MICROSCOPY AUSTRALIA

Learning resources for STORIES & STRUCTURES – *New Connections*

STORIES & STRUCTURES – *New Connections* brings together a story-telling and image-making tradition developed over 60 000 years or more with scientific imaging created on high-tech instruments. This delivers a new vision of our country and its stories. We hope that these images will start new conversations and provide opportunities to make new and lasting connections. Every artwork grows out of the artist's experiences, intellect, beliefs and the tools they use.

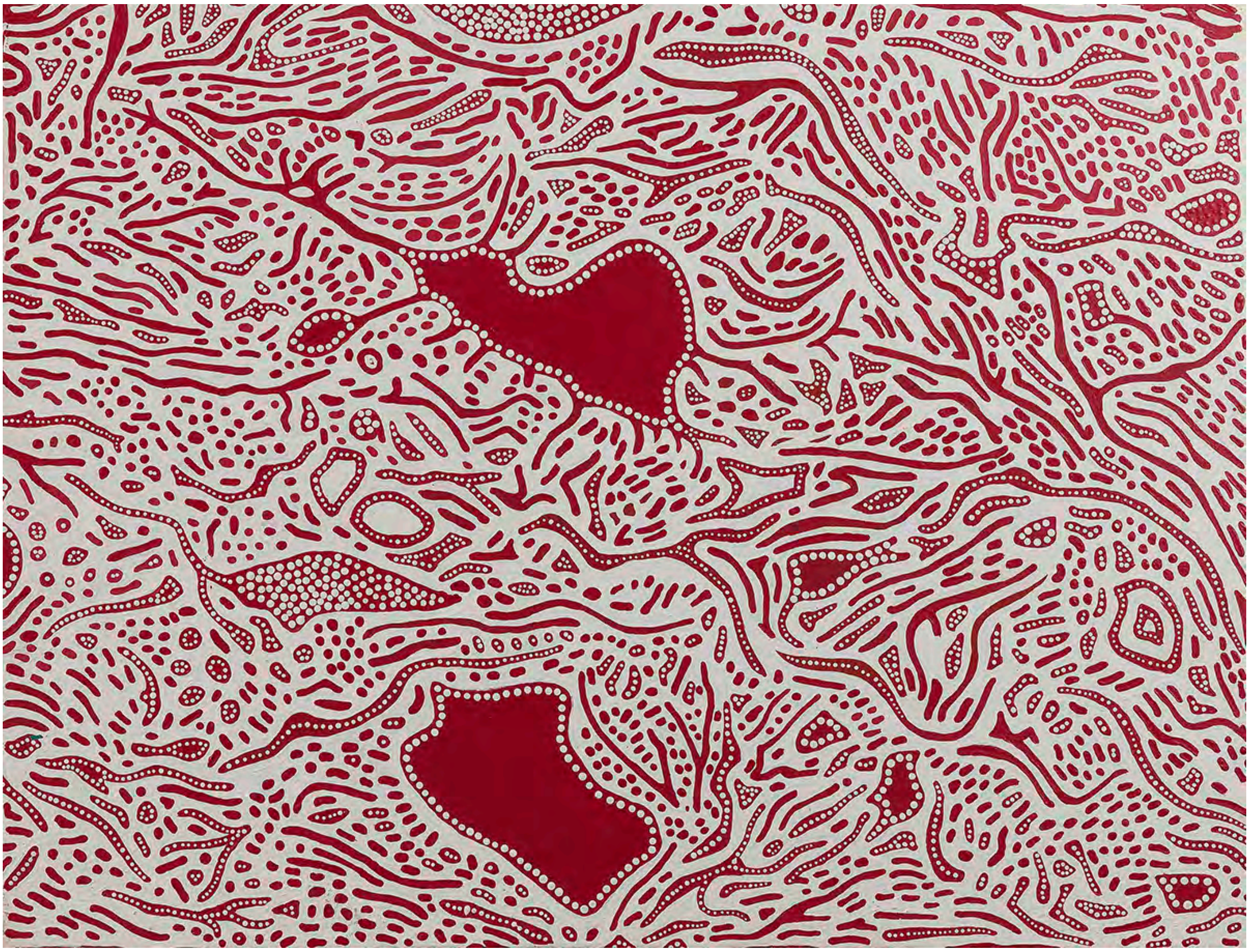
Culture — Sharon Smith

These resources are to assist teachers in exploring the content of the exhibition through classroom activities and discussion and will help you to embed Indigenous perspectives into your teaching.

Each learning resource consists of a brief introduction, followed by an outline for an activity and a list of web resources to draw on.

The learning resources are grouped by school level into three categories – primary, lower secondary and upper secondary. Each resource provides some links to the Australian curriculum. Because of the national scope of the exhibition, links to state-set curriculums are not provided.

Each resource ends with a short list of related careers. There are sure to be many others! A long list of science careers and people profiles can be found at **carrerswithstem.com.au**.



Lukarrara Jukurrpa (Desert Fringe-rush Seed Dreaming) — Priscilla Napurrurla Herbert

Contents

Credits

Resources prepared by **Stones and Bones** in consultation with Microscopy Australia's advisory team.

Edited and designed by Biotext.

MICROSCOPY AUSTRALIA

Primary

Baayami and Gurriya — Arkeria Rose Armstrong

Topic

Rocks – ochre

Curriculum alignment:
Primary

Ochre, a precious rock: exploring the world's oldest paint

Introduction

In our exhibition, several artists have used ochre to paint their artworks and have also responded to the shapes and textures in the micrographs of ochre pigments. The subtle, earthy tones of ochre make it ideal for reproducing the colours and textures of Central Australia.

Aboriginal people around Australia have a strong spiritual relationship with ochre. Ochre is used to decorate the body and paint on stone, often as part of ceremonies. Ochre is also used to create artworks such as those in the exhibition.

Aboriginal people used a variety of additives to turn ochre into paint, including egg yolk, saliva, water, sap and blood. We will make and test the durability of various types of paint made from ochre, and use a variety of additives that seek to emulate the different natural materials

If this resource is used to inform an art lesson, we might make paint with different characteristics. If used in STEAM practice, at earlier stages students could be encouraged to identify the properties of different substances and then predict whether they think those characteristics would make a good paint. This applies to the Science Inquiry Skills area.

The process and the paints would be a good addition to a NAIDOC activity.

Links to the Australian curriculum

The activities outlined here fall into several categories in the Australian Curriculum (www.australiancurriculum.edu.au). Some suggested AC codes are provided.

Foundation to Year 2: ACAVAM106, ACAVAM107, ACLFWC002

Year 3: ACAVAM110, ACSIS054, ACSIS060, ACLFWC024

Year 4: ACAVAM110, ACSHE061, ACSHE062, ACLFWC024

Year 5: ACAVAM114, ACSIS093, ACSIS086, ACLFWC024

Year 6: ACAVAM114, ACSSU095, ACSIS103, ACLFWC024

Ngalyarrpa Jukurrpa (Sandhills Dreaming) — Vanessa Nampijinpa Brown

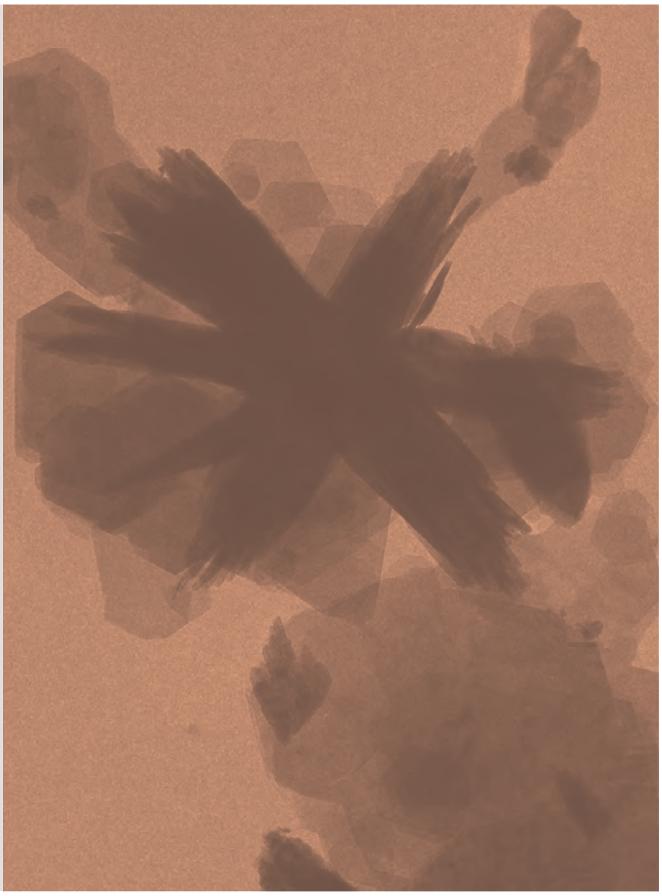
Classroom activity

Making ochre paint

For thousands of years, Aboriginal artists observed the beautiful colours in ochre cliffs and collected these pigments. Some rock art from Northern Australia is over 50 000 years old and depicts past lifestyles and types of extinct megafauna.

A mixture consisting of only ground up raw ochre and water will flake and crumble, and ancient artists must have **experimented with fixatives for their ochre paint**. The exploring, investigating, observing and testing of new mixtures are evidence of the scientific processes used by Aboriginal people. (A fixative is a substance that spreads and preserves the pigment in paint.)

This experiment substitutes different fixatives for natural products. You can also experiment with different substances from the playground and classroom; for example, **Aboriginal artists today use PVA glue to prepare ochre for use in art**.



Materials

You need a range of ochres or coloured rocks (ochre can be obtained from **online providers**); charcoal; water, paintbrushes and small tubs; PVA glue and egg yolk; a mortar and pestle or sandstone slab and a pestle stone; a range of other substances, such as tree sap, sorbolene cream, crushed leaves and so on.

Method

Note that quantities can be changed (for example, halved) but please keep the same ratios.

1. Using the grinding stone and pestle, grind the ochre to a fine powder.
2. To each of 3 tubs, add 2 tablespoons of powder and 5 mL water, mixing carefully to a paste. Label the tubs 'egg yolk', 'PVA' and 'water only'. (In the case of allergy risks, use a vegan egg replacer.)
3. To the 'egg yolk' jar, add one egg yolk. Add another 5 mL of water and stir well. To the 'PVA' jar, add one teaspoon of PVA glue. Add another 5 mL of water and stir well. To the 'water only' jar, add another 5 mL of water and stir well.
4. Your paints are now ready for use.

Testing the durability of ochre paint

1. Paint small stones with each mixture, allow to dry and place outside in the weather.
2. Make observations of your stones over a fortnight; digital photographs will help.
3. Use a magnifying glass or digital USB microscope to record observations of which mixture performs best. Things to look for could include
   - fading
   - cracking
   - flaking
   - powdering.

4. Make a graph or table that charts your results over time for each fixative.
5. We can experiment using other mixtures including oil and fat, sorbolene cream, Vaseline, paw-paw ointment and various plant saps and juices from around the playground.
6. The following are some criteria to assist students in assessing their results. Which binder
   - makes the paint brightest?
   - makes the paint thickest?
   - makes the paint stickiest?
   - lasts the longest?

Questions

- Starting with the exhibition captions, how many different language terms for ochre can you research from around Australia?
- What are some examples of ochre rock art from around Australia and the world? Research some important sites. The sites in Australia are among the world's oldest.
- What other methods did Aboriginal people use to create artworks? What did some of the artworks mean? Research rock art, rock engravings and stone circles from your local area.

Resources

Ochre

- Ochre is the common name for a family of pigments derived from coloured, clay-based minerals. Its name comes from the Greek word for 'yellow'. Aboriginal people have many language names for ochre, Noongar people in Western Australia call **red and yellow ochre Wilgie and white ochre Dardark.**
- Ochre was used around the world to provide colourful pigments for paint, rock art and body decoration.
- Ochre is very valuable to the pigment industry and is mined for paints and dyes.

Ochre and Indigenous people

- **Aboriginal people used and still use ochre to create art works, rock art and body paint**.
- **This article with audio shows ochre collection in the Kimberley region**.
- Ochre was mined and traded by Aboriginal people and was very valuable. Wilgie Mia is **the oldest continually operated mine in the world**.
- Ochre was found at the **Mungo Man burial site**, one of the earliest examples of human occupation in Australia, and at 68 000-year-old **rock art sites in Arnhem Land**.
- Ochre has practical uses. For example, it preserves wooden artefacts by repelling water.
- A coating of ochre protects your skin from insect bites, and eating white ochre can help with stomach upsets. Aboriginal people might have learnt about this by watching animals; some eat white ochre after drinking dirty water. White ochre is also known as kaolin.
- Ochre continues to be of great importance, and there are rules about which colours can be used. You can ask local Aboriginal elders or land councils about your local rules.
- **This video shows people collecting ochre from an ancient quarry in South Australia**.

Career information

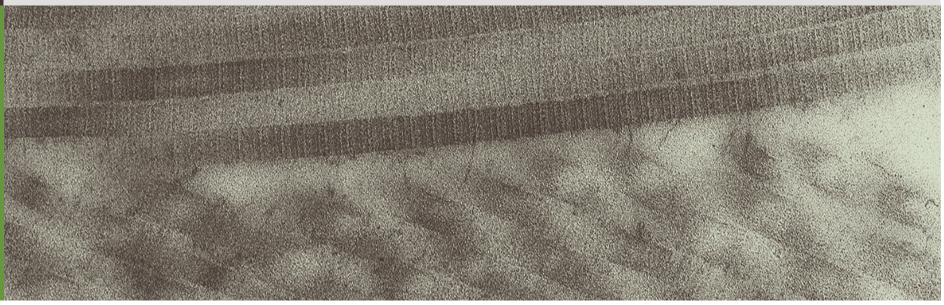
STEM career options related to ochre and other products of the earth include:

- mining and related industries
- land rehabilitation and remediation
- archaeology, including scientific dating techniques, like carbon dating
- artefact preservation and restoration
- geology and earth sciences.

Topic

Fibres – collagen

Curriculum alignment:
Primary



Collagen, skin and new materials

Introduction

In our exhibition, artists have used the textures, colours and skins of various animals, along with micrographs of body tissues, to inspire their artworks. The complex networks of fibres tangled and woven together are strong and resilient. They make a wonderful subject for art, as do the skins of animals.

All these materials contain a natural fibre present in most living things: collagen. Collagen is strong and flexible and is the most abundant protein in your body.

Many of the animals represented in the exhibition have a deep symbolism for Aboriginal people and have spiritual and cultural meanings.

Links to the Australian curriculum

Curriculum connections: food and fibre

Foundation to Year 2: ACAVAM106, ACAVAM107

Year 3: ACAVAM110, ACSIS054, ACSIS060

Year 4: ACAVAM110, ACSHE061, ACHASSI078

Year 5: ACAVAM114, ACSIS093, ACSIS086

Year 6: ACAVAM114, ACSIS103

Gallery activity

Skins

There are several artworks in the exhibition that are either made of animal skins or are inspired by the patterns on animal skins. Some of these skins are soft and supple, others are hard and scaly, and others have different types of body tissues in them.

The crocodile skin has pieces of bone embedded in it, called scutes. Scutes are found in lots of reptiles and even in dinosaurs!

Mammals have developed soft fur and hair on their skin to keep them warm and dry. Humans have lost most of their fur, and use clothes instead, often made from the skin, wool and hair of animals.

Materials and equipment

Crayons and pencils; paper; our collection of skins.

Method

- While you go around the gallery, see what different types of skins you can see and draw or do rubbings of the textures and patterns.
- Touch and feel the various skins we have provided.
- Can you guess what animals they come from?
- What characteristics do each have? Are they soft or hard, flexible or stiff?
- Can you think of a use for each type of skin?
- What do you think the little hard bits in the rough, lumpy skins are?
- Wrap one of the skins around you; how does it make you feel? Warm and safe or uncomfortable?

Questions

- For Aboriginal people all around Australia, skins were very special and useful. Can you think about the different climates Aboriginal people lived in around Australia? Where might we need to keep warm? Where is very hot? What about the difference between night and day? Summer and winter?
- Skins are warm and waterproof, but also made you feel closer to the spirits of your country and your family. Sadly though, Aboriginal people were stopped from wearing them and made to wear clothes made from cotton and wool instead Why do you think Aboriginal people were made to dress differently?
- Today, Aboriginal people are making special cloaks and clothes from skins again, like the one in the exhibition. Are Aboriginal people in your area making things from skins?
- Do you have a special thing you snuggle up to? Can you draw it? What makes it special – is it just how it feels, or was it given to you by someone special? How would you feel if you weren't allowed to cuddle it anymore?

Classroom activity

Strength in numbers

What makes something strong and flexible?

If we overlap lots of small pieces together, is the bundle stronger than the parts?

With students, develop some ideas about whether lots of things together are stronger than things kept on their own, and whether different types of materials are stronger or more flexible than others.

Materials

Lots of twigs, both dry and green (you could also try pine needles; they are plentiful but a bit small). Graph paper and pens.

Method

1. Get students to first break one twig. Try with a dry stick and a green one. Was it easy or hard? Which was easier?
2. Ask students to make a prediction: how many bundled sticks do they think would be too many to break? How do they expect the force needed to break the bundle to increase as we add more sticks? For example, do they expect it to be four times as big if we have four times more sticks? It's good to get them to write down their predictions, so they cannot disown them later!
3. Ask them to experiment with adding sticks until they form a bundle that is too strong to break. They might try comparing dry sticks and green sticks. It might make sense to start with a huge bundle and make it smaller until they can break it – this uses fewer sticks …
4. Students can reflect on how the green sticks flex much more before breaking, and form a more flexible bundle, compared to dry.
5. Can we think of a way to measure the breaking point? A qualitative measure might be: easy; medium; hard, or rating it on a scale of 1 to 3 or 1 to 5. A quantitative measure might be obtained by bridging a gap between two chairs with the bundles and tying weights underneath until they break (that is, give way – not all the fibres will necessarily break), then recording the weights.
6. Ask students to draw a graph of breaking rating or weight against number of twigs. Is it a straight line? Is it what they predicted? If not, why might that be? (It might be that a bundle of some number of twigs, say n twigs, is more than n times stronger than a single twig because the friction of twigs trying to slide past each other helps resist the bending.)

Questions

- If a green stick flexes before it breaks, what about bundles of string?
- Can we bundle together lots of strings to make a strong bundle that is still flexible?
- What is a lot of fibres joined together called?
- Can you see any similarities between string and rope and bundles of collagen fibres?

Resources

Collagen and the body

Our body is divided into different types of tissue, such as muscle and skin. A tissue is a bunch of similar cells that do a specific job in the body.

An important part of our bodies is a type of protein called **collagen**. It makes our skin and many other parts of our body flexible and strong.

Collagen is made of many thin strands that join together into thicker strands called fibres. These fibres are strong, but flexible rather than rigid. Collagen fibres look like string when you see them under a microscope. Collagen is strong because all these long and thin strands overlap and reinforce one another. It is flexible because the strands can bend and slide past each other rather than being locked into a rigid block.

Human history and collagen

Human beings have always used collagen-rich tissues such as skin, sinew and internal organs to make useful things. Before we used plant fibre to make string and cloth, people relied on skins for warmth and sinews for string.

Sinews were used to tie spear and axe heads to their handles, and the strong, flexible parts of animals including intestines, bladders, horn, antlers and bones were used to make tools, bags, water containers and weapons. **Sinew was even used to repair boats**.

Aboriginal people used all these materials, but skins are particularly important and special. **Kangaroo and possum skin cloaks** are owned by Aboriginal leaders and clever people and show how important they are. **These cloaks are still being made** today, and one of our artworks is of a kangaroo skin cloak, decorated with important stories.

Collagen and industry

Strong, flexible collagen is important to industry as well. Leather is used for clothes and tools, but natural and artificial collagen is also used in medicine, including plastic surgery and for replacement skin and other organs. Collagen can be used in the lab, **creating replacement ears and noses**! Today collagen from animals is used, but in the future we hope to use collagen from the people who need the replacement parts. Replacement collagen is also used to make leather substitutes that don't rely on killing animals.

Career information

STEM career options related to collagen, skin and biomaterials include:

- mechanical engineering, including mechanical testing and structural design
- materials science, including the chemistry of materials
- medical science, including development of prosthetics
- taxidermy
- advanced manufacturing of modern materials, including low-energy manufacturing using biological and chemical methods.

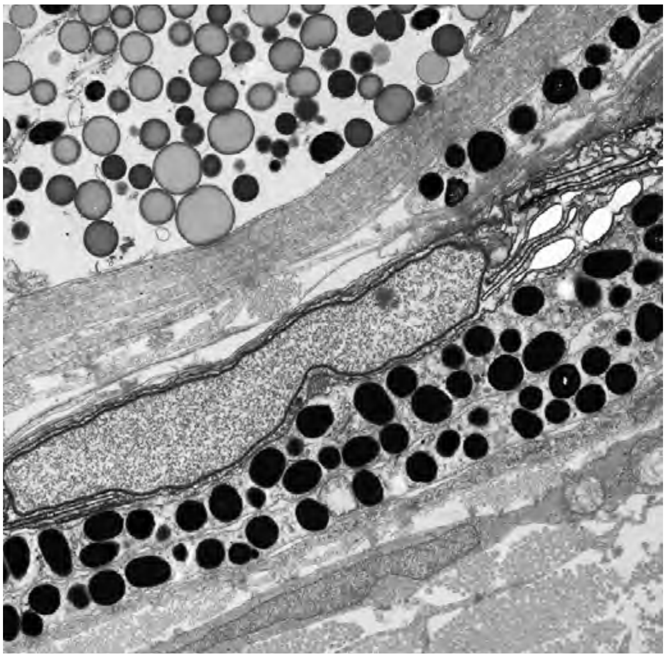


Image: Anne Simpson

Topic

Fibres – string

Malu Minaral — Brian Robinson

Curriculum alignment:
Primary

String

Introduction

In our exhibition, fibres can be seen in both the micrographs and in the artworks they have inspired. For Aboriginal people, fibres literally tied their lives together, allowing people to carry heavy loads, make warm clothing and shelters, catch animals and fish, make tools and create important ceremonial artefacts. One of the exhibition sponsors, CHC Helicopter, depends on fibres to conduct lifesaving rescues. They use rope and strapping for their slings, winches and harnesses. Fibre and string rank as one of humanities' most essential inventions.

Making string, weaving simple baskets and string bags and experimenting with fibre crafts provides an excellent opportunity for STEAM classroom activities.

Links to the Australian curriculum

Curriculum connections: food and fibre

Foundation to Year 2: ACTDEK001, ACTDEK004, ACSSU031

Year 3: ACSIS054, ACSIS060, ACTDEK012, ACTDEK013, ACTDEP014, ACTDEP016

Year 4: ACTDEK012, ACSIS065, ACSSU074, ACTDEK013, ACTDEP014, ACTDEP016, ACHASSK090

Year 5: ACSIS086, ACHASSK120, ACTDEK023

Year 6: ACSIS103, ACTDEK023

Classroom activity

Making and breaking string

Different types of fibre make string with different properties, it can be strong, flexible, waterproof, and combinations of these. Aboriginal people knew this and used different types of fibres to make different objects. Really special objects were secured with extremely strong hair string, made from human hair. Where lots of fibres were overlapped, such as when weaving, then weaker string could be used.

This activity explores the properties of different string-making materials by experimenting with their breaking strengths. We will use commonly found fibres, some of which are surprising, and fibres you can find in the school playground.

Equipment

Various types of fibre, possibly including raffia, toilet paper, grass, Lomandra (a native grass) and any other materials the students think would be suitable. Spring balance. Note book.

Method

Stage 1: Research and testing

- Encourage the students to look at the two commonly available fibre resources, toilet paper and raffia.
- Ask them to list the features that they think make each material suitable as fibre; flexibility, strength, water resistance, etc.
- With the characteristics in mind, go into the school yard to look for other materials that may be suitable. Lomandra (also known as spiny mat rush and basket grass) is a common landscaping plant that is excellent for string making. Any grass is suitable, as are the stems of fibrous plants. See if you can find both dry and fresh samples of some materials as this may affect their strength. Students may be asked to bring materials from home.
- Students can research what fibre resources were used by Aboriginal people in their area. Some commonly used and widely distributed plants include Kurrajong and native hibiscus. Can students find these materials?
- After collection, ask the students to grade each material as to whether they think it will make good string, according to their criteria. Encourage them to pull, twist, bend and wet the material to see what happens, and note any observations.

Stage 2: Making string

1. Making short lengths of string is easy. Longer lengths may be made using a variety of techniques; however, these are best investigated through various **online video tutorials**.
2. In pairs, students are to select a piece of fibre, starting with raffia.
3. They stretch the fibre taut between them.
4. Keeping the fibre taut, students start to twist each end in a clockwise direction. Since they are facing each other, this will twist up the fibre.
5. They continue to twist until the fibre is twisted along its whole length and is 'trying' to untwist itself. They must not let go, or it will untwist.
6. Students then find the middle of the piece, pinch a loop and, keeping firm hold, double the fibre up, also keeping hold of each end.
7. They let go of where they pinched the middle. The fibre will twist over itself, forming a double-ply string. This double ply conveys strength and also locks the string together. To finish the piece, the students should tie the two ends together with an **overhand knot**.
8. They should repeat the process with a range of different materials, starting with toilet paper. Toilet paper makes surprisingly strong string!
9. Each piece of string should be about 30 cm long. A 1 m length of fibre will produce around 30 cm of string.
10. They may go further and try plaiting different strings together.

Stage 3: Testing

1. In their groups, students select good pieces of string from their various materials.
2. They hang the spring balance from a convenient location and then attach their string.
3. The string is loaded with weights. They are added (gently) one at a time until the string snaps. The breaking weight is recorded.
4. **Another technique** is to attach the spring balance and string to a strong surface and then pull on the string until it breaks, noting the reading on the dial.
5. Students record each result in a table and compare the various materials.
6. They can explore more dimensions by wetting each material, swinging it from side to side, flexing the string (etc) and seeing if different materials perform better under different conditions.

Questions

- Which material is the strongest? Does it depend on the conditions such as moisture or flex?
- Consider why this is the case. What properties does the best string-making material possess?
- Reflect on the types of rope and cable used by CHC Helicopter in their rescues and other work. Why have they selected different materials for different needs?
- How does your string's breaking strength compare to the materials used by CHC Helicopter? Can you see why the standards mentioned are important to maintain?

And one other question

- The long intestines of the koala were used as rope by the Yaegl people of northern NSW. Can you find out what aspects of the structure of intestines would make them a good rope?

Resources

Fibre

- Many plants have **tough fibres that make them suitable for making twine**. The fibres in plants generally are there to provide flexible strength to the trunk and branches, so that they don't break in strong winds and floods.
- Grasses and small annual shrubs, like nettles, flax and hemp, have strong fibres in their stems and leaves because they grow in open areas and need to resist the wind and trampling by animals.
- Sinews connect muscles to bone. They have to be strong under tension (that is, pulling forces) and so provide a source of useful fibre.
- Many useful fibres have been obtained from various parts of plants, including leaves, stems (**bast fibres**), fruits and seeds.
- Plant fibres used for making string and cloth include hemp, cotton and flax, which is used to make linen.
- Important characteristics of fibres are their length and strength; these characteristics depend mainly on fibre location within the plant.
- Fibres from fruits and seeds are just a few centimetres long, whereas fibres from stems and leaves can be more than 1 m long.
- The more strands in a string or rope, the stronger it is. Many different techniques are used, including bundling, combining different numbers of strands, wrapping and twisting the cord in different directions, and combining materials with different properties to make stronger composite materials.
- The strength of a string or rope is measured according to its tensile strength, or breaking strength, in pounds, kilograms or newtons.

Resources

Fibre and people

- String, rope and fibres are important technologies for people around the world and throughout history.
- They were used to bind tools like spears and axes together; for fishing lines; to make bags and nets; and to make ropes, in which several strands are wound together. Strong and flexible fibres are used to make string bags, belts and other clothing, and for weaving.
- Some Indigenous cultures used fibre to build their houses, instead of using nails or other fixtures.

  *The fabric of Dani material culture is fibre, plain or rolled into string. The women's skirts are braided of fibre and tied with string; the girls' skirts are held together with string; the women's carrying nets are of string; the exchange system at the core of their ceremonialism centres on knitted string bands and string nets. The Dani use no nails or spikes. All construction is lashed together with vines gathered in the forests. . . . The Dani are technically a Stone Age culture. Stone tools are important but in fact the Dani culture is based on wood and string and could be called a String Culture.**
- **Pacific Islander cultures used their incredible knowledge of fibre to make sailing canoes that carried hundreds of people on ocean journeys of thousands of kilometres.**
- Fibre is also very important for making art and decorations, and **some of the oldest finds in archaeology are beads, which would have been bound on string necklaces.**
- **Australia Indigenous women's fibre crafts**, including weaving, string making and basketry, are among the most complex and beautiful in the world. This link shows the variety of different materials women use to make their fibre crafts and how quick they are at making strong, flexible string.

Ropes in rescue

- One of the sponsors of this exhibition, **CHC Helicopter**, uses ropes and cables engineered to incredible standards in their work of rescue and helicopter transport around the world.
- The strongest is the rescue winch cable. This is a steel cable with a tensile strength of nearly 1500 kg (14 800 N). The cable is 74 m long and consists of six outer wire stands wound round a centre wire core. Each wire stand consists of an inner layer and outer layer of wire wound round a centre wire. The inner wire layer contains six wires and the outer wire layer contains 12 wires. **Examples of similar cables can be found here.**
- **The hoist is used to deploy and recover persons to and from the helicopter in straightforward rescues, and for delivering loads.**
- They also use fibre ropes, including double-twisted polyester and nylon strands. These are more flexible and allow winching in difficult circumstances such as from yachts or off cliffs where the load might swing or come up at an angle.
- Fine cables are used to prevent stretchers from spinning when being winched on-board. These are 85 m long and made from Paracord Mil-Spec.
- This Mil-Spec Paracord is designed to meet the requirements of the US Department of Defense. Mil-Spec Paracord must go through rigorous testing, from raw materials to the final product, in order for it to be certified for US military use. Requirement Mil-C-5040H says that each of the core strands are made up of three twisted-ply strands.

Career information

STEM career options related to string and other fibres and cables include:

- mechanical engineering, including mechanical testing and structural design
- materials science, including the chemistry of materials
- advanced manufacturing of modern materials, including developing new materials from plants and other natural sources
- biology, including studying natural fibres like spider silk and wool
- search and rescue
- fabric design and production.

Lower secondary

Witchetty Grub Dreaming — Jennifer Napaljarri Lewis,

Topic

Rocks and minerals – ochre

Curriculum alignment:
Junior secondary

Ochre, a precious rock: exploring the world's oldest paint

Introduction

In our exhibition, several artists have used ochre to paint their artworks and have also responded to the shapes and textures in the micrographs of ochre pigments. The subtle, earthy tones of ochre make it ideal to reproduce the colours and textures of Central Australia.

Aboriginal people around Australia have a strong spiritual relationship with ochre.

These artworks and the activities in this resource touch on a wide variety of subjects within the Australian curriculum. These include visual arts, chemistry, design and technology, science as a human endeavour, and science inquiry skills.

These activities include making and testing the durability of various types of paint made from ochre and a variety of different additives. The additives seek to emulate the different natural materials Aboriginal people used, including egg yolk, saliva, water, sap and blood. These innovations have allowed rock art of incredible antiquity to survive into the modern day.

Links to the Australian curriculum

Year 7: ACTDEK034, ACTDEP037, ACSHE223, ACSHE121, ACHASSI159, ACAVAM118

Year 8: ACTDEK034, ACTDEP037, ACSSU152, ACSHE136, ACSHE226, ACAVAM118

Year 9: ACTDEK043, ACSIS164, ACSIS165, ACSIS170, ACSIS171, ACAVAM126

Year 10: ACTDEK043, ACSIS199, ACSIS200, ACSIS205, ACAVAM126

Classroom activity

Making ochre paint

This experiment substitutes different fixatives for natural products. In addition, you can experiment with different substances from the schoolground and classroom; for example, Aboriginal artists today use PVA glue to prepare ochre for use in art.

Materials

You need a range of ochre or coloured rocks (ochre can be obtained from online providers); charcoal; water, paintbrushes and small tubs; PVA glue and egg yolk; a mortar and pestle or sandstone slab and a pestle stone; a range of other substances, such as tree sap, sorbolene cream, crushed leaves and so on. In the case of egg allergy risks, a vegan egg replacer can be used.

Method

Note that quantities can be changed (for example, halved) but please keep the same ratios.

1. Using the grinding stone and pestle, grind the ochre to a fine powder.
2. To each of 3 tubs, add 2 tablespoons of powder and 5 mL water, mixing carefully to a paste. Label the tubs 'egg yolk', 'PVA' and 'water only'.
3. To the 'egg yolk' jar, add one egg yolk. Add another 5 mL of water and stir well. To the 'PVA' jar, add one teaspoon of PVA glue. Add another 5 mL of water and stir well. To the 'water only' jar, add another 5 mL of water and stir well.
4. Your paints are now ready for use.

Testing the durability of ochre paint

1. Paint small stones with each mixture, allow to dry and place outside in the weather. Place some under cover, in the rain and in the sun to replicate a range of environmental conditions.
2. Make observations of your stones over a fortnight; digital photographs will help.
3. Use a magnifying glass or digital USB microscope to record observations of which mixture performs best. They could include
   - fading
   - cracking
   - flaking
   - powdering.
4. Make a graph or table that charts your results over time for each fixative.
5. We can experiment using other mixtures including oil and fat, sorbolene cream, Vaseline, paw-paw ointment and various plant saps and juices from around the schoolground.
6. The following are some criteria to assist students in assessing their results. Which binder
   - makes the paint brightest?
   - makes the paint thickest?
   - makes the paint stickiest?
   - lasts the longest?

Questions

- What natural fixatives did Aboriginal people use?
- What do you think was the process of experimentation, observation and exploration for ancient Aboriginal people?
- How do you think modern Aboriginal artists experimented with and adopted new techniques and materials?
- Research the history of modern Aboriginal art, looking at places such as Yuendumu, Warmun, Utopia and Arnhem Land. How have Aboriginal artists innovated with new materials and techniques while incorporating ancient methods and important cultural values?

Resources

Ochre

- Ochre is the common name for a family of pigments derived from coloured clay-based minerals. Its name comes from the Greek word for 'yellow'. Aboriginal people have many language names for ochre, Noongar people in Western Australia call **red and yellow ochre Wilgie and white ochre Dardark**.
- Ochre is a fine-grained, layered sedimentary rock, formed in shallow seas and lakes. It comprises a variety of different **minerals, with different colours, chemical formulas and characteristics.**
- There is one type of ochre that lacks colourful pigments. White ochre is **pure kaolin clay, a layered mineral of silicon dioxide and aluminium oxide (also known as alumina)**.
- This layered structure is seen in exhibition micrographs. Kaolin can be fired to make fine bone china, and is used as a pigment in many industries, including paper production.
- Some ochre contains other minerals, including shiny, reflective **mica**. These minerals give the ochre paint depth and are highly prized both by Aboriginal people and for modern pigment applications.
- Ochre was used around the world to provide colourful pigments for paint, rock art and body decoration.
- Ochres are common in Europe and have been found in association with **archaeological sites** including those associated with **Neanderthal humans.**
- Ochre is very valuable to the pigment industry and is mined for paints and dyes.

Ochre and Indigenous people

- **Aboriginal people used and still use ochre to create art works, rock art and body paint**.
- **This article with audio shows ochre collection in the Kimberley region**.
- Some rock art from Northern Australia is over **50 000 years old and depicts extinct megafauna and past lifestyles**.
- Ochre was mined and traded by Aboriginal people and was very valuable. Wilgie Mia is **the oldest continually operated mine in the world**. Another site is the world's **deepest prehistoric mine**.
- Raw ochre mixed with water flakes and crumbles, and ancient artists must have experimented with fixatives for their ochre paint, exploring and investigating, observing and testing new mixtures. This shows the scientific capabilities of Aboriginal people. (A fixative is a substance that spreads and preserves the pigment in paint.)
- Sites where valuable ochre can be mined are highly spiritually significant and are usually sacred sites.
- Ochre was found at the **Mungo Man burial site**, one of the earliest evidences of human occupation in Australia, and at 68 000-year-old **rock art sites in Arnhem Land**.
- Ochre continues to be of great importance. There are rules about which colours can be used. You can ask local Aboriginal elders or land councils about your local rules.
- **This video shows people collecting ochre from an ancient quarry in South Australia**.

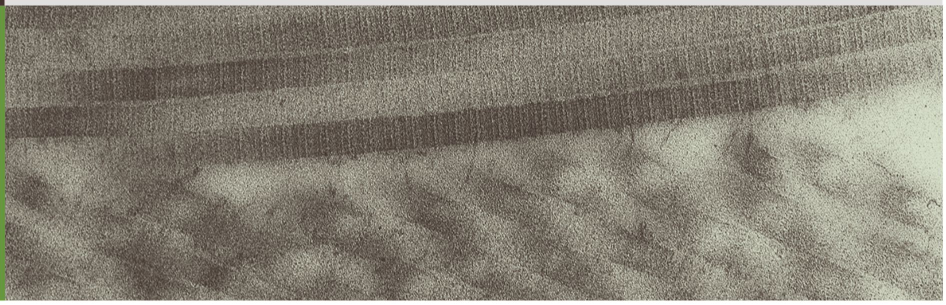
Career information

STEM career options related to ochre and other products of the earth include:

- mining and related industries
- land rehabilitation and remediation
- archaeology, including scientific dating techniques, like carbon dating
- artefact preservation and restoration
- geology and earth sciences
- cosmetics manufacturing
- paint manufacturing.

Topic

Fibres – collagen



Curriculum alignment:
Lower secondary

Collagen, skin and new materials

Introduction

In our exhibition, artists have used the textures, colours and skins of various animals, along with micrographs of body tissues, to inspire their artworks. The complex networks of fibres, tangled and woven together, are strong and resilient. They make a wonderful subject for art, as do the skins of animals.

All these tissues contain a natural fibre present in most living things: collagen. Collagen is strong and flexible and is the most abundant protein in your body.

Many of the animals represented in the exhibition have a deep symbolism for Aboriginal people and have spiritual and cultural meanings.

Human bodies are made up of many tissues, but which contain collagen? The properties of collagen, flexibility and strength, might give us a clue.

Links to the Australian curriculum

Curriculum connections: food and fibre

Animal ethics

Year 7: ACSHE120, ACTDEK029

Year 8: ACSHE135, ACSIS234, ACSIS148, ACSHE226, ACTDEK029

Year 9: ACSHE160, ACSIS170

Year 10: ACSHE194, ACSIS206

Activities

ACTIVITY: What human tissues are rich in collagen?

Ask students to experiment with their (own!) body. They can twist, stretch and pull various parts such as hair and skin and reflect on whether they are flexible and strong, or rigid.

Ask them to make a list of tissues they think are made of (or include) collagen, stating their assumptions as hypotheses. They should provide a list of observed characteristics and reflect on what each tissue might be made of.

They can then use some research about the constituents of various human tissues to confirm or disprove their observations.

ACTIVITY: Collagen claims and fake science

Collagen is big business these days, and a lot of very strong claims are made. However, many of these are motivated by profit and really are more like advertising. As scientists, we need to be able to discern fake science, or pseudoscience, from scientific information based in the empirical method. This activity will require students to make some judgements about information about the uses of collagen.

In class, ask students to research some of the claims about collagen, and apply their scientific filter to see if the claims are backed up by experimental evidence, or whether they are simply advertising. Can they find scientific papers that back up any such claims?'

Here are some links to some accessible papers, advertising and other resources to kick start the research.

- 'Collagen in skin cream can make you look young again!'
- 'Collagen shampoo can make your hair beautiful and strong!'
- 'Collagen capsules can reverse aging!'
- The media has been quick to publicise these claims as new 'miracle cures' for ageing and other health and lifestyle problems, but are these claims backed up by science?
- Should I eat collagen powder?
- A scientific study – does it seem reliable?
- On closer examination, many of the scientific articles claiming to prove effectiveness were written by the company itself and are actually promoting their own products.
- 'There isn't a great deal of data on this but the evidence for topically applied collagen-containing products having any benefit is scant,' says Christopher Griffiths, Professor of Dermatology at the University of Manchester.
- In fact, there are very few scientific studies into most of these products, because of the purely cosmetic benefits they claim to deliver. This lack of real health benefits allows the companies to slip through legislative loopholes and make claims in advertising not backed up by actual science.

ACTIVITY: Classroom discussion – the ethics of scientific advances

Artificial animal- and human-derived collagen is being grown in labs and used in medicine and industry. Some of these uses address current ethical dilemmas, such as vegan leather, while others create whole new ethical problems. This activity opens up a debate on whether there are issues for different cultures regarding the use of these new technologies and techniques.

- What are the ethical issues of using tissues derived from various sources in the medical and fashion industries?
- Many different cultures around the world have prohibitions against using tissues from different animals and human sources. Can you think of any? (Examples – Hindu people revere the cow, and Muslims and Jewish people avoid pig meat and products.)

- Are new technologies using animal tissues a problem for these groups?
- Would you be happy to have pig or horse tissue used in your body? What about tissue grown in a lab but 'seeded' by animal tissue?
- Are you happy to wear leather, knowing that it comes from animals?
- What if you had human tissue from a donated body used in a skin graft?

Once students have done some reading, divide the class in two and debate the benefits and shortcomings of this type of technology.

Resources

Collagen and the body

Our body is divided into different types of organs and tissues, such as muscle and skin. A tissue is a bunch of similar cells that do a specific job in the body. An important part of many tissues in our bodies is a type of protein called collagen. It makes our skin and many other parts of our body flexible and strong.

Collagen is made of many thin strands of individual protein molecules that join together into thicker strands called fibres. These fibres are strong, but flexible rather than rigid. Collagen fibres look like string when you see them under a microscope. Collagen is strong because all these long and thin strands overlap and reinforce one another. It is flexible because the strands can bend and slide past each other rather than being locked into a rigid block.

For a molecular material to make a good fibre it must be long and tough. Collagen fibres stay together in a bundle because they are twisted around each other and surface tension causes them to lock together. The interlocking nature of the collagen fibres means that collagen is an ideal scaffold on which other molecules and cells can be fixed, allowing the growth and differentiation of different body tissues.

The structure of these collagen strands, that twist and overlap, is repeated at the molecular level. Collagen cells are arranged into a triple helix, making them strong even at the smallest scale. Collagen is so strong that a particular type of collagen-rich tissue, cartilage, entirely replaces bone in some organisms, such as sharks and rays.

Human history and collagen

Human beings have always used collagen-rich tissues such as skin, sinew and internal organs to make useful things. Before we used plant fibre to make string and cloth, people relied on skins for warmth and sinew for string.

Sinews were used to tie spear and axe heads to their handles, and the strong, flexible parts of animals including intestines, bladders, horn, antlers and bones were used to make tools, bags, water containers and weapons. Sinew was even used to repair boats.

Aboriginal people used all these materials, but skins are particularly important and special. Kangaroo and possum skin cloaks are owned by Aboriginal leaders and clever people and show how important they are. These cloaks are still being made today, and one of our artworks is of a kangaroo skin cloak, decorated with important stories.

Collagen and industry

Collagen and collagen-rich tissues are very important in the medical industry, but also in things such as fashion and other emerging industries. In particular, cartilage is being investigated as an easily made human tissue.

Artificial and grafted collagen-rich tissues are rapidly becoming part of reconstructive surgery, particularly in plastic surgery. Because of collagen's biomechanical structure, cartilage is easily cultured; that is, cells harvested from organic sources (human or animal) can be induced to grow in the lab. Purely artificial, recombinant collagen is becoming part of the medical world and is also used to create products such as 'vegan' leather for the textiles industry.

These products assist in many medical procedures and in other areas such as drug delivery, because we can grow tissue using a recipient's own tissues, avoiding rejection of collagen derived from other animal sources.

Career information

STEM career options related to collagen, skin and biomaterials include:

- mechanical engineering, including mechanical testing and structural design
- materials science, including the chemistry of materials
- medical science, including development of prosthetics
- taxidermy
- advanced manufacturing of modern materials, including low-energy manufacturing using biological and chemical methods
- search and rescue
- fabric/fashion design and production.

Topic

Fibres – string

Curriculum alignment:
Lower secondary

String

Introduction

In our exhibition, fibres can be seen in both the micrographs and in the artworks they have inspired. For Aboriginal people, fibres literally tied their lives together, allowing people to carry heavy loads, make warm clothing and shelters, catch animals and fish, make tools and create important ceremonial artefacts. One of the exhibition sponsors, CHC Helicopter, depends on fibre to conduct lifesaving rescues. They use rope and strapping for their slings, winches and harnesses. Fibre and string rank as one of humanities' most essential inventions.

Making string, weaving simple baskets and string bags and experimenting with fibre crafts provides an excellent opportunity for STEAM classroom activities.

Links to the Australian curriculum

Curriculum connections: food and fibre

Year 7: ACTDEK034

Year 8: ACTDEK034

Year 9: ACHGK061, ACSIS170

Year 10: ACLFWC179

Making and breaking string

Different types of fibre make string with different properties, it can be strong, flexible, waterproof, and combinations of these. Aboriginal people knew this and used different types of fibre to make different objects. Really special objects were secured with extremely strong hair string, made from human hair. Where lots of fibres were overlapped, such as when weaving, then weaker string could be used.

This activity explores the properties of different string-making materials by experimenting with their breaking strength. We will use commonly found fibres, some of which are surprising, and fibres you can find in the schoolground

Equipment

Various types of fibre; raffia, toilet paper, grass, Lomandra (a native grass) and any other materials the students think would be suitable. Spring balance. Note book.

Method

Stage 1: Research and testing

- Encourage the students to look at the two commonly available fibre resources, toilet paper and raffia.
- Ask them to list the features that they think make each material suitable as fibre; flexibility, strength, water resistance, etc.
- With the characteristics in mind, go into the school yard to look for other materials that may be suitable. Lomandra (also known as spiny mat rush and basket grass) is a common landscaping plant that is excellent for string making. Any grass is suitable, as are the stems of fibrous plants. See if you can find both dry and fresh samples of some materials as this may affect their strength. Students may be asked to bring materials from home.
- Students can research what fibre resources were used by Aboriginal people in their area. Some commonly used and widely distributed plants include Kurrajong and native hibiscus. Can students find these materials?
- After collection, ask the students to grade each material as to whether they think it will make good string, according to their criteria. Encourage them to pull, twist, bend and wet the material to see what happens, and note any observations.

Stage 2: Making string

1. Making short lengths of string is easy. Longer lengths may be made using a variety of techniques; however, these are best investigated through various **online video tutorials**.
2. In pairs, students are to select a piece of fibre, starting with raffia.
3. They stretch the fibre taut between them.
4. Keeping the fibre taut, students start to twist each end in a clockwise direction. Since they are facing each other, this will twist up the fibre.
5. They continue to twist until the fibre is twisted along its whole length and is 'trying' to untwist itself. They must not let go, or it will untwist.
6. Students then find the middle of the piece, pinch a loop and, keeping firm hold, double it up, also keeping hold of each end.
7. They let go of where they pinched the middle. The fibre will twist over itself, forming a double-ply string. This double ply conveys strength and also locks the string together. To finish the piece, the students should tie the two ends together with an **overhand knot**.
8. They should repeat the process with a range of different materials, starting with toilet paper. Toilet paper makes surprisingly strong string!
9. Each piece of string should be about 30 cm long. A 1 m length of fibre will produce around 30 cm of string.
10. They may go further and try plaiting different strings together.

Stage 3: Testing

1. In their groups, students select good pieces of string from their various materials.
2. They hang the spring balance from a convenient location and then attach their string.
3. The string is loaded with weights. They are added (gently) one at a time until the string snaps. The breaking weight is recorded.
4. **Another technique** is to attach the spring balance and string to a strong surface and then pull on the string until it breaks, noting the reading on the dial.
5. Students record each result in a table and compare the various materials.
6. They can explore more dimensions by wetting each material, swinging it from side to side, flexing the string (etc) and seeing if different materials perform better under different conditions.

Questions

- Which material is the strongest? Does it depend on the conditions such as moisture or flex?
- Consider why this is the case. What properties does the best string-making material possess?
- Reflect on the types of rope and cable used by CHC Helicopter in their rescues and other work. Why have they selected different materials for different needs?
- How does your string's breaking strength compare to the materials used by CHC Helicopter? Can you see why the standards mentioned are important to maintain?

And one other question

- The long intestines of the koala were used as rope by the Yaegl people of northern NSW. Can you find out what aspects of the structure of intestines would make them a good rope?

Resources

Fibre

- Many plants have **tough fibres that make them suitable for making twine**. The fibres in plants generally are there to provide flexible strength to the trunk and branches, so that they don't break in strong winds and floods.
- Grasses and small annual shrubs, like nettles, flax and hemp, have strong fibres in their stems and leaves because they grow in open areas and need to resist the wind and trampling by animals.
- Sinews connect muscles to bone. They have to be strong under tension (that is, pulling forces) and so provide a source of useful fibre.
- Many useful fibres have been obtained from various parts of plants, including leaves, stems (**bast fibres**), fruits and seeds.
- Plant fibres used for making string and cloth include hemp, cotton and flax, which is used to make linen.
- Important characteristics of fibres are their length and strength; these characteristics depend mainly on fibre location within the plant.
- Fibres from fruits and seeds are just a few centimetres long, whereas fibres from stems and leaves can be more than 1 m long.
- The more strands in a string or rope, the stronger it is. Many different techniques are used, including bundling, combining different numbers of strands, wrapping and twisting the cord in different directions, and combining materials with different properties to make stronger composite materials.
- The strength of a string or rope is measured according to its tensile strength, or breaking strength, in pounds, kilograms or newtons.

Fibre and people

- String, rope and fibres are important technologies for people around the world and throughout history.
- They were used to bind tools like spears and axes together; for fishing lines; to make bags and nets; and to make ropes, in which several strands are wound together. Strong and fibres are used to make string bags, belts and other clothing and for weaving.
- Some Indigenous cultures used fibre to build their houses, instead of using nails or other fixtures.

  *The fabric of Dani material culture is fibre, plain or rolled into string. The women's skirts are braided of fibre and tied with string; the girls' skirts are held together with string; the women's carrying nets are of string; the exchange system at the core of their ceremonialism centres on knitted string bands and string nets. The Dani use no nails or spikes. All construction is lashed together with vines gathered in the forests. . . . The Dani are technically a Stone Age culture. Stone tools are important but in fact the Dani culture is based on wood and string and could be called a String Culture.**

- **Pacific Islander cultures used their incredible knowledge of fibre to make sailing canoes that carried hundreds of people on ocean journeys of thousands of kilometres.**
- Fibre is also very important for making art and decorations, and **some of the oldest finds in archaeology are beads, which would have been bound on string necklaces.**
- **Australia Indigenous women's fibre crafts**, including weaving, string making and basketry, are among the most complex and beautiful in the world. This link shows the variety of different materials women use to make their fibre crafts and how quick they are at making strong, flexible string.

Ropes in rescue

- One of the sponsors of this exhibition, **CHC Helicopter**, use ropes and cables engineered to incredible standards in their work of rescue and helicopter transport around the world.
- The strongest is the rescue winch cable. This is a steel cable with a tensile strength of nearly 1500 kg (14 800 N). The cable is 74 m long and consists of six outer wire stands wound round a centre wire core. Each wire stand consists of an inner layer and outer layer of wire wound round a centre wire. The inner wire layer contains six wires and the outer wire layer contains 12 wires. **Examples of similar cables can be found here.**
- **The hoist is used to deploy and recover persons to and from the helicopter in straightforward rescues, and for delivering loads.**
- They also use fibre ropes, including double-twisted polyester and nylon strands. These are more flexible and allow winching in difficult circumstances such as from yachts or off cliffs where the load might swing or come up at an angle.
- Fine cables are used to prevent stretchers from spinning when being winched on-board. These are 85 m long and made from Paracord Mil-Spec.
- This Mil-Spec Paracord is designed to meet the requirements of the US Department of Defense. Mil-Spec Paracord must go through rigorous testing, from raw materials to the final product, in order for it to be certified for US military use. Requirement Mil-C-5040H says that each of the core strands are made up of three twisted-ply strands.

Career information

STEM career options related to string, and other fibres and cables include:

- mechanical engineering, including mechanical testing and structural design
- materials science, including the chemistry of materials
- advanced manufacturing of modern materials
- biology, including studying natural fibres like spider silk and wool
- study of plants and their industrial uses
- search and rescue
- adventure tourism.

MICROSCOPY AUSTRALIA

Upper secondary/college

Dry River Bed — Kurun Warun

Topic

Rocks and minerals – ochre

Curriculum alignment:
Senior secondary

Ochre, a precious rock: exploring conflict between cultures regarding mining

Introduction

In our exhibition, several artists have used ochre to paint their artworks and have also responded to the shapes and textures in the micrographs of ochre pigments. The subtle, earthy tones of ochre make it ideal to reproduce the colours and textures of Central Australia.

The relationship Aboriginal people have to this resource is a good case study looking at conflict in the mining sector with Aboriginal communities. It also informs conversations about how Western science and business views Aboriginal perspectives of Country, spirituality and sacred sites.

These activities include researching and reporting on the nature of mining and its relationship to Australia's Indigenous peoples.

Links to the Australian curriculum

Geography

ACHGK049; ACHGK052; ACHGK071; ACHGK072

History

ACDSEH03; ACDSEH148

Science

ACSHE121, ACSHE136

Activities

Inquiry questions

- What are the components of rocks and soils?
- How are nonrenewable geological resources discovered and extracted?
- How are Australia's natural resources extracted, used and managed?
- How can humans manage the earth's natural resources sustainably?

Secondary investigation: ideas, research areas and questions

- Aboriginal people see land very differently from Western people and have a different value system. What do some of these terms mean; sacred site; songline; dreaming; totem; custodian, in the context of Aboriginal attitudes to land and natural resources?
- Given those differences, how do you think mining and other natural resource industries make Aboriginal people feel? If you are an Indigenous Australian, how does it make you feel?
- Using the information above as a starting point, research the legislation regarding mineral exploration and extraction.
- What are the rules regarding access to Aboriginal land under Native Title? How can Aboriginal people reach agreements, such as Indigenous Land Use Agreements and do they represent adequate protection and representation of Aboriginal rights?
- Reflect on the frequently conflicting value systems of Aboriginal people and modern Australia regarding protection of Country and any remediation of mining land.
- Research agreements and conflicts between mining interests and Aboriginal custodians. Compare cases in which conflict has been resolved with those in which Aboriginal values have been ignored or degraded.

Groupwork activity

Investigate whether there are successful cooperative activities in Australia and detail why they are successful. Present the findings to the class. Consider role-playing aspects of the negotiation process.

- How did the different groups present their points of view?
- How was consensus reached?
- Were all parties happy with the decision?

Winter Springs — Evelyn Malgil

- How can Aboriginal people be involved in mining, either as workers or financial beneficiaries, if participation requires damaging and altering natural landforms that are of cultural and spiritual value?
- How can Aboriginal people address this compromise and might this introduce destructive conflict within their communities?

Resources

Ochre

- Ochre is the common name for a family of pigments derived from coloured stone and other minerals. It is found in many locations around the world and derives its name from the Greek word for 'yellow'.
- Ochre is a fine-grained, layered sedimentary rock, formed in shallow seas and lakes.
- It comprises oxidised mineral deposits, including natural iron oxide and hydroxide minerals.
- This type of sedimentary material is usually called clay; however, in ochre deposits the colourful iron oxide can form up to 50% of the total volume. Poor-quality ochre also forms within sandstone and ironstone.
- Ochres were common in Europe and have been found in association with archaeological deposits, including with Neanderthal man.
- Ochre was used in the past to provide colourful pigments for paint and body decoration, and continues to be mined for the production of paints and dyes.
- Ochres are used in the pigment industry and are mined on a commercial scale in Australia and overseas. However, this mining often compromises Aboriginal and Torres Strait Islander cultural values.
- Indigenous Australians used and still use these various pigments selectively to create art works and body paint.
- This video shows ochre collection in the Kimberley region.

Ochre and Indigenous Australians

- As with all parts of the natural world, stone, the right to use, shape, mine and trade it is of critical importance to Aboriginal people, and is part of a complex system of cultural and spiritual obligations.
- Rules and restrictions exist on who can access and use various materials, particularly ochre, which is used for ceremonial purposes across Australia.
- Sites where valuable ochre can be found are highly spiritually significant and are usually sacred sites. Many stories and creation myths are associated with ochre and frequently mark the beginning of songlines and other culturally important pathways through and between Countries.
- In Australia ochre has been found in the Mungo Man burial, one of the earliest examples of human occupation in Australia, and at rock art sites in Arnhem Land, dated to 65 000 years ago. From this time until the modern day, ochre continues to be of great importance to Aboriginal people.
- Its value and relative scarcity made it an important trade item prior to white invasion, and ochre has been traded many thousands of kilometres by various Aboriginal groups. The Mungo Man burial, for example, is painted with ochre from over 400 km from the site.
- Aboriginal people employed extensive and sophisticated mining methods. The deepest Mesolithic mine in the world (in South Australia) contains ochre and other tool-making rocks.
- Wilgie Mia, the oldest continually operated mine in the world, is an ochre pit in Western Australia.
- At this site, valuable ochre of particular quality and unusual colour occurs, and so communities with access to these resources were highly regarded and formed the hubs of important and valuable trading networks.

Resources

Aboriginal people and the mining industry

- Businesses and governments have historically put cultural and spiritual considerations second to economics, growth and development. In some cases, even conservation and natural heritage considerations have damaged Aboriginal sacred sites. When Aboriginal people speak of such activities in their own voices, as in the videos from this link, their pain is clear.
- Wilgie Mia has been under serious threat from mining interests, because the ochre is indicative of the presence of other valuable minerals. Elsewhere, mining has taken place on ochre quarries, destroying sites of significant cultural, spiritual and economic interest.
- This experience is characteristic of Aboriginal engagement with the mining industry, and Aboriginal people frequently experience conflict about their ownership and right to speak for sites where minerals and rock were mined and quarried, as often the same sites are important for today's mineral industry.
- The destructive and damaging activities of industrial-scale mining compromise and often completely destroy Aboriginal sites, causing great hurt to Aboriginal communities culturally.
- Aboriginal people can and do work with scientific and extractive industry bodies, if treated respectfully and as equal partners.
- There has been great progress, and this document by leading Indigenous lawyer, Prof. Marcia Langton, provides a comprehensive overview.
- These relationships can be effective for both partners, allowing better research, exploration and rehabilitation outcomes before, during and after mining commences.
- However, many of these relationships place financial pressure on vulnerable communities, who may feel pressured to sign away rights to address community needs.
- There is also a clear power imbalance between Aboriginal communities, and the government and mining interests. This makes legal negotiations more difficult.
- If negotiations are carried out in good faith, positive outcomes can occur. The Wilgie Mia conflict was negotiated to a mutually satisfactory conclusion and involved an Indigenous Land Use Agreement (ILUA).
- An ILUA is a way of negotiating a binding access agreement under Australia's Native Title Act.
- ILUAs represent a good way for Aboriginal people to negotiate with business, mining interests and the government.

Career information

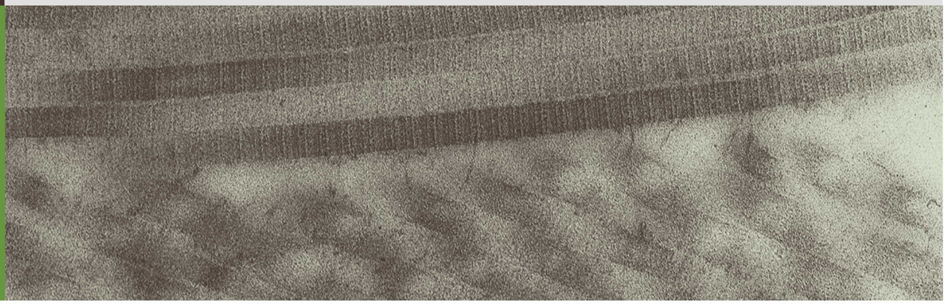
STEM career options related to ochre and other products of the earth include:

- mining and related industries
- land rehabilitation and remediation
- archaeology, including scientific dating techniques, like carbon dating
- artefact preservation and restoration
- geology and earth sciences
- the cosmetics industry
- paint manufacturing and development.

Topic

Fibres – composite materials

Curriculum alignment:
Senior secondary



Composite materials

Introduction

In our exhibition, many artists have used a variety of media, mixed and presented in ways that create something new from these various parts. The natural world is like that also, with living things and the geological landscape being comprised of a mixture of different materials. Sometimes these mixtures are so subtle that it takes powerful microscopes to see what they are made of. In many cases, these composites have unusual properties, like strength, flexibility and resilience, which are lacking in their individual components. It is the mixture that allows these new properties to come about.

People around the world and through history have recognised the unique properties of various composites, from prehistoric tools such as bows and arrows, to the concrete used by the ancient Romans to make so much of their architecture and infrastructure. In the modern day, composite materials are used for both commonplace and innovative solutions to various problems, in new industries and in a multitude of ways.

Links to the Australian curriculum

Chemical fundamentals: structure, properties and reactions

Construction materials

ACHAH131

Experimental design

ACSPH002 and similar.

Mechanics

ACSPH062 (vertical motion due to gravity)

Activity

Testing a composite material

What makes a composite material stronger than its component parts? How much stronger is it? There is a remarkable material that was developed in the Second World War called pykrete, after its inventor, George Pyke. It was invented in part as a way of creating **bulletproof ship hulls** using nothing but water and sawdust. It converts water ice into a bulletproof **composite material** that doesn't melt. **Today the material is being researched as a cheap and biodegradable building material** and even in applications for space travel and construction.

Materials

Water, four 4 L ice-cream containers, shredded newspaper, sawdust, grass, 1 kg weight, metre ruler or tape measure.

Method

- Into each ice-cream container pour 2.5 L of water. Leave one as a control and put several handfuls of sawdust in one, paper in another and dry grass or straw in the third.
- Mix thoroughly and place in a freezer overnight.
- Once frozen, turn each block out onto a bench.
- Using the metre rule, drop the 1 kg weight onto each block in turn, starting at 100 mm and increasing the drop height in 100 mm increments and then increasing the weight, until each block shatters.
- Record the height of drop of the weight needed to make each block shatter. The energy of the falling weight from height h when it hits is given by $E = mgh$. In the equation, m is the mass of the object, E is the energy, g is the acceleration due to gravity (9.81 m s^{-2}).
- Graph the results, comparing which variation of the pykrete recipe produces the strongest block.
- As a further experiment, repeat the four different pykrete recipes and then leave the frozen blocks to melt, timing each.

Questions

- Why is the pykrete stronger and less prone to shattering than plain water ice? What factor in the molecular structure of water ice makes it brittle? Research why the addition of an aggregate makes pykrete so strong.
- What forces are occurring when the pykrete is hit with the weight? Are they shear or compressive forces? Can you work out a way of testing whether pykrete is resistant to other forces?
- Why does the pykrete resist melting?
- Of the substances used, which was the most successful aggregate and why? What physical characteristics of each material contributed to its success?

Composite materials

- A composite is a material made by combining two or more different materials, without mixing or dissolving them. The resulting material has properties that are unique and distinct from those of its components.
- The built environment is full of composite materials, because combining different materials allows us to take advantage of their different properties.
- Reinforced concrete is a good example. The cement part has good strength under compression, but is brittle and can shatter under sideways forces like rocking in the wind. By adding an aggregate of pebbles and reinforcing metal mesh or rods the resulting composite has excellent resistance to shear forces, or forces that deform the material, as well as great strength under compression.
- The ancient Romans developed this composite technology to such a degree only recently has industry has been able to replicate the toughness and durability of Roman concrete.
- In the natural world, many tissues in living things are composites. Plant stems, for example, have fibres of cellulose, a flexible tissue, glued together in a matrix of weak, but very sticky, lignin. This gives them both strength and flexibility, as the fibres remain together in a bundle.
- In the human body, collagen is a tissue found most commonly in a composite form, bound together in bundles as sinew, in a matrix with proteoglycan gluing it together in cartilage, and in a flexible and complex arrangement of keratin scales as hair. In the case of hair, the nature of the composite determines whether your hair is curly, wavy, straight or fine.
- Modern composite materials, like carbon fibre, are essential to the aerospace industry, and many modern composites take the form of a resin matrix reinforced with various fibres for strength and flexibility.
- Composites made by sandwiching a lightweight material between two layers of strong fabric are strong, light and flexible, and are used in plane wings, boat hulls, and to make lightweight solar powered cars and Formula 1 racing cars.

Composite materials in Indigenous culture

- Adopting and exploiting the properties of composite materials led to some of the most important innovations in human culture and technology.
- In many cases, the materials used to create these tools are themselves composites, each part giving unique and useful properties.
- Iconic tools such as the hafted stone axe, bow and arrow, fishing hook and line, and spear thrower all combine different materials to create composite tools that exploit the properties of the components to create efficient, labour-saving devices.
- The presence of composite tools in archaeological deposits points to the development of the human species, from Homo erectus who used simple pebble choppers, to Homo sapiens and Neanderthals who created complex tools, made of several different materials. (However, these are not true composite materials, but instead are a separate class of composite, the composite tool.)
- Indigenous peoples also used true composite materials, with one, the mud brick, being a key marker in the development of human settlement. Ancient mud bricks, made to specific recipes we are only now understanding, have lasted for thousands of years. This is a testament to the skill with which they were made and the nature of the composite material.
- Another critical type of composite material used by Indigenous peoples was various forms of glues and resins, used to bind materials together in a way that is strong and waterproof.

Resources

- Indigenous Australians used resin from spinifex grass and grass trees to create a sticky plastic that is flexible when heated, but dries to a hard, waterproof substance. This was used to bind together different materials such as spear heads and shafts, and was formed into shapes for handles. Its waterproof properties make it important for mending water-carrying vessels and even boats and canoes.
- Various additional substances are added to provide flexibility and strength, including ground grass fibres, kangaroo poo, charcoal and other plant materials. These perform the role of an aggregate in the resin matrix.
- This video shows a method of creating glue from kangaroo poo in Western Australia. Noongar people lacked the metamorphic and igneous rocks essential for making durable stone tools. Instead they had a form of sharp, but very brittle limestone. The glue was used to embed shards of stone in a large blob of the glue, creating durable and extremely sharp tools. Tools like these were made across Australia.
- Today, these ancient plastics are being investigated because their properties can assist in the development of safe, green, biodegradable plastic, building materials, and modern composite materials. The ancient knowledge of Aboriginal people is becoming essential to modern industry.
- Spinifex fibre is incredibly strong at a microscopic level. Its fibres are so small that they comprise a nanofibre. The tiny size and great strength of these bundled fibres make them essential for both Aboriginal and modern industrial applications. Synthetic nanofibres are used in industry but can have significant environmental costs. A natural, cheaply produced and biodegradable nanofibre is therefore very desirable. This research is benefiting Aboriginal organisations involved and the importance of Aboriginal science is increasingly being recognised.

Career information

STEM career options related to composite materials include:

- mechanical engineering, including mechanical testing and structural design (eg aerospace)
- chemistry of materials including development of environmentally friendly materials
- medical science, including development of prosthetics
- advanced manufacturing
- biology and the development of biomaterials
- industrial design using advanced materials
- studying the chemistry and physics of materials.

Topic

Rocks and minerals – crystals

Curriculum alignment:
Senior secondary

Crystals

Introduction

In our exhibition, the microscopic features of crystals have inspired some amazing artworks. Crystals are beautiful objects that amaze through their regular facets, colours and shapes. Crystals look too organised and perfect to be natural, but they have formed according to natural forces acting at a molecular scale. These crystal structures are an essential part of nature, underlying much of the geological environment and even affecting our biology.

Humans have been fascinated by crystals since ancient times, and in the modern day their uses are extraordinary. **The United Nations declared 2014 the International Year of Crystallography**.

Links to the Australian curriculum

Units

- **Senior earth and environmental science, Unit 3:** Living on earth – extracting, using and managing earth resources
- **Chemistry, Unit 1:** Chemical fundamentals: structure, properties and reactions
- **Chemistry, Unit 2:** Molecular interactions and reactions

Codes

ACSCH005, ACSCH031, ACSCH048, ACSCH078, ACSES070, ACSPH010, ACSPH087

Pseudoscience and the scientific method

Science stands in opposition to what is called pseudoscience, where claims are made that cannot be backed up or validated by other researchers. Pseudoscientific claims fail one or all of the tenets of science, including impartiality and repeatability.

Crystals are subject to **many pseudoscientific claims** about their health-giving benefits, effects on mood and character, and capacity to channel manifestations of human wishes and desires. Some of these claims are made with the backing of what seems to be scientific investigations, including that the growth of crystals can be influenced by human thoughts and that therefore crystals can be used to store information. In the case of mysterious 'crystal power', these ideas have been spread by celebrity endorsements, including by Gwyneth Paltrow.

Marcel Vogel is a scientist who spent his life on both mainstream and alternative scientific investigations of the properties, characteristics and potential of crystals.

Use this statement from the NSW syllabus as a guide to your inquiry:

> *How does the reporting of science influence the general public's understanding of the subject? Analyse a pseudo-scientific claim and how scientific language and processes can be manipulated to sway public opinion. Describe the halo effect and, using examples, explain how the influence of positive perceptions can result in the rejection of valid alternative perspectives, including but not limited to celebrities endorsing products or viewpoints.*

Research alternative therapies and claims made about crystals, including those by Marcel Vogel and others, and address whether these statements represent scientific knowledge, or pseudoscientific conjecture.

- Investigate whether these claims have been subject to peer review, and whether any experimental results have been replicated.
- Look for examples of famous people who support crystal healing and other claims. Analyse the language used. Is that language emotive? Does it seek to discredit the scientific method in order to validate those claims?
- Look for articles and other material that refute those claims and analyse whether the refutations are themselves scientific. Do they provide peer reviewed research to support any counterclaims? Do they address any shortcomings in the methodology of the original claim?

What's in your pocket?

Do you have a phone in your pocket or bag? The modern mobile phone is an incredibly complicated piece of technology that uses many advanced materials.

Find out what crystalline materials, if any (for example, silicon) are present in the:

- antenna (the materials here are known as dielectrics)
- computer chips (semiconductors)
- camera
- screen
- battery
- casing
- microphone and speaker.

Remember, metals are crystalline! The **environmental and ethical issues** around **mining for minerals for use in phones** and other technology are also of interest.

Resources

What is a crystal?

- A crystal is a type of solid material that forms in a characteristic way, according to the structure of bonds occurring between the atoms in its molecules. It is often a metal, a mineral or a ceramic but other kinds of molecules can also form crystals, including the proteins that allow life to work.
- Crystal structure is extremely well ordered, being arranged in what is called a crystalline lattice. The same basic building block is repeated over and over again.
- Crystals are an example of homogenous solids, and therefore the way they behave, their refractive properties, strength and other physical characteristics, are consistent and predictable.
- The nature of the crystal lattice means that crystals form in characteristic shapes, with different shaped faces. Some are squares, others have five or more sides.
- **This link takes you to a detailed series of lessons on crystal structures**.
- Crystals refract and reflect light in characteristic ways. This gives different crystals their characteristic colours and sparkle.
- **This link is to a gallery of different crystals**.
- Crystals form when a molten substance such as lava and magma cools, when a liquid freezes or evaporates, leaving behind dissolved materials like salt, or in solution, where a dissolved mineral can precipitate out gradually.
- **The speed of crystallisation affects the crystal structure, and the material is either fine grained, called cryptocrystalline, or coarse grained**.
- The size and shape of the crystals formed depends on how fast and under what conditions the substance has either cooled, frozen or precipitated.
- Under the earth some molten rocks cool slowly and under enormous pressure, forming huge and beautiful crystals. The same rock when cooling on the surface produces a very different material, often volcanic glass like obsidian. In a volcanic glass there is no crystal structure at all.

Crystals and industry

- Crystals can be grown in labs and factories, and much of the crystal used today has been created synthetically. Examples include synthetic diamond and graphite, synthetic silicon crystals and synthetic quartz (silicon dioxide, SiO_2).
- **Crystals are essential parts of modern industry and technology**, being used in electronics, lasers, watches and other fine mechanical devices, optics, superconductors and the cutting and fabrications industries.
- Liquid crystal displays (LCDs) have revolutionised screen technology, and light emitting diodes (LEDs) are allowing us to light our world with reduced CO_2 emissions.
- **Crystals can even be used to make electricity**.
- The capacity of crystals to store and release energy from light, magnetic and electrical fields has allowed the incredible range of technological uses. Superconductors, magnets and computer chips are all crystalline materials.

Crystal dating

- The capacity of crystals to change and store energy is used in dating archaeological finds.
- **Thermo-luminescence dating** allows us to accurately date ancient finds for times for which **carbon dating does not work**.
- **This type of dating has been used when investigating ancient sites of Aboriginal occupation around Australia**.
- Using this method of dating, the human story as we evolved and travelled around the earth has been rewritten.

Career information

STEM career options related to crystalline materials include:

- engineering, including mechanical testing
- materials science, including the chemistry of materials and metallurgy
- development and manufacturing of advanced materials for technology – like materials for phones, electricity generation and carbon capture
- studying the chemistry and physics of materials.

MICROSCOPY AUSTRALIA

All year levels

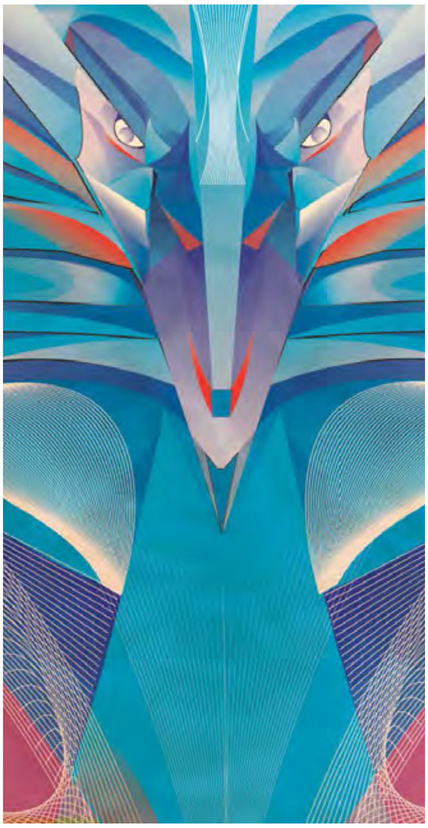
Your Autochthonous Seam — Julian Oates

Visual arts activities

Here are some starting points for visual art explorations and activities that could be done either in class or at the exhibition. All images and texts are available at: storiesandstructures.micro.org.au.

Most activities can be adapted to different stages of the curriculum.

Explore



Yulu the Kingfisher Man
— Jason Coulthard

Exploring the exhibition images

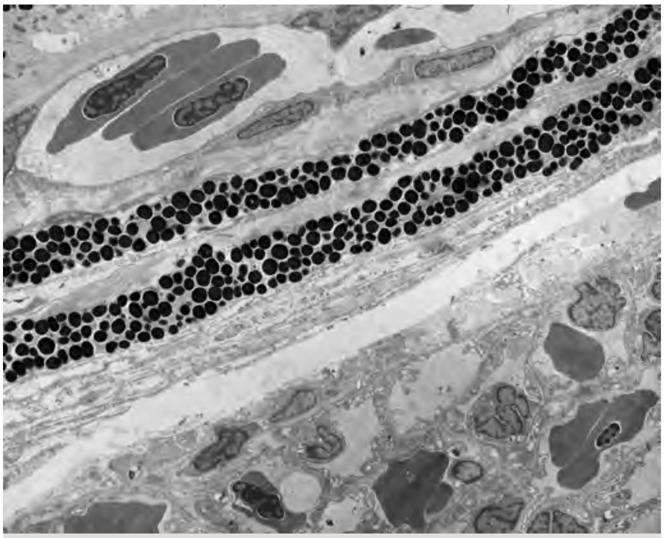
- Locate and list the titles of artworks in which traditional earth pigment colours are used. What is the same and what is different in the microscopic structures of two of the pigments used?
- In the exhibition, find an artwork where a carving tool was used to create lines. Name the artist and the title of the work. How does it connect to the structures in the micrograph?
- Locate and list the titles of two artworks where secondary colours are used. What reasons may have influenced the artists' colour choices?
- Identify the shapes and patterns in the micrographs and explore how these are repeated at different scales in natural structures. Identify and describe artworks and the associated micrographs where these parallels are apparent.
- After viewing the exhibition, locate the example of microscopic imagery that you consider to be the most similar to its Aboriginal art partner. Why did you make your choice?
- Aboriginal cultures can use art as a language to document their history. Select three examples from this exhibition in which this is the case. Briefly explain why using art as a language is important.
- Identify artworks that have drawn conceptual connections between the micrographs and social or political issues. What are the issues they are addressing and how are the micrographs related to these ideas?
- Locate and select two artists and their artworks from very different parts of the country. Make a simple sketch of each example. Use that as the basis to describe the similarities and differences using some of the terms listed below.

  - Line
  - Shape
  - Size
  - Direction
  - Colour
  - Tone
  - Texture
  - Subject matter
  - Repetition

Create

Creating your own artworks

- Choose one microscopic image. Observe and use the patterns and structures to inspire a work that connects the subject of the micrograph to something important in your life.
- Find a microscopic image relating to skin. From looking at the image and reading the description, write down words that describe ideas about skin that spring into your mind. How would you express those ideas in an artwork?
- Look at your own skin under the microscope. Draw the patterns that you see. Use these patterns as the basis of an artwork that illustrates what skin means to you.
- Explore the structure of different sands, soils or plants under the microscope. Do drawings or take photographs of the structures that you see. Using the images, make a collage or mural relating to the part of the country where they were collected.
- Choose one microscopic image. Observe the patterns, tilt your head and select an area. Use parts of the microscopic image to inspire a simple landscape.
- Choose and download a micrograph from the exhibition website. Manipulate, enhance and/or colour it digitally to tell a story connected to its subject matter.
- Choose one or more pattern elements from a micrograph and develop it into a repeating design to adorn a household item or set of items.



Fish Eye – Blood Flow — Image: Shaun Collin

Microscopy as art

- Carefully observe and follow the patterns and structures of one microscopic image. Imagine that the microscopic image is a large mural painted on a wheat silo in the Australian countryside. Write a paragraph about this gigantic outdoor artwork. Consider the strongest visible elements. You may decide to consider the following: line, balance, shape, tone, size, direction, unity, proportion, texture and repetition.
- Describe one micrograph that you think looks least like what you would expect to find in nature. What is it about the image that makes you think that? What did you expect nature to look like at the microscopic scale?

These ideas were developed by Dotti Le Sage and Microscopy Australia.