'How can I get there?' map and add side-path comments that may be goals, strategies or tasks that can help you reach your dreams.

14 If you always retreat from uncertainty, then you may end up with a limited range of knowledge and know-how. If you always dive into the unknown, your life may be exciting, although possibly very short!
(a) Gather your thoughts on the above statements.
(b) Share your thoughts with your partner. Suggest real-life examples for each statement.

15 Visual thinking tools can be very useful in helping you decide which learning opportunities are worth taking on.
(a) In your team, brainstorm examples of potential learning situations that may require careful consideration.
(b) With your team, analyse two of these potential learning situations using either a SWOT or PMI visual thinking tool (see section 1.11).
(c) Reflect on the ideas or strategies that you might use when you are deciding whether or not to jump into a new learning situation.

Layers of learning

Learning can happen in layers. For instance, when you learn a new game you start by learning what the game is about — you acquire the specific conscious knowledge. As you play the game, you begin to develop the more intuitive know-how that is necessary to play it well.

Imagination: using skills of fantasy, visualisation and storytelling. These skills help you to create and explore hypothetical worlds.

Intuition: where your creative ideas germinate and develop.

Intellectual skills: of language and reasoning. You use these to segment, analyse and communicate your experience.

Immersion: in the experience using practical tools to explore, investigate and experiment.

The Is of learning

Your learning may involve the use of tools from drawers in your learning cupboard:

- imagination
- intuition
- intellectual skills
- immersion.

The illustration above describes how these tools can be put to use to enhance your learning.

The Rs of learning power

Resilience is about believing in yourself and having the ability to tolerate sometimes feeling a little uncomfortable. As learning is an emotional business, your ability to tolerate emotions is important. Learning is not always fast and smooth; there can be frustrating flat spots, exhilarating highs and upsetting setbacks. Resilience helps you to stick with it and recover from any disappointments. It is important in learning to help you tolerate your emotional seesaw.

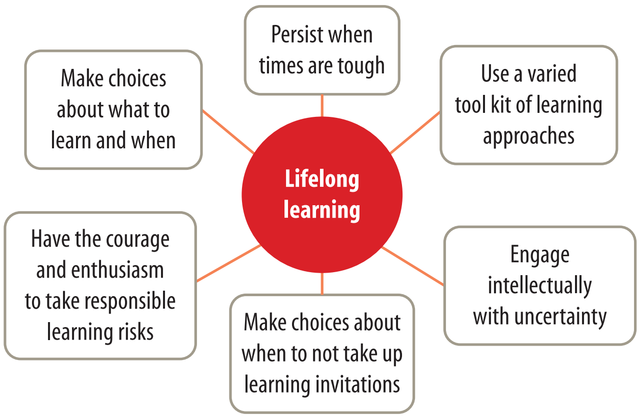
Reflectiveness is being self-aware and mindful of what could be and what has been. It involves being open-minded and sometimes standing back and looking at the big picture; asking yourself if your own assumptions are getting in the way of the truth.

Responsibility is being able to manage yourself and your learning. It's about monitoring your progress and thinking about other options and different perspectives.

Resourcefulness is knowing what tools you have and when to use them. It's about taking responsible risks and using a range of appropriate learning tools and strategies.

Lifelong learning

Learning can be considered as 'what you do when you don't know what to do'. Learning to learn can involve using your social and material tools and resources to get better at knowing when, how and what to do when you don't know what to do. Your understanding of the world is shaped by what you experience directly or what is communicated to you by others.



WAYS OF KNOWING

Many argue that we are currently in an age of information overload. We are constantly being bombarded with information from a variety of sources, many of these associated with the media. Some of the information that you are exposed to may not be accurate or the whole story. The information may be **biased** in the selection, emphasis, word choice and context used. It is important that when interpreting information you are aware of these possible biases. You also need to be aware of your own biases!

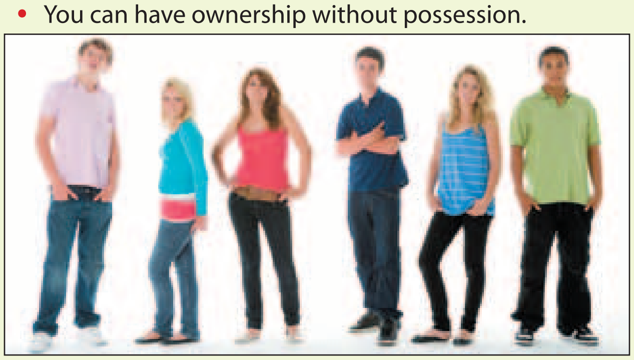
In making sense of this new information, you need to focus on the ways in which you build your knowledge. How you — as a 'knower' at the centre of your learning — use your senses (e.g. sight, sound, smell, touch and taste) to **perceive** your world, and emotion, reason and language to **interpret** what you sense. As you read through the information in this chapter, view them through the lenses of these four ways of knowing.

INQUIRY: INVESTIGATION 1.1

Where do you stand?

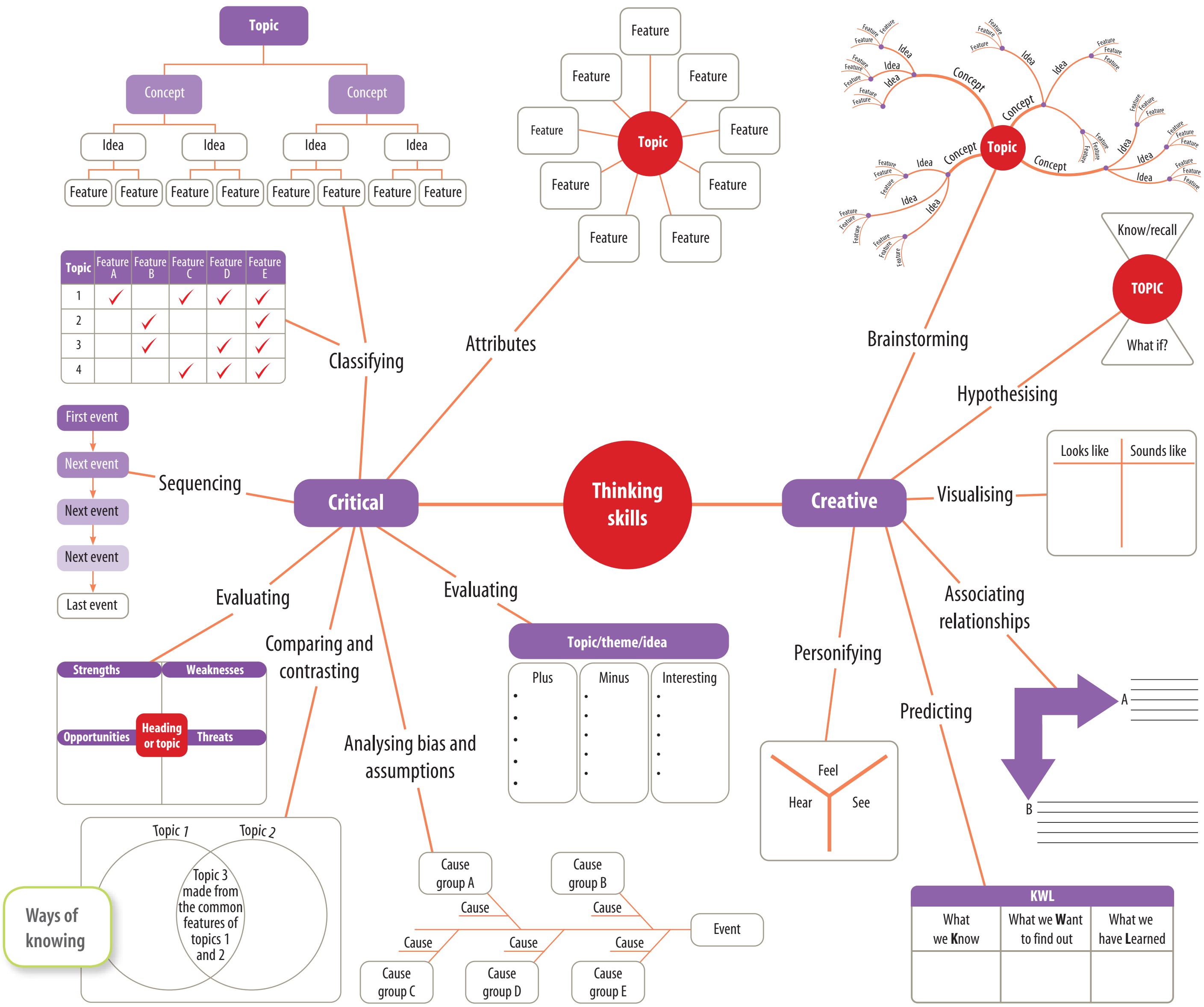
(a) On your own, score each of the statements below on a scale of 0 to 4 where 0 = strongly disagree and 4 = strongly agree.

- Books are better than movies.
- Fiction is more interesting than non-fiction.
- Only wealthy students should get an education.
- Science classes should include science fiction stories.
- If something is too hard, it's not worth trying.
- Students who get below 50 per cent on a test do not deserve an education.
- At 15 years of age you have a sense of who you are.
- You are weak if you feel the need to belong.
- If you failed before, don't bother trying again.
- You can have ownership without possession.



0 Strongly disagree | 1 Disagree | 2 Neutral | 3 Agree | 4 Strongly agree

(b) For three of the statements in part (a), share your opinions by being involved in constructing a class 'opinionogram'.
(i) Divide the classroom into five zones, and assign a score of 0 to 4 to each zone.
ii) Each student now stands in the zone that indicates their score for the first statement.
(iii) Discuss the reasons for your opinion with the students in your zone.
(iv) Suggest questions that could be used to probe students in different opinion zones.
(v) With students in other zones, discuss their views and share with them the reasons for your opinion.
(vi) Reflect on what you have heard from others. Decide if you want to change positions and, if so, change. Give a reason why you are changing.
(vii) Repeat steps (ii)–(vi) for two other statements.
(viii) Reflect on what you have learned about the opinions and perspectives of others.
(ix) In your teams, discuss any insightful comments, ideas or opinions.
(x) Suggest questions that could be used to more closely probe reasons for your classmates' opinions. Share these probing questions with your class.
(xi) Suggest how you have demonstrated resilience, reflectiveness, responsibility and resourcefulness during this activity. Comment on things that you may change if you were to do the activity again.



UNDERSTANDING AND INQUIRING

REMEMBER, THINK AND SHARE

1 (a) In what order do you think that immersion, intuition, imagination and use of intellectual skills happen in your learning? Give an example.
(b) Do you think it is the same order for all types of learning? Explain.

2 What are your attitudes to your learning? Do you believe that learning is important to you? If you do not value your learning, your learning power will be weakened. Discuss your responses to these statements with your class. Comment on similarities and differences highlighted from your discussion.

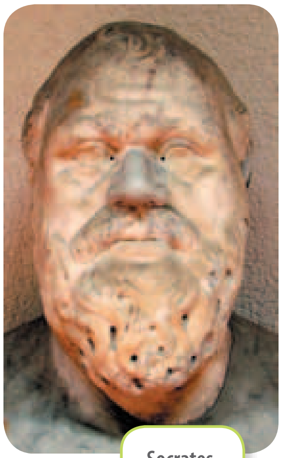
3 Do you think strategically about your learning? Give an example of how you do this. What are your goals? What resources do you need to achieve them? What are your current strengths and weaknesses? Suggest how you can utilise your strengths and develop your weaknesses.

4 (a) Construct a mind map on the four Rs of learning power.
(b) Add to this map examples of how you could show and develop each of these. You may wish to include sketches, figures or quotes.
(c) Share your mind map with others and add any of their ideas that you think are helpful in developing these Rs.

5 Use a Y chart to show what resilience looks, sounds and smells like.

work sheet 1.1 Layers of learning

Change my mind

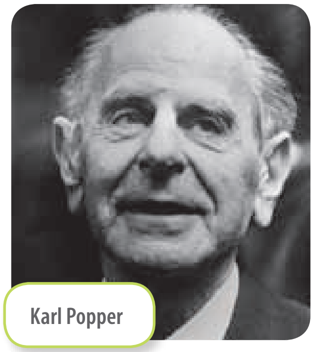

Socrates

'One thing only I know, and that is that I know nothing.' This statement is often linked to a Greek philosopher called Socrates (470–399 BC), who had a major impact on Western thinking and philosophy. This statement, however, also goes against what is commonly thought about science and scientists. Some consider that science will always have the answers and that scientists know all. Not only is such a belief untrue, it is also potentially dangerous. Thinking flexibly and with an open mind are better traits for a scientist to possess. The history of science and philosophy is littered with theories that at one time were considered to be answers, but were later disregarded.

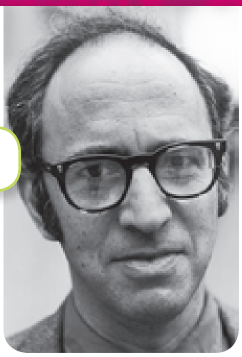
A tree of knowledge

What is now considered science may also be described as a branch of philosophy. This branch is involved in trying to explain our observations from both inside and outside our bodies. There are many different ways to analyse the tree of knowledge that we call science. Three of these ways are:

- **inductionism** — suggests that scientific knowledge is proven knowledge and that large amounts of first-hand data, unbiased observations and a structured method can lead to theories that can become universal laws


Karl Popper

- **falsification** — the philosopher Karl Popper (1902–1994) believed that no theory was ever proven beyond doubt. He believed that theories were just educated guesses and if they failed rigorous testing they should be thrown out.


Thomas Kuhn

- **paradigms** — or ways of thinking. Thomas Kuhn (1922–1996) saw science as being generated by basic theories or groups of ideas that are followed and defended by scientists. These paradigms are accepted even when data suggests that they may not be true. Only when the evidence against the theory becomes too great does the paradigm change, to be replaced by another, until it, too, is replaced.

HOW ABOUT THAT!

Newton (1643–1727) and Descartes (1596–1650)

Newton's theory of universal gravitation stated that everything was attracted to everything else. This would mean that the sun's gravity would keep the Earth and other planets in orbit. Descartes, however, did not think that force could be transmitted through empty space and suggested that the Earth was in some kind of whirlpool that revolved around the sun.

Another difference between these theories was their predictions about the shape of the Earth. Newton's theory suggested that the Earth would be flatter at the poles and fatter at the equator due to the effects of gravitational force. Descartes' theory suggested the opposite. In 1737, two expeditions left France to travel around the world and measure the curvature of the Earth to resolve the dispute. Upon their return, both expeditions provided measurements that supported Newton's prediction.

Changing theories

Theories can change overnight, or take a very long time to change. Theories that were once popular and well accepted may be discarded when too much evidence builds up against them. They are replaced by a theory which better fits the observations. The examples in this section describe a past instance of rival theories and a current debate in astrophysics.

INVISIBLE STUFF

Until recently, it was accepted that about 23 per cent of our universe was made up of stuff that we can't even see. This invisible dark matter is said to lurk in the hearts of galaxies and keep the outermost stars from flying off into the void. It is thought to be responsible for the appearance of clusters of galaxies. But what if this isn't the case?

Newton's theories are again being questioned. A growing number of astrophysicists support a controversial new theory called Modified Newtonian Dynamics (MOND), which has led to some surprising predictions about the evolution of the universe. Previously, galaxies were thought to have formed from relatively dense pockets of matter with dark matter holding them together. The laws of the MOND theory suggest a different picture is possible. If correct, this theory could overthrow the established view of gravity and dark matter. These two areas underpin almost everything known about astronomy. MOND may also lead to a rethinking of Einstein's theory of relativity.

1933	Fritz Zwicky coins the term 'dark matter' to describe unseen mass or 'gravitational glue' in galaxy clusters.
1978	Astronomers show that many galaxies are spinning too quickly to hold themselves together unless they are full of dark matter.
1983	Mordehai Milgrom publishes a modified gravity theory called MOND. It explains why galaxies don't fly apart without using dark matter, but remains at odds with Einstein's relativity.
1990s	Studies of galaxies and galaxy clusters show that their gravity bends light more strongly than is expected without dark matter. MOND researchers start devising improved theories to explain extra light bending.
1994	Jacob Bekenstein and Roger Sanders prove that any theory that resolves the light-bending issue and meshes MOND with relativity must involve at least three mathematical fields.
2000	New data on the cosmic microwave background reinforces the standard, dark matter picture of the universe.
2004	Jacob Bekenstein devises a version of MOND that is consistent with relativity.
2005	Constantinos Skordis and others show that relativistic MOND provides a good fit to the microwave background data.

Dark matter vs MOND. Will the MAXIM Pathfinder spacecraft detect gravitational anomalies that will support MOND?

UNDERSTANDING AND INQUIRING

THINK AND DISCUSS

1 Brainstorm and list scientific theories that are no longer in favour.

2 Isaac Newton defined his three laws of motion. What were they and are they still accepted?

3 What is bad science? Give examples.

4 (a) State what you think the modern goals of science are.
(b) Suggest the goals of science 100 years ago.
(c) Comment on any similarities and differences.

5 (a) Use an annotated sketch to describe what you believe is the commonly held image of a scientist.
(b) Use a visual thinking tool to describe the media's representation of scientific research.

INVESTIGATE AND PRESENT

6 Find out more about the life and times of Newton and Descartes. Write a newspaper article of the times to describe their rival theories.

7 Research one of the following scientists and outline a theory that they have been involved in constructing:
Charles Darwin, Michael Faraday, Ernest Rutherford, Jean-Baptiste Lamarck, Francis Crick, Gregor Mendel, Albert Einstein.

8 Research a scientist of your choice and find out some of their contributions to science and what life was like when they were alive. Dress up as the scientist and take on their character in discussions with other classmates.

9 What is herb lore? Does it have any place in science?

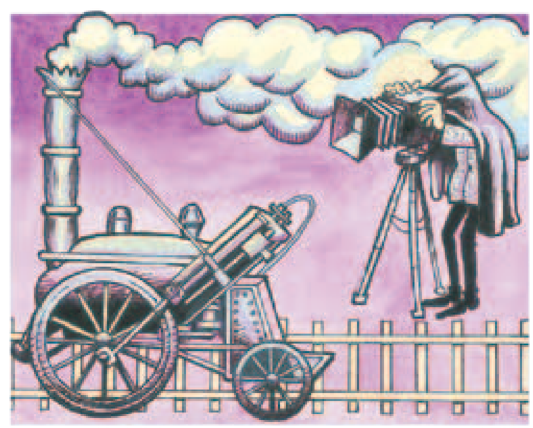
1.4 SCIENCE AS A HUMAN ENDEAVOUR

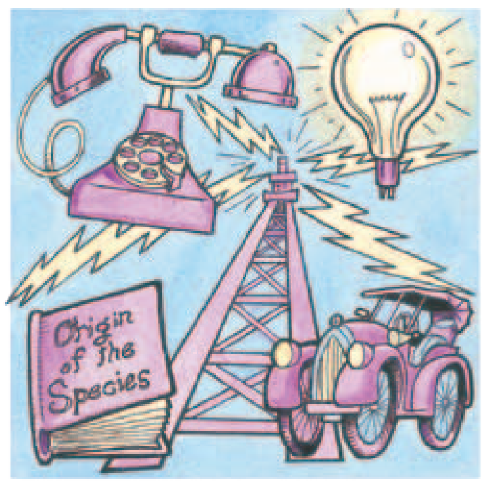
The quest continues

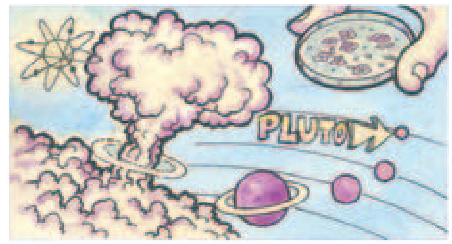
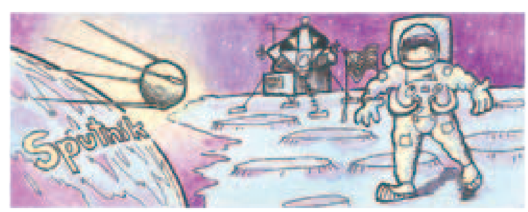
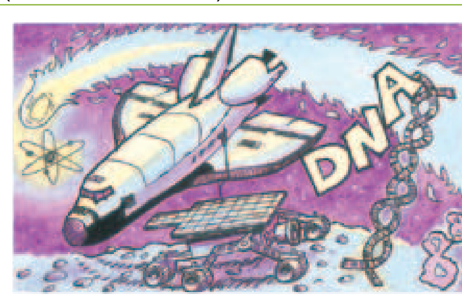
Why question? Why bother asking questions about the world around you? Why not just accept the way things are? What makes scientists do what they do? Do we really need science?

Science does not occur in a vacuum. Science is about people and their quest to find out about the hows, whys and wheres of the world around them. Science employs as its most important tools imagination, insight and the desire to understand or find out for the individual or for others. Some discoveries have been made accidentally, others after sequential and thorough use of scientific methods and procedures. The societies in which scientists live greatly influence the science in which they become involved.

Science quests throughout history

Year	Scientific events	Other events
1784	Benjamin Franklin invents bifocals.	Life expectancy is about 35.5 years.
1829	Stephenson's *Rocket* launches the start of the railway age.	Jean-Baptiste de Larmack dies and Jules Verne turns 1.
1831	Faraday discovers electromagnetic induction.	
1833	Gauss's electric telegraph key is invented. Anselme Payen isolates the first enzyme — diastase.	
1834	Lindsay achieves continuous electric light.	
1837	Photography is invented.	
1838	Matthias Schleiden suggests that all plants are made up of cells.	
1842	Ether anaesthesia is invented.	
1845	Parson's giant telescope begins a new era of astronomy.	
1846	Guncotton, the first modern explosive, is invented.	
1848		The Year of Revolutions: Second Republic in France
1852	Vulcanite (hard rubber) is created.	Third Empire begins under Louis Napoleon.
1853	The internal combustion gas engine is invented.	
1854	Chemically produced aluminium is created.	
1855	Ruhmkorff's bichromate battery is created.	
1857	Singer's domestic sewing machine is invented. The first electric street lighting is installed in Lyon.	
1858	Rudolf Virchow suggests that cells can only arise from pre-existing cells.	
1859	Darwin's *On the Origin of Species* is published.	Gregor Mendel turns 37 and Charles Darwin turns 50.
1863	Huxley's *Man's Place in Nature* is published and TNT is invented.	Jules Verne's *Five Weeks in a Balloon* is first published.

Year	Scientific events	Other events
1864	Nobel introduces nitroglycerine and Pasteur introduces pasteurisation.	Jules Verne's *A Journey to the Centre of the Earth* is first published.
1865	Aerophore, a compressed-air diving apparatus, is invented by Rouquayrol and Denayrouze. Gregor Mendel discovers patterns of inherited characteristics.	Jules Verne's *From the Earth to the Moon* is first published.
1868	Leclanché invents a dry-cell non-rechargeable battery.	
1869	Celluloid is discovered. Dmitri Mendeleev proposes the periodic table.	Marie Curie turns 2 and H.G.Wells turns 3.
1870	Chewing gum and the washout toilet are introduced.	Jules Verne's *Twenty Thousand Leagues Under the Sea* is published.
1873	Remington introduces the mass-produced typewriter.	Jules Verne's *Around the World in 80 Days* is published.
1876–1878	Thomas Edison makes his first talking machine — the phonograph.	
1878	The cathode-ray tube (later the basis for television) is invented and Alexander Graham Bell invents the telephone.	
1879	Swan makes the first practical electric light bulbs in London and Edison makes them in the USA.	
1885	Daimler and Benz work on the first motorcar with an internal combustion engine.	
1887	Hertz discovers electromagnetic waves (the basis for radio).	
1889	Data-processing computer using punched cards is invented.	
1892	Ivanovsky discovers the virus. Diesel engine is invented.	
1893	The solar-electric cell is invented. The first open-heart surgery is performed.	
1894	Marconi's wireless telegraphy is invented.	Aldous Huxley is born.
1895	Röntgen discovers X-rays.	H. G. Wells's *The Time Machine* is published.
1896	Cavendish discovers electrons.	
1898	Krypton and neon are discovered. Holland's submarine is invented. Curie discovers the two radioactive elements radium and polonium.	H. G. Wells's *The War of the Worlds* is published. Albert Einstein turns 19, Alexander Fleming turns 17 and Howard Florey is born.
1899	Electric wave-wireless telephone and the wire tape-recorder are invented. Guglielmo Marconi invents the 'wireless'.	H. G. Wells's *The First Men in the Moon* is published. The Boer War begins.
1900	Planck's quantum theory is proposed. Von Zeppelin's dirigible airship is invented.	Life expectancy is about 45 years.
1901	The first signals are sent across the Atlantic Ocean and received. The first electric hearing aid is invented. Wilhelm Röntgen's discovery of X-rays wins him one of the first Nobel Prizes.	Australia becomes a federation.
1902	The ionosphere is discovered by Kennelly-Heaviside and hormones are discovered by Bayliss and Starling.	
1903	The Wright brothers fly in their first successful 'heavier than air' machine.	
1905	Einstein's *Special Theory of Relativity* is published and the first artificial joint is used in arthritic patient's hip.	Jules Verne dies.
1911	Ernest Rutherford ('father of nuclear energy') proposes a model for the atom.	Aldous Huxley has his 17th birthday.

Year	Scientific events	Other events
1914		World War I begins.
1927	George Lemaître theorises that the universe has been expanding from a 'primal atom'. His theory is later popularised as the 'big bang'.	
1928	Penicillin is accidentally discovered by Alexander Fleming.	
1929	Electroencephalogram is first introduced and Hubble's Law, a strong pillar of the 'big bang' theory, is discovered.	
1930	Pluto is discovered.	
1931		Aldous Huxley's *Brave New World* novel is first published (written in 1930).
1933	The first electron microscope is built.	
1936	The first artificial heart is invented.	James Watson turns 4, Rosalind Franklin and Isaac Asimov turn 16, Francis Crick turns 20.
1939		World War II starts.
1943	Barbara McClintock suggests the existence of 'jumping genes' in her studies on maize.	
1944	Pfizer is the first to mass-produce penicillin.	Infant deaths steadily decline.
1945	Kidney dialysis machine is first used and the first atomic bomb is detonated during a secret test in Alamagordo, New Mexico.	World War II ends.
1947	The sound barrier is broken. The supersonic age begins.	
1948		George Orwell's *Nineteen Eighty-Four* is written.
1953	Watson and Crick decipher the structure of DNA.	
1957	*Sputnik* is launched.	
1963		Robert A. Heinlein's *Time for the Stars* is first published. John F. Kennedy is assassinated.
1965		Frank Herbert's *Dune* is first published.
1969	'One small step for a man — one giant leap for mankind' — Neil Armstrong is the first man to walk on the moon.	
1971	Nuclear magnetic resonance imaging is used to diagnose illnesses. Black holes are discovered by sensors of the *Explorer 42* spacecraft in the Cygnus constellation.	
1972	The first global views of Mars are returned by *Mariner 9*.	
1976	Genentech company is formed by the venture capitalist Swanson and the biochemist Boyer to exploit Boyer's gene-splicing techniques. The *Viking 1* makes the first landing on Mars.	Isaac Asimov's *The Bicentennial Man* is published.
1977		George Lucas' *Star Wars* is released.
1980		Life expectancy is about 75 years.
1982	Sally Rider is the first US woman in space.	Robert A. Heinlein's *Friday* is first published. Anne McCaffrey's *The Crystal Singer* is published (written 1974–1975).
1983	Barbara McClintock wins the Nobel Prize for Medicine for her discovery of 'jumping genes'.	
1984	Meteorite ALH-84000 is discovered in Antarctica.	
1988	The National Institutes of Health and the Department of Energy embark upon the International Human Genome Project.	
1989	Physicist Stephen Hawking's *A Brief History of Time* is published.	

Year	Scientific events	Other events
1990	Gene therapy is first attempted on a human.	Retirees outnumber teenagers for the first time in history.
1995	The first electronic atlas of the human body is created — the visible man whose frozen cadaver was sliced into one-millimetre increments.	
1996	The first complete genome of a life form, a yeast, is sequenced. US scientists reveal that meteorite ALH-84000 is Martian and contains organic compounds and microfossils.	
1997	The cloning of Dolly the sheep is revealed.	
1998	Evidence of planets orbiting stars in other galaxies is found.	
1999	Simple organic molecules discovered in outer space, leading to new hypothesis about extraterrestrial life.	Human chromosome 22 is sequenced.
2000	Australia's first cloned animal is born — Suzi the calf. Scientists at Monash University are involved in developing a method of growing body parts from embryonic stem cells.	Olympic Games are held in Sydney. Human chromosome 21 is sequenced.
2001		'9/11': Hijacked planes crash into the World Trade Center in New York.
2003	The Human Genome Project completed. More than 20 000 human genes mapped.	Australia's population reaches 20 million.
2004	The remains of an 18 000 year old, one metre tall hominin skeleton found on the Indonesian island of Flores is formally named *Homo floresiensis* and nicknamed the 'hobbit'.	
2006	A paralysed man has a brain implant that allows him to control a computer using the power of thought. The definition of a planet is changed and Pluto is now considered a dwarf planet. A genetic study suggests that human and chimp ancestors may have interbred long after their lineages had split.	Commonwealth Games are held in Melbourne. Steve Irwin (known as The Crocodile Hunter) dies after being stung by a stingray while filming a marine documentary.
2008	The first direct observations of exoplanets are made. Ice is discovered on Mars.	US president Barack Obama is elected.
2010	The first self-replicating synthetic bacterial cell is created.	

UNDERSTANDING AND INQUIRING

INVESTIGATE

1 Find out more about one of the scientific quests in the timeline in this section and present your findings as a poster to the class.

2 Add other scientific quests, events or Australian Nobel Prize winners to the science quests timeline.

3 (a) Select a year (or time period) and find out as many different scientific discoveries as you can.
(b) Find out what life was like for people who lived at this time and take note of any other events that were occurring during that time.
(c) Suggest implications of the scientific discoveries or events on the people of that time and on people in future times.

4 Find out about the winners of scientific Nobel Prizes and their work. Present your information as an autobiography.

5 Find out about the Nobel Prize winners' sperm bank. Discuss the ethics associated with it.

THINK AND CREATE

6 Use the information in this section to produce a crossword or scientific trivial pursuit game.

7 Create a timeline for the events that you feel were the most important science quests.

INVESTIGATE, THINK AND CREATE

8 Find out about a scientific discovery and what life was like during the time of this discovery. Write a story or play about the event and then act it out to the class.

9 Read one of the novels shown in the science quests timeline and suggest future inventions or discoveries that the ideas in the novel may lead to.

The evolution revolution

Do you and the apes that you see at the zoo share a common ancestor? This concept caused much controversy between religion and science.

Darwin points out the similarities between humans and apes, by an unnamed artist in *The London Sketch Book*, 1874

The theory of evolution — bigger than one man

The concept of organisms sharing common ancestors contributed to the development of the **theory of evolution**. Although this theory is usually credited to one man — **Charles Darwin** (1809–1882) — it is really a culmination of the ideas of many individuals both in Darwin's time and before it.

With technological advances and new knowledge, refinements have been made to Darwin's theory and continue to be made. The theory of evolution itself is evolving.

Evolution ownership

Like many other scientific theories, although one person may be credited as its sole creator it is really a story of awareness, relationships, passion and wonder. The development of a theory usually requires an appreciation and connection of what has been before and the transfer of this knowledge to new knowledge or discoveries. It often involves seeing links, patterns or connections that can tie all of the knowledge together into a new framework of understanding.

GRANDPA SOWS HIS OWN SEEDS

Erasmus Darwin (1731–1802) was not only a British physician and leading intellectual of his time, but also Charles Darwin's grandfather. He believed that all living organisms originated from a single common ancestor and in 1794 published *Zoonomia* — a book that sowed the seeds for later ideas regarding the theory of evolution.

CLASSIFYING LIFE

Carolus Linnaeus (1708–1778) is considered the founder of **taxonomy** — the branch of biology concerned with naming and classifying the diverse forms of life. He developed his classification system 'for the greater glory of God', rather than in the interest of scientific understanding. His ideas, however, were used as a basis for the development of the theory of evolution.

Carolus Linnaeus (1708–1778), the 'father of taxonomy'

HINTS IN THE GROUND

Without the contribution of geologists, the theory of evolution may still not have been developed. **Geology** bestowed a great gift upon Darwin's generation of scientific thinkers — the gift of time.

In the eighteenth century, it was believed by many that the Earth was only around 6000 years old and that — other than changes brought about by sudden, dramatic catastrophes (like Noah's biblical flood) — it was unchanging. This was the theory of **catastrophism**.

An underground time machine

James Hutton (1726–1797) proposed the theory of **gradualism**, which suggested that Earth's geological features were due to the cumulative product of slow but continuous processes. He used money from his farming and the invention of a process for manufacturing the chemical sal ammoniac to devote his life to his scientific quests. It was not until almost ten years after he presented his theories to the Royal Society of Edinburgh in 1785 that they were taken seriously enough to be vigorously attacked. Hutton's response was to publish *Theory of the Earth* in 1795. Hutton's geological theories were built upon by others who also observed evidence that contradicted the theological teachings of the time.

English surveyor William Smith (1769–1839) made great contributions to the development of geology and could be considered the 'father of English geology'. He is credited with creating the first nationwide geological map (more information can be found in his biography, *The map that changed the world* (2002)) and was the first person to make a systematic study of fossils.

Smith was the son of a blacksmith and his life was not an easy one. He published his first geological map of Britain in 1815. Unfortunately, the map was plagiarised and he became bankrupt and then served time in debtor's prison. He did not receive recognition for his contributions until many years later, in 1831.

Smith's work as a surveyor took him down into mines where he observed different layers of rocks (strata) and the fossils that they contained. Smith noticed a regular pattern to the distribution of types of fossils in the particular rock layers in the different locations where he worked. This pattern suggested that the Earth must be very old and that successive strata had been laid down one on top of the other. His observations also suggested that different types of organisms had appeared, lived for a while, and then been replaced by others.

Born in the same year as William Smith, Baron Georges Cuvier (1769–1832) played a key role in the development of **palaeontology** (the study of fossils). He is credited with recognising that fossils in deeper strata were older than those in strata closer to the surface.

Sir Charles Lyell (1797–1875) was born the year that James Hutton died. He incorporated Hutton's gradualism into **uniformitarianism theory** —

Geologist William Smith (1769–1839) is credited with creating 'the map that changed the world'.

Diagram showing characteristic fossils in the different layers of strata. These studies led to the development of stratigraphy.

Baron Georges Cuvier (1769–1832)

the antithesis of catastrophism. Lyell was also to play a key role in Darwin's decision to finally publish, and formally presented Darwin's (and Wallace's) theory of evolution to the scientific community in1858.

USE IT OR LOSE IT!

Jean-Baptiste de Lamarck (1744–1829) was one of the first scientists to suggest that populations of organisms changed over time and that old species died out and new species arose. He believed that if a particular feature was not used then it would eventually be lost over succeeding generations. He also suggested that changes acquired within the lifetime of an individual could be passed onto its offspring. The example often given to describe this theory relates to the long necks of giraffes. Lamarck's explanation would be that the giraffes had to stretch to reach the leaves high up in the trees, stretching their necks. He would then suggest that the lengthened necks that resulted from this stretching were passed on to their offspring.

Jean-Baptiste de Lamarck (1744–1829) is often referred to in terms of the 'use and disuse' and acquired inheritance theories. Although his theories have been discredited in favour of Darwin's, his theories are making a comeback in new findings in the science of epigenetics.

SEEDS OF INHERITANCE

Gregor Mendel (1822–1884), an Austrian monk, used peas of different colours and shapes in his experiments and is responsible for the development of the fundamentals of the genetic basis of inheritance. Although most of his work was destroyed, his gene idea was recognised 34 years after his death and provided a mechanism for natural selection.

Living around the same time as Mendel, Herbert Spencer (1820–1903) suggested the concept of the survival of the fittest. Born twelve years after Mendel, August Weismann (1834–1914) demolished Lamarck's theory of the inheritance of acquired traits, and is well known for his experiment that cut the tails off mice to collect evidence that tail loss during the parent's lifetime was not inherited by their offspring. He was later also to suggest that **chromosomes** were the basis of heredity.

Gregor Mendel (1822–1844) used peas of different shapes and colours to collect data that provided him with patterns of inheritance. Much of Mendel's work was destroyed by the church.

DARWIN'S JOURNEY OF SELECTION

In 1831, a 22-year-old Charles Darwin set sail on a five-year voyage on the *HMS Beagle*. It was a journey that would greatly change his views on life. He noted the similarities and differences in the flora and fauna inhabiting the different regions that he visited. His observations made him question the belief at the time that the Earth was only a few thousand years old and that its organisms were the unchanging work of a creator.

Darwin was particularly puzzled by the features of animals on the Galapagos Islands near South America. On these islands, he noticed a number of different species of finches that were similar

Charles Darwin

in size and colour, but varied in the size and shapes of their beaks. He recorded that these **variations** suited them to particular types of foods.

Darwin's doubts doubled

By the time Darwin had sailed from Galapagos, his observations and awareness of the ideas of the geologist Sir Charles Lyell (who had been influenced by James Hutton) led him to doubt the church's position that the Earth was static and only a few thousand years old. He was particularly influenced by Lyell and Hutton's views that geological change resulted from slow, continuous actions rather than sudden events.

After returning home in 1837, Darwin began his notebooks on the origin of different species and in 1844 (at 35 years of age), wrote his essay *On the Origin of Species*. Aware of the controversy that such ideas may fuel, this essay was to remain unpublished for over ten years.

WHY DO SOME DIE AND SOME LIVE?

While Darwin continued to develop his theory, an English naturalist reached the same conclusion. His name was **Alfred Wallace** (1823–1913). Wallace was a school teacher with a passion for botany and collecting plants and insects. Like Darwin, Wallace had travelled extensively and made many detailed observations of variations in the species that he came across. In 1848, he began a series of expeditions, first to the Amazon and later to the Malay Archipelago where he stayed for eight years.

In February 1858, while he was recovering from a bout of malaria, Wallace remembered

Alfred Wallace (1823–1913) sent his theory of evolution to Darwin.

reading a book titled *Essay on the Principle of Population* (1798). This book was written by the mathematician, economist and founder of demography Thomas Malthus (1766–1834), and had also influenced Darwin's thinking. Wallace connected what he had remembered from this book to his observations. It is documented that the idea of survival of the fittest then came to him in a flash. In his autobiography, *My Life: A Record of Events and Opinions* (1905), Wallace wrote:

> It occurred to me to ask the question, why do some die and some live? And the answer was clearly that, on the whole, the best fitted lived.

Within two evenings, Wallace had written an essay on his theory of evolution and sent it to Darwin in the next mail.

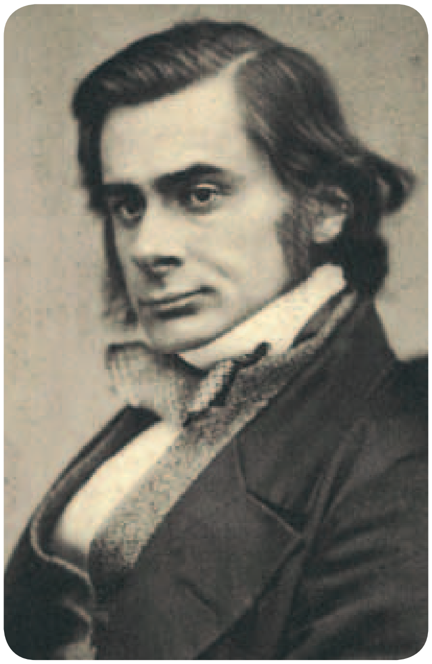
PUBLISH OR PERISH

Imagine the shock of seeing your life's work summarised in a letter, sent to you for comment on its possible publication. This is what must have happened when Darwin opened Wallace's letter describing his theory of evolution. This forced Darwin to reconsider publishing his previously unpublished work on his theory. Given his wife and family's religious connections, this must have been a difficult personal time for him and later for his family.

On the advice of Sir Charles Lyell and the eminent botanist Sir Joseph Hooker, Darwin decided to publish his work along with Wallace's essay in a joint paper. In July of 1858, Sir Charles Lyell presented Darwin's previously unpublished 1844 essay along with Wallace's work to the Linnean Society of London. Later, in 1859, Darwin finally published his book *On the Origin of Species by Means of Natural Selection*. Many people were outraged by the suggestion that humans could be related to apes. There were many debates and arguments about the theory of evolution. A young anatomist, Thomas Henry Huxley (1825–1895), fought the case for evolution in many public debates. He did this so fiercely that he became known as 'Darwin's bulldog'. Eventually, the scientific community came to accept Darwin's theory, some even expressing embarrassment at not having thought of such a simple explanation before.

NATURAL SELECTION

Darwin's theory was different from others in that it included a process by which evolution could occur. Although this process is often referred to as 'survival of the fittest', he called it **natural selection**. He believed that by this process a single species could have given rise to many new species, and that these new species were much better suited to the environment in which they lived.



Thomas Henry Huxley (1825 –1895) was often described as 'Darwin's bulldog' and had his own adventures in his early twenties aboard the *HMS Rattlesnake*.

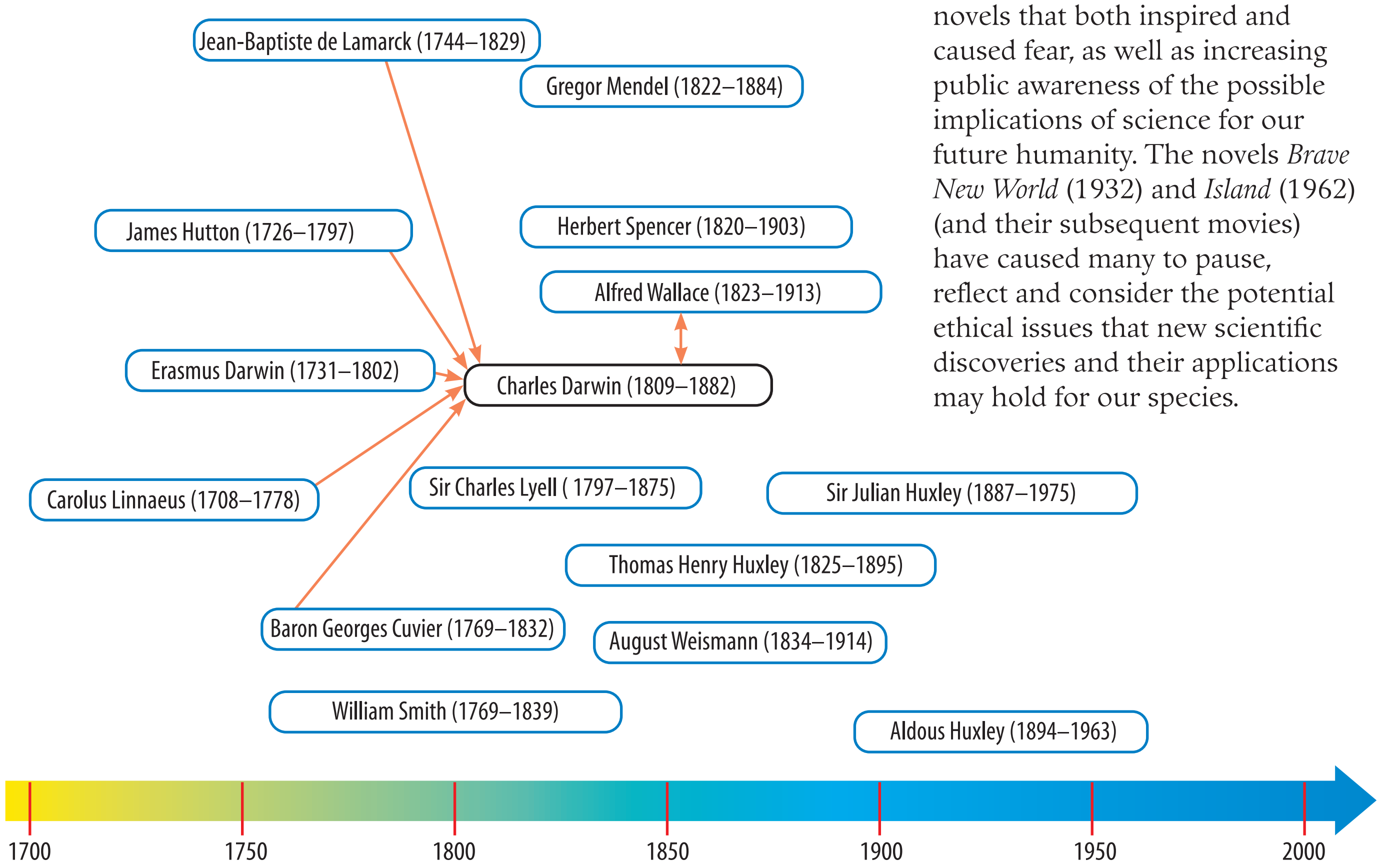
Natural selection proposes the following:

1 There is variation of inherited characteristics in a species and some of these variations will increase the chances of surviving in a particular environment.
2 In the struggle to survive, those members with favourable traits will have an increased chance of survival over others.
3 Surviving members have an increased chance of reproducing and passing on their inherited favourable traits to their offspring.
4 Over time and many generations, organisms will possess traits that are better suited to their environment and increase their chances of survival.

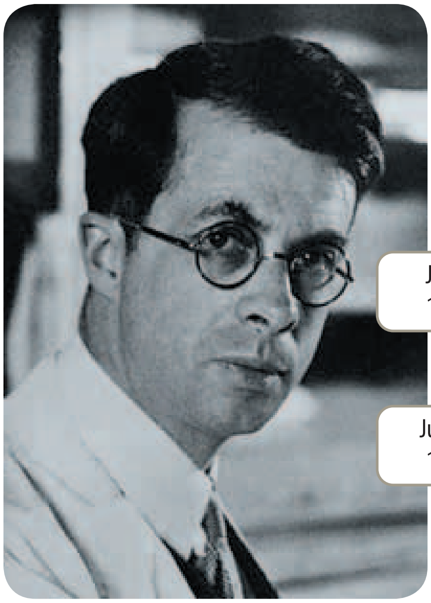
Some view this as the time when science broke away from religion. Would it still have occurred if Wallace had not sent his theory to Darwin? Would the theory of the less well-known Wallace have been taken seriously? Given the changing ideas and new knowledge being discovered at that time, would someone else have come up with the same idea?

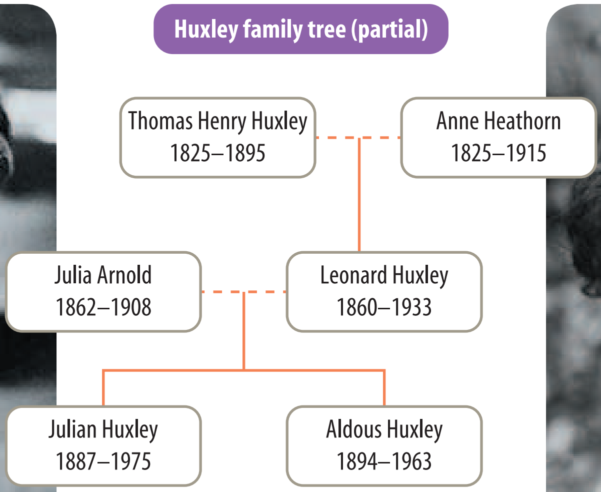
Brave new world

There are two other Huxleys that have had an impact on how we see the world. Both of these are the grandsons of Thomas Henry Huxley. Sir Julian Huxley (1887–1975) was involved in the formulation of Darwinian evolution that incorporated developments in genetics and palaeontology. Aldous Huxley (1894–1963) was the author of novels that both inspired and caused fear, as well as increasing public awareness of the possible implications of science for our future humanity. The novels *Brave New World* (1932) and *Island* (1962) (and their subsequent movies) have caused many to pause, reflect and consider the potential ethical issues that new scientific discoveries and their applications may hold for our species.



The theory of evolution is a culmination of ideas from many different individuals.





Julian Huxley

Aldous Huxley

UNDERSTANDING AND INQUIRING

REMEMBER

1 Who are the two people jointly credited with developing the theory of evolution?

2 What did Darwin conclude from the observations he made during his voyage on the HMS *Beagle*?

3 Summarise the process of natural selection.

4 Outline the contributions of the following to the theory of evolution: Linnaeus, Darwin, Lyell, Hutton, Wallace, Mendel.

INVESTIGATE, THINK AND DISCUSS

5 (a) Use the timeline and information in this section to answer the following questions.

(i) Research the time period in which these scientists grew up (refer to section 1.4 to get started).

(ii) Imagine what life was like and the sorts of beliefs that were held by the majority in the society in which they lived. Collect resources and record notes to summarise your findings.

(iii) As a class, in teams, select one of the scientists discussed in this section. Rigorously research your scientist to find out as much as you can about their life (both personal and professional). Write a biography about your scientist.

(iv) Research the other characters in this section that may have influenced your selected scientist and construct a PMI chart about your findings.

(v) As a class, discuss how your combined research could be organised into a novel about the development, presentation and final acceptance of Darwin and Wallace's theory of evolution.

(vi) Write your own novel of the collective material and then create a screenplay or storyboard that enables you to tell the story of the development of the theory to others.

(vii) Present your screenplay or storyboard to the class. Try to make your presentation as creative as possible.

(viii) Find out more about the people and books mentioned in these pages (e.g. *Theory of the Earth* (1788), *Zoonomia* (1794), *An Essay on the Principle of Population* (1798), *Principles of Geology* (1830–33), *The Origin of Species* (1859), *The Map That Changed the World* (2002)) and their contributions to our scientific understanding of the world in which we live.

(b) Add other social, cultural, religious, political or historical events to the timeline. Select one of the scientists and incorporate this information into what life must have been like for them. Comment on the influence that their contributions to the theory of evolution may have had on their personal lives.

(c) Suggest where the discovery of DNA would fit into the timeline. Discuss the effect that this has had on the evolution theory.

1.6 SCIENCE UNDERSTANDING

DNA — this is your life!

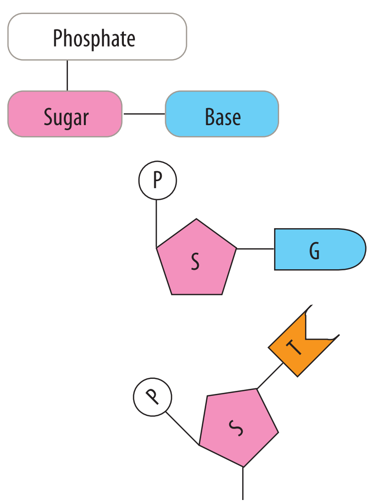
Even though DNA is as old as life itself, we have only recently been introduced to it. Like the story of the theory of evolution, DNA has its own story: a story of passion, imagination and determination that has involved the use of new technologies and the development of many more.

Greetings, DNA!

The abbreviation **DNA** is so well known, that it is often used as a word itself. DNA is the abbreviation for **deoxyribonucleic acid**. As the name suggests, it is a type of nucleic acid. It was not until around 1869 that we were formally introduced to DNA, when it was discovered by **Friedrich Miescher**. Working in a laboratory located within a castle in Germany, Miescher — a young Swiss post-graduate student — isolated it from the nuclei of cells from pus on bandages. Miescher gave the compound that he isolated from these cell nuclei the name nuclein.

In parts of three

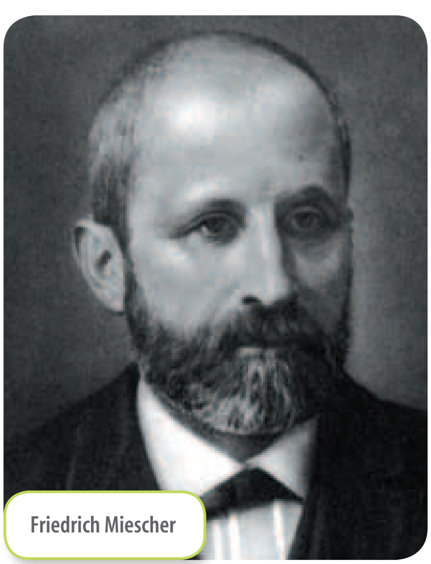
In 1929, over fifty years since its discovery, **Phoebus Levene** showed that DNA was made up of repeating units called **nucleotides**. Each of these nucleotides consisted of a sugar, a phosphate group and a nitrogenous base. In the nucleotides that make up DNA, the sugar was found to be **deoxyribose** and the nitrogenous base in each nucleotide was one of four different types: **adenine** (A), **thymine** (T), **guanine** (G) or **cytosine** (C).

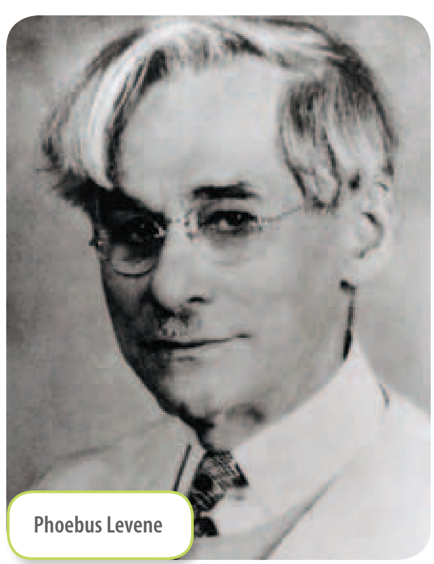


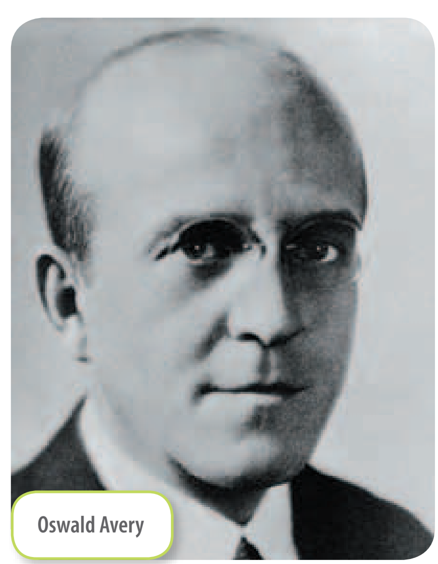
Levene also suggested that the nucleotides could be joined together to form chains. Although his theory was correct in terms of the chain formation, it was incorrect in other aspects of its structure. His tetranucleotide model contributed to scientists of the time favouring proteins, rather than DNA, as the carrier of genetic information.

DNA carries messages from one generation to next

The experiments of Alfred Hershey and Martha Chase in 1953 supported those of Oswald Avery in 1943, suggesting that DNA rather than proteins were the molecules through which genetic information was carried between generations.

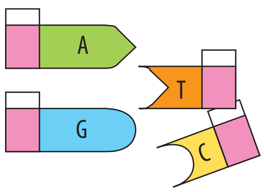

Friedrich Miescher


Phoebus Levene


Oswald Avery

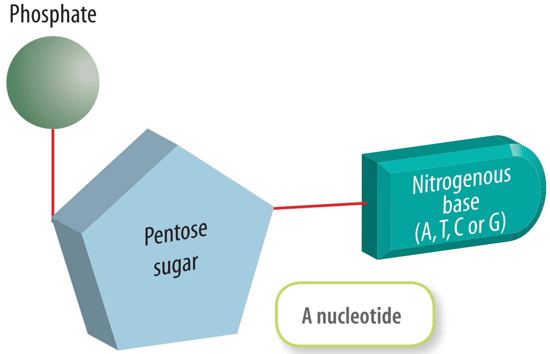
A with T & G with C

In 1950, **Erwin Chargaff** contributed to our understanding of the structure of DNA by his careful and thorough analysis of the four different types of nucleotides and their ratios in DNA. His research led to the concept of **base pairing**. This concept states that in DNA every adenine (A) binds to a thymine (T), and every cytosine (C) binds to a guanine (G). This is now known as **Chargaff's rule**.



Examples of how base pairing using Chargaff's rule can be shown

Erwin Chargaff



A nucleotide

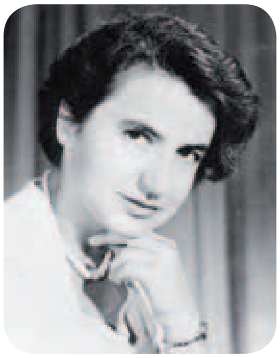
eBook plus **Interactivity**

Complementary DNA
Construct a replicate DNA strand by dragging the correct complementary base into sequence.

int-0133

A key piece of the puzzle

The next piece of the puzzle to solve the structure of DNA was contributed (some say without her knowledge) by Rosalind Franklin. Rosalind Franklin and Maurice Wilkins had decided to crystallise DNA so that they could make an X-ray pattern of it. They were specialised in making X-ray diffraction images of biological molecules so that they could be analysed to find out information about their three-dimensional structures. Franklin's X-ray diffraction picture of a DNA molecule provided important clues about the shape of the molecule.



Rosalind Franklin provided a key clue to solve the structure of DNA.

Double helix

James Watson and Francis Crick were building a DNA model to try to solve its structure. They were shown Franklin's X-ray diffraction image of DNA, which strongly suggested that DNA was a helical shape. They used this information, as well as that from Chargaff and other researchers (such as their American colleague Linus Pauling), to successfully solve the structure of DNA. At last the structure was identified!

Rosalind Franklin's X-ray diffraction picture provided important clues about the shape of the DNA molecule.

UNDERSTANDING AND INQUIRING

REMEMBER

1 State what DNA is an abbreviation for.

2 Provide an example of a nucleic acid.

3 Identify the year and name of the scientist who first discovered DNA.

4 State the source of cells in which DNA was first isolated.

5 Use a diagram to show how the three sub-units that make up DNA are organised.

6 Outline what the research of Hershey, Chase and Oswald suggested.

7 Describe what is meant by Chargaff's rule.

8 Describe Rosalind Franklin's contribution to the discovery of the structure of DNA.

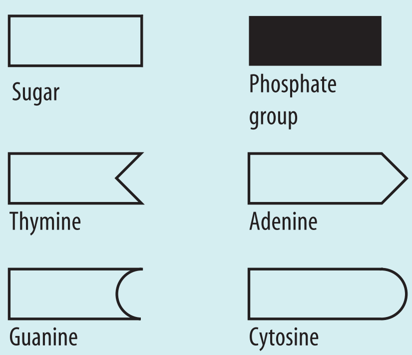
9 Explain how Watson and Crick used information available to determine the structure of DNA.

THINK AND CREATE

10 Use your own materials to construct a model of the double helix structure of DNA.

11 Use the information in this section and other sources to construct a timeline on the development of our understanding about DNA.

12 Construct a paper model of DNA. Some suggested shapes you could use to represent the parts that make up a DNA molecule are shown below.



13 Evaluate the model you made in question 12. Which aspects of the structure of DNA does your model show accurately? In what ways is your model different from an actual DNA molecule?

INVESTIGATE

14 Select one of the scientists discussed in this section, research them and write a biography about their life and scientific contributions.

15 Find out more about DNA and how knowledge about its structure is being used in research and other applications. Present your findings as a documentary, animation or in a multimedia format.

16 Investigate more about the history of how we have obtained our genetic knowledge. Present your findings as a timeline.

17 Investigate the effect that our increased knowledge about the structure and function of DNA has had on: (a) our species (b) other species (c) our planet.

18 Investigate and report on the development of the Watson and Crick double helix model of the structure of DNA.

19 Use internet research to help you to identify three questions that could be investigated about DNA. Collate these questions as a class, and then select one to investigate and report on.

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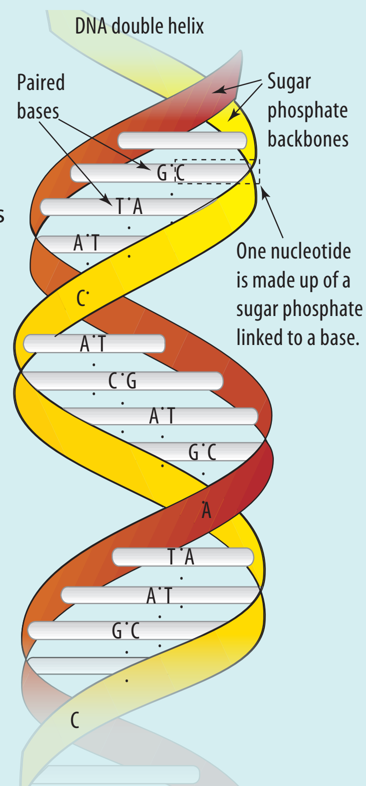
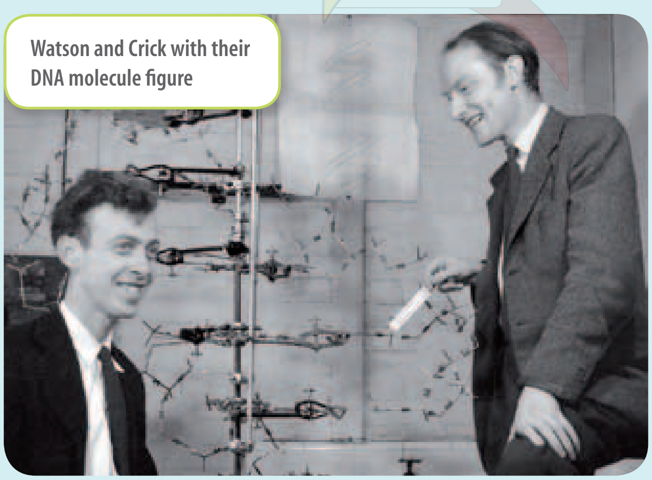
20 Discuss the following statement:

'Had Maurice Wilkins and Rosalind Franklin had a more harmonious working relationship it is likely that Franklin would have been involved in writing the scientific paper where the structure of DNA was first described, and that she would have been given the same credit for discovering the structure of DNA as Watson and Crick.'

Use the **Rosalind Franklin** weblinks in your eBookPLUS to research this question further.

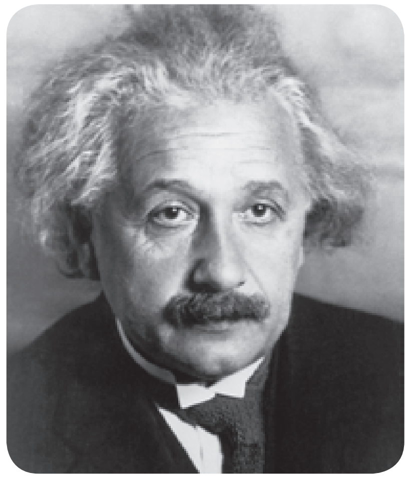




Watson and Crick with their DNA molecule figure

Einstein's impact

Albert Einstein's (1879–1955) contribution to modern physics is unique. Over a hundred years ago, when he was only 26 years old, he published a series of original theories that changed the way we see the universe. He published revolutionary ideas on the photoelectric effect, special relativity and Brownian motion.



In his study on **Brownian motion**, Einstein confirmed the existence of atoms. While other scientists were debating whether light was a particle or a wave, his theory of the **photoelectric effect**, which described the interaction of light and matter, suggested it was both.

His theory of **special relativity** examined the nature of space and time. The relativity theory is called 'special' because it doesn't include the effects of gravity. He showed how space and time could mix and match depending on your point of view. Special relativity stated that an atomic clock travelling at high speed in

Albert Einstein
Old Grove Rd.
Nassau Point
Peconic, Long Island

August 2nd, 1939

F. D. Roosevelt,
President of the United States,
White House
Washington, D. C.

Sir:

Some recent work by E. Fermi and L. Szilard, which has been communicated to me in manuscript, leads me to expect that the element uranium may be turned into a new and important source of energy in the immediate future. Certain aspects of the situation which has arisen seem to call for watchfulness and, if necessary, quick action on the part of the Administration. I believe therefore that it is my duty to bring to your attention the following facts and recommendations.

In the course of the last four months it has been made probable — through the work of Joliot in France as well as Fermi and Szilard in America — that it may become possible to set up a nuclear chain reaction in a large mass of uranium, by which vast amounts of power and large quantities of new radium-like elements would be generated. Now it appears almost certain that this could be achieved in the immediate future.

This new phenomenon would also lead to the construction of bombs, and it is conceivable — though much less certain — that extremely powerful bombs of a new type may thus be constructed. A single bomb of this type, carried by boat and exploded in a port, might very well destroy the whole port together with some of the surrounding territory. However, such bombs might very well prove to be too heavy for transportation by air.

Einstein's 1939 letter to President Roosevelt

A mushroom-shaped cloud is often associated with an atomic bomb explosion.

a jet plane ticks more slowly than a stationary clock. His theory also explained how an object could shrink in size and gain mass at the same time. It was this theory that led to the famous equation $E = mc^2$ which links energy and matter. This led to the realisation that huge amounts of energy are released in nuclear reactions. While this has provided some benefits, it has also led to detrimental applications such as the production and use of atomic bombs.

Shifting tides

What are the laws of nature? A physical law may be a hypothesis that has been confirmed by experiments so many times that it becomes universally accepted. Current research and advances in technology are increasingly leading some to question the constants or laws that have formed the basis for our science laws (including Einstein's theory of special relativity).

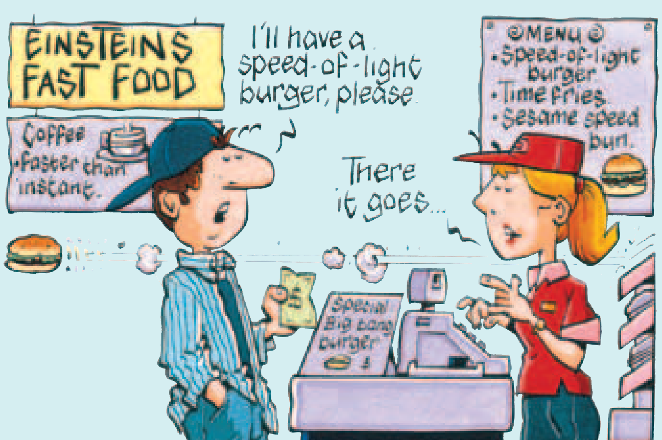
It is good to question what we think we know. Sometimes, the changes in technology and in our attitudes, values and beliefs can alter what we previously thought was a given. Questioning your assumptions can also lead you to deep insights.

An image of Einstein — is this how he would have liked to have been remembered?

UNDERSTANDING AND INQUIRING

INVESTIGATE, THINK AND DISCUSS

1 (a) Carefully examine the cartoon below and then research Einstein's theory of relativity.
(b) On the basis of your findings, explain which ideas the cartoonist is trying to incorporate. Suggest how the cartoon could be improved.
(c) On your own or in a team, design your own cartoon to demonstrate possible applications of Einstein's theory of relativity.



2 (a) Find out what prompted Einstein to write the letter to President Roosevelt.
(b) What were Einstein's thoughts on this application of theories that he had been involved in?
(c) If you were Einstein, suggest how you would feel and what you would do if you were in his situation. Present your thoughts in a letter that you would write to a close friend.

3 Use the **Einstein** weblink in your eBookPLUS to find out more about Einstein. Then create your own Einstein web page.

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4 Find out more about Einstein's life. Seek information on his professional achievements, his background and personal milestones, and the social and political climate in which he lived. Present your findings in an annotated timeline. Where possible, include images and photos.

5 Search the internet for images of Einstein on t-shirts. Select five designs and construct a PMI chart about them.

6 Reflect on Einstein's quote 'Imagination is more important than knowledge'. What is your opinion on this statement, in terms of science?

Nuclear news

Scientific discoveries have led to an amazing number of creative inventions that have provided us with technologies to further increase our knowledge, make life easier and save lives. Some applications of our scientific knowledge have, however, also destroyed life.

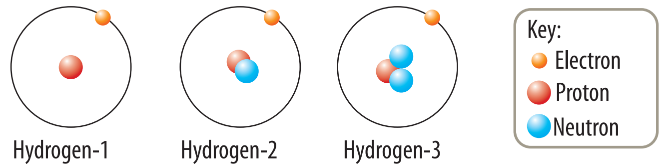
Nuclear energy in the news

Applications of our knowledge of the atom have enabled us to develop technologies that have had both beneficial and disastrous consequences. The dreadful effects of the atomic bombs dropped in Japan in 1945 and the Chernobyl nuclear power station accident in 1986 colour the emotions of many with regards to the appropriateness of such technologies.

More recently, the 2011 earthquakes in Japan and consequent damage to their nuclear power plants are fresh in our minds. During the time of this disaster, the media was littered with articles — some using unfamiliar scientific terminology and ideas, and some written to instil fear. Headlines used terms such as radiation, radioactivity, isotopes and millisieverts — terms that many readers may not have understood. This disaster also provided those opposed to the use of nuclear energy with a new weapon of their own to wield against its possible future or continued use.

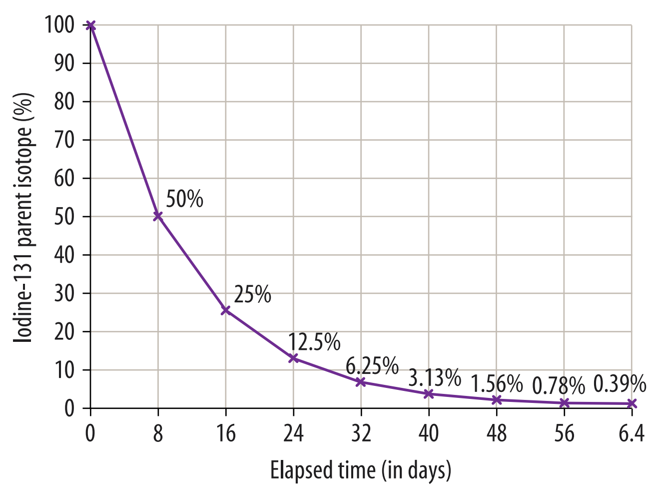
What is radioactivity?

The **atoms** of **elements** are made up of a **nucleus** that contains positively charged **protons** and **neutrons** with no charge. Outside the nucleus, **electrons** are organised in shells. Most of the elements in the periodic table have more than one **isotope**. While isotopes have the same number of protons, they differ in the number of neutrons that they contain. This can make them unstable.



Uranium is an example of an element that is associated with nuclear energy. Small amounts of uranium occur naturally in soil and rocks. The three naturally occuring isotopes of uranium are uranium-234, uranium-235 and uranium-238. When each of these breaks down or decays, it produces alpha particles and gamma rays. The rate at which a particular isotope decays is specific to that type of isotope. This rate of decay is described in terms of the time taken for the concentration to fall to half its initial value. This is called its **half-life**. While the half-life of uranium isotopes is more than a billion years, the half-life of the isotope iodine-131 is about eight days.

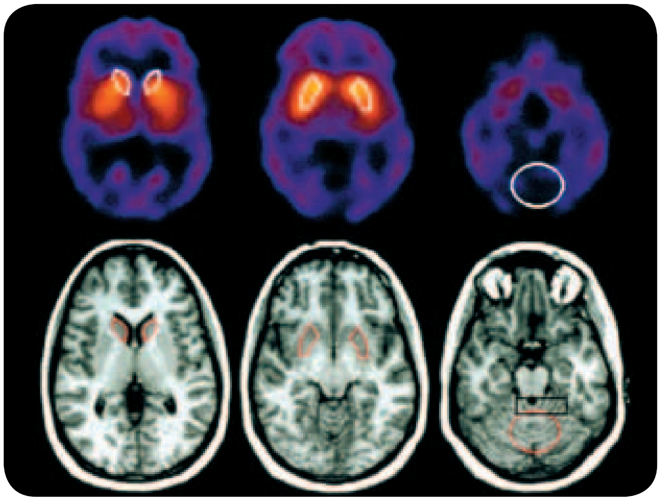
Decay curve for iodine-131



Iodine-131 is used in nuclear medicine and is also a product of nuclear fission. The half-life of iodine-131 is about eight days. High concentrations of iodine-131 are dangerous, as they can cause thyroid cancer.

Using nuclear energy

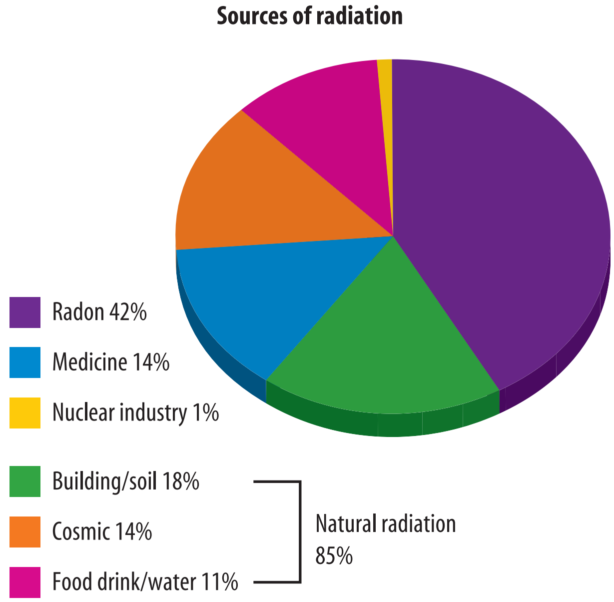
Scientists have developed many different ways to use radioactive substances; such as in the diagnosis and treatment of diseases, in the dating of fossils and other archeological artifacts, in scientific experiments to track reactions — even to power submarines, cities and smoke detectors.



Nuclear medicine imaging techniques use isotopes with a short half-life. Isotopes such as fluorine-17 can be used to find tumour cells using a technique known as a positron emission tomography (PET).

Radiation — it's all around us

Radioactive substances occur naturally as part of the Earth's crust. The radiation that we are exposed to from this source is called **background radiation**.



Most of our annual radiation dose is due to radiation exposure from natural sources such as radioactivity in rocks and soil and cosmic radiation. The rest may be related to human activities such as X-rays and other medical procedures, and a very small amount due to fallout from past testing of nuclear weapons.

WHAT'S THE PROBLEM?

Nuclear radiation is the result of hundreds of different types of unstable atoms. Although many of these exist in our natural environment, many are created in nuclear reactions. Of main concern to human health is ionising radiation, because it can damage living tissue.

The absolute age of fossils or organic archaeological artifacts can be determined by a technique called **carbon dating**, which uses an isotope of carbon.

The three main types of ionising radiation are **alpha particles**, **beta particles** and **gamma rays**. Alpha particles are only dangerous if emitted inside the body, as they cannot penetrate our skin. Although beta particles can penetrate our flesh, they can be easily stopped by materials such as wood or aluminium. Exposure to beta particles may be like a slow-healing sunburn. Gamma rays are a concern, however, as they can deeply penetrate through our natural barrier. It is for this reason that people working in fields that expose them to radiation wear special badges to detect and monitor their exposure.

The biological effect of radiation can be measured in radiation dose units called **sieverts (Sv)** or **millisieverts (mSv)**. For workers in uranium mining or nuclear power plants, the public dose limits for exposure are generally around 1 mSv/year above the background exposure.

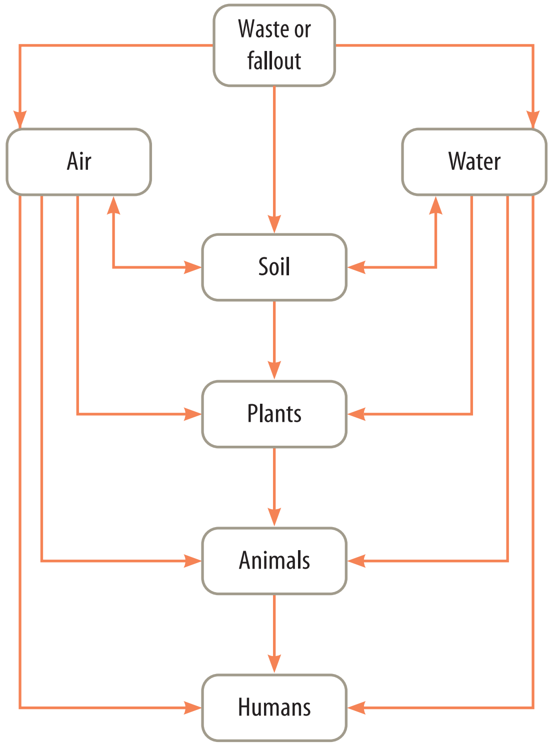
WHY DID PEOPLE TAKE IODINE TABLETS?

High doses of iodine-131 have been linked to thyroid cancer. It is for this reason that people living near the nuclear plant in Japan after the 2011 earthquake were given potassium iodide. When given within around 24 hours of exposure, it can prevent the thyroid from taking up the radioactive form.

eBookplus **eLesson**

Australian nuclear future
Watch an ABC *Catalyst* episode about the future for nuclear energy in Australia.

eles-1075



The reason that food, water and air in Japan during the time of the nuclear power disaster was tested for iodine-131 can be seen in the figure above.

IS THIS THE END FOR NUCLEAR POWER?

Japan nuclear radiation fears intensify: aftershocks rock Tokyo as the Japanese government's ability to handle the radiation crisis comes under question.

There's nothing like a meltdown to concentrate the mind.

It might come as a surprise to those only old enough to think the great scientific battle of our time is about a thing called climate change, but there's a far larger shadow that has hung over an Armageddon-fascinated race. The tragic events in Japan have brought nuclear power back into focus. Seldom has a scientific debate been less about the science and more about the emotion. But it's for good reason.

For close to 50 years, the greatest fear of our time was nuclear holocaust. And when that receded with the fall of the Berlin Wall, the fear shifted to the ageing technology in 'shonky' countries. Despite the likes of its number one Australian fan, Ziggy Switkowski, postulating that the events in Japan will create a 'pause' here, it's hard to share his enthusiasm. Those events will hang like a noose over any debate for the next 20 years at least. With political parties so attuned to what those much-maligned 'focus groups' say, even those who are bullish on the energy source won't touch it. Which must be a source of some annoyance to them. Having a generation who haven't grown up pondering the mushroom cloud meant that eventually it might be discussed again. Those hopes have been dashed, regardless of what happens to the Japanese reactors.

And that's a quandary for those looking at a sustainable energy future. At present, nuclear is the major player anywhere baseload-wise. There's a frantic race to find an alternative, and when one inevitably emerges, nuclear will be killed off. It will be good riddance. Not because it is good or bad, but because instead of wasting time debating something that takes years to build, we can spend it, and resources, considering options that are publicly palatable, the most important consideration of all. Just ask any politician. Or their focus groups.

The Age, 16 March 2011

UNDERSTANDING AND INQUIRING

THINK, ANALYSE AND INVESTIGATE

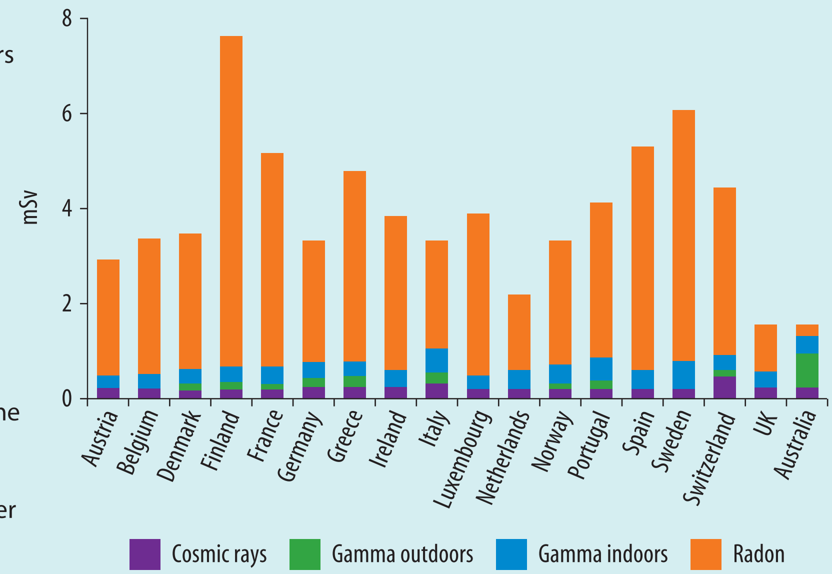
1 Use the **Nuclear power in Japan** weblink in your eBookPLUS and your own research to report on: eBook*plus*
 (a) the need for nuclear power in Japan, its history and uses
 (b) the consequences of Japan's 2011 earthquake and tsunami on their nuclear power supply
 (c) how the media reported on the 2011 Japan natural disaster
 (d) examples of how science was used in the media to explain the disaster or justify resulting actions
 (e) public views about Japan's natural disaster and possible nuclear power meltdown
 (f) publicised views of scientists during this time
 (g) the effect of Japan's 2011 earthquake and tsunami on global views regarding nuclear power
 (h) your opinion about building nuclear power plants in Japan.

2 Use the **Chernobyl accident** weblink in your eBookPLUS and your own research to report on: eBook*plus*
 (a) the need for nuclear power in Russia, its history and uses
 (b) the causes and consequences of the Chernobyl accident in 1986
 (c) media reports of the Chernobyl accident and its consequences over the last 25 years
 (d) examples of how science was used in the media to explain the disaster or justify resulting actions
 (e) public views and opinions about nuclear power as a result of the Chernobyl accident
 (f) similarities and differences between the Chernobyl accident and the Japan disaster — in particular, the fear of a potential nuclear meltdown.
 (g) publicised views of scientists during this time
 (h) the effect of these events on global views regarding nuclear power.
 (i) your opinion about building nuclear power plants in Australia.

3 Read through the article *Is this the end of nuclear power?*
 (a) Find out what is meant by the term 'Armageddon-fascinated', and comment on whether you agree with the author's statement. Include reasons for your opinion.
 (b) Do you agree with his view that the scientific debate has been 'less about science and more about emotion'? Justify your view.
 (c) What is meant by a 'nuclear holocaust'? Do you agree that this has been mankind's greatest fear for almost 50 years? Explain.
 (d) Do you think that different generations will share their common views on nuclear energy due to their own personal timeline of histories? Justify your view.
 (e) What is meant by the term 'a sustainable energy future'?
 (f) How does nuclear energy rate as sustainable energy? What are the benefits, limitations and weaknesses of nuclear power?
 (g) Summarise the opinion of the author as expressed in the article.
 (h) State your own opinion on the key points raised in the article. Provide reasons for your opinions.

4 Use the graph below and internet research to answer the following questions.
 (a) Which two countries receive the highest average annual doses from natural radiation sources?
 (b) Find out possible reasons for this being the case.
 (c) Find out if there are any dangers to human health from such a high annual dose.
 (d) The radiation patterns for the two countries are different. Find out the implications of this difference.

Average annual doses from natural radiation sources

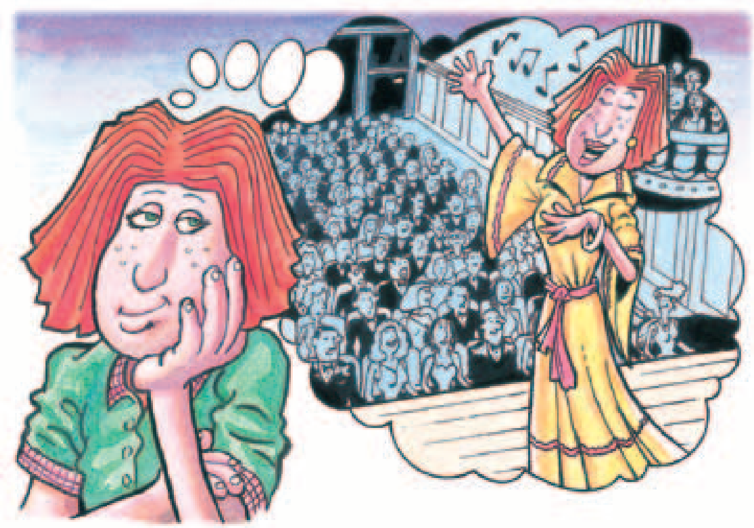


THINK, DISCUSS AND CREATE

5 There has been a lot of negative media attention about nuclear power. If nuclear power is bad, why is it used? Find out more about the positive aspects of nuclear power. Create your own brochure, newspaper article, advertisement, marketing campaign or documentary on the benefits of nuclear power.

Decisions, responsibilities and ethics

If you really wanted something, how far would you go to get it? What wouldn't you do?



Difficult decisions

If you wanted the lead in the school play, what would you do? Might you take up music lessons or buy the selecting teacher gifts? How about stealing a script so you can get that bit of extra practice in?

GOALS AND RIGHTS

Shona in the illustration above wants to get a place in the school musical. This is Shona's **goal** — it is something she wants to achieve. However, Shona does not have a **right** to a place in the musical, although, as a student of the school, she does have the right to try for a place. A right is something we have if we can expect to be treated in a certain way, no matter what the consequences. A right is different from a need.

NEED AND DUTY

A **need** is something we require. We all have the need to feel we are doing something worthwhile. If Shona gets a place in the musical, she will have a **duty** towards her fellow actors. We often think of having a duty as being required to act in a certain way; for example, telling the truth. Shona may have several duties, such as learning her lines and attending rehearsal sessions.

SHADES OF GREY

Duties often derive from goals and rights. For example, if you are accused of a crime and appear in court, you have a right to a lawyer, regardless of whether you are innocent or guilty. Your lawyer has a duty to try to get you acquitted — this is your lawyer's goal.

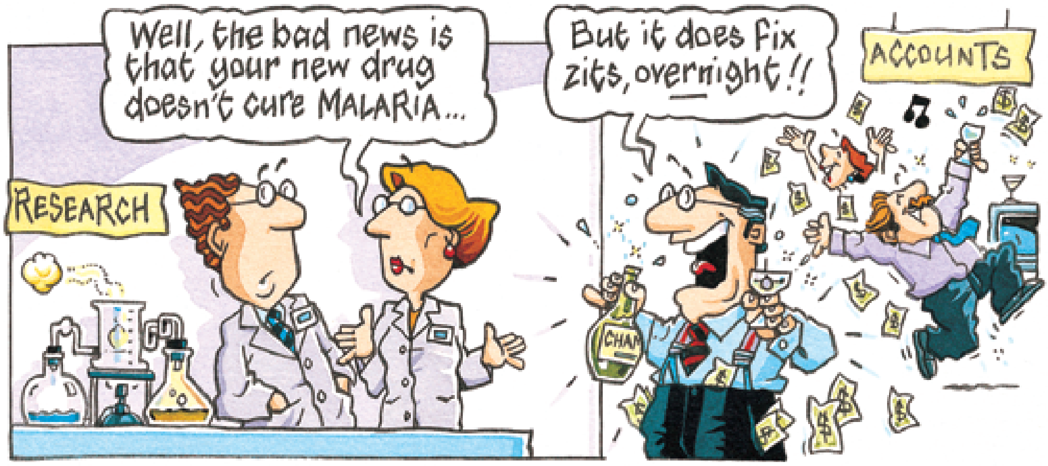
Some situations can become very complicated. For example, a dying man asks his doctor not to keep him alive any longer. Does the doctor have a duty to carry out the man's wishes because of the man's right to decide when and how to die? Or does the doctor have a duty to ignore the man's wishes because of the goal of preserving life?

Science and ethics

Scientists are also influenced by goals, rights, needs and duties. A goal of many scientists is to investigate the world around us and attempt to develop explanations of why and how it behaves as it does. Some scientists may also consider this to be their duty or the fulfilment of a need — or even their right to do so!

Science is often used to help us answer questions about how we can apply this knowledge. For example, if we want to know the effect of a particular diet, drug or some other factor on athletic performance, science can provide some answers.

The goals, rights and duties of scientific investigations become less clear when science is asked to provide us with answers about what we *should* do and *how* we should behave. **Ethics** are involved in shaping our ideas about what is right and wrong.



Should science delve into the mysteries of life? Who decides what will be researched and how discoveries will be used? Is science all about fame and fortune, or is it about seeking the truth? What is your image of science?

ETHICS

Ethics involve your moral values. While some ethical values are universal and widely accepted around the world, other ethical values vary — not only between countries, but also between different religions and communities. They may also vary within families, between different generations and throughout different times in history.

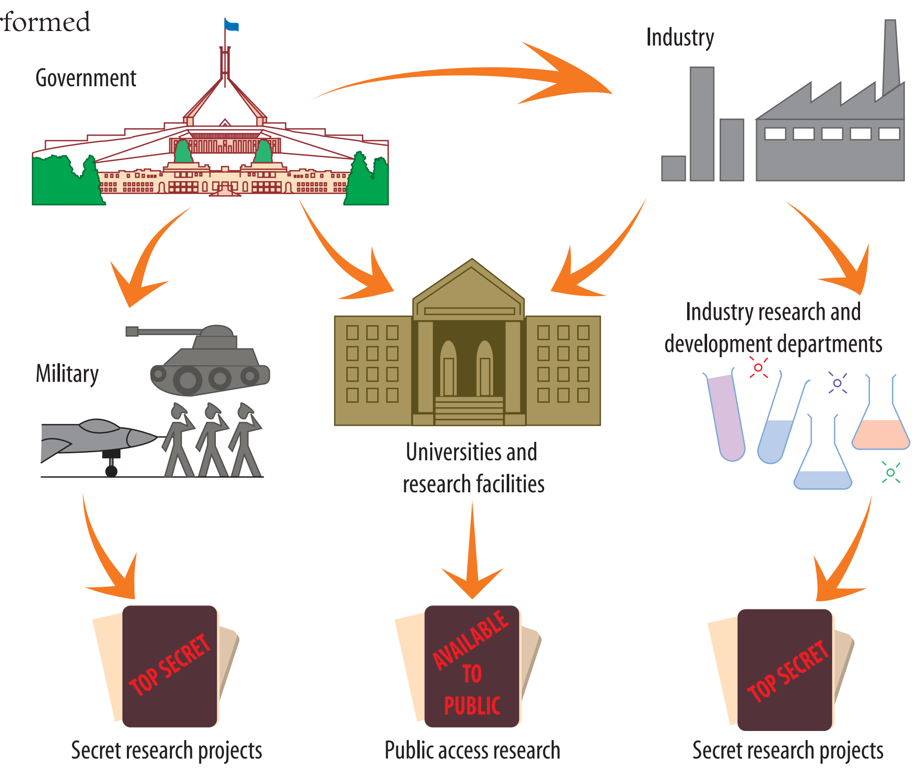
A particular scientific investigation or application of technology may be acceptable to one group of people, but highly offensive to another. Different belief systems might give rise to different ethical principles and practices. These may influence the types of scientific investigations performed and the ways in which they are conducted.

Scientific research — cash or cure?

Scientific research is responsible for discoveries that have been of great value to humankind. A quick glance around us shows lots of products of science that increase our efficiency and improve our lifestyles. Scientific research is also responsible for discoveries that have had negative effects on individuals, communities, countries and our environment. But when we talk about responsibility, is it science and the discoveries that are responsible, or is it the way in which the knowledge has been used? Who is responsible for how the knowledge is used? These issues are relevant to many examples of current scientific research.

MEDICAL RESEARCH

Medical research can be driven by need or greed. Sometimes it can provide important information, knowledge and understanding that can not only improve life, but also save it. Sometimes it can achieve this goal as well as make a lot of money for those involved in the research or its funding.



An example of the movement of money in science

Public institutions, such as universities, carry out medical research to increase our understanding and contribute to the development of possible solutions to current or potential future problems. Some of this research is linked to making money and some purely for the knowledge and understanding that it provides.

Medical research in private companies may also contribute to our knowledge, understanding and problem solving — their key goal, however, is to make a financial profit. The type of research being funded may be influenced more by its money-making potential than by its potential to reduce human suffering and improve quality of life.

Bid to activate cells goes horribly wrong
LONDON: The drug involved in the trial that resulted in six volunteers becoming critically ill is designed to activate the killer cells of the immune system. TGN1412 appears to have done so in this case to spectacularly damaging effect.
The Australian, 17 March 2006

Global pleas for drug test victims
DOCTORS in London treating six young men who became seriously ill after taking part in a drug trial are consulting experts around the world to try to save their lives.
The Age, 18 March 2006

Drug trial sent men's immunity 'haywire'
A PROTOTYPE drug that went catastrophically wrong, leaving six young British men dangerously ill, may have caused the victims' immune system to go haywire.
The Age, 23 March 2006

Human guinea pigs in agony
THE ads made the job sound more like a holiday at Club Med than a medical experiment.
Their heads felt like they were going to explode. 'Free food for the duration of your stay — and no shopping or washing up', promised the internet site calling for healthy young men to volunteer.
The Advertiser, 19 March 2006

DOUBT CAST OVER DRUG TRIAL SAFETY
THE adverse side effects that occurred in a drug trial that hospitalised six healthy volunteers could have been predicted.
BBC News

HUMAN GUINEA PIGS

A new drug, TGN1412, was designed to treat leukaemia and certain autoimmune diseases such as rheumatoid arthritis. In rheumatoid arthritis, the body's immune system turns upon its own tissue and

HOW ABOUT THAT!

Bird flu

In the past century, variations of the bird flu virus H5N1 have been responsible for pandemics in which large numbers of humans died. The viruses H1N1 in 1933, H2N2 in 1957 and H3N2 in 1968 preceded the appearance of H5N1 in 1997.

Some articles in the media suggest that the offspring of a modified H5N1 virus may contribute to the end of the human race. Scientists have stated that if there is mixing of the genetic material of the human flu virus with this bird flu virus, it may create something that our immune systems can't fight. In such a situation, millions of people may die. Individual genetic variations may be a key factor in the outcome of who will live and who will not survive.

Our main chance of survival may be the development of a vaccine against a virus that does not yet exist. It is another example of how possible need can direct the journey of scientific discoveries. In this frenzy to create vaccines, many issues arise. How much information should be shared with companies, governments, countries and the public? Will only those who can afford treatment receive it? Is this the new form of natural selection? Who is responsible for taking control and regulating the research and its discoveries?

HOW ABOUT THAT!

Old viruses

Only about 75 per cent of the world's children are being vaccinated against viruses such as measles, whooping cough and chickenpox. Some new vaccines, for example against hepatitis and meningitis, have hardly been used at all. If these vaccines can reduce the chance of others becoming ill or dying from particular diseases, who has the responsibility to make sure that they are effectively used? Should the individual take responsibility, or should it be the community, government or scientists?

attacks it. TGN1412 is a powerful antibody that works by binding to the immune system's T cells, causing them to activate and multiply rapidly.

TGN1412 made headlines in 2006 after its first trial on human subjects. It was given to six healthy young men in the UK, and caused severe adverse reactions that required intensive care. One man's head swelled to three times its normal size, causing excruciating pain. The worst affected trial volunteer was 20-year-old Ryan Wilson, who was in a coma for three weeks after taking the drug.

Drug trial volunteers are mainly young people, and many are backpackers and students who are attracted to the payments made by pharmaceutical companies. Other controversies have arisen following drug trials in Nigeria and India, where it was unclear whether patients had given their informed consent.

How much information should be given to drug trial volunteers? Who should be involved in trialling new drugs?

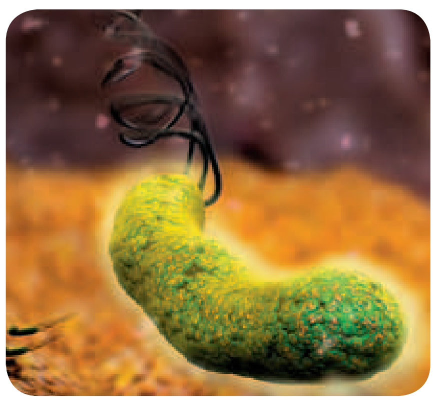
ANIMALS FOR TESTING

Is it ethical to use animals in scientific research? Animals are used in scientific research to test the effects of cosmetics, different surgical techniques, types of diseases and their treatments, and to find out more about how their and our bodies function. During some of this research animals may experience pain, suffering and even death. There are many ethical issues related to the use of animals in scientific research, the types of animals used and whether the research itself is ethical.

TAKING RISKS

If acid inside your stomach eats into your stomach lining, an ulcer can result. This very painful condition can also cause bleeding and can be difficult to treat. In some cases, surgery is required. It was thought that lifestyle factors, such as spicy food and stress, were key factors that triggered these painful ulcers.

In 2005, Australian scientists Barry Marshall and Robin Warren received the Nobel Prize in Medicine for their research on stomach ulcers. They showed that the actual cause of many stomach ulcers was not lifestyle, but the presence of the bacteria *Helicobacter pylori*. This revolutionary finding meant that ulcers could be treated with antibiotics.



Helicobacter pylori bacteria in the human stomach cause stomach ulcers. They move their hair-like structures to travel around the stomach lining.

Their discovery, however, was not recognised for a number of years. Their ideas faced strong opposition from the scientific community. Firm in his conviction that these bacteria were the real cause of ulcers, and that they could be easily cured by antibiotics, Marshall took a drastic step. He drank a container of *Helicobacter pylori* to infect himself! Fortunately for him (and us), although he experienced considerable discomfort, he was cured by antibiotics.

Were Marshall's actions ethical? There are strict regulations on experimentation on humans. Did this give him the right to infect himself? Was it his duty? Apparently Marshall had carried out a risk assessment and had decided that the benefits of experimenting on himself outweighed the risks involved. Do you agree with his conclusion? If you were him, is this what you would have done?

AGRICULTURE — FOOD FOR THOUGHT

With an increasing global human population comes the need for an increased food supply. Traditional plant breeding methods are being replaced with new technologies.

(A) The realist
Drug trials are expensive and will add to the cost of the drugs, which is already high.

(B) The humanist
Testing takes time and we already know that these drugs have been effective. There are people dying who are in need of these drugs now.

(C) The ethicist
We have a responsibility to test these drugs to ensure that they are completely safe for all members of society. The most rigorous testing should always be carried out.

One of these includes the use of genetic modification (GM). This technology enables plants to be designed with features that increase crop yields and quality.

Some applications of genetic modification enable the development of crops that are resistant to herbicides, (for example, canola), can make their own pesticides (for example, cotton) or contain added nutrients (for example, rice).

There is considerable debate about the use of genetic modification because it involves changing the plants at a molecular level. The actual DNA of the plant is modified. This technology can involve moving genes between different species, so that the resulting plant is transgenic (contains DNA from different species). Ethical issues include the following:

- Is it right to interfere with nature?
- Does the addition of an animal gene to a plant make it suitable for vegetarians?
- Should GM foods show this status on their labels?
- Who should receive the profits?
- Who has ownership of the modified plants?

INQUIRY: INVESTIGATION 1.2

Where do I stand on ethical issues in science?

KEY INQUIRY SKILLS:

- communicating
- processing data and information

Recent scientific and technological advances are associated with some very complex and difficult decisions, responsibilities and ethical issues.

1 On your own, score each of the statements below on a scale of 0–4, where 0 = strongly disagree and 4 = strongly agree.
   - Immunisation of children should be compulsory.
   - Genetic manipulation of food crops and animals should be illegal.
   - IVF technology should be publicly funded.
   - Nuclear reactors should be built in each Australian state and territory.
   - Cosmetics should be tested on other animals prior to their availability to humans.
   - The development of new drugs should be done by non-profit organisations rather than those that may make a profit from it.
   - If an effective but expensive drug is available to cure a life-threatening disease, it should be available to everyone, not just those who can afford it.
   - Genetically modified food should be clearly labelled as such.
   - Close relatives of humans, such as monkeys and chimpanzees, should not be used as animals in scientific research that tests the effectiveness of treatments against various diseases.
   - Scientists should be allowed to experiment on themselves.

2 Research two of the issues above. Construct a table with reasons for and against. Compare and discuss your table with others. Organise a class debate on one of the issues.

3 For at least two of the statements, share your opinions by being involved in constructing a class 'opinionogram'.
   (i) Divide the classroom into five zones, and assign a score of 0–4 to each zone.
   (ii) Each student should stand in the zone that indicates their score for the first statement.
   (iii) Have a member of the class record the number of students at each point of the scale.
   (iv) Discuss the reasons for your opinion with the students in your zone.
   (v) Suggest questions that could be used to probe students in different opinion zones.
   (vi) Share reasons for your opinion with students in other zones and listen to their reasons for their stance.
   (vii) Reflect on what you have heard from others. Decide if you want to change positions and, if so, change. Give a reason why you are changing.
   (viii) Have a member of the class record the number of students at each point of the scale.
   (ix) Repeat steps (ii)–(viii) for the other two statements.
   (x) Reflect on what you have learned about the opinions and perspectives of others.
   (xi) Suggest questions that could be used to more closely probe reasons for your classmates' opinions. Share these probing questions with your class.
   (xii) Construct graphs showing the opinion scales for each statement and comment on any observed patterns.
   (xii) Construct a PMI chart for each statement based on opinions and statements made by others in the class.
   (xiii) Select one of the statements (ensure it is different from the statement debated in part (b)) and organise a class debate.

UNDERSTANDING AND INQUIRING

THINK AND DISCUSS

1 (a) Laura is a member of the pre-musical performance squad. Shona would like to be a member of the squad. Think about this situation and the goals, rights, needs and duties that Laura and Shona each have, and then copy and complete the table below.

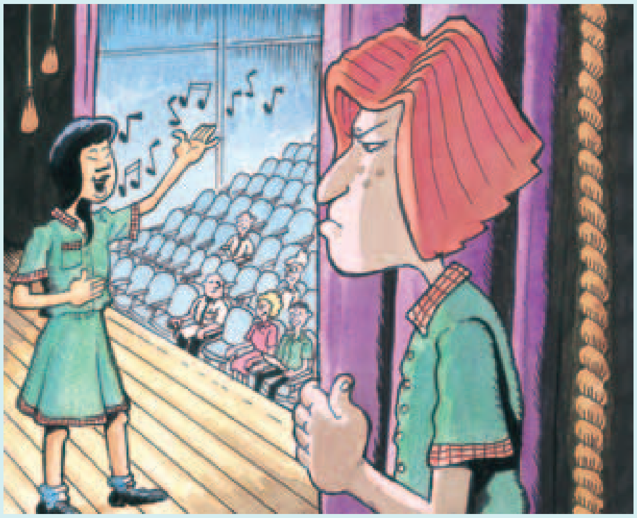
(b) How people behave in any situation is largely determined by how they perceive the relative importance of their goals, rights, needs and duties.

(i) Describe how Shona may behave if she perceives that her goals and needs are of greater importance than those of others.

(ii) Contrast this with the behaviour you may expect if she perceives her duties as being less important than those of others.

(iii) How do you think Laura and Shona should behave towards each other?

Person	Goals	Rights	Needs	Duties
Laura				
Shona				
Teacher in charge of casting				
Audience for the musical				
Rest of the cast				



2 We have had to face some very complex and difficult issues because of recent scientific and technological advances. Examples of issues being faced in Australia include:

- compulsory immunisation of children
- genetic manipulation of food crops and animals to optimise such things as their resistance to pests and their growth rate
- irradiating food to maximise its shelf life
- public funding of IVF technology
- reducing irrigation to improve water quality of rivers
- building a new nuclear reactor in Australia.

Research one of the issues above. Make a table of the reasons for and against the issue and present your findings to the class.

3 Discuss the following statements with your team. Record your discussions in PMI tables.

- Scientists have a responsibility to consider the wider effects of their research.
- Science should have an international rule book that states what is allowed and what is not.
- Individuals can influence the type of scientific research performed.
- The government controls what is done with scientific research.
- Science should not have to answer to anyone.
- Companies should have total ownership of any research they financially support.
- Scientific discoveries should belong to everyone.

INVESTIGATE AND REPORT

4 Select a topic from the following list and research the types of issues facing science and scientists.
Stem cells, nanotechnology, virology, radiation, nuclear power, genetic engineering, genetic testing, IVF, abortion, vaccinations, AIDS, H5N1, mad cow disease, gene therapy, SARS, H1N1, biological warfare, chemical warfare, earthquakes, nuclear power plants

(a) Organise your findings in a web page, PowerPoint presentation, poster or visual thinking tool.

(b) Discuss your findings with others in your team. As a team, try to identify relevant values, beliefs, opinions and attitudes which may contribute to people having different perspectives.

(c) Present your findings to the class and get them to construct their own PMI charts based on the information that you provide.

5 (a) Find out more about pandemics H1N1 in 1933, H2N2 in 1957, H3N2 in 1968 and H5N1 in 1997.

(b) Could they have been avoided? If so, suggest how.

(c) Write a story from the perspective of a child who lost one of their family or friends to one of these pandemics.

6 Research and organise a class debate on one of the following.

(a) The Manhattan Project
(b) Embryonic stem cell research
(c) Chernobyl and nuclear power stations
(d) Genetic testing
(e) Organ transplants

work sheets
1.2 Science and ethics
1.3 Difficult decisions

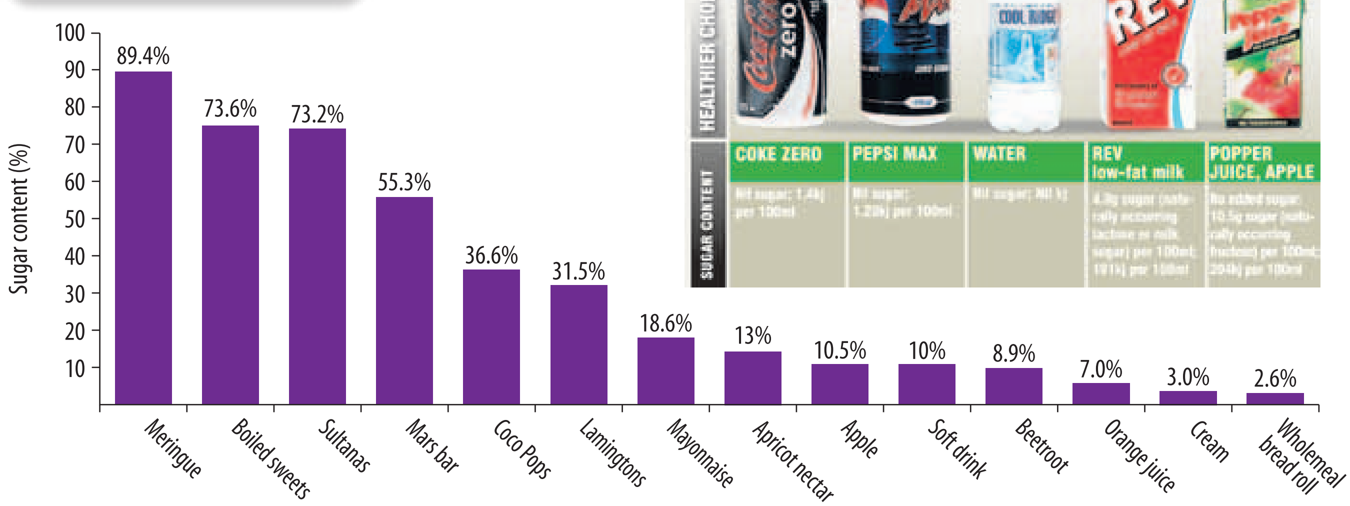
Banned! It's for your own good!

Imagine being told 'No treats for you! You will have spinach, capsicum and tomato on wholegrain bread and no butter!' Who tells you what to eat? Should you listen? Do others really care what you put into your mouth?

In 2006, the Victorian government decided to address the types of food that are available to school students. One of the reasons for this was the growing concern about the number of obese children in the state. Soft drinks containing sugar were the first to be on their no go list. Do you think the government has the right to make such a decision? What is your opinion on this issue?

How much sugar?

To calculate how much sugar is in a can or bottle of drink you must first find the nutrition information section on the label. A typical non-diet soft drink might contain 11.04 grams in 100 mL.



To calculate the mass of sugar in one 375 mL can of drink, use the formula below:

$$\text{Mass of sugar} = \frac{11.04 \times \text{volume}}{100}$$

$$\text{So, mass of sugar} = \frac{11.04 \times 375}{100} = 41.4 \text{ g}$$

Since one teaspoon of sugar has a mass of approximately 4 grams, divide the mass of sugar in one can of drink by 4.

$$\frac{41.4}{4} = 10.35 \text{ teaspoons}$$

Therefore, one can of soft drink might contain over 10 teaspoons of sugar.

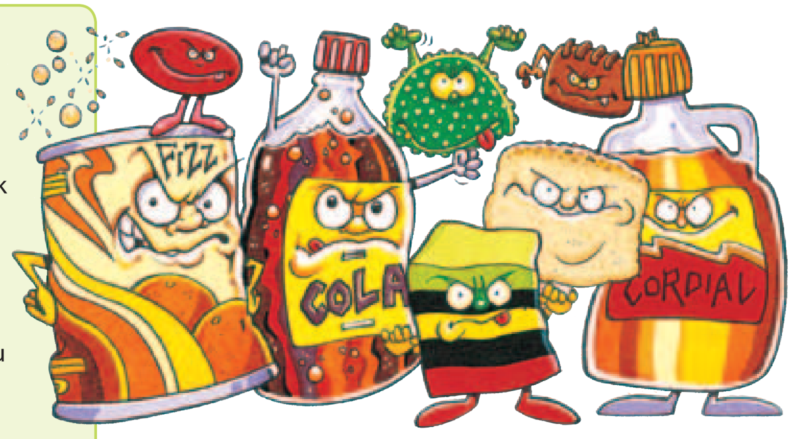
INQUIRY: INVESTIGATION 1.3

Fizz and tell

1 Survey the class to find out:
  (a) how much soft drink they consume in a week (in millilitres)
  (b) which types of soft drinks are consumed.

2 (a) Present your results in a format that can be shared with others.
  (b) Comment on your results. Were they what you expected or were you surprised? Were there patterns? What other sorts of information would you like to know to further analyse the data?

3 Comment on whether your data supports the following statement: 'Almost 80 per cent of teenagers consume soft drinks weekly, with 10 per cent drinking more than one litre per day.'



INQUIRY: INVESTIGATION 1.4

More fizz and tell

Consider the following statement:

'Sugar-loaded soft drinks should be banned from all Australian schools to reduce teenage obesity.'

1 Construct a PMI chart on the statement.

2 Do you agree with this statement?

3 (a) In the classroom, construct a human graph to show people's opinions on the statement. Stand in positions to indicate your feelings about the statement. For example:

  Strongly disagree (0) — stand next to the left-hand wall
  Agree (2) — stand in the centre of the room
  Strongly agree (4) — stand next to the right-hand wall.

  (b) Have a discussion with students standing near you to find out the reasons for their opinion.
  (c) Listen to the discussions of students in other positions.
  (d) Construct a SWOT diagram to summarise what you have found out.
  (e) Record the results of the human graph and examine them to answer the following questions.
    (i) What was the most popular attitude? Suggest a reason for this.
    (ii) What was the least popular attitude? Suggest a reason for this.
    (iii) Do you think this attitude pattern is representative of other Australians your age? Explain.
  (f) On the basis of your discussions, have you changed your attitude since the start of this activity? If so, how is it different and why?

UNDERSTANDING AND INQUIRING

ANALYSE AND EVALUATE

1 (a) What types of drinks may be banned from Victorian state schools?
  (b) How much sugar do most non-diet soft drinks contain?
  (c) Calculate the mass of sugar in a two-litre bottle of Coke.
  (d) Calculate the number of teaspoons of sugar in a two-litre bottle of Coke.
  (e) Calculate and graph the amount of sugar in a 375 mL can or bottle of each of the drinks in the table at the beginning of this section.

THINK AND DISCUSS

2 Do you think that too much soft drink is being drunk by people your age? Should it be changed or monitored? What are some implications about the amount of soft drink consumed?

3 What are your opinions on the state government being able to dictate the types of foods that are available to children in schools?

4 Do you think the Victorian government's ban on soft drinks in schools will help reduce obesity in teenagers? Give reasons to support your opinion.

5 What other lifestyle habits should the government be involved in? How should they approach this? Provide reasons why you think they should be involved.

INVESTIGATE AND SHARE

6 Is childhood obesity a real issue in Australia? Research various resources to gather as much relevant information as you can. On the basis of your research and personal beliefs, construct an argument to prepare for a debate with someone who has an opposing view.

1.11 THINKING TOOLS

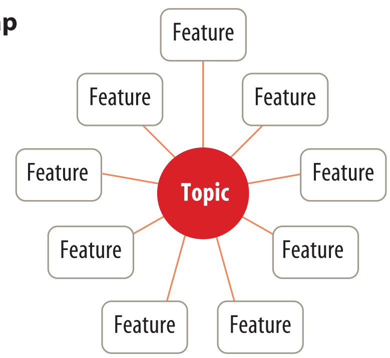
See quest

Visual thinking tools can be used to help share your thinking and to be able to see how and what other people are thinking. They can be used to clarify key ideas, show links and suggest relationships, and prompt discussions on many different topics and issues. They can also be useful in helping you to evaluate ideas and to consider various alternatives in your decision making. Examples of some of the types of thinking and their visual tools are shown in the table throughout this section.

Thinking tools

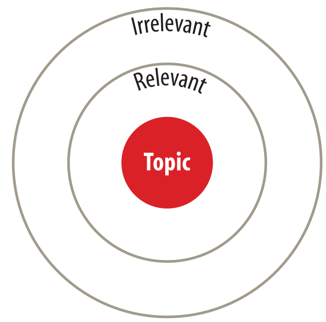
Single bubble map

Q: *What do I already know about this topic?*



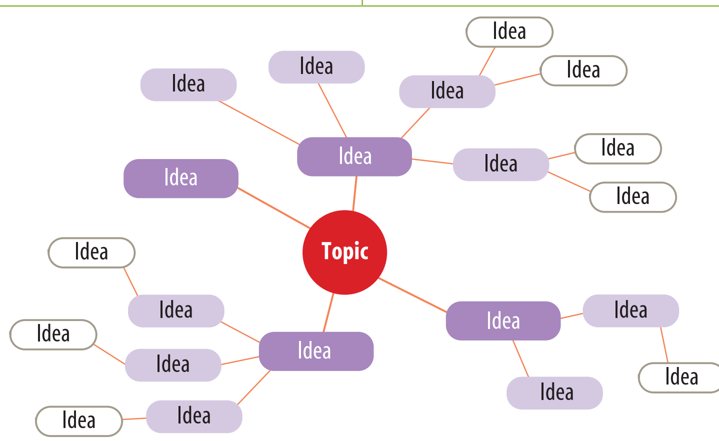
Target map

Q: *How can we agree on what is relevant to our discussion?*



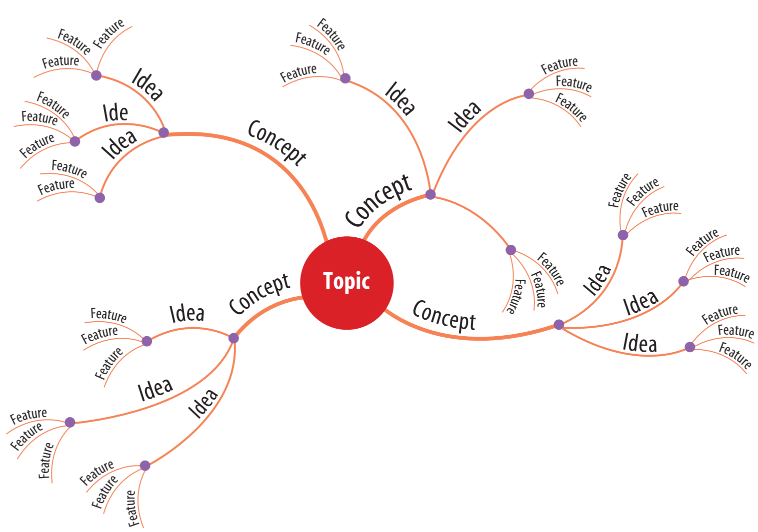
Cluster map

Q: *How could I develop this idea?*



Mind map

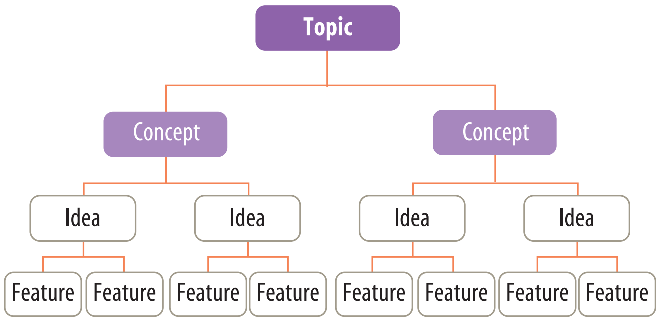
Q: *What are the main points?*



Thinking tools

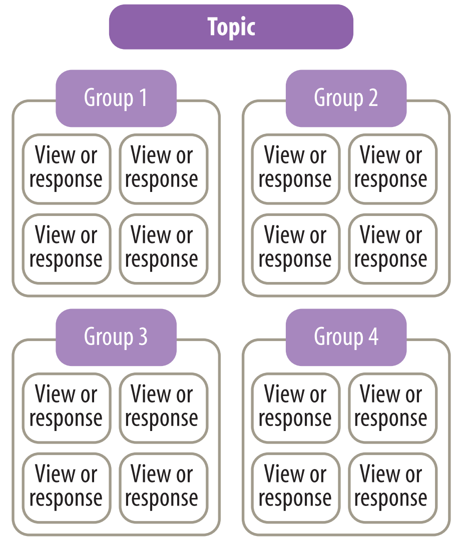
Tree map

Q: How do the parts of a topic relate to each other?



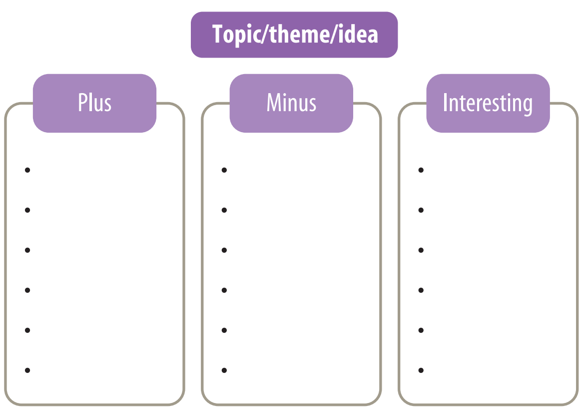
Affinity map

Q: What are the common themes in different viewpoints?



Plus, minus, interesting (PMI chart)

Q: What are other points of view? How can I prepare to make a decision?



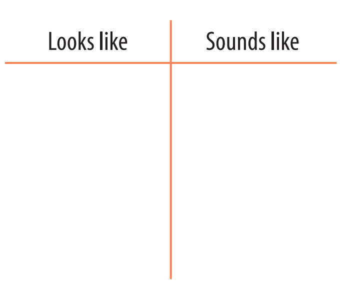
KWL

Q: What do I know about this topic? What do I want to know about it? What have I learned?

KWL		
What we **K**now	What we **W**ant to find out	What we have **L**earned

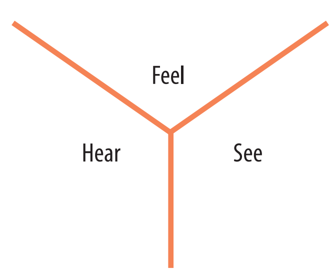
T chart

Q: What does the problem or situation look and sound like?



Y chart

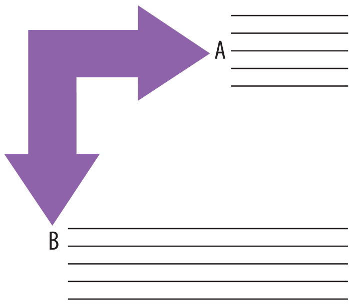
Q: What does the problem or topic look like, sound like and feel like?



Thinking tools

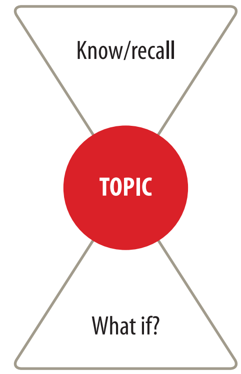
Corner thinking

Q: *What is the relationship between these ideas?*



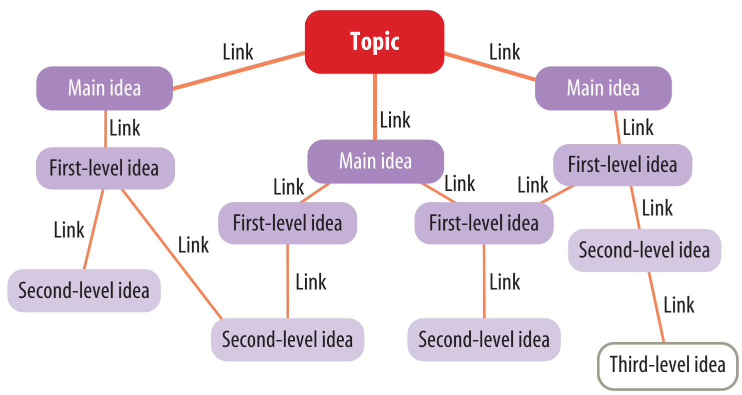
Hourglass

Q: *What is the topic? What do I/we know about it? What if . . .?*



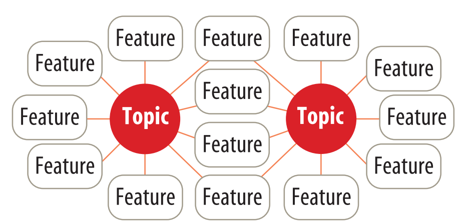
Concept map

Q: *How can I describe this topic to someone else?*



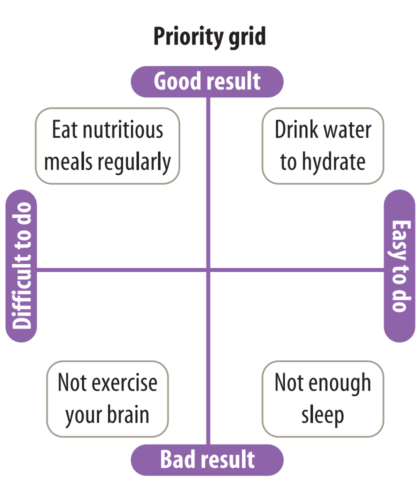
Double bubble map

Q: *What are the main points?*



Priority grid

Q: *What are the relative strengths and weaknesses of this idea? What is the best way to tackle the problem?*



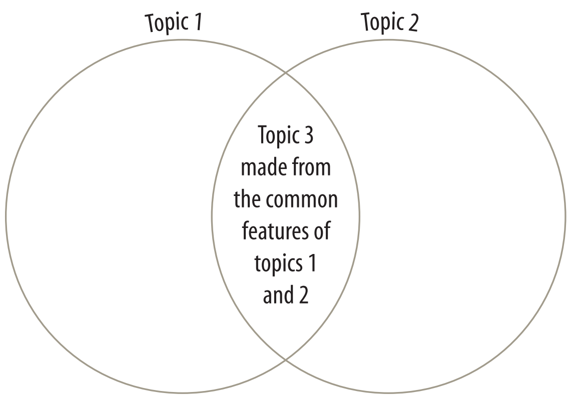
Continuum

Q: *How extreme is this idea? How strongly do I and others feel about it?*

Thinking tools

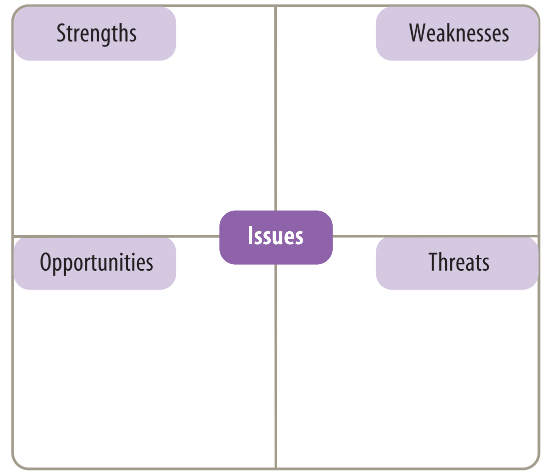
Venn diagram

Q: How can I describe this topic to someone else?



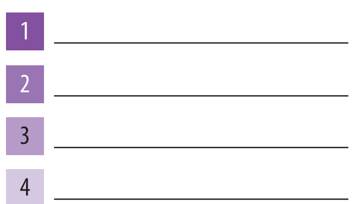
SWOT analysis

Q: What are the strengths and weaknesses of the idea?



Ranking ladder

Q: How important is this? Which is the highest priority?



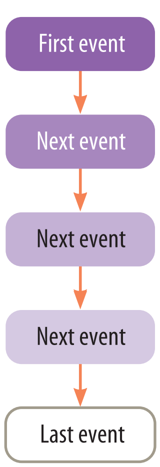
Matrix

Q: How do the parts of a topic relate to each other?

Topic	Feature A	Feature B	Feature C	Feature D	Feature E
1	✓		✓	✓	✓
2		✓			✓
3		✓		✓	✓
4			✓	✓	✓

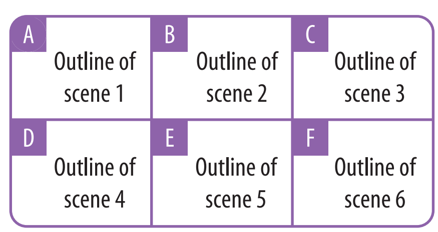
Flowchart

Q: How can you record the stages that occurred?



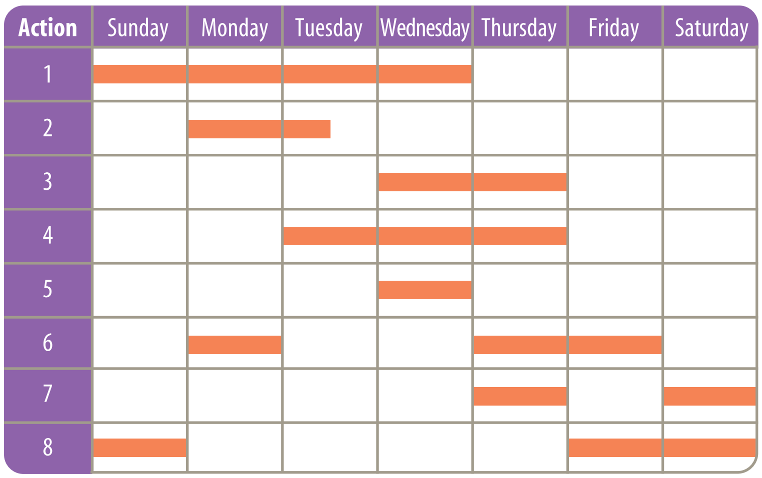
Storyboard

Q: What are the main ideas or scenes?



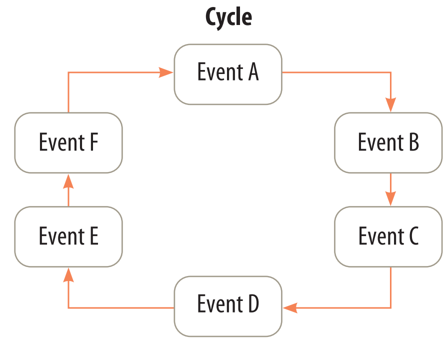
Gantt chart

Q: How do actions in the story or event overlap?



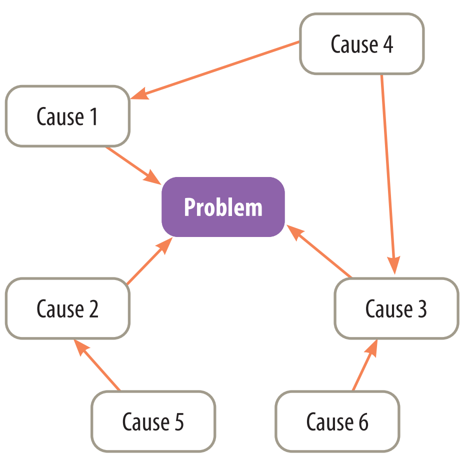
Cycle map

Q: What patterns can be seen in these events?



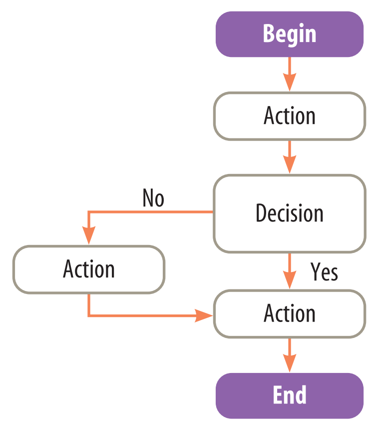
Relations diagram

Q: What is causing the problem?



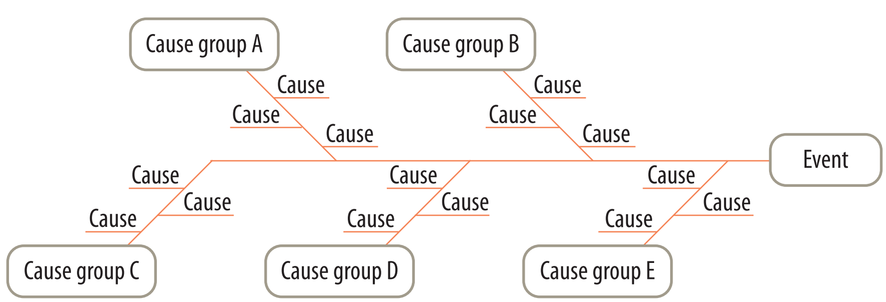
Algorithm

Q: How can different decisions I make solve this problem?



Fishbone

Q: What could have caused this event to happen?



STUDY CHECKLIST

SCIENCE AS A HUMAN ENDEAVOUR

- investigate the history and impact of developments in genetic knowledge
- consider how information technology can be applied to different areas of science
- describe how science is used in the media to justify people's actions
- use knowledge of science to evaluate claims, explanations and predictions
- recognise that financial backing from governments or commercial organisations is required for scientific developments and that this can determine what research is carried out
- outline examples of how scientific understanding, models and theories are contestable and are refined over time through a process of review by the scientific community
- provide examples of how advances in scientific understanding often rely on developments in technology and technological advances are often linked to scientific discoveries
- suggest how values and needs of contemporary society can influence the focus of scientific research
- provide examples of how advances in science and emerging sciences and technologies can significantly affect people's lives, including generating new career opportunities

SCIENCE SKILLS

- use internet research to identify problems that can be investigated
- evaluate information from secondary sources as part of the research process
- develop ideas from your own or others' investigations and experience to investigate further
- combine research from primary and secondary sources
- outline issues relating to investigations involving animals
- design and construct appropriate graphs to represent data and analyse graphs for trends and patterns
- suggest more than one possible explanation of the data presented
- use spreadsheets to present data in tables and graphical forms
- describe how scientific arguments are used to make decisions regarding personal and community issues
- present ideas using oral presentations and contribute to group discussions
- use secondary sources and your own findings to help explain a scientific concept
- use the internet to facilitate collaboration in joint projects and discussions

ICT

eBook plus Summary

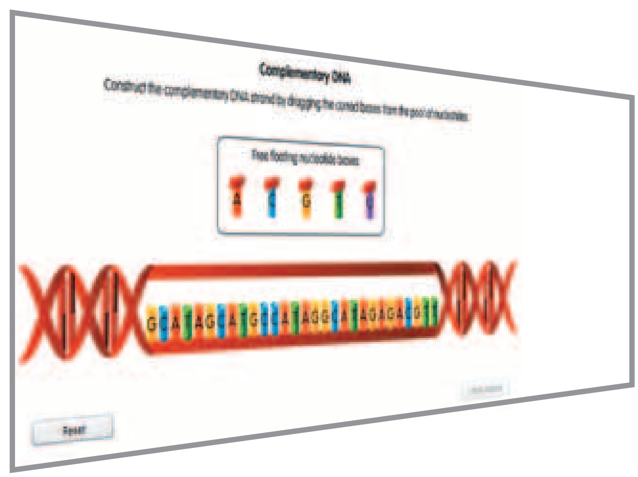
eLESSONS

Meet Professor Veena Sahajwalla
Meet an engineer who is also a television presenter on *The New Inventors*.
Searchlight ID: eles-1071

Australian nuclear future
Watch a video from the ABC's *Catalyst* program about the future for nuclear energy in Australia.
Searchlight ID: eles-1075

INTERACTIVITY

Complementary DNA



Construct a replicate DNA strand by dragging the correct complementary base into sequence.
Searchlight ID: int-0133

INDIVIDUAL PATHWAYS

eBook plus

Activity 1.1	Activity 1.2	Activity 1.3
Think Quest	Developing thinking	Investigating Think Quest further

LOOKING BACK

1 Charles Darwin's theory of evolution sat unpublished for over ten years.

(a) Suggest why it took him such a long time to make his ideas public.

(b) There have been many caricatures of Charles Darwin over the years. Suggest what the creator of the cartoon at right is suggesting. Do you consider this accurate in terms of Darwin's theory? Explain your answer.

(c) Outline the key ways in which the theory of evolution differed from the accepted theological view of the time.

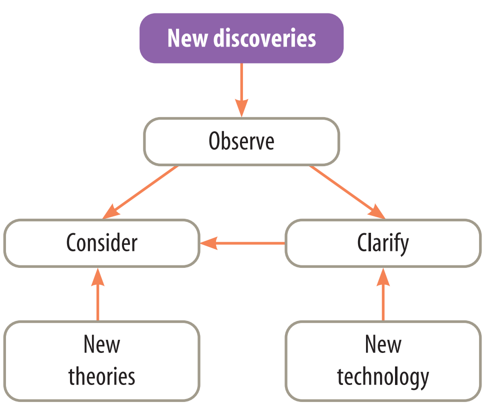
(d) Identify the other scientist who is responsible for proposing the theory of evolution. Suggest why he is not as well known as Charles Darwin.

(e) Identify at least five other people involved in the development and acceptance of the theory of evolution and state their key contribution.

(f) If a scientist were to propose a new theory about creation that signficantly differed from the currently accepted view, suggest how this might be received by the scientific community and the general public.

(g) Suggest a possible alternative to the theory of evolution. Provide reasons to support your theory.

2 Carefully observe the figure below.



(a) Do you think that this figure effectively summarises how we mix new information to rethink ideas and improve our scientific knowledge?

(b) Can you think of an example of how our scientific knowledge has developed in a way similar to that suggested by the model?

(c) Suggest how the model could be improved.

3 Research examples of drugs or tests that are known to encourage people to tell the truth.

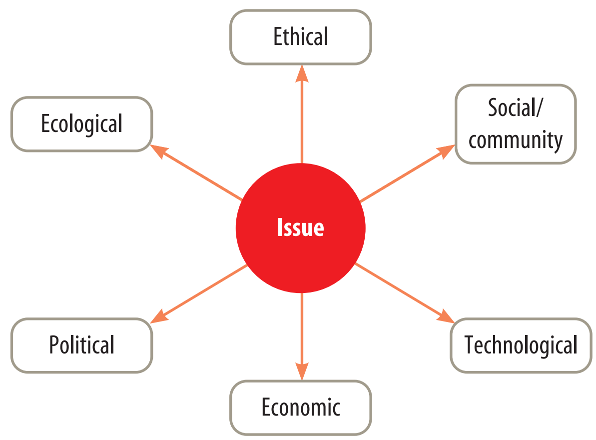
(a) Find out how they work.

(b) Do you believe that you have the right not to be forced to tell the truth? Explain why.

(c) Do you think that lie detector tests and truth serums or treatments should be used to force people to tell the truth or test whether they are telling the truth? Justify your response.

4 Use the issues map below to help you identify various perspectives on one of the following issues.

- Watering of gardens should be illegal.
- Cars should be driven only when there are at least four occupants.
- Scientists should be allowed to research whatever they want.
- If a vaccine for the dangerous variant of H5N1 is synthesised, it should be given only to children under 10 years of age.

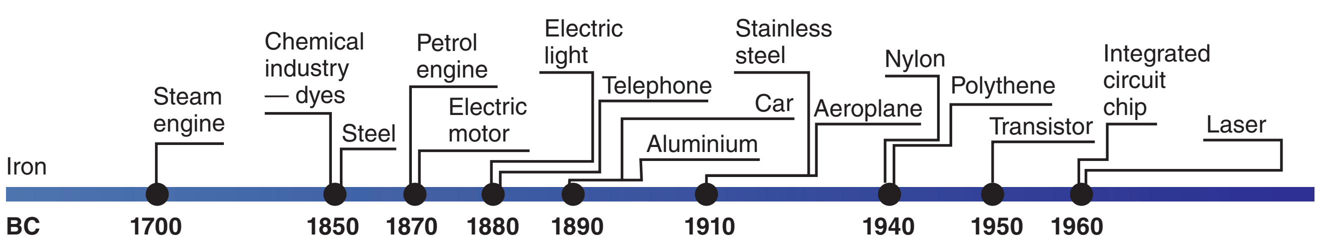


5 Study the timeline below of the developments of various inventions. These are approximate times because their development involved building on the ideas of others over time.

(a) Select an invention from the timeline that interests you.

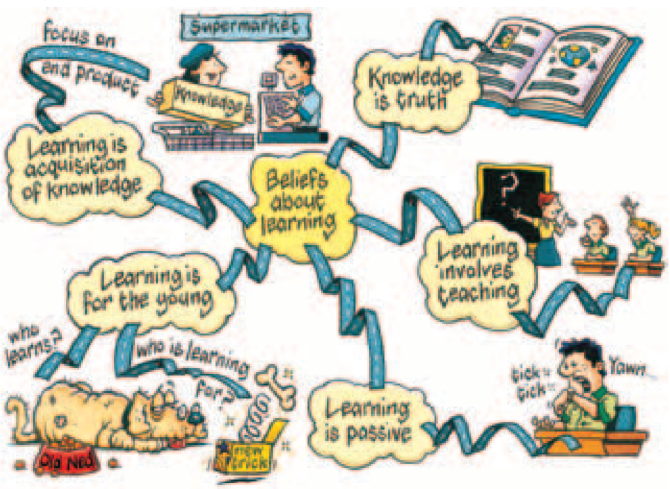
(b) Investigate how and why it was developed and who was involved.

(c) Write a story about the history of its development and invention.



6 Research the experimentation undertaken by the CIA involving truth drugs, LSD, mind control and biological weapons in the 1950s in America.
   (a) What sort of testing did they do, to whom and for what reason?
   (b) Do you think that their actions were justified? Explain.
   (c) Collect information on Frank Olson, a CIA agent. What do you consider the true story to be?
   (d) Find out more about *The Manchurian Candidate* books and movies. Construct a SWOT on the strength of the evidence and details that you find out.

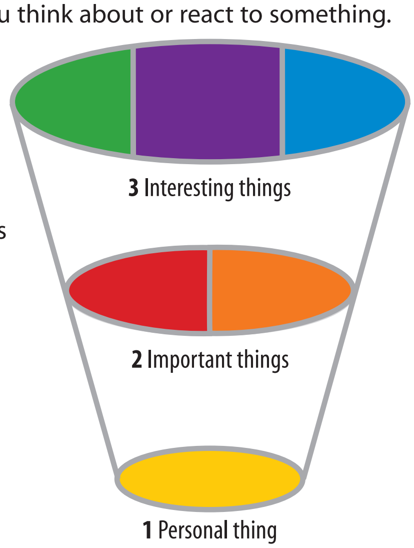
7 Consider each of the belief statements in the mind map below. Rank them from those you agree with the most to those you agree with the least. Explain your ranking. Compare and discuss your ranking with others.



8 In your learning journal, reflect on:
   (a) what you have learned from this chapter
   (b) any parts of the chapter that were of particular relevance to you
   (c) ways in which information in this chapter may have changed how you think about or react to something.

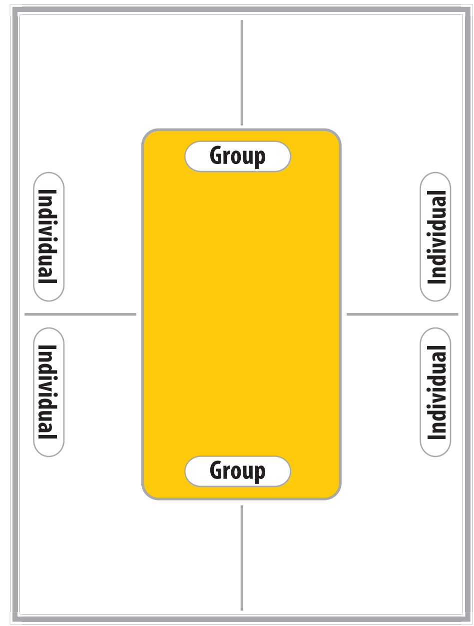
9 Use the 321 tool shown at right to unlock your thinking on:
   - 3 interesting points
   - 2 important points
   - 1 personal point

   for each section in this chapter.



10 Scientific ideas and theories can change over time. Does this mean that those previously accepted were totally wrong? Discuss and explain your response.

11 Use the 'learning placemat' below to show:
   (a) the key points that each team member (groups of four) remembers from this chapter
   (b) a group summary of a discussion about individual learning.



12 Suggest factors that may influence a decision as to whether money should be spent on researching a cure for a particular disease. Provide possible reasons for these factors.

13 Suggest consequences that our increased knowledge of the structure and function of DNA has for both individuals and the society in which we live.

14 Should the labelling of genetically modified foods be compulsory? Justify your response.

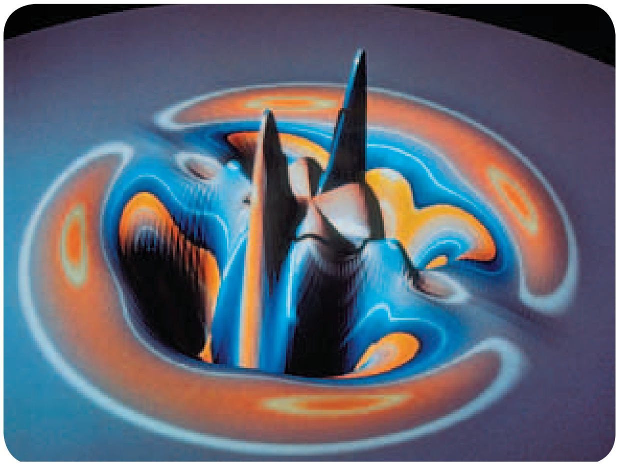
15 Should Australia build nuclear power plants to supply our growing population with the energy supplies we need? Justify your response.

16 With great advances in technology, there have also been disasters. In 1937, the *Hindenburg* — a hydrogen-filled airship — violently exploded while it was docking at a refuelling tower. Find out more about the development of this technology, the cause of the *Hindenburg* explosion and the consequences of this event for subsequent developments in aviation.

17 Carefully read through each of the following statements. For each statement, decide whether you agree or disagree and then justify your response.
   - Scientific discoveries and understanding often rely on developments in technology and technological advances.
   - Financial backing from governments or commercial organisations determines the type of scientific research and development that is carried out.
   - Scientific understanding, models and theories are changed over time through a process of review by the scientific community.
   - The focus of scientific research can be influenced by the current values and needs of society.

- Advances in science and technologies can have a significant effect on people's lives.
- Scientific knowledge should be used to evaluate whether you should accept claims, explanations or predictions.

18 Computer animations, like the simulation shown below involved in studying black holes, have greatly increased our knowledge and improved our understanding of how our world operates. Research other examples of how information technology has been used to enhance our scientific knowledge and understanding.



19 Margaret Burbridge (below) was a British astronomer. She contributed to discoveries about the origin of elements by examining light emitted from galaxies.
  (a) Find out more about her research and contributions.
  (b) Suggest why there are so few women recorded throughout our scientific history.
  (c) Suggest ways in which more women can be encouraged and provided with opportunites to be involved in scientific research, and acknowledged for their involvement and discoveries.

20 Different cultures may hold different views about the world. Ancient civilisations of Egypt, China and Babylon explained the night sky and creation in a way quite different from scientists of today. Australian Indigenous people also hold their own views and understanding. Below are some figures that provide clues as to how these people made sense of their world. Research and report on ways other cultures have developed their knowledge and transmitted it from one generation to the next.

21 Use the **Dreamtime stories**, **Emu in the sky** and **Indigenous stories** weblinks in your eBookPLUS and listen to one of the Dreamtime stories available from the Indigenous Australia page of the Australian Museum. Draw a picture to illustrate the story.

eBook*plus*

The emu, the possum and the Southern Cross

A depiction of a Dreamtime story by artist Michael J. Connolly.
Source: Michael J. Connolly (Mundagutta–Kulliwarri) www.dreamtime.auz.net/

work sheet 1.4 Think quest: Summary