STEM trail 1: Change how we see

When we look at objects, paintings or the world around us, we can take in information at different levels.

Even looking at something as simple as a flower can make us think differently about exactly what we are seeing.

In this trail we will look at three views of the natural world and ask how they might tell us how scientists view their surroundings.

Coastal gums

Margaret Preston was an Australian artist who worked in the early to mid-20th century. Look at this picture, what do you see?

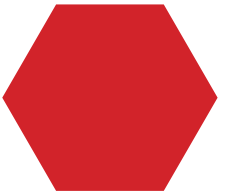
A vase of flowers. They are the flowers of a coastal gum tree, which grows around Sydney where Margaret lived as an adult.

Australia has over 900 different species of eucalypt or gum tree, the oldest of which go back over 52 million years to when Australia was part of the supercontinent Gondwana. Fossils scientists have revealed that many of these species look the same today as they did millions of years ago. Why are some plants more successful? What makes a species last that long?
See the bright red stamens? They are the male parts of the flower. Brightly coloured flowers attract birds and insects that carry pollen on their bodies from flower to flower, thereby fertilising the plants to ensure they survive and flourish.

Margaret Preston's *Coastal gums* (1929) is on loan from the Cbus Art Collection.

Red poppy

What happens when you change the scale of what you see? Tim Maguire shows us an image of a red poppy in close-up, very different from how Margaret Preston showed us the coastal gums.

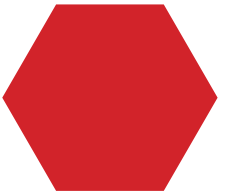


Scientists use instruments such as magnifying glasses, microscopes and powerful electron microscopes to look at how things are constructed at a cellular and even smaller molecular level.

What do you think the inventions of these instruments did to change the way we see the world around us? Can you think of other examples of how technology changes our relationship to our environment to help us see it in new ways? Imagine how the first men in space felt when they could look back across the blackness of space to view our tiny blue planet. Different perspectives are important in shaping the questions we ask.

Untitled 20040701 berries—cyan

What can we learn from looking at one part of something to draw conclusions about the whole?



The history of the scientific method is based on the idea that we can learn about our world by looking at its small parts in great detail. It is part of the process of coming up with a question, making a hypothesis, testing that idea by experiment and drawing conclusions about where to proceed next.

In this work by Tim Maguire, he zeroes in on a single berry, presenting it in large scale. It is as if we can see the whole bounty of nature by examining the luxurious richly detailed surface.

Our perception of reality is tested by the artist's use of a clever colour separation technique to see the colours cyan (blue), magenta (pink), yellow and black. The same colours are separated in mechanical and digital printing for books and magazines. We live in an increasingly digital world. How do you think digital images affect the way we see?

STEM trail 2: Understand how our world works

In this trail we will follow three artists as they view trees and look at how our scientific understanding has changed.

Old Australian giants

In this painting by Henri Tebbitt, we see large gum trees with ferny undergrowth set against a mountain backdrop. The trees are painted in detail on the edge of a clearing. Tebbitt endeavoured to reproduce nature faithfully with considerable biological detail.

Scientists have revealed that forests are very complex but also fragile ecosystems in which there is competition for food and light.

Can you count all the different types of plants you see in this picture? What is the relationship between the large trees and smaller plants? How do you think they compete for food and water and what is the effect of shade?

When a tree falls, as you can see in the picture, there is suddenly more sunlight and space for other trees to grow and the race is on to fill it. In the foreground the artist shows us a burnt stump partly covered with ferns. Fire has always been an important part of the Australian landscape. Did you know that many eucalypt species need fire to sprout their seeds?

Scientists now know that there is a lot more going on under the soil of forests than we could ever imagine, as we will learn in this trail.

Yellow landscape

Here we see a very different landscape painted by Fred Williams—one of his views from high in the You Yangs near Geelong out over the flat sparsely treed plain. He has not painted a horizon so the land appears limitless. It is completely different from the forested glade of Tebbitt's painting. Why do you think this is so? What does this picture tell us about the amount of rainfall this area might receive?

When we look at this landscape we can think about how the more widely dispersed trees will affect animals living there. How does this affect issues such as shade and food?

Scientists are now using drones and aerial photography to help them learn more about the distribution of plant species and how the environment is changing.

Recent research has also shown that trees communicate under the soil with each other in amazing ways. For example, in the dry grasslands of Africa, thorn trees emit chemicals that warn other trees that giraffes are coming to eat their leaves and so prime them to pump bitter chemicals into their canopy to make it taste nasty to the giraffes. Did you know that trees could 'talk' to each other in this way?

A dying tree

Weaver Hawkins' trees seem to take on an other-worldly look. They are animated, highly colourful structures and they might remind us of undersea corals as much as trees.

Perhaps this is no accident: corals are communities of tiny animals and scientists now know that trees also live in complex communities.

Recent studies have revealed the extent to which trees are linked together underground through a 'wood-wide web' of fungal threads. They are known to share food, water and communicate via these networks. They also communicate with trees of other species in ways scientists are continuing to discover.

How does this new knowledge make you feel about trees? What can you do to continue to learn about the other plant and animal species that surround us every day?

Scan the QR code to watch the Intelligent Trees film or visit

geelonggallery.org.au/national-science-week

STEM trail 3: What we do matters

In this trail we look at a number of paintings of our coastline in more detail. The National Science Week program specifically looks at reefs, the marine environment and pollution of our oceans. 2018 is International Year of the Reef.

The Cowrie Pool, Torquay

This painting is interesting both because of the image it portrays but also because of its unusual frame.

It shows children gathered around a rock pool in Torquay hunting for those elusive gems of the shoreline, cowrie shells. Many people still walk the beaches of our coastline hoping to find one of these beautiful tropical shells.

Can you spot the cowries hiding among the other shells in the frame?

Look at the photographs of cowries below. Have you ever found one?

Since ancient times cowries have also been highly prized and have been used also as currency at times. Can you imagine using a shell to pay for something?

Cowries are interesting to scientists too, since they live mainly in tropical areas and their arrival on our beaches can indicate the movement of ocean currents.

Did you also know that the Cowrie is the shell of a predatory animal that emerges from rock crevices to feed at night on sponges and algae?

Photographer: Bernard Dupont

Breamlea landscape

We can look at this painting and think about how our use of the land affects the marine environment.

We can see cattle grazing and farming activities happening right beside the sea. These landscapes near Geelong are now much more heavily settled, so our own impact on fragile ecosystems is increasing as more houses are built and people visit the beach more often. Scientists know and are teaching us that what we do on land can have a big effect on the sea and the creatures in it.

Run-off of fertilizers which are high in nitrogen from farms can pollute the sea and lead to algal blooms that damage other marine species. Farming practices are known to have had a big impact on the health of the Great Barrier Reef.

Did you know we can all help to protect our oceans? Reducing plastic waste and our carbon footprint, not purchasing products that exploit the sea and its creatures and eating sustainably caught seafood can all make a big difference to the future of our shared marine heritage.

Port Phillip Heads

This painting, by the Heidelberg School artist RE Falls, shows us the entrance to Port Phillip Bay in 1888.

It is a view still familiar to many and seems unchanged, however, this is deceptive. Did you know that only 6,000 years ago Port Phillip Bay was a shallow basin of rivers and land rich with wildlife hunted by the local Indigenous population until it flooded at the end of the last Ice Age?

Change is part of the environment in which we live; however man-made change is accelerating its effect on the environment.

Port Phillip Bay is now a large and busy port, with over 4,000 ships coming through these heads every year. Did you know that global shipping affects the marine environment through pollution, discharge of ballast water, wildlife collision and even sound disturbance of marine mammals? We can protect the sea through continuing regulation of shipping lanes and the creation of marine reserves.

Scan the QR code to view A Plastic Ocean (official trailer) or visit

geelonggallery.org.au/national-science-week

STEM trail 4: Making a positive difference—science and the environment

Beyond Eden

Artists and scientists both work to help us understand our environment and this has never been more important than now, with climate change one of the world's most important issues.

Mandy Martin uses her art to make us look at our relationship with the environment. Her paintings are often large scale and they draw us into the picture space and its images and themes.

This is an image of a woodchipping mill near Eden, NSW, on the edge of a bay that was once a major whaling station. The artist uses the mill and images of the factory as visual symbols for the breakdown of the natural environment by human beings' need for natural resources like wood and coal. What do you see when you look at *Beyond Eden*?

Artists can create work that touches our emotions and activates our senses. This can be especially effective with a complex issue like climate change. Can you think of a time when an image, photograph or perhaps a television documentary made you think about how we affect our world?

Artetyerre

Billy Benn Perrule is an Indigenous artist who paints his country because of his strong cultural and emotional connection to the traditional lands of his people—the dramatic Harts Range in the Northern Territory. His painting keeps his country alive.

As more and more of us choose to live in cities and suburbs, how do we feel about protecting the environment? Even if we never go to a place, does its survival matter to us?

Scientists need our support and the support of governments. They communicate their work to us on both an intellectual and emotional level. What can we do to feel more connected to our special places and the environment in general?

Recent data from the Yale Centre for Climate Change Communication supports the importance of communicating difficult environmental issues in ways that make people care about positive change. Emotions drive people and people drive change.

Design structure for Concerto in B sharp

In this drawing by Trevor (Bo) Jones the beauty of the bee as a highly structured, complex and social organism is revealed in a unique way.

There is humour in Jones' musical title, and how we perceive and play with the meaning of words: BE E SHARP; BE SHARP; B SHARP.

This drawing was first exhibited in Geelong Gallery in 1978, and was accompanied by a violin encased in glass that was an actual beehive. The bees flew via a shute between inside and outside, collecting and processing pollen. The violin 'hive' hummed its own music in tune with the bees' activity.

Did you know that bees are so important to our survival? They pollinate 70 of the 100 crops that feed 90% of our global population. Yet we know bee numbers are under threat as never before from changes to our environment due to climate change, disease and the use of pesticides.

What can we do? We can choose not to use pesticides in our gardens, particularly neonicotinoids which are still widely available in Australia. We can support organic farming practices and bee populations by planting bee friendly plants such as lavender.

STEM trail 5: What choices do we have?

Pointing east, pointing west

Lindy Lee's art explores her Chinese heritage through the philosophies of Taoism and Buddhism, which ask us to be aware of humanity's close relationship to nature and the universe.

One of the themes for this year's National Science Week is the ethical and social responsibility of DNA testing and cloning technology. Lindy Lee's work focuses on portraiture and the concept of the self. The duplicated but slightly manipulated images in this work could act as a metaphor for the issues raised in this topic.

What different vision of the future might the DNA revolution gives us? Humanity saved with gene therapy; the elimination of hereditary diseases and cancer; or a nightmarish future of hybrid, genetically modified organisms and a genetic underclass? Is it ethical for scientists to manipulate genes and if so, under what and whose guidelines? These ideas are not science fiction but important issues for us all to consider now.

DNA technology has already sequenced the entire genetic code of a human being as well as many other species. This research is leading to new advances in drugs and medical interventions. Most of us would think that anything that can help life is good but the ethics are very important to think about. Who gets access to these expensive technologies? Who decides? What if we found we were carrying a gene that impacted on our ability to secure insurance or employment?
If cloning can become more widespread, this picture allows us to imagine what it would be like to have multiple copies of ourselves. How would you feel? How much of our identity depends on our characteristics being unique to us?

Country Road, Wandin 1987

In this work by Jenny Watson we can begin to imagine the process through which our human biological characteristics might be subjected to genetic manipulation. A bottle or test-tube filled with everything that makes us who we are. What would we like to improve? What would we like to lose?

This painting is like a diary of words and images. It is a picture of bottled memories of aspects of her childhood. Like Lindy Lee, Jenny Watson paints a complex form of self-portraiture in which she sometimes casts herself as different characters, to bring forth her thoughts, dreams and experience as a woman.

Genetic technologies are advancing quickly and this raises important ethical questions that are explored in National Science Week. What do you think are the positive and negative potential effects of this technology?

At home

This painting is a gentle portrait of a tiger and her cub and was created in 1897 when tigers were still abundant in the wild.

What makes this picture so charming is the intimacy and tenderness of the composition. It is a family portrait we can relate to.

Perhaps the emotion portrayed here reflects something that we feel in our own relationships. Does that recognition make us feel differently about the future of these amazing animals?

Tigers are some of our most iconic yet now most endangered species. Of the nine subspecies, three are now extinct and all that remain are endangered. Habitat loss, climate change and threat by humans all contribute.

We know that the adult in this scene is a female because they almost always raise their cubs alone.

To see some incredibly rare footage of a tiger and her newborn cubs, exactly like this painting, use the QR code below.

DNA technology may give us the chance to save certain endangered species from extinction, tracking the health and diversity of shrinking populations and maintaining the genetic diversity of captive ones.

Should we try and save species like these even if their habitat is almost gone or no longer exists? Which species are the most important? Scientists are grappling both with the technology and the allocation of resources around just these issues in conservation.

Scan the QR code to view rare footage of a tiger and her newborn cubs or visit

geelonggallery.org.au/national-science-week

Hexagon information

Hexagons are one of the most amazing shapes in nature, science and maths.

They occur naturally as the building block of beehives: this is because the hexagon is the most efficient way to fill a space without any gaps and using the least amount of material. For bees this means they do not waste any excess wax, which is biologically laborious for bees to make.

A lot of crystals are also made of hexagons and snowflakes are also in this shape. Water freezes in the shape of hexagons and soap bubbles also form hexagons where they meet.

In our world the element carbon is the building block of all life and the way carbon forms the rings that make up organic compounds is known as a benzene ring. This is also shaped like a hexagon.

Hexagonal structures are very stable and are also used in engineering for providing the greatest strength without excess weight.