Teacher Support Materials

Connected 2 2009

Contents and curriculum links

General themes in *Connected* 2 2009

1. Science and scientists

Two of the four articles in this issue offer contexts for talking about the work of scientists ("Double, Double, Toilet Trouble!" and "DNA Talks Every Time"), and two introduce a scientist and describe his or her particular areas of research ("The Magic of Science" and "Dead Pigs with Maggots, Please!"). All four articles point to, or comment on, topics such as:

- the different branches of science
- the kinds of training scientists need
- the specialist work areas and the equipment that scientists use
- the language of science
- safety procedures in science
- the impact of technology on scientists' work
- the "magic" factor – scientists' excitement about what they do.

2. Agents of infection

"Double, Double, Toilet Trouble!" and "The Magic of Science" provide contexts for talking about:

- disease-causing agents, such as viruses and bacteria
- protection against infectious diseases:
    - through safe laboratory practices
    - through personal hygiene
    - through safe food preparation and storage
    - at a community level (safe drinking water supplies, sewage disposal)
- the role of special-purpose laboratories, such as the Institute of Environmental Science and Research (ESR), and of health agencies in keeping New Zealanders safe from infectious diseases.

3. Forensic science

"DNA Talks Every Time" introduces forensic science, which uses DNA from blood samples collected at the scene of a crime to identify criminals and, when used in conjunction with other evidence, to convict them.

4. Decomposition

"Dead Pigs with Maggots, Please!" introduces the end of the life cycle: decomposition. Students will learn what decomposition is and why it is important. The scientist in the article uses decomposition data to design a new method of working out "time since death".

The Magic of Science

Possible achievement objectives

Note: All achievement objectives are quoted from *The New Zealand Curriculum* (2007).

Science

Students will:

Nature of Science

Understanding about science (UaS)

- L1/2: Appreciate that scientists ask questions about our world that lead to investigations and that open-mindedness is important because there may be more than one explanation.
- L3: Appreciate that science is a way of explaining the world and that science knowledge changes over time.
- L3: Identify ways in which scientists work together and provide evidence to support their ideas.

Investigating in science (IiS)

- L1/2: Extend their experiences and personal explanations of the natural world through exploration, play, asking questions, and discussing simple models.
- L3: Build on prior experiences, working together to share and examine their own and others' knowledge.

Communicating in science (CiS)

- L1/2: Build their language and develop their understandings of the many ways the natural world can be represented.

Participating and contributing (P&C)

- L1/2: Explore and act on issues and questions that link their science learning to their daily living.

Living World

Life processes (LP)

- L1/2: Recognise that all living things have certain requirements so they can stay alive.
- L3: Recognise that there are life processes common to all living things and that these occur in different ways.

Evolution (Ev)

- L1/2: Recognise that there are lots of different living things in the world and that they can be grouped in different ways.
- L3: Begin to group plants, animals, and other living things into science-based classifications.

Technology

Nature of Technology

Characteristics of technology (CoT)

- L2: Understand that technology both reflects and changes society and the environment and increases people's capability.
- L3: Understand how society and environments impact on and are influenced by technology in historical and contemporary contexts and that technological knowledge is validated by successful function.

Key ideas

- Virologists are scientists who study viruses.
- Technology helps scientists to do their work.
- Some living things are so small that we cannot see them with our eyes alone.
- There are different sorts of microscopic living things, including viruses and bacteria.
- Viruses and bacteria have particular ways of meeting their needs in order to survive.
- When some kinds of viruses and bacteria live inside an animal or plant, this can cause sickness or even death for the host organism.
- To stop getting sick, we need to interrupt one or more of the life processes of the harmful viruses and bacteria.

Shared learning goals

We are learning to:

- develop an understanding of the work and equipment of a particular scientist, virologist Richard Hall (UaS, LP, Ev, CoT)
- explore the work of scientists and how technology helps them to do their work (UaS, CoT)
- think about what kind of personal qualities or interests might lead us to want to be scientists or technologists and what subjects we might need to study at school and university (UaS, CoT)
- describe and discuss the characteristics of viruses and bacteria (LP, Ev)
- explain how viruses and bacteria meet their needs (LP)
- discuss how microscopes have helped scientists to learn more about our world (UaS, CoT)
- discuss how we can interrupt the processes of viruses and bacteria to help protect people from getting sick due to infection by them (LP).

Developing the ideas

Focus questions

- *Look at the title of this story – what do you think might be "magical" about science?*
- *Look at the pictures – do they give you some ideas about the magic of science?*

The students may come up with several ideas, such as scientists find out how things work and make exciting discoveries, scientists can look at things too small to see with their eyes alone, and scientists invent things or find cures.

Comparing viruses and bacteria

This section relates to the following learning goal. We are learning to:

- **describe and discuss the characteristics of viruses and bacteria (LP, Ev).**

Students may be more familiar with viruses in the context of computers than the context of health but, given recent fears about pandemics, they are likely to have heard of viruses in connection with the flu.

Ask them if they know of some other conditions caused by viruses or bacteria and list these on the whiteboard.

Use the comparison of viruses and bacteria on page 12 of the students' book to introduce discussion of both. Ask the students to identify the key features of viruses and bacteria that are being compared (shape, size, how they reproduce, how they make people sick, how they may or may not be controlled).

(This comparison is focused on disease-causing viruses and bacteria. Students need to be reminded that not all viruses and bacteria are harmful.)

To help the students visualise how small bacteria and viruses are, suggest they measure 1 millimetre on a piece of paper, then imagine a thousand bacteria lined up side by side in that space. Another estimate is that up to 40 million bacteria live in 1 gram of soil. A gram of soil would not quite fill a tablespoon. The head of a pin can hold 500 million rhinoviruses, the cause of the common cold.

The students could use the Internet to find images of bacteria and viruses, including those that cause the conditions they suggested earlier, such as the common cold, swine flu, measles, or norovirus.

Ask the students to sort the images into two sets, one of viruses and one of bacteria, and then compare the images in each set.

What similarities or differences can the students observe from the images they have collected? (An example might be that some bacteria have one or more whip-like projecting parts, or flagella, to help them move.)

Observing through a microscope

This section relates to the following learning goals. We are learning to:

- **develop an understanding of the work and equipment of a particular scientist, virologist Richard Hall (UaS, CoT, LP, Ev)**
- **discuss how microscopes have helped scientists to learn more about our world (UaS, CoT).**

A microscope is an optical instrument (or technological outcome) for looking at things that scientists cannot see by using just their eyes. Microscopes magnify or make bigger the sample that the scientists want to see.

The ability to gather more or improved evidence enables scientists to make new discoveries and to change or modify their scientific theories. Improvements in technology, such as more powerful microscopes, contribute to new scientific discoveries and changed scientific thinking over time.

The first microscopes invented were optical or "light" microscopes. These use a combination of visible light and glass lenses to magnify a sample. Technologists have more recently developed digital microscopes, which use a camera and transmit the image of the sample to a computer screen, and electron microscopes, which can create very highly magnified images.

The South West Schools website includes several pages about microscopes and using them at http://www.southwestschools.org/jsfaculty/Microscopes/index.html

The Nobel Prize website includes a diagram of what can be seen with the eye alone and by using the different types of microscope at http://nobelprize.org/educational_games/physics/microscopes/powerline/index.html

Students can explore the idea of being able to learn more by seeing more through using a basic optical microscope to look at familiar things. (If the school does not have access to a microscope, a parent or student might own one they are willing to loan.) The students could examine common objects such as hair or leaf skeletons under the microscope.

If you don't have access to microscopes, the students could look at magnified pictures, including those they sourced earlier of viruses and bacteria, and discuss the same questions.

Focus questions

- *What can you see when looking through a microscope that you cannot see with just your eye?*
- *What can you learn by seeing tiny things more clearly?*
- *Why do you think that scientists know more about bacteria and viruses than they used to?*

More about viruses and bacteria

This section relates to the following learning goal. We are learning to:

- **explain how viruses and bacteria meet their needs (LP).**

Viruses and bacteria don't actually set out to make us sick – our getting sick results from the processes by which viruses and bacteria meet their own needs.

Focus questions

- *What do humans need to stay alive?*
- *What do you think viruses and bacteria need to stay live?*

You could frame up this discussion by introducing what scientists describe as the characteristics of life. Some of these characteristics include:

- movement
- respiration
- sensitivity
- growth
- reproduction
- excretion
- nutrition.

A thing must have all of these characteristics (sometimes called activities) to be considered alive. Students will be familiar with most of these characteristics, but you may need to unpack sensitivity, or using various senses to monitor and respond to the environment in which the organism lives. For humans, these include seeing, smelling, and hearing.

The acronym "Mrs Gren" can help students remember the characteristics of life:

- <u>M</u>ovement
- <u>R</u>espiration
- <u>S</u>ensitivity
- <u>G</u>rowth
- <u>R</u>eproduction
- <u>E</u>xcretion
- <u>N</u>utrition.

Look at some simple examples of living and non-living things with the class, discussing whether they meet the characteristics of life. An example – a mouse – is given here.

- Movement: A mouse moves to food with its legs, and it can also scuttle away from danger.
- Respiration: A mouse breathes in oxygen and uses this to help make energy.

- Sensitivity: A mouse is sensitive to changes in its home area. It can smell food, for example.
- Growth: A mouse starts out as a baby and grows into an adult.
- Reproduction: The female mouse gives birth to baby mice.
- Excretion: Mice produce urine and poo, and these are eliminated from the body.
- Nutrition: Mice need to eat food for nutrition.

You will need to scaffold your students in discussing whether viruses and bacteria show the characteristics of life. You could choose to focus on some rather than all of the characteristics. Use the comparison on page 12 as a starter for this discussion.

Bacteria have all the characteristics of life.

- Some bacteria can glide, some twist in a spiral fashion, and some propel themselves with their flagella.
- Aerobic bacteria absorb oxygen from their environment. (Anaerobic bacteria do not require oxygen to grow.)
- Bacteria may not have eyes, noses, and ears, but they are responsive (show sensitivity) to their environment in other ways.
- Bacteria will grow slightly in size and length.
- Bacteria reproduce very rapidly by dividing in two. See the further activity Multiplying bacteria in "Dead Pigs with Maggots, Please!"
- Bacteria produce waste products, and when they are inside us, the build-up of these waste products can make us sick.
- Bacteria need food. In "Dead Pigs with Maggots, Please!", the bacteria that decompose the pig's body are using it for their nutrition.

Scientists are still debating whether viruses are living organisms or not. Remind the students that viruses can live only inside the cells of a host organism. Ask the students if they think the viruses themselves are living organisms. How would they justify this opinion?

Viruses lack most of the internal structure or "machinery" that is necessary to grow and reproduce: they cannot do either outside a host cell. When a virus is not infecting a host cell, it is technically dormant and no biological activities are happening within the virus.

How do we fight off harmful viruses and bacteria?

This section relates to the following learning goal. We are learning to:

- **discuss how we can interrupt the processes of viruses and bacteria to help protect people from getting sick due to infection by them (LP).**

Focus questions

Suggest students look at the image on page 2. Ask them to think about some recent times when they have been sick.

- *How did you know you were getting sick?*
- *When you go to the doctor, what kinds of questions does he or she ask?*
- *Why do you think it's important to know what has made us sick?*

The symptoms (signs) we feel give us some idea of what might be wrong. The doctor will ask more about our symptoms, check our bodies, and sometimes take samples for scientists such as Richard Hall to identify. Knowing whether a virus or bacteria has made us sick helps the doctor to know how to treat us.

Our bodies have an immune system, or a collection of cells, tissues, and organs that work together to fight off invaders like viruses and bacteria. Doctors can prescribe antibiotics to help our immune system fight a bacterial infection. There are some antiviral medicines, but the main defence against viruses is to be vaccinated against them ahead of time. A vaccine is like a lesson for the immune system on what to look out for and fight against if we are exposed to the harmful virus the vaccine protects us against.

To stop viruses or bacteria making us sick, we need to disrupt or halt one or more of the processes related to their characteristics of life. (Have your students look over the Mrs Gren list again.) Ask them what processes an antibiotic or vaccine is likely to disrupt or stop. Answers might include:

- all processes (by killing the virus or bacteria)
- disrupting or halting their ability to multiply.

Viruses and bacteria can also be spread from one person to another in a variety of ways. The diseases that viruses and bacteria cause are described as infectious or communicable. Both these words mean that the germ or the disease it causes can be transmitted or spread.

Richard Hall works in a special space (page 5) called a laboratory: either a room or a whole building where scientific work can be carried out safely. Technologists have developed a variety of tools and equipment that enable scientists to work safely with dangerous material or specimens, including viruses and bacteria.

Focus questions

- *Look at the picture on page 2 – what are some of the ways viruses and bacteria move from person to person?*
- *What kinds of things might we do at home or school to prevent viruses spreading?*
- *Look at the pictures on pages 4 and 5 and 8 and 9 – what safety gear does Richard use when he is working with viruses?*
- *What other things does he do to keep safe?*

On the whiteboard, list the suggestions in two columns, one for home and school, and one for Richard Hall's laboratory. Ask students what connections they can see between the two lists.

Branches of science

This section relates to the following learning goal. We are learning to:

- **explore the work of scientists and how technology helps them in their work (UaS, CoT).**

Ask the students to see how many kinds of science they can find pictured or suggested in the account of how Richard Hall became a virologist (pages 6 and 7). Answers could include:

- biology (the pictures of Richard out tramping and his interest in dinosaurs)
- astronomy (his love of stars)
- chemistry (the chemistry set he was given)
- physics (a branch of science he thought he should study).

The students know that Richard is a virologist, which is a type of microbiologist.

The students could work together to draw a tree of science on a large sheet of paper, labelling each branch with the name of a different area of science and what its subject matter is, adding to the tree drawing as they read the different articles in *Connected 2 2009*.

If the students have already discussed how microscopes are used, they might like to add nanoscience, or investigation of the very small, to their tree. Nanoscience is a major context on the Science Learning website at http://www.sciencelearn.org.nz/contexts/nanoscience

The American Museum of Natural History's Ology website explains some of the different branches of science at http://www.amnh.org/ology

Being a scientist

This section relates to the following learning goal. We are learning to:

- **think about what kind of personal qualities or interests might lead us to want to be scientists or technologists and what subjects we might need to study at school or university (UaS, CoT).**

Pages 6–9 suggest some ideas about what it means to be a scientist. Read through these pages together, then ask the students to work in pairs to list what things about becoming or being a scientist are important for Richard Hall. Share the lists in class discussion. Listed items may include:

- character traits like curiosity about how things work
- fascination with particular subjects, such as dinosaurs and stars
- a helpful family (Richard's father took him to astronomy meetings and the family gave him a chemistry set)
- ambition – knowing that he wanted to be a scientist

- wanting to make something that "can help people" (page 9)
- education – studying branches of science, such as chemistry and physics, or related subjects like maths
- the support of other scientists working in a team
- an interest in the history of science or the heroes of science. (Richard mentions Galileo.)

Ask your students how they would prioritise these items in terms of their importance.

Students may enjoy viewing the video of Dr Peyman Zawar-Reza, from the University of Canterbury, talking about how he became a scientist on Sciencelearn at http://www.sciencelearn.org.nz/contexts/enviro_imprints/sci_media/video/becoming_a_scientist

Points to talk about could include what branches of science New Zealanders have succeeded in and what things have contributed to their success.

The history and progress of science

This section relates to the following learning goal. We are learning to:

- **explore the work of scientists and how technology helps them to do their work (UaS, CoT).**

Page 8 tells students that science has been around for a very long time.

One of the earliest recorded scientists was Archimedes of Syracuse, a Greek who lived over 2000 years ago. He understood the principle of why things float, and he invented a screw pump that could raise water from a lower to a higher level.

Richard mentions Galileo, who lived 400 years ago. Galileo is the subject of an article in *Connected 3 2009* – you may wish to read some of this article with the class.

The Science Discovery website gives examples of great discoveries over time in several different areas of science at http://science.discovery.com/convergence/100discoveries/big100/big100.html

A timeline tracking the invention of microscopes is available on the Nobel Prize website at http://nobelprize.org/educational_games/physics/microscopes/discoveries/index.html

Two scientists who had a big impact on disease prevention and immunisation were:

- Edward Jenner (1749–1823), who developed an early vaccine against smallpox
- Louis Pasteur (1822–1895), who made several breakthroughs in disease prevention, including developing a vaccine against rabies and a process for making wine and milk safe to drink (called pasteurisation).

Further activities

1. Celebrated New Zealand scientists

Groups of students could each research a different scientist from the NZEdge website at http://www.nzedge.com/heroes

2. Comparing Jenner and Pasteur

Comparing Jenner and Pasteur could be a fruitful activity for supporting understanding about science. As they look into what these scientists discovered, groups of students could research the following **focus questions**:

- *What did Jenner or Pasteur already know?*
- *What did they discover, and how did they discover it?*
- *What problems did they have? Who helped them?*
- *How did they tell other people?*
- *What uses have been made of their discoveries?*

Double, Double, Toilet Trouble!

Possible achievement objectives

Note: All achievement objectives are quoted from *The New Zealand Curriculum* (2007).

Science

Students will:

Nature of Science

Understanding about science (UaS)

- L1/2: Appreciate that scientists ask questions about our world that lead to investigations and that open-mindedness is important because there may be more than one explanation.
- L3: Appreciate that science is a way of explaining the world and that science knowledge changes over time.
- L3: Identify ways in which scientists work together and provide evidence to support their ideas.

Investigating in science (IiS)

- L1/2: Extend their experiences and personal explanations of the natural world through exploration, play, asking questions, and discussing simple models.
- L3: Build on prior experiences, working together to share and examine their own and others' knowledge.

Communicating in science (CiS)

- L1/2: Build their language and develop their understandings of the many ways the natural world can be represented.
- L3: Begin to use a range of scientific symbols, conventions, and vocabulary.

Participating and contributing (P&C)

- L1/2: Explore and act on issues and questions that link their science learning to their daily living.
- L3: Explore various aspects of an issue and make decisions about possible actions.

Living World

Life processes (LP)

- L3: Recognise that there are life processes common to all living things and that these occur in different ways.

Technology

Nature of Technology

Characteristics of technology (CoT)

- L2: Understand that technology both reflects and changes society and the environment and increases people's capability.

Key ideas

- There many kinds of tummy bugs, most of which are caused by viruses and bacteria.
- Tummy bugs are extremely unpleasant and can be deadly.
- Tummy bugs can spread rapidly between people and affect large numbers of people who have all been exposed to the same cause.
- Hygiene (a set of conditions or practices that keep people safe or prevent disease) is important in limiting the spread of viruses and bacteria.
- When a lot of people in one area or at one time get sick, health experts and scientists are usually called on to investigate why.
- Scientists work in logical steps: first identifying what the agent of infection (the germ) is; then investigating and testing to identify the source of the infection; then working out what steps need to be taken to fix it. More than one kind of scientist may be involved, working with other health experts.
- At community, national, and international level, there are organisations that work together to keep us healthy through developing better understanding (science) and creating equipment to help fight disease (technology).

Shared learning goals

We are learning to:

- compare bacteria and viruses (LP, although viruses are not considered living by all scientists)
- explain how some viruses and bacteria make us ill (IiS)
- describe how viruses and bacteria get transmitted and some ways of preventing or limiting this (LP)
- understand that scientists investigate problems by using logical steps to arrive at an explanation (UaS)
- appreciate that many organisations need to work together to ensure the health of a group of people, of the country, and even of the world (UaS, CoT).

Developing the ideas

"Gloop" and poop

Connected 2 2009 has a high "yuck" factor – after getting over being "grossed out" by tummy bugs, poo samples, dead pigs, and maggots, students may enjoy talking about how they cope with yucky stuff, how they think scientists might do so, and what the rewards might be for the scientists.

The language of science

Connected 2 2009 includes some demanding science vocabulary. As part of reading "Double, Double, Toilet Trouble!" and dealing with the names of several diseases, students may benefit from discussing ways of dealing with new scientific words. Most readers have to work harder when reading this kind of article. Some strategies include:

- checking the sentence or paragraph to see if the words are explained in context
- seeing if a longer word can be broken down into parts and using what they know and recognise from the parts to predict what the whole word might mean
- looking up words in glossaries or dictionaries.

Deadly tummy bugs

This section relates to the following learning goals. We are learning to:

- **compare bacteria and viruses (LP, although viruses are not considered living by all scientists)**
- **explain how some viruses and bacteria make us ill (IiS)**
- **describe how viruses and bacteria get transmitted and some ways of preventing or limiting this (LP).**

Page 10 is a newspaper report about community outbreaks of a tummy bug in 2008.

Focus questions

- *What do the two hospitals, the rest home, and the school that have been affected by outbreaks have in common?*
- *What things might be different between them?*
- *Why did Taranaki Hospital exclude all but essential staff from the affected ward?*

All four outbreaks have happened where large numbers of people are living and working closely together. This suggests:

- that people in close contact can pick up infectious diseases very easily from one another
- that tummy bugs can be caused by contamination of something that all or many of the people have shared, commonly food or water.

In the two hospitals and the old people's home, people who are already unwell or are older may be more at risk of catching tummy bugs.

The hospital attempted to "lock down" the ward to isolate the affected people.

When a new flu was identified in Mexico in 2009, health experts tracked over 300 people who had just flown back to New Zealand from North America, some with symptoms of flu. Many people flew on to various places around New Zealand. Each person would have met up with family or friends or other people in the community. If each of the original 300 or so met up with only four further people, that is a very large number of people. You could use further activity 1 (below) to illustrate this point.

You may also like to mention that, if a person infected with the common cold or the flu sneezes without using a tissue, everyone within about 4–5 metres may be contaminated. The students could measure out this space and find out how many people could be standing in it as part of a crowd. This is a dramatic way of showing how infections can spread rapidly if we don't take sensible steps to protect ourselves and other people, for example, by covering our sneezes.

The opening paragraph on page 11 gives an example of how dangerous tummy bugs can be. For soldiers, unhealthy trenches were as deadly as the fighting. Dysentery and cholera are two of the most severe conditions involving diarrhoea and vomiting.

Fighting disease outbreaks

This section relates to the following learning goals. We are learning to:

- **understand that scientists investigate problems by using logical steps to arrive at an explanation (UaS)**
- **appreciate that many organisations need to work together to ensure the health of a group of people, of the country, and even of the world (UaS, CoT).**

If you began with "The Magic of Science", you may have already considered practices, in laboratories and at home or school, that help to stop the spread of germs from person to person. If not, see the suggestions in the notes under How do we fight off harmful viruses and bacteria? for that article.

In this context, introduce the idea that hospitals and doctors' clinics face extra challenges in that they are either dealing with sick people or with the infectious agents that cause sickness. What extra things might they need to do to stop bacteria and viruses spreading?

If the students talk about using disposable medical supplies or antibacterial solutions, ask them what it would have been like before these technological advancements. Would more people have got sick?

"Double, Double, Toilet Trouble!" sets a scenario: "Suppose about 25 percent of the kids at your school" showed tummy bug symptoms. A health investigation into the cause of the outbreak gets under way.

Focus questions

- *Why is control of infectious diseases so important?*
- *What official organisations concerned with public health can you identify in this article?*
- *What does each contribute to preventing the spread of an infectious disease?*

Answers to the first question may include the rapid spread of infectious diseases already discussed, personal suffering and loss, real risks to life, and economic costs.

To illustrate how government organisations prepare for possible epidemics or pandemics, you could show the students your school pandemic procedures pack. This was sent to all schools in 2008. Visit the Ministry of Health website for further

information on pandemic preparedness at
http://www.moh.govt.nz/moh.nsf/indexmh/pandemicinfluenza-resources

Further activities

1. How many people did you come in contact with today?

1. Give the students a piece of paper each and ask them to note down on it everyone they come in contact with today.
2. The next day, ask the students to write their name on a sticky and place this on a large board or sheet of paper. Around their name, ask them to write the names of everyone they came in contact with the previous day. Once every student has done this, they will be able to see how many people we all come in contact with. They may want to group some contacts, like "my whole class" or "people at the supermarket". This would be a good opportunity to discuss how close a contact needs to be for an infection to be passed on. Add your own circle of contacts.
3. To prevent embarrassment, you might need to volunteer to be the person who was coming down with an infectious virus in this scenario.
4. Ask the students to highlight the name of the "infected" person wherever it appears in each circle of contacts. The students should be able to see how many people can be infected by contact with one person.
5. Challenge students to come up with a diagram that shows the information they have collected in a way that demonstrates to others how quickly infections can be spread.

2. Good bacteria

If you have now looked at the first two articles, the students may feel that viruses and bacteria are "bad". It is important to stress to the students that most viruses and bacteria are harmless and that some bacteria are helpful, such as the bacteria that help things to decompose, as described in "Dead Pigs with Maggots, Please!".

You could make yoghurt in the classroom to demonstrate how bacteria can be useful. You may be able to borrow a yoghurt maker or use instructions from the Internet, such as these from the Utah Education Network at
http://www.uen.org/Lessonplan/preview?LPid=2515

Further references

The following websites provide information about microbes, viruses, and bacteria:

- Microbe World includes information on the tools microbiologists use at http://www.microbeworld.org/microbes/tools.aspx It also describes the work that scientists do at http://www.microbeworld.org/scientists/do.aspx
- Science Learning has several suggestions for relevant activities at http://www.sciencelearn.org.nz/science_stories/microorganisms
- Windows to the Universe has a page on bacteria at http://www.windows.ucar.edu/tour/link=/earth/Life/classification_eubacteria.html

These websites provide information about food safety and hand washing:

- The New Zealand Foodsafe website has an education focus and downloadable resources at http://www.foodsafe.org.nz
- Washup.org has downloadable resources at http://www.washup.org
- The CDC website provides downloadable resources for public education, including a food safety quiz for kids at http://www.cdc.gov/foodsafety/edu.htm

The Biology4Kids website at http://www.biology4kids.com has some useful information and resources. In particular, it has a video of students performing an experiment to show how diseases spread as epidemics at http://www.biology4kids.com/extras/video/micro_epidemic.html It also includes a video that demonstrates the scientific method at http://www.biology4kids.com/extras/video/study_scimethod.html

DNA Talks Every Time

Possible achievement objectives

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- L1/2: Extend their experiences and personal explanation of the natural world through exploration, play, asking questions, and discussing simple models.
- L3: Build on prior experiences, working together to share and examine their own and others' knowledge.
- L3: Ask questions, find evidence, explore simple models, and carry out appropriate investigations to develop simple explanations.

Communicating in science (CiS)

- L1/2: Build their language and develop their understandings of the many ways the natural world can be represented.
- L3: Begin to use a range of scientific symbols, conventions, and vocabulary.

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Nature of Technology

Characteristics of technology (CoT)

- L2: Understand that technology both reflects and changes society and the environment and increases people's capability.
- L3: Understand how society and environments impact on and are influenced by technology in historical and contemporary contexts and that technological knowledge is validated by successful function.

Key ideas

- Blood contains cells, and cells contain DNA. Scientists can extract DNA from the cells in blood.
- DNA is made up of only four bases (the rungs of the DNA ladder), but because they can be put together in so many different ways, we all have different DNA.
- When handling bodily samples such as blood, scientists need to follow sterile procedures and rules (protocols) to ensure that such samples and the results are carefully documented.
- Scientists help the police and lawyers do their work.

Shared learning goals

We are learning to:

- explore the equipment, processes, and protocols a forensic scientist uses when gathering and testing samples for evidence (UaS, CoT)
- understand the individuality of each person's DNA (LP)
- understand that scientists can help police to use DNA as evidence that someone was at a crime scene (UaS, P&C).

Developing the ideas

Focus questions

- *Has anybody heard of DNA?*
- *Where did you hear about it?*
- *What things do you know about it?*

Handling DNA safely

This section relates to the following learning goals. We are learning to:

- **explore the equipment, processes, and protocols a forensic scientist uses when gathering and testing samples for evidence (UaS, CoT).**
- **understand that scientists can help police to use DNA as evidence that someone was at a crime scene (UaS, P&C).**

In "DNA Talks Every Time", scientists collect blood samples from a crime scene so that they can extract DNA from the samples. They can compare the readout on the DNA with those in the National DNA Database. This may give the police a lead on who committed the crime or, if they already have a suspect or suspects, confirm that they are on the right track.

The scientists who go to the scene of the crime need to use sterile swabs and sample containers so that bacteria and mould do not grow in the sample.

Being sterile is more than just being clean. Cells are tiny parts of living things – too tiny to see without a microscope. The scientists need to make sure that no cells from any other living things get into the evidence. Although this isn't mentioned in the article, you could explain to the students that forensic scientists have to be very careful that they do not contaminate the samples they are collecting with their own DNA. Ask the students to look at the pictures on pages 19 and 20.

Focus questions

- *What is the scientist in both pictures wearing to avoid contaminating the blood sample with his or her own DNA?*
- *What kinds of cells might get from the scientist into the sample?*

(Answers include skin cells, saliva, or sweat.)

To sterilise their permanent equipment, scientists put it in an autoclave, which cleans the equipment with high-pressure steam. Some items will be disposable, for example, the swabs or the thin latex gloves.

You could ask the students what other people might need to use sterile equipment, prompting them if necessary to think of doctors, surgeons, vets, and dentists.

As a closing thought, even though scientists have to handle DNA carefully, it's actually quite resilient. If conditions are dry and cold, DNA can last a very long time. The driest continent (contrary to what one would think) is Antarctica, and scientists have got DNA out of Antarctic fossils that are about 40 000 years old.

No DNA quite the same

This section relates to the following learning goal. We are learning to:

- **understand the individuality of each person's DNA (LP).**

Pages 20 and 21 give a simple explanation of DNA. It is built like a spiral staircase or twisted ladder (a double helix).

The rungs or links are made up of four bases that combine in pairs. Although there are only four bases and they combine in particular pairings, the variations produced are numerous. You could use further activity 1 (below) to illustrate this point.

Another way to think of DNA is like a recipe or code that tells the cells of living things how to perform their functions in our body.

Forensic scientists help police and lawyers with their work

This section relates to the following learning goal. We are learning to:

- **understand that scientists can help police to use DNA as evidence that someone was at a crime scene (UaS, P&C).**

The scientists in this story are helping the police to identify criminals by testing blood from the crime scene for DNA.

DNA is like a chemical fingerprint. The chances of one person's DNA being exactly like another person's DNA are very small.

Science that helps to solve crime is called forensic science. If the students have made a tree of science (as suggested in "The Magic of Science"), they could label a new branch.

Technology has developed new and improved tools that help forensic scientists to test crime-scene samples. When the police have kept the evidence from crimes committed in the past, these cold cases can be looked at again with the help of the new technology. Sometimes people are freed from prison because it can be shown that the DNA at a crime scene did not come from them.

If you would like to discuss with the students cases when DNA profiling has got people out of prison, the Project Innocence website provides examples at http://www.innocenceproject.org

Further activities

1. Coloured circles

The following activity demonstrates the huge variety you can arrive at with a code of only four components.

- Choose four paint colours and tell the students that they represent the four bases of DNA.
- Ask the students to paint a string of circles, one after the other, using any combination of those four colours. For example, a student may paint four red circles followed by two green then yellow, black, yellow, red, red, green.
- Compare the circle strings that the students have made to show how different they look.
- The four bases are connected in particular pairs on the DNA double helix. Make a base-pair rule, for example, a yellow circle must pair with a black one and a red circle with a green one.
- Ask the students to paint a line of the following pairs in any order:
    - yellow and black
    - black and yellow
    - red and green
    - green and red.

- Compare the sequences of pairs to see how different they look.

Focus questions

- *Think about the activity we have just done. Is it likely that any two people would have DNA that is exactly the same?*
- *Is anyone here an identical twin, or does anyone know any identical twins? Do you have any ideas about why they might look identical? (Their DNA is the same.)*

2. Court case

Go over the scenario in this article. Encourage the students to think about how it might play out as a court scene.

- The scientist argues that the DNA evidence should be trusted. What kinds of points will he make?
- The defendant (accused) argues that he did use the ATM a few hours before the crime, just after he had cut his hand. (DNA will not show what time the person was there, only that they were there.)
- What might the lawyer for the police argue?

Ministry of Education resources

The *School Journal,* Part 4 Number 3, 2003, has two relevant articles:

- "Hanging by a Thread" looks at the discovery of the structure of DNA.
- "DNA and the Kiwi Connection" is a brief article about Maurice Wilkins, the New Zealander who was awarded the Nobel Prize (along with James Watson and Francis Crick) for the discovery of the structure of DNA.

Further references

- The Nobel Prize website has a game in which you create some DNA by matching base pairs, and then you guess which animal it belongs to. Go to http://nobelprize.org/educational_games/medicine/dna_double_helix/readmore.html
- The NZEdge website has an article on Maurice Wilkins, a New Zealander who was involved in discovering the structure of DNA at http://www.nzedge.com/heroes/wilkins.html
- The Science Learning website provides instructions for a DNA-modelling activity at http://www.sciencelearn.org.nz/contexts/you_me_and_uv/teaching_and_learning_approaches/modelling_dna

Dead Pigs with Maggots, Please!

Possible achievement objectives

Note: All achievement objectives are quoted from *The New Zealand Curriculum* (2007).

Science

Students will:

Nature of Science

Understanding about science (UaS)

- L1/2: Appreciate that scientists ask questions about our world that lead to investigations and that open-mindedness is important because there may be more than one explanation.
- L3: Appreciate that science is a way of explaining the world and that science knowledge changes over time.
- L3: Identify ways in which scientists work together and provide evidence to support their ideas.

Investigating in science (IiS)

- L1/2: Extend their experiences and personal explanations of the natural world through exploration, play, asking questions, and discussing simple models.
- L3: Build on prior experiences, working together to share and examine their own and others' knowledge.
- L3: Ask questions, find evidence, explore simple models, and carry out appropriate investigations to develop simple explanations.

Communicating in science (CiS)

- L1/2: Build their language and develop their understandings of the many ways the natural world can be represented.
- L3: Begin to use a range of scientific symbols, conventions, and vocabulary.

Living World

Life Processes (LP)

- L1/2: Recognise that all living things have certain requirements so they can stay alive.
- L3: Recognise that there are life processes common to all living things and that these occur in different ways.

Evolution (Ev)

- L1/2: Recognise that there are lots of different living things in the world and that they can be grouped in different ways.

Material World

Properties and changes of matter (P&CoM)

- L3: Compare chemical and physical changes.

Key ideas

- Some bacteria are decomposers.
- Decomposers feed on dead animal or plant matter and waste products.
- Decomposers have an important role in breaking down organic matter so that it can be used again by plants.
- When something rots, nothing is lost. The original material recombines to form new substances.
- We can see some decomposers, for example, worms or maggots, but other decomposers are too small to see.
- We can study other animals to learn more about humans.
- Science looks for new ways of doing things. (Rachel is researching a new method for working out "time since death".)
- Scientists work together to solve problems.

Shared learning goals

We are learning to:

- develop an understanding of the work and equipment of a particular scientist, microbial ecologist Rachel Parkinson (UaS)
- explore the work of scientists and how technology helps them to do their work (UaS)
- understand that many animals have qualities that make them similar to each other, so scientists can use information from one species to make inferences about another (LP, CiS)
- understand that bacteria affect other organisms in a wide variety of ways, including when those organisms decompose or rot away at the end of their life cycle (Ev)
- investigate what happens in decomposition (IiS)
- appreciate that scientists are people who work together to find out things (UaS).

Developing the ideas

Going rotten

This section relates to the following learning goal and also the similar learning goal for "The Magic of Science". We are learning to:

- **develop an understanding of the work and equipment of a particular scientist, microbial ecologist Rachel Parkinson (UaS).**

Like "Double, Double, Toilet Trouble!", this article also begins with an emphasis on the "yuck" factor. How do scientists deal with such things?

Your students might like to compare what Rachel wears when she is collecting her samples from under the pongy pig, which is crawling with maggots, and when she is working with these samples later in the laboratory.

Focus questions

- *Why do you think that Rachel wears old clothes when collecting a sample from under the pig?*
- *What else does she wear? Why?*
- *What does she wear while working on the sample in the laboratory?*

The major contrast is between the old clothes and the white lab coat. If some dirt gets on the old clothes, they can be washed. Rachel uses disposable covers on her shoes at the pig burial site so that dirt is not tracked back inside. Students might find it interesting to speculate whether she is wearing some kind of mask to deal with the smell – she has her back to the camera in the outdoor picture. She wears disposable gloves in both settings to keep her hands clean and/or protect the sample.

Next, get your students to look back at what Richard Hall needs to wear when working with viruses ("The Magic of Science"). Why doesn't Rachel need to cover up to the same degree as Richard?

Although Rachel is dealing with yucky stuff, her samples are presumably not as dangerous as those that Richard is dealing with and the level of protection she needs for herself or for the samples is more moderate.

Another kind of scientist

This section relates to the following learning goal. We are learning to:

- **explore the work of scientists and how technology helps them to do their work (UaS).**

Rachel is a molecular microbial ecologist. If your students made a tree of science (see "The Magic of Science"), the students could add ecology and (from page 32) biochemistry and microbiology.

You could help the students to unpack this job title. The students may already have heard of molecules, microbes, and ecology and can refer to a dictionary to help them gain a clearer idea of what each of these words means.

Rachel has to remove unwanted elements from her field samples – maggots and dirt (page 31). Why?

Although the text does not specifically say so, the picture on page 27 shows a further technique that Rachel uses to study the bacteria present in the sample she collected from under the pig.

In her laboratory, she is likely to give the bacteria the best conditions for growing and reproducing so that she has a enough of them to study. These conditions include an ideal temperature and some food (a petri dish, as in the picture on page 27). When the bacteria reproduce (and they can do this very quickly), they form colonies (like townships), and this makes them easier to see and identify under a microscope.

It is hard to see one individual, but when there are a huge number together, they can be seen more easily under the microscope. Ask the students to imagine they are in an aircraft, looking down. Would it be easy to see one chicken on a farm? What about 1000 chickens on a farm?

(Even without the technology to see the bacteria, we can usually clearly see the results of what they are doing, for example, the rotting pig.)

Bacteria can reproduce very quickly in the right conditions, as fast as every 20 minutes. They reproduce by making copies of their own DNA and then dividing in half (which is called binary fission). You may like to use further activity 1 (below) to illustrate this point.

Decomposition

This section relates to the following learning goals. We are learning to:

- **understand that many animals have qualities that make them similar to each other, so scientists can use information from one species to make inferences about another (LP, CiS)**
- **understand that bacteria affect other organisms in a wide variety of ways, including when those organisms decompose or rot away at the end of their life cycle (Ev)**
- **investigate what happens in decomposition (IiS).**

Focus questions

- *What causes once-living organisms to decompose?*
- *Why is decomposition an essential life process?*
- *Why does Rachel study the decomposition of pigs?*

Students might find it easier initially to visualise decomposers that they can see with their eyes, such as fungi growing on trees or in forest litter, or woodlice, worms, and maggots, which consume a variety of dead organic matter. The major decomposers, however, are bacteria.

The bacteria that Rachel studies live on the decaying pig. Each species lives on the pig when the decomposition is at the right stage to provide them with suitable nutrition.

Decomposition is an essential process, as it recycles nutrients. It is only through the action of decomposers that this recycling of nutrients from decaying or dead organic matter to other organisms happens. You could use further activities 2 and 3 (below) to illustrate this key idea.

We can study other animals to learn more about humans. Pigs make a good comparison to us because we are omnivores and we also have similar skin.

Bacteria do other useful things, too. They help us by breaking down food and making nutrients for us. You could demonstrate this through the yoghurt-making activity outlined in the section Further activities in "Double, Double, Toilet Trouble!"

Becoming a scientist

This section relates to the following learning goal. We are learning to:

- **appreciate that scientists are people who work together to find out things (UaS).**

You may have already discussed growing up to become a scientist in conjunction with "The Magic of Science". This article also explores what personal interests attracted Rachel to science, what subjects she liked at school and studied at university, where she does her work, and how she works in a team, in her case, comparing notes with a soil scientist.

Focus questions

- *What do you think you might like about a job like Rachel's?*
- *What does she say about why she likes the job?*
- *What other kind of scientist is mentioned, and why do Rachel and this scientist need to work together?*
- *Can you think of a time when you worked together with someone else to solve a problem? Did you each have different skills or knowledge?*
- *Rachel works both in the field and in the laboratory. Can you think of other kinds of scientists who might do this?*

Further activities

1. Multiplying bacteria

This activity is designed to demonstrate how quickly the number of bacteria can increase if they are multiplying every 20 minutes.

- Give one student a large ball of play dough. This represents one bacterium.
- Set an alarm to go off 20 minutes later. When this happens, ask the student to divide the dough into two equal pieces, and give one piece to another student. This represents the bacterium reproducing.
- Set the alarm again. Twenty minutes later, get the two students with dough to each divide their pieces and give one away to another student. Now four students have dough.
- Continue to divide the dough every 20 minutes, so that the students can see the numbers growing. By five exchanges, everyone in the class should have a piece of dough.

If the students graph this process of doubling, they will see that the growth curve is exponential – that is, it starts slowly and then goes up very steeply.

Focus questions

- *Do you think the bacteria would keep reproducing like this forever?*
- *What could limit the reproduction of bacteria?*

The article mentions that the number of bacteria in us is greater than the number of our own cells. The students may ask how many cells we do have. It is estimated that the average adult human body contains about 50 trillion cells. Placed end to end, they would stretch around the earth 240 times. A 10-year-old has about half that many cells. If you could count these cells at a rate of one cell per second, it would take you over 13 000 years to complete the task!

2. Decomposition photoboard

The following activity will show the students decomposition at work.

- Prepare a compost bin at the school if it does not already have one.
- Explain to the students that the word "compost" comes from the word "decompose".
- Place onto the compost some apples or pumpkin or anything else that composts quickly.
- Get the students to go to the compost bin every few days and photograph the state of decomposition. Make sure they understand that there are bacteria on the food scraps and that these and other decomposers are breaking down the food.
- Have the students continue to take photographs for a few weeks, and at the end of this time, the claoss could display a photographic essay that shows decomposition over time.

You could add an extra part to this activity to demonstrate how you can tell how long it has been since something started to decompose.

- Without telling the students, leave some apples or pumpkin in another compost bin for one or two weeks.
- Ask the students to look at these partially decomposed food scraps and compare them to the photos they have taken in order to work out how long the scraps have been decomposing.
- Make sure the students understand how this links to what Rachel does (working out a method for telling "time since death").

3. Nothing is lost

- Start rotting a piece of fruit, then seal it in a plastic bag so that the gases cannot escape.
- Weigh the bag periodically and record the weight so that the students can see that it weighs the same even though the fruit is rotting away (or disappearing).
- Ask the students to put forward their ideas about what is happening, backing them up with evidence.

Ministry of Education resources

BSC Book 53: *Moulds Are Fungi: Structure, Function, and Interrelationships* looks at the fact that moulds (like bacteria) can be useful. They are decomposers, and they can also be used to make cheese and medicines. The book also mentions that moulds need particular conditions in which to reproduce.

Further references

The Windows to the Universe website offers levels of suitability for each topic (beginner/intermediate/advanced). Topics include Cells: The Building Blocks of Life!, Scientists Who Studied Life, and A Matter of Scale. Go to http://www.windows.ucar.edu