

Science quests

10

We live in a time of great change. The future will present us with many challenges and discoveries — some so exciting and absurd that they may be beyond our wildest hopes and dreams . . .



Think about these

Which ticks faster — a stationary clock or one travelling at high speed in a jet plane?

How many nanometres are there in a metre?

What effect did the H1N1 virus have in 1918?

What's all the fuss about stem cells? Why are they in such demand?

Key outcomes

Describe the scientific base of science-related occupations in the community.

Use relevant scientific concepts and relationships to enable involvement in debates of contentious and/or ethically based science-related issues of broad community concern.

Provide examples of the work of scientists in developing scientific knowledge or solving a scientific problem.

YourQuest

Towards immortality

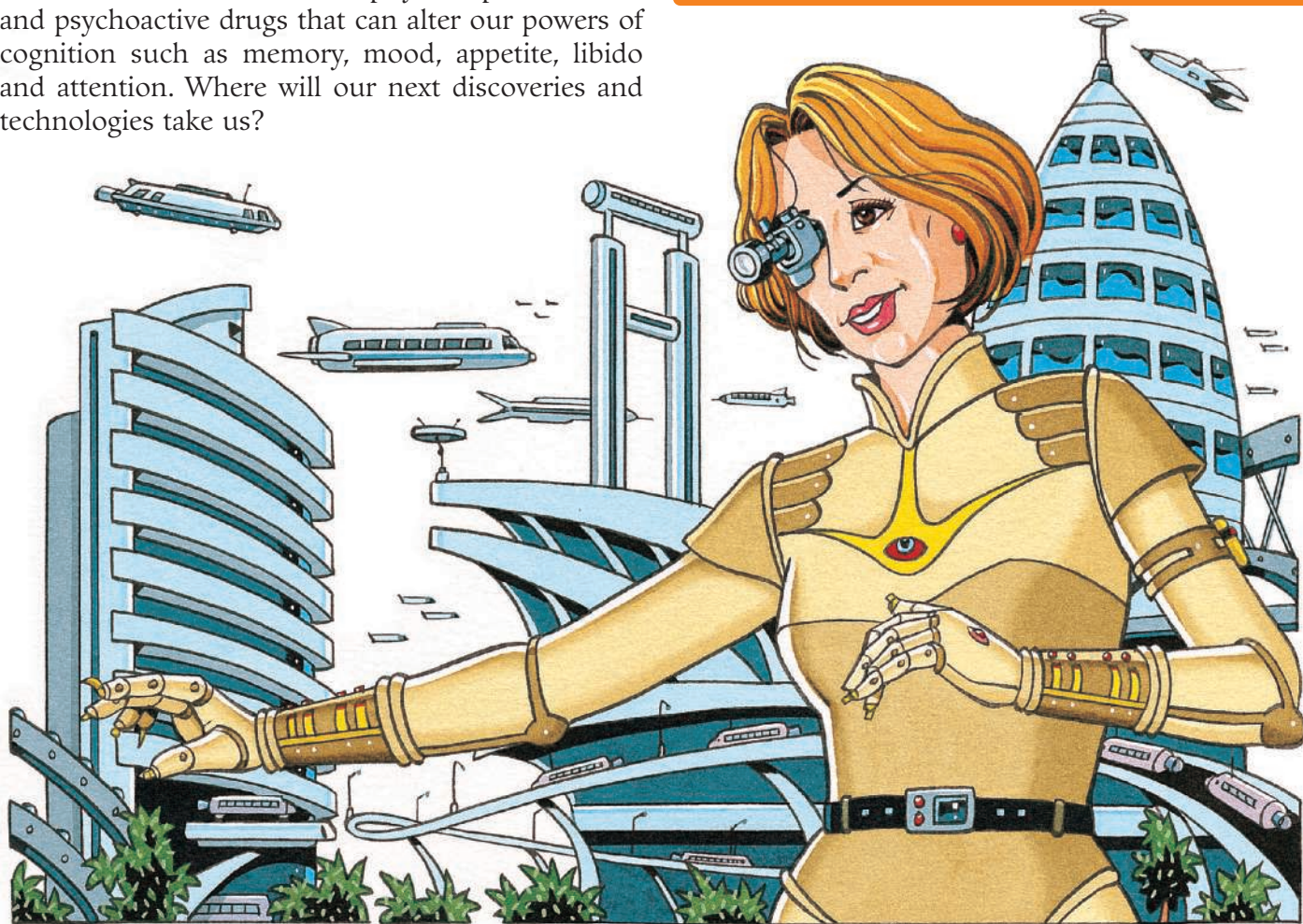
Is artificial evolution of our species possible? DNA technology, drugs and implants for existing or experimental therapies could make this a reality. We can already insert new genes into various parts of the adult human body. In the future, this may also include gametes and embryos. We also have the technology to cut and paste various genetic sequences, not only within the same species, but between species. The ramifications of this are yet to be experienced.

We also have the power to replace body parts with natural organs, mechanical organs or tissues derived from stem cells. We already have drugs such as steroids to enhance physical performance, and psychoactive drugs that can alter our powers of cognition such as memory, mood, appetite, libido and attention. Where will our next discoveries and technologies take us?

try This

Life in 2050

1. Research and make notes on how current scientific research may affect life in the future. Some questions you may wish to consider are: What future technologies and applications will change our lives? How far may our life spans be extended? Will we all be disease-free? Will some people be more entitled to medical services than others? How much of us will remain organic and how much integration with computers and other synthetic materials can occur before we are no longer considered human?
2. (a) Creatively weave your findings from question 1 into a science fiction story about life in 2050.
(b) Design a cover page for your story.
(c) Put together some promotional material for your story and include this on the back cover of your book.
(d) Share your story with your class.



Daring to dream



Why not go on a journey that will take you beyond your wildest dreams?

Creatively critical

A clever scientist realises that science is not just about critical thinking with clarity, accuracy and detail. It is also about thinking flexibly and creatively, with an open mind. Reading, writing or watching science fiction can help unlock your mind's doors to 'take a step outside of reality'. Science fiction can take you to another universe where anything is possible. It provides you with the opportunity to dream and imagine endless possibilities and creations.

Science fiction authors in the past, such as Aldous Huxley (1894–1963) and Arthur C. Clarke (1917–), have had a considerable impact by taking others on a journey beyond their wildest dreams. It is only in our time that some of their dreams are becoming a reality.

In our image?

Mary Shelley's novel *Frankenstein*, in which scientist Victor Frankenstein creates a 'Monster' who eventually turns on and kills Frankenstein and those he loves, has led to a genre of stories in which the 'creation' destroys the 'creator'. The popularity of such a theme has contributed to 'technophobia', or the fear of technological advances. These advances may not be only in robotics, but also in other types of 'creation' such as new chemical compounds

or transgenic organisms produced by genetic manipulation.

Science fiction tells tales of how humans may attempt to 'outdo' nature and are often then confronted by menaces of their own making. The tales also describe how the human spirit, determination and imagination are used to solve and conquer these menaces.

Isaac Asimov has been universally acknowledged as the father of robotics. He has written many stories about the human fear of robots. His story *Evidence* (1946) suggests that a well-programmed robot could not only look human but if programmed with the 'Three Laws of Robotics', it would be more ethical than many politicians.

By using human ova and hormone control, one can grow human flesh and skin over a skeleton of porous silicone plastics . . . The eyes, the hair, the skin, would be really human, not humanoid . . . if you put a positronic brain and such other gadgets . . . inside, you have a humanoid robot.

(From *Evidence* by Isaac Asimov)

In another of Asimov's stories, *The Bicentennial Man* (1976), he deals with the issues of the ethical responsibility that humans have for their 'creations', the relationship between organic and inorganic matter and the futuristic line between living and

non-living. The novel is about a 'humanoid' robot, Andrew, who, unlike other robots, desperately wants to become human. The story begins with him questioning another robot:

'Have you ever thought you would like to be a man?' Andrew asked. The surgeon hesitated a moment, as though the question fitted nowhere in his allotted positronic pathways. 'But I am a robot, sir.'

(From *The Bicentennial Man* by Isaac Asimov)



In Anne McCaffrey and Mercedes Lackey's 1994 novel *The Ship Who Searched*, the benefits of becoming more 'machine' were explored. In this story, a paralyzing alien virus leaves the heroine unable to live without a mechanical support system and she is transformed into a 'shell person' or 'brain ship' to adventure throughout the universe.

No amount of simulator training conveyed what it really felt, to have a living, breathing ship wrapped around you . . . Never mind that her 'skin' was duralloy metal, her 'legs' were engines, her 'arms' the servos she used to maintain herself inside and out . . . That all of her senses were ship's sensors linked through brainstem relays. None of that mattered. She had a body again!

(From *The Ship Who Searched* by Anne McCaffrey & Mercedes Lackey)

New worlds?

It is believed that biotechnology promises the greatest revolution in human history. The commercialisation of molecular biology has occurred with astonishing speed and is considered to be the most stunning ethical event in the history of science.

Since the discovery of DNA, science fiction authors have incorporated the new scientific concepts and used them to create futuristic worlds in which humans are forced to cope with their 'creations'.

Problem-solving was his specialty, and he had been selected for it before birth. Gene analysis had chosen the best DNA chain from his parents' sperm-and-ovum bank. This, and subsequent training, had fitted him perfectly for command.

(From *War with the Robots* by Harry Harrison)

Aldous Huxley's *Brave New World* (1931), Harry Harrison's *War with the Robots* (1962), Michael Crichton's *Jurassic Park* (1991) and Julian May's *Jack the Bodiless* (1992) have all picked up on futuristic genetics.

If this insect has any foreign blood cells, we may be able to extract them and obtain paleo-DNA, the DNA of an extinct creature. We won't know for sure, of course, until we get whatever is in there, replicate it, and test it. That is what we have been doing for five years now. It has been a long, slow process — but it has paid off.

(From *Jurassic Park* by Michael Crichton)

All four of us children inherit from the Remillard side of the family a dominant polygenic mutant complex: we're smart, we have extremely high metafunctions, and our bodies age up to a certain point and then persistently rejuvenate. The traits have a reduced penetrance and exhibit variable expressivity. You know what that means?

(From *Jack the Bodiless* by Julian May)

Of all of these authors, Aldous Huxley gave the most thorough description of the impact that genetic

manipulation may have on our society. The technology in his book *Brave New World* also described a society in which different human castes were 'created', 'produced' and 'brainwashed' to 'happily' meet different needs and services. The following transcript is made by a 'Beta individual'.

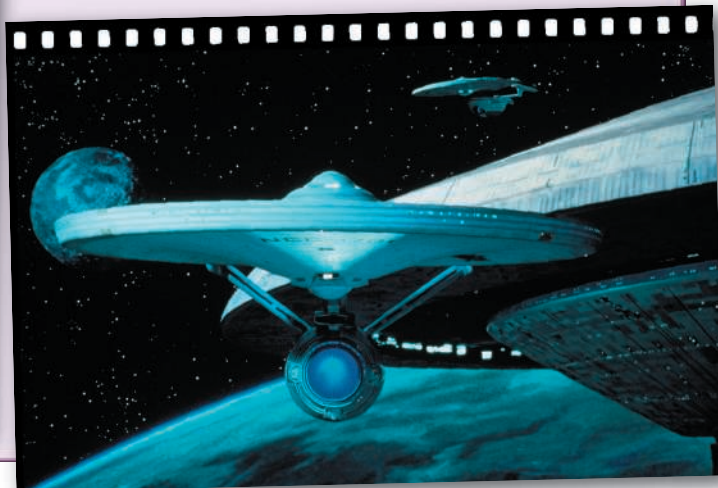
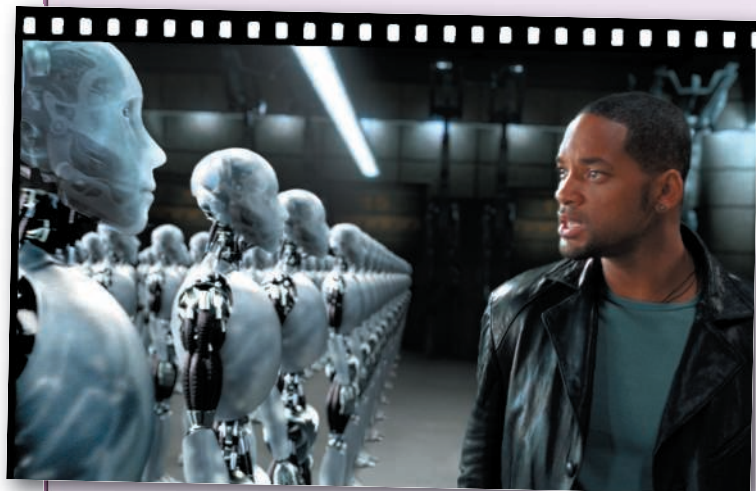
Alpha children wear grey. They work much harder than we do, because they're so frightfully clever. I'm awfully glad I'm a Beta, because I don't work so hard. And then we are much better than the Gammas and Deltas. And Epsilons are still worse. They're too stupid to be able . . .

(From *Brave New World* by Aldous Huxley)

Robert Swanson, a venture capitalist, and Herbert Boyer, a biochemist, formed a commercial company to exploit Boyer's gene-splicing techniques. Their company, Genentech, quickly became the largest and most successful of the genetic engineering start-ups. Since this time, many similar companies have 'sprung up' with the purpose of creating genetically modified organisms that can be utilised for financial gain. What will your future hold? How will the new technologies affect you? And what about your children? That is, of course, if the government allows you to have them!

Now showing

Many of the earlier science fiction stories are being remade as movies, while new science fiction stories continue to inspire and set your synapses firing. Some science fiction movies explore DNA and genetic engineering (e.g. *Gattaca*, *Jurassic Park* and *X-Men*). Other movies take us on journeys through time and space (e.g. *Star Trek*, *The Matrix* and *The Time Machine*). The issues and chaos of disease are expressed in *Outbreak* and *The Andromeda Strain* and the potential dangers of robotics are woven into movies such as *I, Robot* and *2001: A Space Odyssey*.



'Punk' in science fiction?

Films such as *Blade Runner* and the *Matrix* trilogy provide examples of cyberpunk. This form of science fiction is a blend of cybernetics and punk. The term became widespread in the 1980s, especially to describe novels from authors such as William Gibson and Bruce Sterling. Cyberpunk often explores possible 'near-futures' of Earth that resemble dystopia rather than utopia.

In many cyberpunk stories, there is a conflict between computer hackers, artificial intelligence and big corporations. Characters in these stories are often alienated loners, living on the edge of their society. Their lives are ravaged by the negative impacts of advanced technology, with even their own bodies often having undergone some form of invasive modifications. In these possible futures, the advanced technology may be blended with a loss of social order, control and morality.

Over the last few years, offshoots of the cyberpunk genre have resulted in the 'birth' of related genres such as 'biopunk', 'steampunk', and 'postcyberpunk'. In postcyberpunk, it is heartening that there are characters who act to improve social conditions or at least try to prevent their further decay. Will your creative science fiction writing produce another science fiction genre?

He'd operated on an almost permanent adrenaline high, a byproduct of youth and proficiency, jacked into a custom cyberspace deck that projected his disembodied consciousness into the consensual hallucination that was the matrix.

(From *Neuromancer* by William Gibson)

activities

THINK, DISCUSS AND CREATE

- 1 (a) Watch a science fiction movie of your choice. For example: *Gattaca*; *X-Men*; *Star Trek*; *The Time Machine*; *Outbreak*; *I, Robot*; *Frankenstein*; *20 000 Leagues Under the Sea*.
(b) Construct a mind map to summarise what the movie was about.
(c) Construct a PMI where the 'P' lists the 'accurate science' in the movie and the 'M' lists the 'inaccurate, false or misleading science'. Under 'I' list things that you found interesting or inspirational about the movie.
(d) Share your PMI with others, adding any new ideas that you agree with to your PMI.
(e) Suggest changes that you would include if you were to do a remake of the movie.
- 2 On your own or in a team, write your own science fiction story.
(a) To start, think about some science concepts, principles or theories that you think would be good in a story. Research these ideas, so that you can put 'meat on the bones' of your story and so that its science content is not superficial.
(b) Design a cover page for your story that is representative of the plot.
(c) Publish a class magazine that contains contributions from all students.
(d) Read a different class member's story each night and construct a PMI of it.
(e) Provide a copy of the story's PMI to its author, so that they have some feedback.
- 3 Write a short story that leads on from the following: 'I woke up at 2.30 in the afternoon in a hospital bed. Two things were different. My skin had been peeled off my left arm exposing electronic circuitry and my right foot was missing.'

THINK

- 4 Suggest fears that people may have about future robots, computers, chemicals or genetically engineered organisms.
- 5 Will computers become more intelligent than human beings? What implications may this have?
- 6 What is artificial intelligence?
- 7 'Nature never appeals to intelligence until habit and instinct are useless. There is no intelligence where there is no change and no need of change.' Discuss what you think H. G. Wells meant by this in his novel *The Time Machine*.

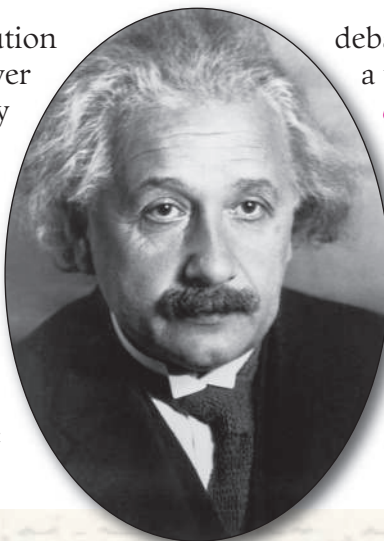
INVESTIGATE

- 8 Read and comment on the social implications of any of the novels described on these pages.
- 9 What are the rules for the modern robot? Security, safety and sex are considered the big concerns. As robots will be entering homes and workplaces, the need for strict guidelines is hugely important. The presence of armed robotic spy planes and animatronic sex dolls already on the market raises questions about whether and how their use should be regulated. Discuss this with your team and construct a robot rule book.
- 10 Find out more about the International Human Genome Project, genetic engineering, robotics or other technologies by going to the website for this book and clicking on the Future Technologies links (see 'Weblinks', page 305).
- 11 How important do you think science fiction is in addressing issues that may affect humanity in the future? Can it help us deal with the ethical dilemmas we may face with increasing progress in biotechnology, genetic modification and computing? If you believe that science fiction authors should not be the ones addressing these concerns for us, who should?

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

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.



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

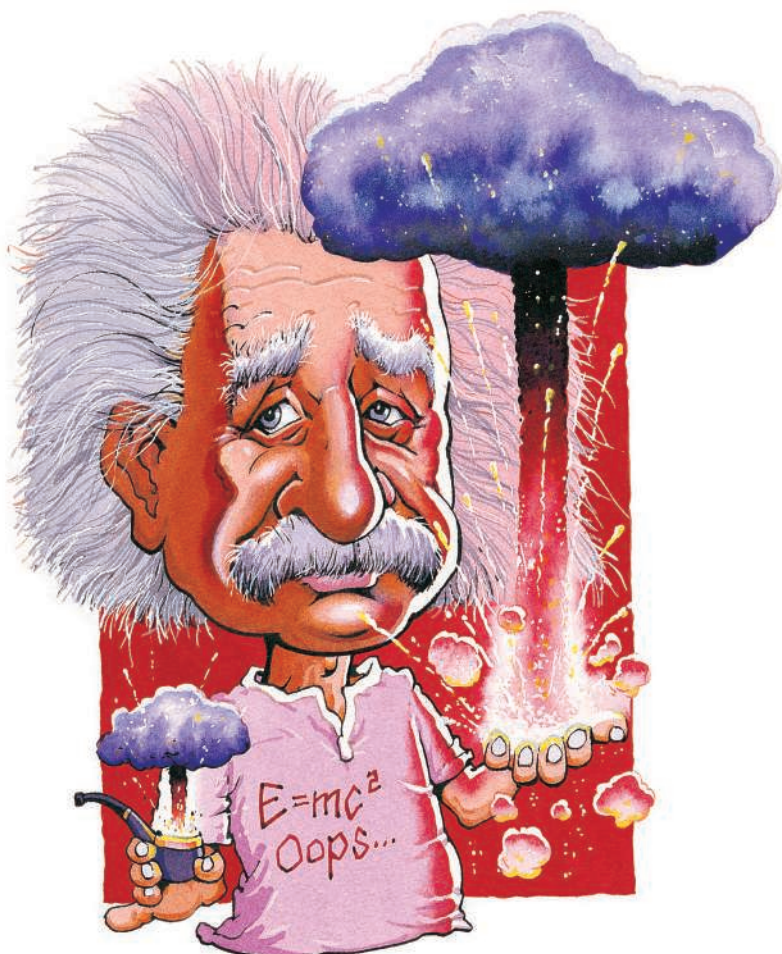
Einstein's 1939 letter to President Roosevelt

view. Special relativity stated that an atomic clock travelling at high speed in 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, see page 19).

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.

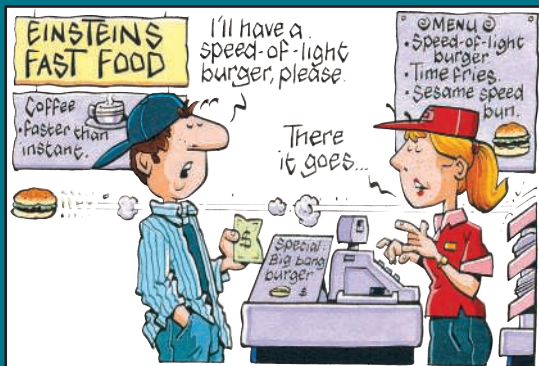


An image of Einstein — is this how he would have liked to have been remembered?

activities

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 Find out more about Einstein by going to the website for this book and clicking on the Einstein links (see 'Weblinks', page 305). Then create your own Einstein web page.
- 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 that he lived in. Present your findings in an annotated timeline. Where possible, include images, pictures and photos.
- 5 Search the Internet for images of Einstein on t-shirts. Select five designs and construct a PMI on them.
- 6 Reflect on Einstein's quote 'Imagination is more important than knowledge'. What is your opinion on this quote, in terms of science?

Science at work: Nano news

When we are talking about nanotechnology, we need to think in nanometres. A nanometre is one billionth of a metre — $1/1000\,000\,000^{\text{th}}$ of a metre. To understand nanotechnology and nanoscience, you need to learn to think small — very small.

While nanotechnology is about the very small, its implications and potential applications are enormous. With the development of this technology comes not only super-smart and super-strong materials and medicines, but also the possibility of creating other technologies that are not currently feasible for mainstream production.

Sun smart

Due to the current cost of solar cells, extensive use of solar energy is not economical. Nanotechnology has the potential to manufacture solar cells inexpensively, making the move to solar power more feasible. Will cities of the future be powered by the sun?

Nanobots

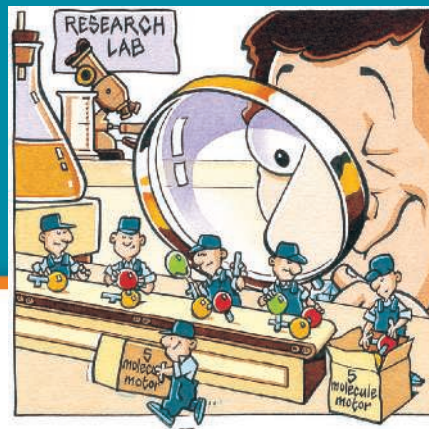
Some suggest that in the future, nanomedicine may bring about the eradication of disease! This major accomplishment would require combining nanotechnology with biotechnology.

Nanotechnology may make possible the creation and use of materials and devices working at the level of molecules and atoms. Imagine minuscule machinery that could be injected to perform surgery on your cells from the

inside. They could be programmed to seek out and destroy invaders such as bacteria, protozoans or viruses or even cancerous cells. Heart attacks due to the blockage of your arteries may also be a thing of the past. These nanobots may be able to cruise through your bloodstream to clear plaque from your artery walls before it has a chance to build up. Could these nanobots also be programmed to stop us from growing old?

Cell upgrade

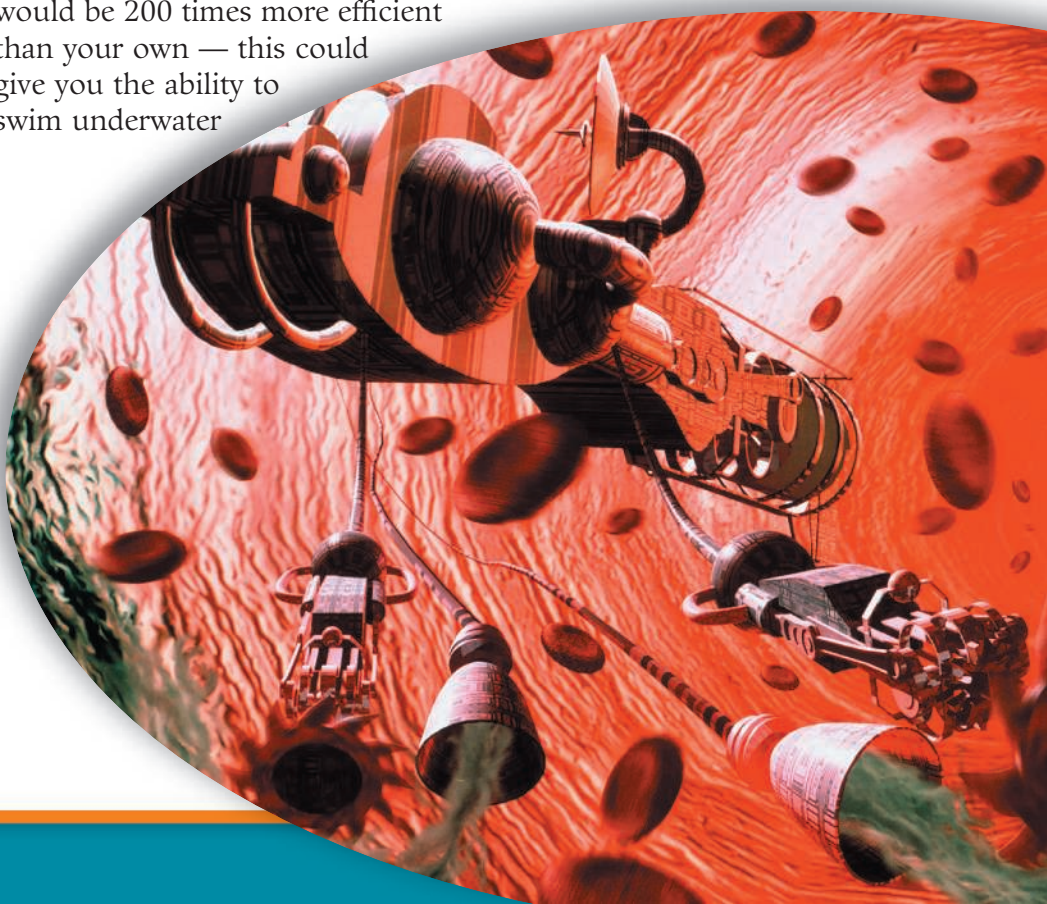
Scientists have already designed an artificial red blood cell. This tiny machine carries stores of oxygen and carbon dioxide and has sensors that detect levels of these gases so that they can release or absorb the gases as required. These artificial cells would be 200 times more efficient than your own — this could give you the ability to swim underwater



without breathing for several hours or not take a breath in a 15 minute sprint!

Delving deeper

Tiny human-made **nanoparticles** (about 0.1–100 nanometres) are small enough to pass through a cell membrane. They are currently being developed to deliver drugs directly to cancer cells. The basic structure of nanoparticles is called a **dendrimer**. Attached to these cancer fighting dendrimers are methotrexate, folic acid and a fluorescent stain. Methotrexate is a drug that kills the cancer cells and the fluorescent stain allows monitoring of the process. Folic



acid acts as the 'bait' to attract the cancer cells. This vitamin is essential in cell reproduction and, as cancer cells are actively multiplying, they have a high need for it. When they accept the nanoparticle, the methotrexate poisons the cell, killing it. These dendrimers are then removed from the bloodstream as they pass through the kidneys.

Nanoscaffolds

The implantation of nanoscale scaffolds to encourage nerve tissue to regrow may bring hope to people with optic nerve damage. Your optic nerve connects your eye to your brain. It can be severed by traumatic injuries (e.g. in a car crash) or damaged by glaucoma which is caused by excessive pressure in your eyeball. This can result in loss of vision. By using these nanoscaffolds like garden trellis, they encourage the growing axons of optic nerve cells to bridge gaps that would otherwise exist and to reconnect.

Nanofactories

What will future production factories look like? Imagine millions of tiny robots working together on an invisible, submicroscopic production line. Not only could they assemble almost anything and do it atom by atom, but they could also be programmed to make more of themselves! If you have watched *Star Trek*, maybe this is the technology that they use to generate their clothing and food supplies. Is this yet another example of fiction becoming fact?

Smart stuff

How about wearing clothing that literally reflects your mood? Or how about your wallpaper or lighting changing colour with mood changes or programming? Intelligent fibres, interactive textiles and smart fabrics that have been created with nanotechnology may change colour in a flash.

What if 'one size fits all' really was the case? Imagine shoes that instantly changed shape to mould perfectly around your feet and clothing that changed texture or shape to match your environmental conditions.

Imagine the effects of paint that has 'musical' nanomachines mixed into it. After putting this paint onto your walls or furniture, you could program it to produce music, tones or vibrations to suit your moods.

Tiny but tough

Imagine a car, train or plane made of diamond and just as strong as current models but 50 times lighter. Nanotechnology may be used to rearrange carbon atoms into an inexpensive workable diamond material. This may lead to the production of a car so light that you could pick it up and carry it!

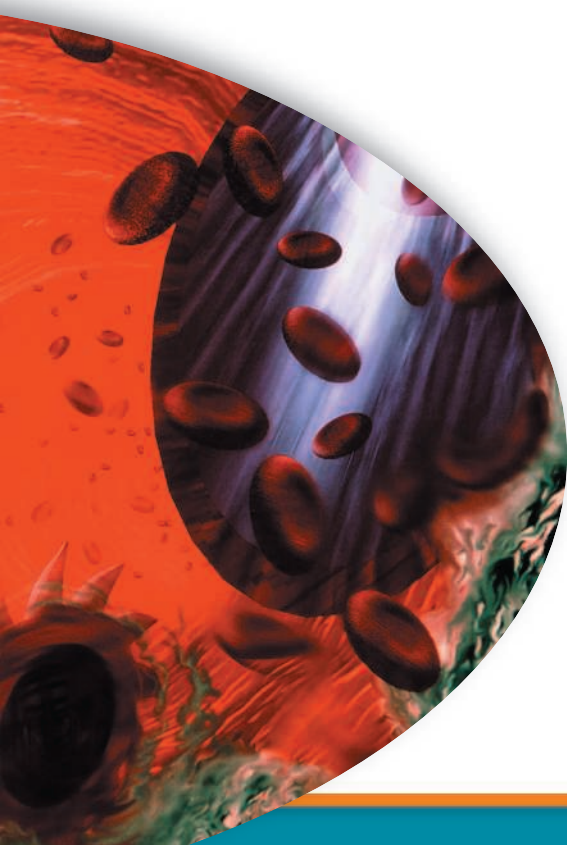
No boundaries?

While some see nanotechnology as the technological saviour of the twenty-first century, others see its dark side and are watching warily. Nanotechnology operates at the scale of atoms and molecules. It is fundamentally different from current technologies in that it builds from the bottom up. The underlying principle of nanotechnology is both disturbing and mesmerising — if you can control and rearrange atoms, you can literally create anything! What are our boundaries and responsibilities, or don't we want any?

activities

INVESTIGATE, SHARE AND DISCUSS

- 1 Find out more about the research of Eric Drexler, his book *Engines of Creation* and intelligent nanomaterials.
- 2 (a) Research a possible application of nanotechnology that interests you, including its implications. Possible topics include:
 - spacesuits
 - clothing
 - medicines e.g. drug delivery, biosensors, bioresorbable materials
 - cosmetics e.g. anti-aging, skin care
 - artificial cells or body parts
 - aeroplanes or spacecraft
 - nanobots
 - nanomachinery
 - nanofactories
 - nanodevices
 - nanomaterials e.g. quantum dots, dendrimers, nanotubes, fullerenes.(b) Share and discuss your findings with other members of your team. Construct a PMI to summarise your discussion.
(c) Create a science fiction story that incorporates your findings. Share your story with the class.



Science at work:

Visualising viruses

The race is on

We are in a time of biological revolution. Every day, more secrets are unlocked and, with each discovery, more questions are generated. One of the current races for scientists is to unlock the mysteries of the viruses that are a current or potential threat to members of our species, or species that are important to us.

One such 'treasure hunt' is to find out more about the avian flu virus H5N1. In 1918, more than 40 million people died as a result of infection with H1N1, a variation of this virus. The potential threat of the H5N1 virus mutating with a human flu virus has caused great concern and some panic. There is a rush to find out as

much as we can, so that we may use this knowledge to help us in any future battles.

Making models

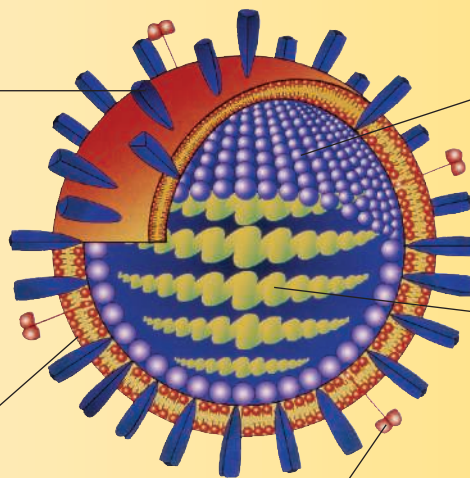
Scientists often use models to help them visualise the features of their studies. They may even add colour to different parts to emphasise its features or chemical composition. These models can be representations of the types and arrangements of atoms or molecules in a virus. Aside from helping scientists visualise their shapes, models also enable them to predict how viruses may interact with other molecules. This may provide clues as to what we can do or create to protect us from 'attack'.

Spreading viruses

The way that viruses spread is specific to the type of virus. They can be spread through the air, transfer of body fluids, and organisms such as mosquitoes and fleas. The mode of transmission can have a considerable impact on the number of people that a virus may infect. When a disease spreads very quickly through a large number of people in a particular area, it is called an **epidemic**. When this occurs worldwide, it is called a **pandemic**. With increased air travel and global intermingling of people, the likelihood of pandemics is increased. Although the H5N1 virus has recently made headlines, other viruses

Neuraminidase, the N in H5N1, is the second main surface protein, and the other main target for the immune system. Neuraminidase is involved in helping the new viruses to bud off from cells. By inhibiting the action of neuraminidase, chemicals such as Tamiflu can reduce the severity and spread of these viral infections.

The **lipid envelope** is picked up from the infected cell as a new virus buds off.



The **M1 matrix protein** helps put new viral RNAs together and transport them to the cell membrane, where a new virus is formed.

RNA carries the instructions for making new viruses. The RNA strands come packaged along with the enzymes needed to make more copies of the RNA.

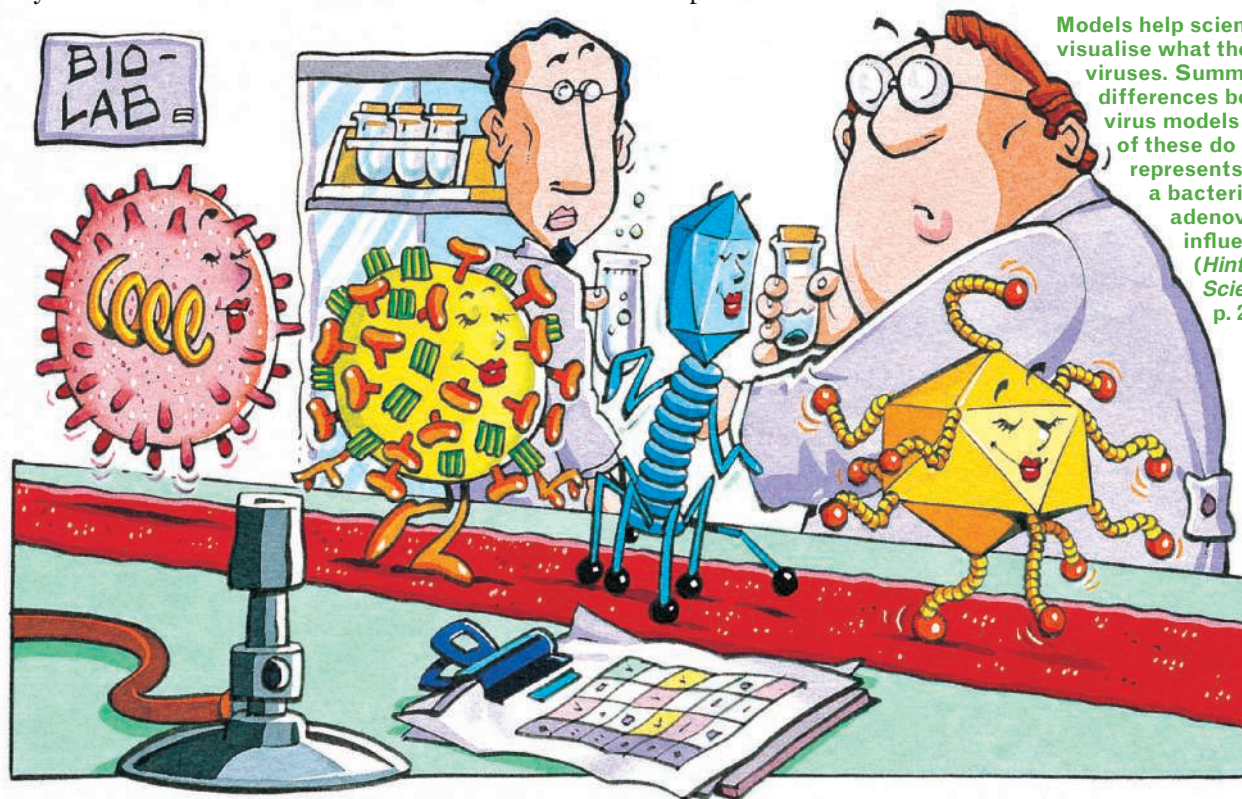
Haemagglutinin, the H in H5N1, is one of the two main surface proteins and is a key target for our immune systems. It is responsible for binding the virus to the cell that is being infected. The H protein in H5N1 has a mutation that allows it to bind to both human and bird cells.

such as smallpox, SARS and HIV are lurking with dangerous potential.

Viruses are often more difficult to treat than bacteria because they live in the cells of the host

they infect. This makes it difficult to kill the virus without killing the cell. One of the most effective methods for treating viruses has been the use of vaccination. Vaccination helps to build the

body's immune system to defend itself against the virus. Antibiotics which may be effective against many bacterial infections are useless against viruses.



Models help scientists to visualise what they know about viruses. Summarise some differences between the virus models shown. Which of these do you think represents a H5N1 virus, a bacteriophage, an adenovirus and an influenza virus? (Hint: Refer to Science Quest 1 p. 232.)

activities

INVESTIGATE, SHARE AND DISCUSS

- 1 Find out more about the research on H5N1 and how it may be applied in the future.
- 2 The success of the flu virus is due to tricks that it has evolved to dodge or hijack the defence mechanisms of the cells it invades. Find out examples of how it achieves this.
- 3 (a) What is a pandemic?
(b) How is it different from an epidemic?
(c) Find out more about two pandemics in human history and write up your findings as a news report, diary entry, web page or PowerPoint presentation.
- 4 (a) What is known about the structure of the Human Immunodeficiency Virus (HIV) that causes AIDS?
(b) How may some of this information be used in the future?
- 5 (a) Select a virus that is responsible for a human disease and find out what is known about its structure.
(b) Make a model of the virus. Use labels to provide details of the different parts, describing what they are and what they do.
- 6 Virologists are involved in the study of viruses. Find out more about what these scientists do. Write a science fiction story that includes a virologist as the key character.
- 7 Australian scientists Sir Gustav Nossal and Professor Peter Doherty have made significant contributions to science. Find out more about their work and how it relates to the study of viruses.
- 8 Find out why we currently have no vaccine for the common cold. Comment on whether you think there may be one in the future. Discuss this with your team.
- 9 Suggest dangers that are associated with the study of viruses. Do you think that research on viruses should be allowed? Give reasons for your opinion.
- 10 What are the differences between viruses, viroids and prions? Give examples of a disease that can be caused by each.
- 11 Some viruses have been linked with biological warfare. Find out three of these and outline the threats that they pose. Research current regulations and efforts to reduce the threat of biological warfare.

Science at work:

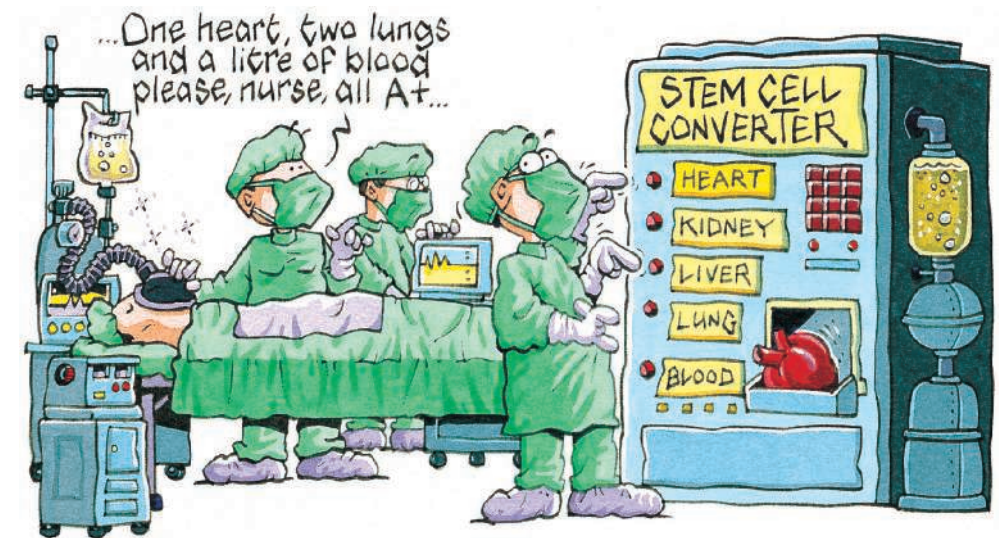
Stem wars

What's the stem of the trouble? What are stem cells and why are people arguing about them?

Why are they important?

Stem cells are important because they are so versatile. They have the ability to differentiate into many different and specialised cell types. They may differentiate into blood cells, bone cells, heart cells, liver cells, nerve cells or skin cells. This ability makes them invaluable in the treatment and possible cure of a variety of diseases where they may replace faulty, diseased or dead cells.

Stem cells can be divided into categories based on their ability to produce different cell types:

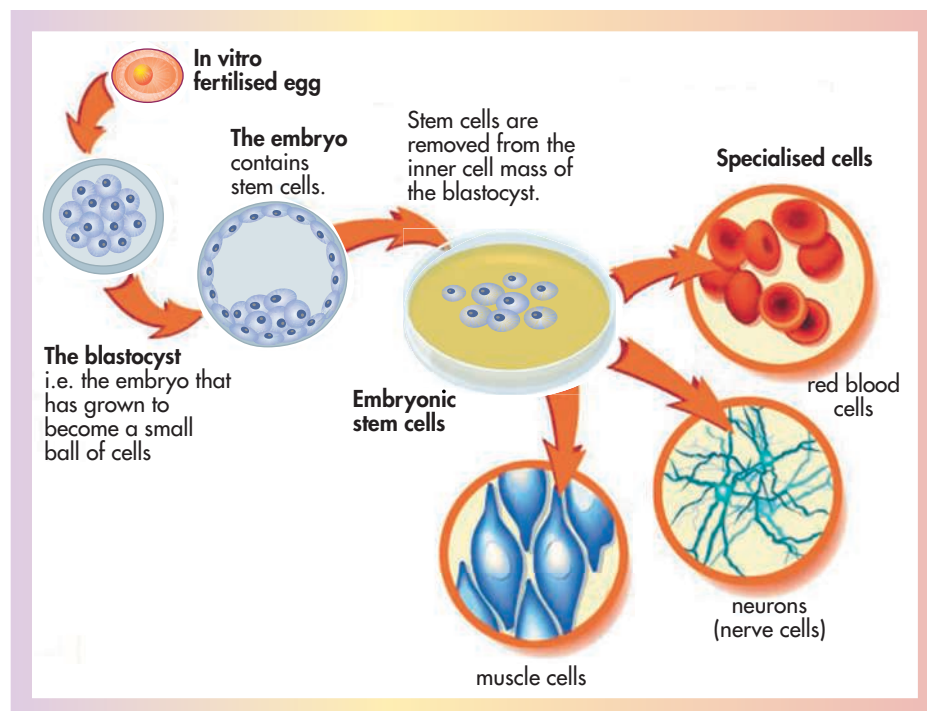


- **totipotent stem cells** are the most powerful as they can give rise to all cell types
- **pluripotent stem cells** can give rise to most cell types (e.g. blood cells, skin cells and liver cells)

- **multipotent stem cells** can give rise to only certain cell types (e.g. various types of blood or skin cells).

Stem cell sources

Stem cells can be described as being **embryonic stem cells** or **somatic stem cells**. Embryonic stem cells are pluripotent and can be obtained from the inner cell mass of a blastocyst (the mass of cells formed at an early stage of an embryo's development). Somatic stem cells are multipotent and can be obtained from bone marrow, skin and umbilical cord blood.



Embryonic stem cells are removed from the blastocyst and cultured to produce different cell types.

sciFacts

In 1998, it was reported that a researcher from the University of Wisconsin had found a way to isolate cells from the inner mass of an early human embryo and develop the first embryonic stem cell lines. The stem cell issue had entered the public arena.

So what's the problem?

The source of embryonic stem cells raises many ethical issues. Embryonic stem cells can be taken from spare human embryos that are left over from fertility treatments or from embryos that have been cloned in the laboratory. Some say that this artificial creation of an embryo solely for the purpose of obtaining stem cells is unethical. There has also been concern about the fate of the embryo. In the process of obtaining stem cells, the embryo is destroyed.

Discovery offers hope on cancer

Melbourne researchers have taken a giant step towards understanding the genesis of breast cancer by inducing female mice to grow new mammary glands from stem cells.

The Age, 5 January 2006

New way of growing stem cells cuts risk of viruses

A Sydney scientist says he has developed a new way to grow embryonic stem cells without using tissues from dead animals — a technique that could speed the approval of stem cell therapies for humans.

Sydney Morning Herald, 23 January 2006

Embryonic cell research is not needed

The present system has already allowed great medical advances.

The Age, 30 September 2005

Some parents have decided to have another child for the sole purpose of being able to provide a diseased or ill child with stem cells. In this case, the blood from the umbilical cord or placenta is used as a source of stem cells. Some suggest that this is not the 'right' reason to have a child and that they should not be considered as a factory for spare parts for their siblings.

Push for 'free' vote on stem cells

Pressure is mounting in Howard Government ranks for a conscience vote on stem cell and cloning legislation ...

The Age, 23 March 2006

Open minds are crucial in the debate on stem cell research

Politicians who decide on issues involving complex science need to be thoroughly briefed ...

Sydney Morning Herald, 24 March 2006

We must move ahead on stem cells

To maintain its world-leading reputation, Australia needs to change the law to allow the therapeutic cloning of cells.

The Age, 30 September 2005

activities

INVESTIGATE, SHARE AND DISCUSS

1 Investigate some of the following questions.

- (a) Which inherited genetic diseases are potentially treatable with stem cells?
- (b) How many different kinds of adult stem cells exist and in which tissues can they be found?
- (c) Why have the adult stem cells remained undifferentiated?
- (d) What are the factors that stimulate adult stem cells to move to sites of injury or damage?

2 View an animation about stem cells by going to the website for this book and clicking on the Genetic Science Learning Center link (see 'Weblinks', page 305). Use these ideas to construct your own story, cartoon, PowerPoint presentation or animation on stem cells.

3 In your team, discuss the following questions to suggest a variety of perspectives.

- (a) Is it morally acceptable to produce and/or use living human embryos to obtain stem cells?

- (b) Each stem cell line comes from a single embryo. A single cell line allows hundreds of researchers to work on stem cells. Suggest and discuss the advantages and disadvantages of this.
- (c) If the use of human multipotent stem cells provides the ability to heal humans without having to kill another, how can this technology be bad?
- (d) Parents of a child with a genetic disease plan a sibling whose cells can be used to help the diseased child. Is it wrong for them to have another child for this reason?

4 Find out how stem cell research is regulated in Australia and one other country. What are the similarities and differences of the regulations? Discuss the implications of this with your team mates.

5 Research aspects of stem cell research and put together an argument for or against the research and its applications. Find a class member with the opposing view and present your key points to each other. Ask questions to probe any statements that you do not understand or would like to clarify. Construct a PMI to summarise your discussion.

Science at work:

Spare parts

Grow it back!

Want to grow back some missing body parts or create spares? Researchers are racing to create skin, cartilage, heart valves, breasts, ears and other body tissues in tissue-engineering laboratories. Some burns victims have had uninjured skin shaved off their bodies and grown in laboratories and others have had 'pre-grown' skin grafted onto their bodies.

One method used to grow new tissues involves the injection of synthetic proteins that induce tissue to grow and change. These proteins give messages, depending on the combination, to make more fat or bone. Using these methods, 'spare parts' could be

grown on-site, or elsewhere and transferred later. Some would need surgery for shaping, others would grow using scaffolding (such as freeze-dried joints or cartilage) to give shape.

Imagine a future in which injection of growth proteins into the areas where a person is missing a body part would enable bone, joints, fat, tissue, nerves and blood vessels to grow. Imagine being able to grow an ear, joint, nose or finger for immediate use or as a spare!

Mix 'n' match

Transgenic organisms result from combining the genetic information of two different organisms. Genetic information from Arctic fish has

been added to tomatoes to make them frost resistant, and genetic information from a bacterium has been added to cotton and potatoes to give them resistance against certain insect pests. Do these altered organisms belong to the same species as those that are not altered? What other changes may result from these new DNA additions?



RADICAL BID TO GROW NEW BONE STEM CELL THERAPY A WORLD FIRST

Michelle Pountney
Health reporter, 6 April 2006

A MELBOURNE man is the first person in the world whose own stem cells are being used to try to mend a broken leg.

The cutting-edge stem-cell technology has helped Jamie Stevens, 21, back on his feet.

A motorcycle crash nine months ago left him with a severely broken left thigh bone. Part of the femur stuck through his leg, and other parts of the bone were missing.

The bone failed to heal and Mr Stevens' leg was held together by a large titanium plate.

Royal Melbourne Hospital orthopedics director Richard de Steiger decided Mr Stevens was the ideal first patient for a revolutionary stem-cell trial at the hospital.

About seven weeks ago, Mr de Steiger harvested bone marrow from Mr Stevens' pelvis.

The adult stem cells were then separated from the other cells.

A sub-group of stem cells called mesenchymal precursor cells — those that can transform into tissues including bone cartilage and heart — were isolated and grown.

Last week about 30 million of these cells were implanted into the 5cm x 3cm hole in Mr Stevens' thigh bone.

The cells are expected to regenerate new bone and grow through the calcium phosphate.

Yesterday, just four days after surgery, Mr Stevens went home.

'It's good to be part of something that is on the brink,' he said. 'I wouldn't say I understand it. It's all pretty cool.'

It will be three to four months before the result of the operation is known.

'This is radical and the first procedure in the world to use a patient's own stem cells and make them turn into bone-forming cells that are the patient's own cells, to stimulate healing of a fracture,' Mr de Steiger said.

The cells are harvested, cultured and expanded using Australian biotechnology company Mesoblast's specialist adult stem-cell technology.

Mr de Steiger hopes that eventually the technique will be refined to a simple injection, avoiding further surgery.

Using a patient's own cells avoids the potential problem of the body's rejection of foreign cells.

The only other alternative to repair Mr Stevens' leg would have been a painful bone graft, taking a chunk of bone from his hip and plugging it into the hole in his thigh.

'The conventional way used over many years involves a large incision at the pelvis and taking out quite a large amount of bone in Jamie's case,' Mr de Steiger said.

'In this situation there is the risk of a separate incision, reported continuing pain from that incision, and separate infection risk at that site.'

Mr de Steiger said orthopedic specialists at the Royal Melbourne hospital treated about 200 fractures of the long leg bones each year.

About 19 per cent become 'non-union' fractures that fail to heal; 10 of these patients will be recruited to be part of the year-long trial.

Mr Stevens said he was no more nervous about being the first patient in the world to have the procedure than he would have been having a graft.

'I think the benefit outweighs the old procedure, and being able to avoid having a big chunk of bone taken out of the hip . . . the recovery period of it was a lot quicker.'

After living in limbo for nine months, Mr Stevens said he was looking forward to resuming the life he enjoyed before his accident.

If there are too many arguments about using someone else's stem cells, why not grow your own to mend, replace and renew?

Recently, the Genetic Manipulation Advisory Committee (GMAC) approved the release of more than 500 transgenic tomato plants into Queensland and Victoria. A gene has been added to these tomatoes so that caterpillars, which would normally eat the tomatoes, are killed. It is hoped that this addition will reduce the amount of pesticide that needs to be used.

CSIRO scientists have also modified potatoes by switching off the gene that causes cut or bruised potatoes to go brown. They have achieved this by copying the gene, reversing it and then replacing it in the potato plant. This technology could also be applied to other fruit and vegetables.

Cloning around

Genetic engineering techniques enable the DNA in organisms to be altered so they can produce

proteins and medicines that humans need. These techniques can also produce organs with minimal possibility of rejection for transplants. Cows have been genetically altered to produce more milk or leaner meat, and bacteria have had human genetic information added to them so that they produce insulin for diabetics and blood clotting factors for haemophiliacs. Cloning can then be used to produce these altered organisms in large numbers.

For all of its advantages, cloning may be considered a form of asexual reproduction because it does not involve the fusion of two cells. Although it may enable the production of large numbers of 'identical' offspring, their similarities may lead to a decrease in biodiversity and reduce their genetic survival if they are exposed to unfavourable circumstances.

The impact of the environment on the cloned individuals also needs to be considered, as genetic inheritance is not the sole determining factor in the phenotype of an organism.

sciFacts

Sticky stuff?

Scientists at CSIRO are studying Australian frogs and their ability to produce a sticky glue-like substance. These frogs, from the genus *Notaden*, produce this substance as a protective measure against predators.

The CSIRO scientists want to mimic the design of this glue so that they can produce a medical adhesive that could be used to repair damaged cartilage, close up wounds and to bond cartilage, tendons and bone. Could their research also provide us with a substance to help us to stick in our replacement spare parts?

activities

THINK AND DISCUSS

- 1 If cloning takes over as the main form of human reproduction, sperm and eggs would no longer be essential.
 - (a) Suggest advantages and disadvantages of this. Give reasons for your suggestions.
 - (b) If 100 clones were made of a single individual, would they all look and act the same? Explain your answer.
 - (c) Suggest the evolutionary consequence that this may have on the human race.
- 2 Should human DNA be inserted into the DNA of other organisms? Give reasons for your opinion.
- 3 Suggest improvements to the human design. List both advantages and disadvantages to these improvements.
- 4 Would you eat genetically modified food? Find out published arguments for and against this issue. Once researched, decide on your viewpoint and present your arguments in a class debate on the issue.

INVESTIGATE

- 5 Find out about the relationship between cloning and biotechnology.
- 6 For one of the following transgenic organisms: tomatoes, potatoes, pigs, cows, fish, tobacco, cotton or

bacteria, find out the following and present your findings in a report and as a class presentation:

- (a) how and why they were 'made'
- (b) any biological, social, economic or ethical issues that may result from the change to the organism
- (c) your own comments on what you think and feel about these changes

7 Debate issues related to:

- (a) the development of transgenic organisms
- (b) the cloning of human tissues and organs.

8 Find out the requirements for space travel. Suggest how a human could be genetically engineered to be well suited to travelling in space.

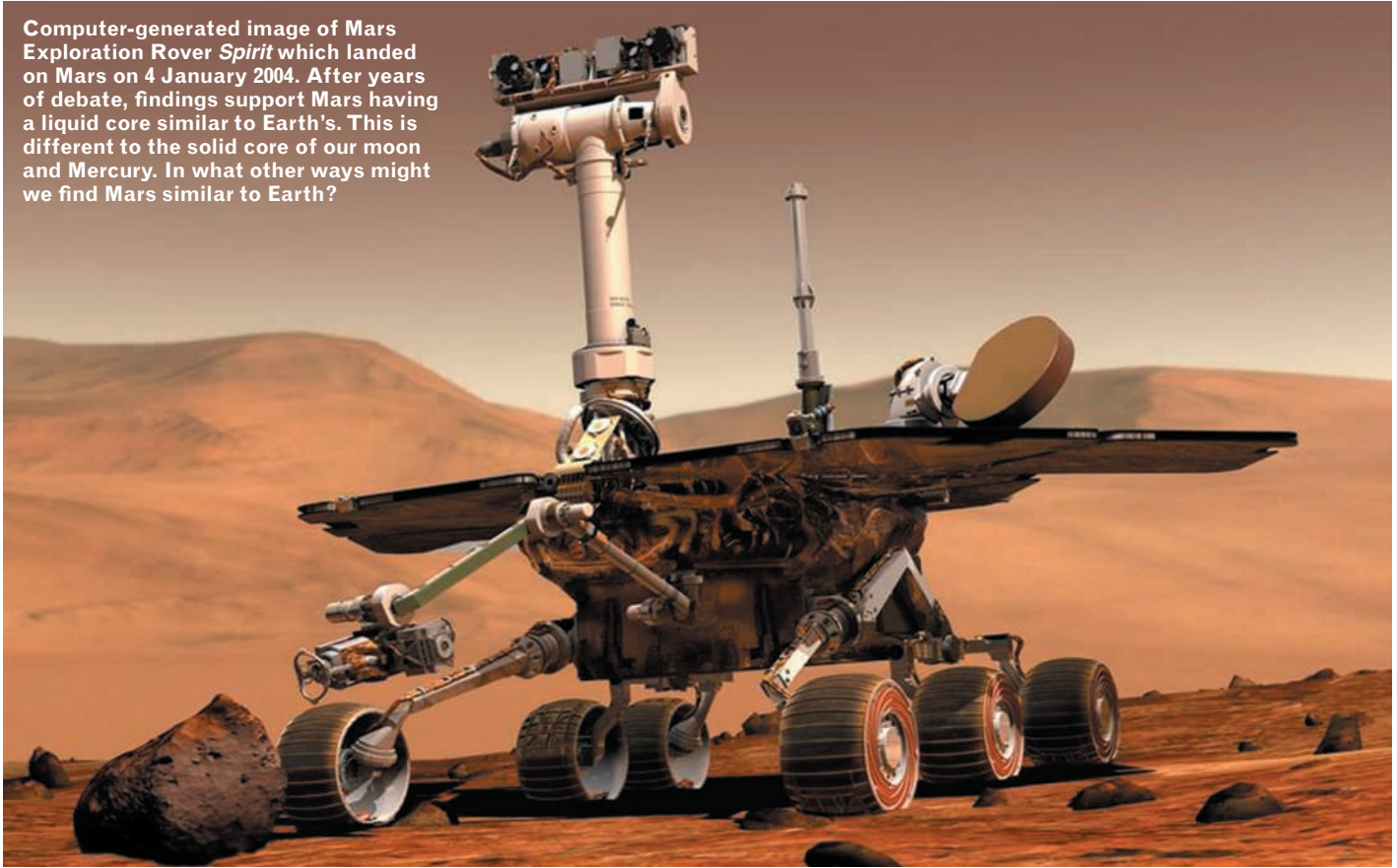
IMAGINE

- 9 Design a futuristic human. Give reasons for your changes to the original human design and present your information in a poster.
- 10 Imagine you are living in the future and your partner has asked you to have his children. You think that this is wonderful until you realise that he means his clones. What would you say?
- 11 Imagine that you have just woken up in a laboratory and have been told that you are a clone. Write a story about your life.

Science at work:

Space trekking

Computer-generated image of Mars Exploration Rover *Spirit* which landed on Mars on 4 January 2004. After years of debate, findings support Mars having a liquid core similar to Earth's. This is different to the solid core of our moon and Mercury. In what other ways might we find Mars similar to Earth?



H. G. Wells (1866–1946) was an extraordinarily powerful and imaginative storyteller. *The Time Machine* (1895), *The Island of Dr Moreau* (1896), *The Invisible Man* (1897), *The War of the Worlds* (1898) and the *The First Men in the Moon* (1901) are some of his powerfully imaginative stories. H. G. Wells had his own ideas on what life on Mars would look like and he incorporated these into his writings.

No life has yet been discovered on Mars. This does not mean that it does not or has not existed. In 1997, new technologies enabled a data collecting mission to begin to send large amounts of information back to Earth on what Mars is really like — and if creatures similar to those from H. G. Wells's imagination really do glide across its surface!

The red planet

Throughout history, sky watchers have observed the bright red dot in the sky. Some believed that it carried

war or pestilence or, for some cultures, even the need for human sacrifice. Maybe as a consequence of this, the Romans named Mars after their god of war. Other observers theorised that Mars held intelligent life, which had created canals to channel water to cities. H. G. Wells's *The War of the Worlds*, in which the Martians attack the Earth, and Tim Burton's 1996 comedy *Mars Attacks* are two stories that utilise imagination and the science of their times.

Almost 30 Earth missions have failed to get to Mars, the next planet beyond Earth. In 1965, *Mariner 4* made the first successful attempt when it flew within 10 000 kilometres of Mars, transmitted back photographs of Martian meteor craters and revealed that the planet did not have a measurable magnetic field. About seven years later, the first soft landing was made by the Soviet probe *Mars 3*. This landing allowed the first television pictures to be sent from the surface of the red planet.

Spectacular 3-D colour images of the Martian surface were taken by the European Space Agency's probe *Mars Express* in 2004. These images showed gullies that appear to have been carved by water. Also in 2004, NASA landed two rovers, *Spirit* and *Opportunity*, on the Martian surface with the task of examining the chemical composition of rocks. In 2006, these rovers are still exploring the frigid wasteland of Mars. Already they have survived seven times longer and driven 10 times further than they were designed for. But the rovers may be in for some stiff competition in the future — space scientists are increasingly considering using balloons to explore planets, especially those with hostile environments like Mars.

Move over 'red rover'

If we ever make it to Mars ourselves, we will need to come up with new strategies and technologies to survive the Martian environment. We will need to be able to leave our spacecraft and 'land vehicles'. Specially designed spacesuits will need to provide us with a personal environment that supplies our nutrients and recycles our wastes, protects us from the outside and enables us to do what we want or need to do.

Australian aerospace engineers are involved in the development of these futuristic Martian spacesuits such as *MarsSkin* and mechanical counter pressure (MCP) suits. *MarsSkin* suits are tight and elastic and contain an inner layer of lycra microfibres that transports heat and moisture away from the body



sciFacts

Astronauts have not been sent to Mars because the problem of extended periods of weightlessness on the human body has not been resolved. Bone density drops after three months and currently cannot be restored, causing future health problems.

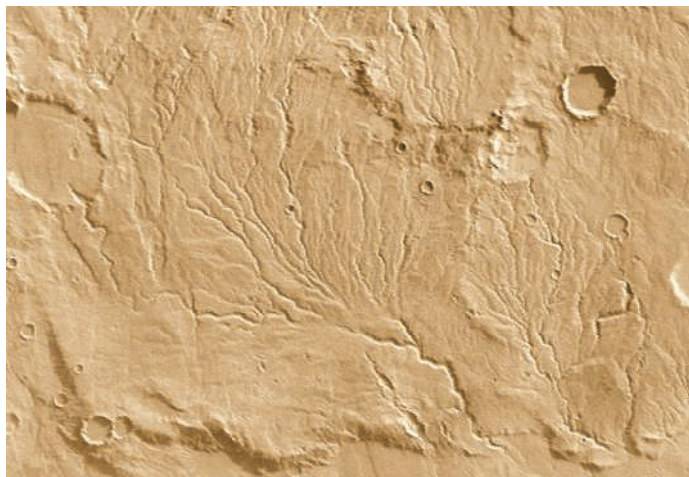


Image of Mars taken from *Mars Express* — valley networks suggest that rivers once flowed on Mars.

and includes sensors to monitor hydration, heart rate and body temperature. Their tough outer layer provides protection against harsh environments. MCP suits have electronic polymer fibres within tight-fitting elastic material and use electricity to mould the suit to the human body. The extra pressure this suit provides reduces the chance of the wearer 'passing out' in the much lower Martian atmospheric pressure.

activities

INVESTIGATE, IMAGINE, DISCUSS AND CREATE

- 1 Locate, read and summarise the similarities and differences between science fiction novels about life on Mars or Martians. Try reading Brian Aldiss' *The Forgotten Life*, Ray Bradbury's *Martian Chronicles*, Arthur C. Clarke's *The Snows of Mount Olympus* and *Sands of Mars* and H. G. Wells' *The War of the Worlds*.
- 2 What sorts of projects and research are aerospace engineers involved in?
- 3 (a) Research the differences between current conventional spacesuits and possible future spacesuits.
(b) Research the possible effects of the Martian atmosphere on the human body.
(c) Suggest spacesuit modifications on the basis of your findings. What sorts of science need to be developed to allow this?
(d) Use your findings to design, sketch and label your future Martian spacesuit.
- 4 Find out about organisations that are focused on research about travel to and colonisation of Mars. Report your findings in a *Mars Mania* Field Guide brochure, PowerPoint, web page or creative story.

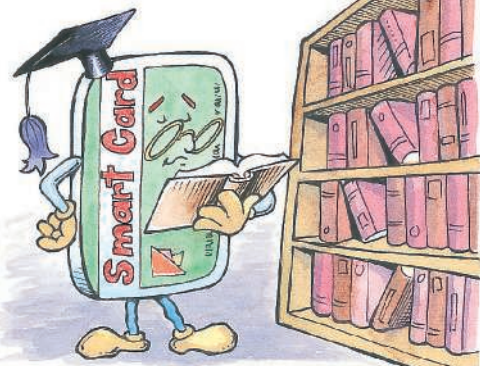
Science at work: Home alone?

Living in the electronic age has both positive and negative consequences. Electronic 'wizardry' can save, extend and improve our lives. It can bring warmth, contentment and security. It can also invade our privacy.

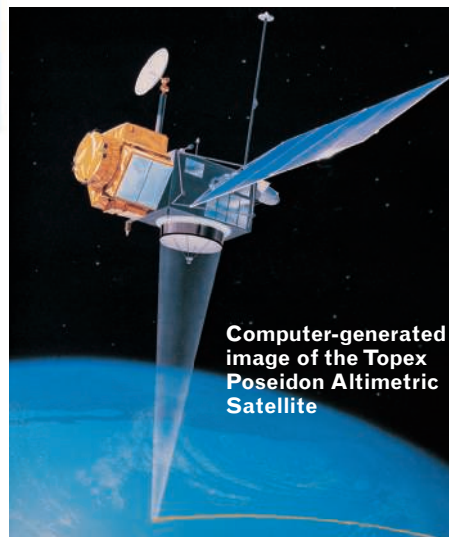


Smart cards

These cards look like an ordinary credit card but feature a micro-processor chip which records and releases personal data. It works like a tiny electronic information manager and is great for quickly accessing and storing data such as daily blood sugar levels of diabetics, hospital records, or performing day-to-day activities like tracking vending machine purchases. This type of consumer electronic technology may replace the era of mass media with that of the era of personal media.



Like 'virtual pets' and other electronic experiences, smart cards will soon be added to the tools of our busy electronic lifestyle, which already includes mobile phones, computers, televisions and microwaves. But are we being watched? Are our 'tools' keeping surveillance on us and letting others know what we are doing and when? Are there any laws protecting our privacy?



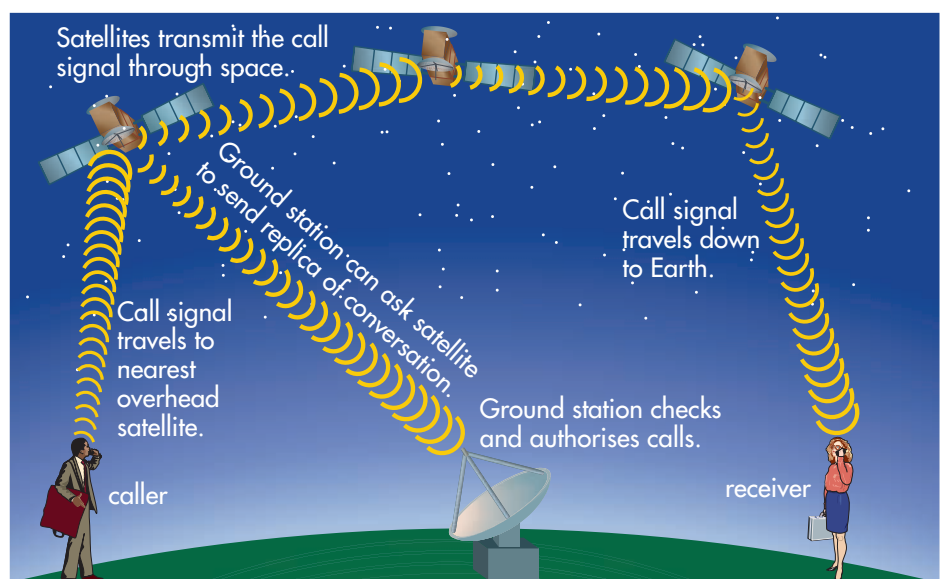
Computer-generated image of the Topex/Poseidon Altimetric Satellite

Spies in space?

On 20 December 1996, a Titan rocket lifted off from its base in California into space. Its sole purpose was to place intelligence-gathering satellites in orbit. Many other satellites have been sent up into our skies to keep track of activities on Earth.

Phoning home?

Arthur C. Clarke is a prolific science fiction writer who is best known for *2001: A Space Odyssey* (1968). He has both physics and mathematics degrees and a strong interest in the frontiers of science and the field of astronomy. As an RAF officer during World War II, Clarke was in charge of the first experimental trials of radar talk-down equipment. In 1945, more than six decades ago, he published an article describing how instantaneous world communication could be made



Who's listening in on your satellite calls?

possible using satellites. Twenty years later, his vision became reality.

In *Dial F for Frankenstein* (1965), Clarke writes about new communication technology taking control and causing industrial accidents, launching guided missiles, closure of airports due to erratic radar, and banks and stock exchanges closing due to unreliable information-processing systems. His unusually grim ending of the story states:

'... all control over the newly installed communication satellites has been lost... Let's get back to the Lab,' he said. 'There must be an answer somewhere.' But he knew already that it was far, far too late. For Homo sapiens, the telephone bell had tolled.

(From *Dial F for Frankenstein* by Arthur C. Clarke)

Did you know that . . .

- As long as a mobile phone is switched on, your location can be tracked. This information has been used in a murder trial.
- Digital mobile phone records of who, where and when you called are kept on computer file for seven years.
- There are video cameras small enough to be disguised as pens, buttons or screws.
- In early 1997, Melbourne City Council introduced 10 video cameras in the city's western end and increased this to 23 cameras over the following years. These cameras are now also in other suburbs near popular night spots and train stations. They are monitored by a private security firm with logs available to selected council staff, police and lawyers on application.
- Telephone numbers dialled on your home telephone are recorded and can be shown on your telephone account.
- Many traffic lights now have red light cameras that photograph drivers who don't stop at red lights.
- *Ikonos* is watching. He is almost 800 kilometres away and orbiting the Earth at seven kilometres a second. He is a commercial satellite. Circling our planet 14 times every day, he beams images back to Earth every minute of every day. These images are being sold throughout Australia and New Zealand. Where were you and what were you doing?

activities

REMEMBER

- 1 What are smart cards and how do they work?
- 2 How could satellites make it easy to eavesdrop on satellite telephone calls?
- 3 Who or what is *Ikonos* and what does it do?

THINK AND DISCUSS

- 4 Should Australia, like many other countries moving into the 'technotronic' age, formulate and strengthen privacy laws? Brainstorm class responses to this question. Make a list of what you think would be good for the society that you live in.
- 5 Make a list of all of the electronic appliances that you have used.
- 6 Design and sketch futuristic electronic devices onto a poster.

INVESTIGATE

- 7 Find out more about:
(a) smart cards (b) satellites.
- 8 (a) Make a list of websites that provide information on satellites, new technologies and electronics.
(b) Search websites for information on the latest space research news. Try the following and other relevant

websites: Space News, NASA Human Space Flight, Project Galileo: Bringing Jupiter to Earth, The Astronomy Cafe, Center for Mars Exploration, Black Holes and Neutron Stars. Use a search engine to find the web address of these sites.

- 9 Collect information about a modern communications system and present it as a web page or PowerPoint presentation to the class.
- 10 Find out about the orbits of weather and communications satellites. Use models or labelled diagrams to present your findings.
- 11 Use the Internet to access data obtained from satellites.
- 12 Evaluate the following forms of sending and receiving information:
(a) posted letter
(b) email
(c) telephone
(d) fax.
- 13 Find out some of the privacy issues related to mobile phones. Suggest and discuss rules that you think should be in place for the use of mobile phones while you are at school and when you are out of school.

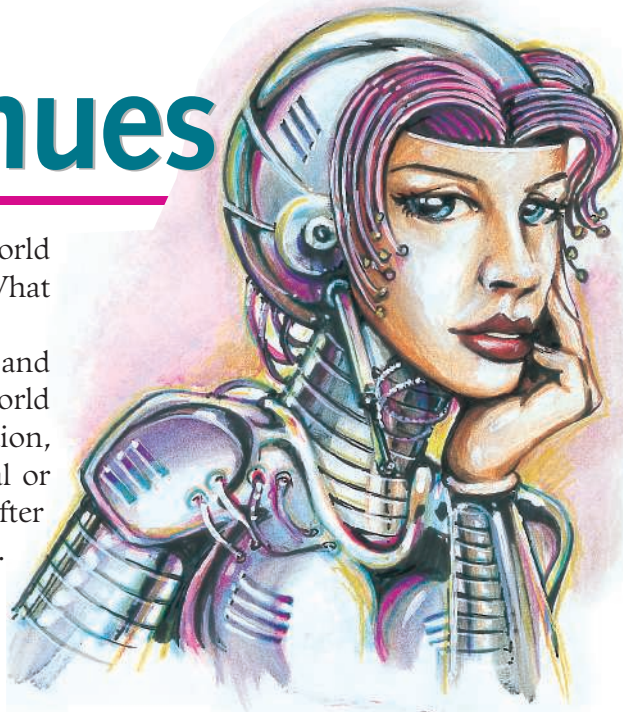
CREATE

- 14 Construct a satellite model and use descriptive labels to show how it works.

The quest continues

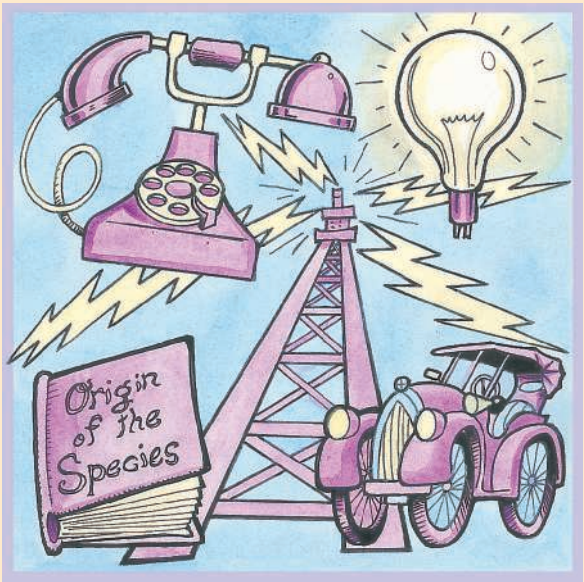
Why question? Why *bother* asking questions about the world around you? Why not just *accept* the way things are? What makes scientists do what they do? Do we really need science?

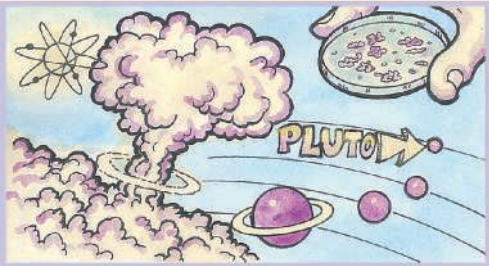
Science does not occur in a vacuum. Science is about people and their quest to find out about the hows, whys and wheres of the world around them. Science employs as its most important tools imagination, insight and the desire to understand or find out for the individual or for others. Some discoveries 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.

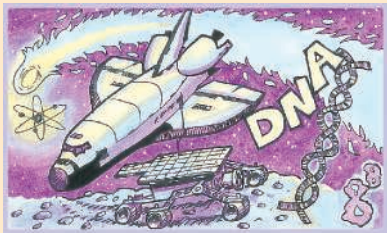


Science quests throughout history

Year	Scientific events	Other events
1784	Benjamin Franklin invents bifocals.	Life expectancy is about 35.5 years.
1829	Stephenson's <i>Rocket</i> 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 new era of astronomy.	
1846	Gun Cotton, 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 and 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 <i>On the Origin of Species</i> is published.	Gregor Mendel turns 37 and Charles Darwin turns 50.

Year	Scientific events	Other events
1863	Huxley's <i>Man's Place in Nature</i> is published and TNT is invented.	Jules Verne's <i>Five Weeks in a Balloon</i> is first published.
1864	Nobel introduces nitroglycerine and Pasteur introduces pasteurisation.	Jules Verne's <i>A Journey to the Centre of the Earth</i> 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 <i>From the Earth to the Moon</i> 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 <i>Twenty Thousand Leagues Under the Sea</i> is published.
1873	Remington introduces the mass-produced typewriter.	Jules Verne's <i>Around the World in 80 Days</i> 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 and 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 <i>The Time Machine</i> is published.
1896	Cavendish discovers electrons.	
1898	Krypton and neon are discovered and Holland's submarine is invented. Curie discovers the two radioactive elements radium and polonium.	H. G. Wells's <i>The War of the Worlds</i> 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 <i>The First Men in the Moon</i> 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.	

Year	Scientific events	Other events
1905	Einstein's <i>Special Theory of Relativity</i> 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.
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 <i>Brave New World</i> 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 Alamogordo, New Mexico.	World War II ends.
1947	The sound barrier is 'broken'. The supersonic age begins.	
1948		George Orwell's <i>Nineteen Eighty-Four</i> is written.
1953	Watson and Crick decipher the structure of DNA.	
1957	<i>Sputnik</i> is launched.	
1963		Robert A. Heinlein's <i>Time for the Stars</i> is first published. John F. Kennedy is assassinated.
1965		Frank Herbert's <i>Dune</i> is first published.
1969	'One step for man — a 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 <i>Explorer 42</i> spacecraft in the Cygnus constellation.	
1972	The first global views of Mars are returned by <i>Mariner 9</i> .	
1976	Genentech company is formed by the venture capitalist Swanson and the biochemist Boyer to exploit Boyer's gene-splicing techniques. The <i>Viking 1</i> makes the first landing on Mars.	Isaac Asimov's <i>The Bicentennial Man</i> is published.
1977		George Lucas' <i>Star Wars</i> is released.
1980		Life expectancy is about 75 years.
1982	Sally Rider is the first US woman in space.	Robert A. Heinlein's <i>Friday</i> is first published. Anne McCaffrey's <i>The Crystal Singer</i> is published (written 1974–1975).

Year	Scientific events	Other events
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 <i>A Brief History of Time</i> is published.	
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 — Suzy 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 <i>Homo floresiensis</i> 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.

activities

INVESTIGATE

- Find out more about one of the scientific quests in the timeline on pages 292–5 and present your findings as a poster to the class.
- Add other scientific quests, events or Australian Nobel Prize winners to the science quests timeline.
- Select a year (or time period) and find out as many different scientific discoveries as you can.
 - 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.

- Suggest implications of the scientific discoveries or events on the people of that time and on people in future times.

- Find out about the winners of scientific Nobel Prizes and their work. Present your information as an 'autobiography'.
- Find out about the Nobel Prize winners' sperm bank. Discuss the ethics associated with it.

THINK AND CREATE

- Use the information on these pages to produce a crossword or scientific trivial pursuit game.

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

INVESTIGATE, THINK AND CREATE

- 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.
- 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.

